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An Analysis of Some Factors Affecting Catch Rates of Sub-65' Groundfish Fishing Vessels in 4X/Sub-Area 5 of Southwest Nova Scotia

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Preface

The initiative for this analysis was the requirement to resolve problems arising from excess fishing capacity in the 4X/Sub-area 5 demersal fishery. Two possible tactics have provided the basis for the direction of the analysis. One method of capacity control focuses on licence replacement policies; what regulations must be enforced to prevent an increase in the fleet capacity when a vessel is replaced, or, by extension, what regulations are needed to affect a specified reduction in the fishing power when a new vessel replaces an older one. The second tactic (may) de-emphasizes vessel-dimension control, rather it focuses directly on controlling catch through a vessel catch allocation scheme. In this case the concern is how to determine future vessel catch allocations based on past fleet performance as a function of vessel dimensions, and what the consequences of such an allocation scheme would be.

While these concerns are fundamentally different in nature, neither is mutually exclusive and both controls may be implemented together. In either case, the analysis required to appraise either possible policy direction is the same; determination of factors affecting catch success in the study fleet. This report is deliberately analytical; it attempts solely to investigate the relation between CPUE, catch, and vessel dimensions. It specifically does not consider the merits of policy alternates.

Abstract

The relation between vessel dimensions and their catch success is examined for the sub-65' groundfish fleet operating in the NAFO areas 4X and 5 of South-West Nova Scotia. The vessel dimensions examined are length overall (LOA), gross tonnage (GT), brake horse power (BHP) and cubic number. Catch success is measured as catch (either weight or value) per day fished, and per year. The interrelation of the vessel dimensions and the trends in these dimensions as a function of vessel age are also examined.

Regression analyses were done on data for the years 1984 and 1985 with all data sets aggregated, and when disaggregated by year and gear class - Mobile gear and Longlines. Regressions were further done with the data dissaggregated on a stock and seasonal (quarter) basis.

The vessel dimension of gross tonnage proved the best indicator of catch success (R^2 = 40.2%). Because of the high correlation between the vessel dimensions investigated, multiple regression of CPUE on all vessel dimensions usually provided little increase in R^2 values, e.g., for the total fleet, both years, regression of CPUE on GT and BHP resulted in an increase in the R^2 value of only 1.4%

When catch success was examined on a stock basis, R^2 values ranged from 51.6% for 4Vn Cod, using GT as the dependent variable, to 1.3% for 5Z haddock, using LOA as the depandent variable. No clear pattern was apparent when analyses were done on a quarterly basis; for some stocks larger R^2 values were obtained while for other stocks the R^2 values were smaller. In other cases disaggregating the data by year affected whether seasonal disaggregation increased the R^2 values.

The relative performance of specific vessels, in terms of their CPUE, was examined between seasons and between years. Relatively high correlations were obtained for vessels ranked by catch success, for the 4Vr and 4VsW Cod stocks, r = 0.74, though for the largest data set, 4X Cod and 4X Haddock, the correlation coefficient was only 0.40. Inter-annual comparisons between years showed that considerable variation occurred in the relative performance of vessels, but there was considerable affect of gear type upon this.

The amount of time spent fishing per year, and the fraction of time at sea spent fishing, was examined as a function of gear type and vessel dimensions. Large variations for vessels of similar dimensions is evident, and different gear types even showed differences in the sign of the regression. Smaller vessels spent a higher fraction of the sea-time fishing than did larger vessels.

Investigation of the effect of vessel age on catch success was confounded by changes in vessel dimensions, particularly gross tonnage, with year of construction. In a stepwise regression of CPUE on GT, year of construction, LOA, and BHP, GT explained 35.6% of the variation, year built 3.6%, and LOA, 0.2%; BHP made no further reduction to the error residuals. The results indicate that replacement of the oldest 25% of the fleet would increase fleet capacity by 3.9% for the Mobile gear and 2.9% for Longliners.

Regression of total catch on vessel dimensions resulted in lower R^2 values compared to those obtained using CPUE as the dependent variable. Again a significant age affect was found for total catch, equal to the equivalent of 0.8' LOA per year.

The outstanding feature of the analyses is the large variation in CPUE that is unexplained by the regression analyses. The effect of possible model error and missing or unknown dependent variables are discussed. Further contributions to unexplained error in the regressions from the nature of the data base are reviewed.

Key words: fishing power, fleet capacity.

Résumé

On étudie la relation entre les dimensions des bateaux de moins de 65 pieds qui pêchent le poisson de fond dans les divisions 4X et 5 de l'OPANO, au sud-ouest de la Nouvelle-Écosse, et le succès de pêche qu'ils obtiennent. Les dimensions retenues sont la longueur hors-tout, la jauge brute (JB), la puissance au frein (PF) et l'indice volumétrique. Le succès de pêche est quantifié sous forme de prises (poids ou valeur) par jour de pêche et par an. On examine également l'interrelation entre les dimensions du bateau et les tendances qui apparaissent lorsque ces dimensions sont considérées comme fonction de l'âge des bateaux.

Des analyses de la régression ont été effectuées pour 1984 et 1985 avec tous les ensembles de données regroupées et, également, avec des données désagrégées par année et catégorie d'engin (engins mobiles et palangres). On a aussianalysé la régression par stock et par saison (trimestre).

La jauge brute s'est avérée le meilleur indice du succès de pêche (R^2 = 40.2 %). En raison de l'importante corrélation qui existait entre les dimensions des bateaux considérés, la régression multiple des PUE sur l'ensemble des dimensions n'a généralement abouti qu'à une faible augmentation des valeurs R^2. Ainsi, pour la totalité de la flottille au cours des deux années retenues, la régression des PUE sur la JB et sur la PF n'a donné qu'une augmentation de 1.4 % de la valeur R^2.

Un examen du succès de pêche obtenu selon le stock a révélé un échelonnement des valeurs R^2, allant de 51.6 % pour la morue de 4Vn lorsqu'on utilisait la JB comme variable dépendante à 1.3 % pour l'aiglefin de 5Z lorsqu'on utilisait la LHT comme variable dépendante. Aucune tendance nette n'est apparue dans les analyses effectuées par trimestre : pour certains stocks on a obtenu des valeurs R^2 plus grandes et pour d'autres stocks des valeurs R^2 plus petites. Dans d'autres cas, la désagrégation des données par année a eu un effet déterminant sur la variation des valeurs R^2 obtenue dans les analyses par saison.

On a examiné le rendement relatif de certains bateaux, sous forme de PUE, d'une saison à une autre et d'une année à l'autre. On a pu établir des corrélations importantes pour les bateaux classés d'après leur succès de pêche dans les stocks de morue de 4Vr et 4VsW (r = 0.74), quoique pour les plus grands ensembles de données, soit ceux qui portaient sur la morue et l'aiglefin de 4 X, le coefficient de corrélation n'ait été que de 0.40. Les comparaisons entre les années considérées ont révélé des écarts considérables dans le rendement relatif des bateaux, imputables en bonne part au type d'engin.

On a également examiné le temps annuel consacré à la pêche et la fraction du temps passé en mer qui était consacré à la pêche, comme fonctions du type d'engin et des dimensions du bateau. Cette analyse a révélé de vastes écarts pour les bateaux de dimensions comparables et même des différences dans le signe de la régression pour des types d'engin distincts. Il est apparu que les plus petits bateaux ont consacré une plus grande partie de leur temps en mer à la pêche que les gros.

L'étude des effets de l'âge des bateaux sur le succès de pêche a été faussée par les changements de dimensions, en particulier la jauge brute, selon l'année de construction. Dans une analyse de régression par degrés des PUE sur la JB, sur l'année de construction, sur la LHT et sur la PF, 35.6 % de l'écart était attribuable à la JB, 3.6 % à l'année de construction et 0.2 % à la LHT. La PF ne réduisait pas davantage le variances résiduelles. Les résultats obtenus révèlent qu'en remplaçant le quart le plus vieux des bateaux de la flottille on accroîtrait la capacité de la flottille de 3.9 % en bateaux de pêche aux engins mobiles et de 2.9 % en palangriers.

La régression des prises totales sur les dimensions des bateaux a abouti à des valeurs R^2 plus faibles que celles obtenues en utilisant les PUE comme variable dépendante. Là encore, l'âge avait un effet important sur les prises totales, soit l'équivalent de 0.8 pi de LHT par année.

Le trait dominant des analyses effectuées est le grand écart dans les PUE, inexpliqué par les analyses de la régression. On aborde à ce sujet la possibilité d'une erreur dans le modèle, de l'omission de variables dépendantes ou de la présence de variables inconnues. On examine rôle qu'a pu jouer la nature de la base de données dans les erreurs iquées des analyses de la régression.

Mots-clés : puissance de pêche, capacité de la flottille.

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1. Introduction

This analysis has been undertaken as a consequence of the study group concerned with capacity management in respect to the western Scotia-Fundy small vessel (100') fleet. This group was concerned with possible solutions to the biological and economic overfishing of fish stocks in the 4WX NAFO management divisions and the relatively large latent excess fleet capacity which exists that could enter the fishery.

The study group noted that to achieve the $F_{0.1}$ level of fishing mortality, major reductions in the short-term total catches of the major species (cod, haddock and pollock) are necessary. They noted that the deployed fleet capacity is about twice the size at which a fishing mortality of $F_{0.1}$ would be generated. Because many vessels that are active in other fisheries (e.g. the Digby scallop fleet and the S.W. Nova lobster fishery) also have licences to participate in the study area demersal fisheries, even more vessels could enter the fishery in response to relative declines in the financial attractiveness of the fisheries which they presently prosecute.

This study is one step towards developing fleet capacity controls and management of fishing effort in a manner that explicitly considers the factors that determine the fishing power of a vessel.

2. Vessel Characteristics

2.1 Introduction

Implicit in the present vessel replacement policy is that the fishing power of a boat is some function of its physical dimensions; at present the regulatory dimension used is the length of the boat. Among other possible vessel characteristics that may affect the fishing power of a vessel are its gross tonnage (GT), the main engine power, usually measured as brake horsepower (BHP), and the Cubic Number (CN) of the hull. Thus it is of interest to know how these variables are inter-related, for example, is the engine power a simple function of GT? or, how does the GT vary as a function of vessel length?

If engine power, measured as brake horsepower is always well described by the GT, then it may be sufficient to use only GT in a future regulation on vessel size. Alternatively it may be desirable to allow some flexibility of choice to fishermen while limiting the vessel as some function of GT and BHP, e.g., some fishermen may prefer to trade GT for increased engine power, or vice versa. Knowledge of how these variables are inter-related in the existing fleet may provide useful insight.

No matter what vessel specifications are used to limit the fishing power of a vessel, naval architects, at the behest of fishermen, will attempt to design around them. If only length is limited, beam and/or draught (and/or depth) may be increased. Even a cursory examination of many newer vessels shows this to be a common occurrence. Likewise, restrictions on BHP may be circumvented by fitting Kort nozzles or, perhaps, more powerful auxilliary engines. Knowledge of trends in these characteristics may provide insights as to how future vessels may be designed to increase their fishing power given that one or more of their dimensions are regulated.

Definitions of how vessel dimensions are measured are given in Appendix I. How a vessel's linear dimensions are specified is not necessarily simple. Transom sterns as opposed to counter-sink sterns will increase the length between posts, but not the length overall; they will also increase the vessel's GT. Likewise a flared bow which may improve a vessels sea keeping characteristics, (and thus its safety) will decrease the vessel's length between posts but not its LOA. Trade-offs within the vessel, e.g., smaller engine rooms and crew accommodation, may permit an increase in the fish hold capacity without any increase in the vessel's GT. Shelter decks (not yet common in Canada) may substantially increase a vessel's GT, while increasing its fishing power to a much lesser degree, for no change in the length or BHP of the vessel. Insulating the deck head of the fish hold will reduce its hold capacity, and thus its ability to carry fish, without affecting the vessel's GT. Most of these problems have been duly agonized over in many management fora.

2.2 The Study Fleet

The fleet examined (the study fleet) consisted of tonnage class 2 (25 - 49.9 GT) and tonnage class 3 (50 - 149.9 GT) demersal-fish fishing vessels, i.e., trawlers, longliners, Scottish and Danish seiners,operating in the Scotia Fundy region. In most analyses the fleet examined was slightly reduced by only considering vessels that were less than 65' LOA. Because not all vessels reported effort, or reported effort for all voyages, in cases where effort was required the data base has been further reduced. The fleet structure is that for 1984 and 1985.

2.3 Fleet Characteristics

Figure 2.1 shows the frequency distribution of vessel length overall (LOA) of the study fleet registered for Mobile gear(trawlers, Scottish and Danish seiners) and Longliners. Figure 2.2 shows the frequency distribution of vessel GT, Figure 2.3 the frequency distribution for fleet main engine BHP, and Figure 2.4 the frequency distribution for fleet fish hold capacity.

The registered fish hold capacity of a vessel is not measured. The value recorded is that estimated by the vessel owner/operator. Although hold capacity can not be increased when a vessel is replaced, there is neither confirmation or enforcement of this regulation (Pers. comm., C. Jones, Licensing, DFO, Halifax). Quality upgrading, through boxing at sea will introduce a further complication into the interpretation of a vessel's fish hold capacity as a determinant of its fishing power.

2.4 Vessel Variable Inter-Relationship

2.4.1 GT as a Function of LOA

Table 2.1 shows the results of regressing GT as a function of LOA. Significant regressions (p 0.05) were obtained for all vessels, Mobile gear, and Longliners when GT was regressed on LOA. The regressions explained 85.4%, 83.6% and 87.0% of the variation for all vessels, Mobile gear and Longliners respectively.

Because GT could be expected to have a logarithmic relation with vessel length, i.e.

$$GT = a(LOA)^b$$

FIGURE 2.1
DISTRIBUTION OF LENGTH OVER ALL

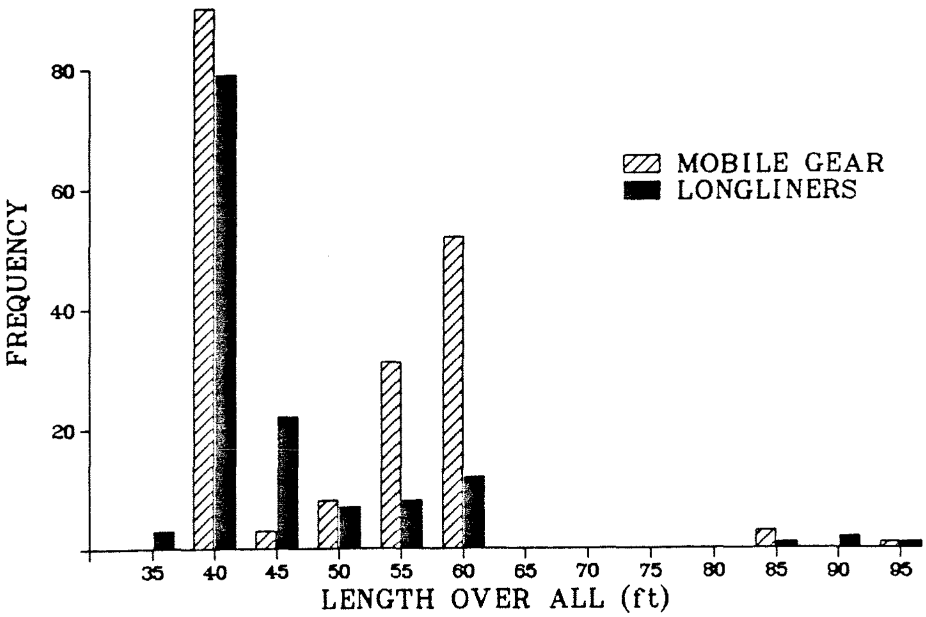


FIGURE 2.2
DISTRIBUTION OF GROSS TONNAGE

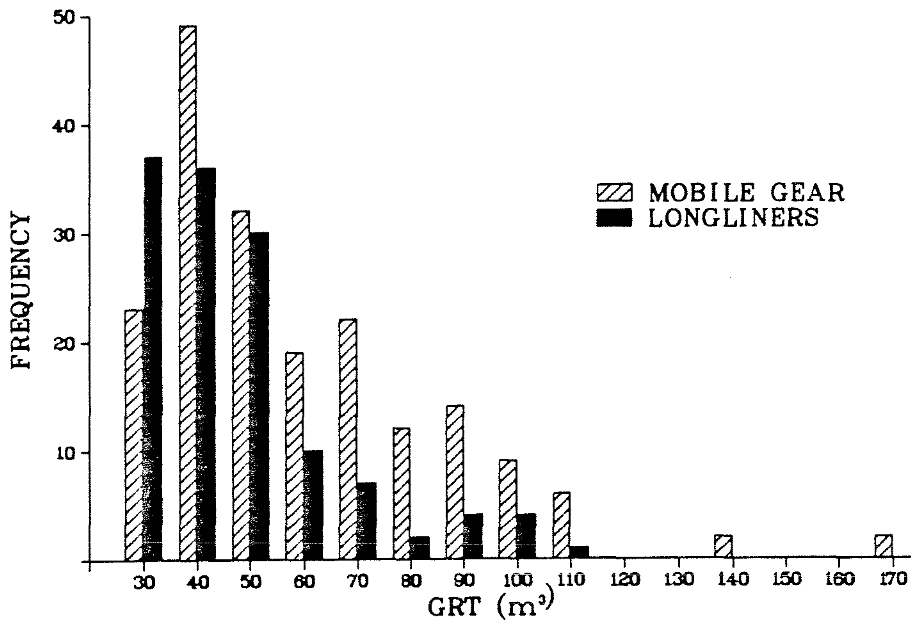


FIGURE 2.3
DISTRIBUTION OF STUDY FLEET ENGINE POWER

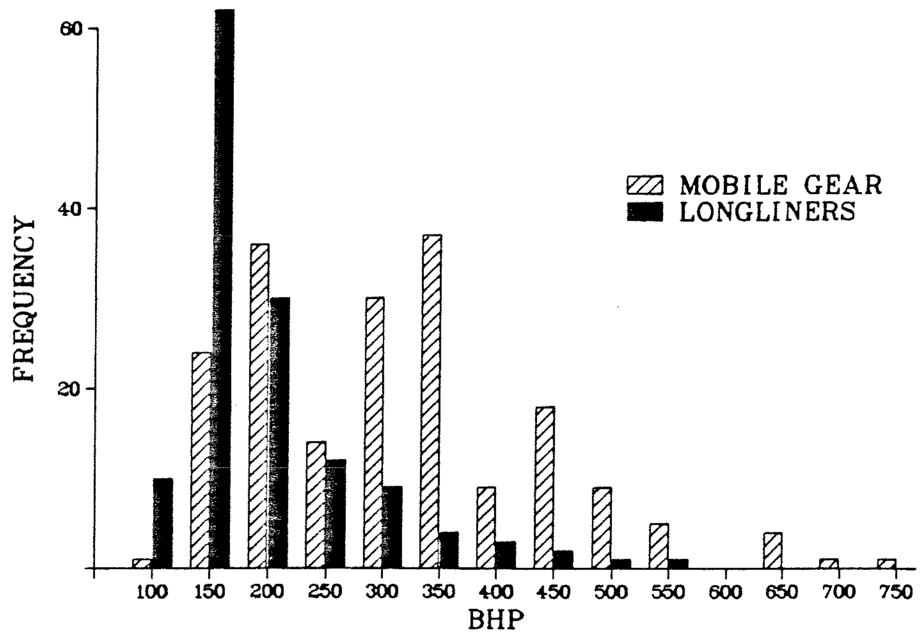
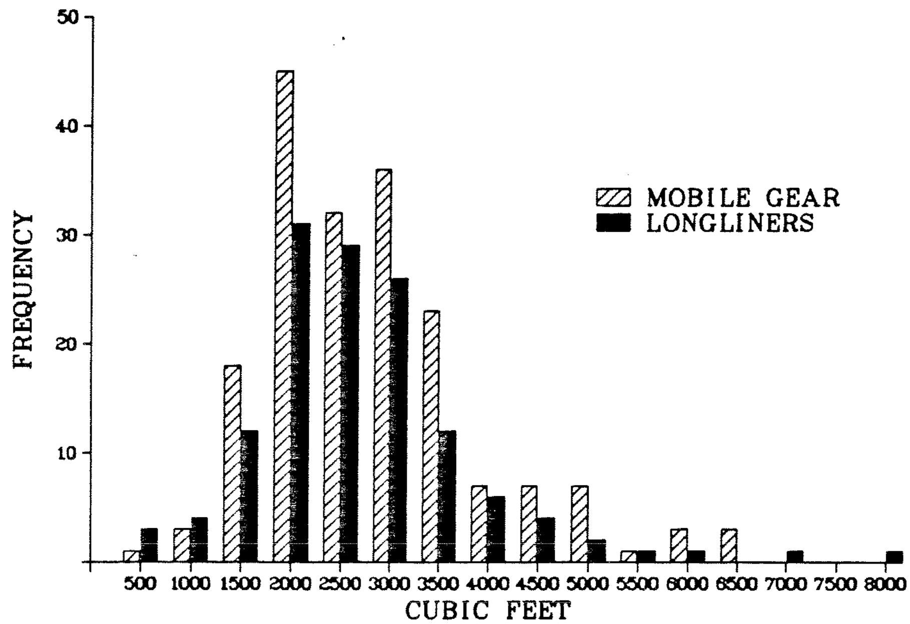


FIGURE 2.4
DISTRIBUTION OF FLEET HOLD CAPACITY



a regression analysis of

$$\ln GT = \ln a + b \ln L$$

was also done. Curiously, the R^2 values decreased slightly in value when the regressions were done using log-transformed LOA as the dependent variables for the "all vessels" and "longline" categories. However there is little difference in the fit of the original and log-transformed data.

Table 2.1
Regression Statistics for GT Versus LOA

	a	b	R^2
All Vessels	-63.1	2.23	85.4
Mobile Gear	-65.0	2.26	83.6
Longliners	-61.4	2.20	87.0
Log Transformed Variables			
All Vessels	-4.20	2.05	83.1
Mobile Gear	-4.28	2.07	84.1
Longliners	-4.05	2.01	79.5

2.4.2 BHP as a Function of LOA

Table 2.2 shows the results of regressing BHP on LOA. All regressions had p-values $<$ 0.001 for the test $b \neq 0$. Unlike the situation for the regression of GT on LOA where there was little difference between the regression coefficients for the mobile-gear and the longliner fleet, a clear difference is evident in the BHP-LOA relation for the two gear types. For the mobile gear, the regression explains only 53.7% of the variation compared with 87.0% for the longline fleet. The regression coefficient for the mobile gear fleet was about four times greater than that for the longline fleet (the regression coefficients are significantly different, p-value$<$0.01). Log transformations of BHP resulted in a small increase in the R^2 value for the mobile gear catagory only.

Table 2.2
Regression Statistics for BHP Versus LOA

	a	b	R^2
All Data	-131.5	8.32	52.1
Mobile Gear	-122.4	8.76	53.7
Longliners	- 61.4	2.20	87.0
Log Transformed Variables			
All Data	0.279	1.50	51.8
Mobile Gear	0.159	1.42	54.9
Longliners	0.732	1.20	46.0

2.4.3 **BHP as a Function of GT**

Table 2.3 shows the result of regressing BHP on GT. All regressions coefficients were highly significant. Again there was a clear difference in the power-size relation between the mobile fleet and the longline fleet, though the amount of variation explained by the regression was about the same. In the case of the Longliners, the regression coefficient was about 0.7 times that for the mobile gear fleet. These two coefficients are significantly different (p-value 0.01).

Table 2.3
Regression Statistics for BHP on GT
189 Trawlers, 135 Longliners

	a	b	R^2
All Data	106.2	3.68	59.4
Mobile Gear	132.1	3.82	62.6
Longliners	101.6	2.74	66.8

2.4.4 BHP as a Function of LOA and GT

Table 2.4 shows the result of a step-wise regression of BHP as a function of LOA and GT. These regressions show that in all cases, only a tiny improvement is obtained when BHP is regressed as a function of two variables instead of one.

Table 2.4
Multiple Regression Statistics of BHP on LOA and GT

$$BHP = a + b(LOA) + c(GT)$$

	a	b	c	R^2
All Data	-57.1	1.85	0.0453	59.4
Mobile Gear	-58.4	0.0542	1.79	62.7
Longliners	-56.5	1.71	0.0848	67.3

2.4.5 Fish Hold Capacity

Table 2.5 lists regression statistics of hold capacity as a function of LOA and GT. In none of the cases did the regression relations provide good fits. For example in the best fit, that of capacity as a function of GT for the Longline fleet, the regression explained only 33.9% of the variability. Capacity regressed as a function of vessel LOA explained, at best, 25.5% of the variability for the longline fleet, and 25.1% of the variability for the total fleet examined together.

The poor relations obtained for the capacity measurements probably arise because hold capacity is difficult to measure, fishermen are not required to measure their vessel's capacity, and there has been no validation of the capacity figures that are reported. At least two entries in the original data record show values which are so large as to appear clearly erroneous. These data were excluded from subsequent fish hold capacity analyses. The value given for a particular vessel may be inflated or deflated depending on whether the owner considered a positive or negative "error" to be in his interests.

Table 2.5
Regression Statistics for Capacity as a Function of LOA and of GT

	a	b	R^2
	Regressed on LOA		
All Vessels	-104.6	52.3	25.1
Mobile Gear	-145.4	52.4	24.4
Longliners	-134.4	53.8	25.5
	Log Transformed LOA		
All Vessels	6.91	0.0164	13.2
Mobile Gear	6.74	0.0198	23.9
Longliners	7.14	0.0113	4.6
	Regressed on GT		
	a	b	R^2
All Vessels	1302	24.8	0.328
Mobile Gear	1303	24.3	0.317
Longliners	1278	26.2	0.339

2.4.6 Measures of Vessel Cubic Capacity

One measure of the size of a boat is its "cubic number",

$$CN = \frac{\text{length x breadth x depth}}{100}$$

Depth is the distance from the keel to the surface of the main deck. The GT of a vessel should be a reasonably linear function of the cubic number. Figure 2.5 shows a plot of GT as a function of the cubic number for the mobile gear and longline fleets. While the plot shows a positive relation, considerable scatter is evident in GT for vessels of similar cubic number.

Results of regression analyses of GT as a function of LOA, breadth, and depth are listed in Table 2.6. When the whole fleet is considered the best predictor of GT is (LOA x breadth)$^{3/2}$ though a stepwise regression on the log transforms of LOA, breadth and depth is practically as good. A $^3/_2$ power function is used to give the predictor variables dimensions of volume as for GT. For the mobile fleet both these predictor variables perform well with the stepwise regression on the logged variates having a slightly higher R^2 than that for (LOA x B)$^{3/2}$, 85.9% compared to 84.8%. For longliners, regression of GT on (LOA x B)$^{3/2}$ had the largest R^2 of the predictor variables examined.

2.5 Trends in Vessel Design Characteristics

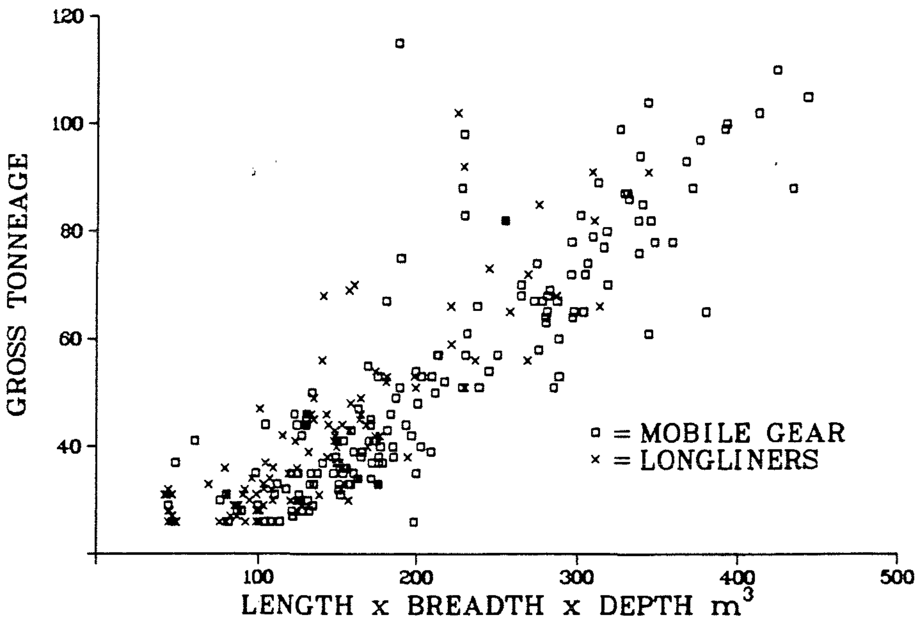
It is of interest to know if there have been trends in time in the relation between vessel design parameters, e.g., has vessel GT, BHP or capacity been increasing for vessels of the same length. Several complications prevent a simple analysis of vessel data, or at least a simple interpretation of the results. In 1976 barriers on vessel replacement were intoduced at 45' and 65'. Owners whose replacement vessels were not constrained by these limits would have no reason to compromise their vessel designs. Owners who were constrained to replacement vessels at the

Table 2.6
Coefficients from regression of Gross Tonnage on Vessel Dimensions

Model, Gross Tonnage versus:	R^2 (%)	b_0	b_1	b_2	b_3
All Vessels					
LOA	79.6	-50.84	6.992		
LOA^3	81.1	15.80	0.01030		
LOA x B x D	78.6	10.80	0.2087		
(LOA x B) 3/2	84.2	7.824	0.05907		
(LOA x D) 3/2	75.7	15.40	0.1665		
(B x D) 3/2	43.0	7.304	2.783×10^{-7}		
stepwise on log LOA, B, D	83.3	-1.3307	1.553	0.5921	0.07369
Mobile Gear					
LOA	79.8	-56.17	7.338		
LOA^3	81.9	14.63	0.01061		
LOA x B x D	81.1	6.642	0.2203		
(LOA x B) 3/2	84.8	5.983	0.0601		
(LOA x D) 3/2	77.8	11.90	0.1753		
(B x D) 3/2	41.4	1.3119	5.865×10^{-7}		
stepwise on log LOA, B, D	85.9	-1.674	1.588	0.7169	0.0977
Longliners					
LOA	75.1	-42.75	6.401		
LOA^3	75.1	17.50	0.009654		
LOA x B x D	71.5	11.83	0.2184		
(LOA x B) 3/2	80.2	7.779	0.06169		
(LOA x D) 3/2	67.3	16.93	0.1694		
(B x D) 3/2	35.0	1.333	1.629×10^{-7}		
stepwise on log LOA, B, D	76.4	-0.9446	1.444	0.5192	0.1257

FIGURE 2.5

RELATION BETWEEN GT AND CUBIC NUMBER



45' or 65' limit may have increased other vessel dimensions to augment the fishing power of their vessels.

In 1981, additional length replacement barriers were introduced at 5' intervals. These limited the ability to upgrade vessel fishing power. Thus the fleet may be considered to consist of three populations, vessels built prior to implementation of the 1976 policy, those built while only the 45' and 65' barriers were in place, and those built after the 1981 policy of 5' length replacement intervals were introduced.

In the first analysis, the vessel's GT, BHP and hold capacity have been compared with the value predicted by the regression relation that best explains the variation of these dimensions when they are regressed as a function of vessel LOA. The difference between the actual vessel parameter and the predicted value is then regressed as a function of the age of the vessel. If vessels of the same length have progressively larger GT, BHP or capacity, then the residuals should show a progression from negative values for older vessels to positive values for new vessels. Figures 2.6 to 2.7 show the distribution of the residuals as a function of age. The trend to increasing GT and BHP for vessels of the same length as a function of age is clearly apparent, newer vessels have increased GT and use engines of greater power. Figures 2.8 and 2.9 show the same results separately for each gear type. The population examined consisted of 323 vessels.

FIGURE 2.6
TREND FOR GROSS TONNEAGE

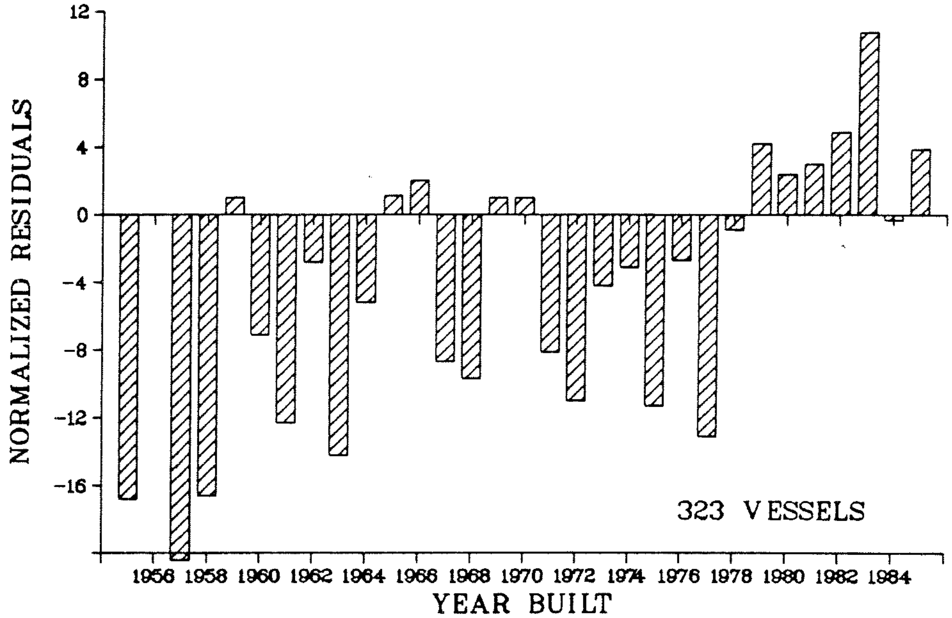
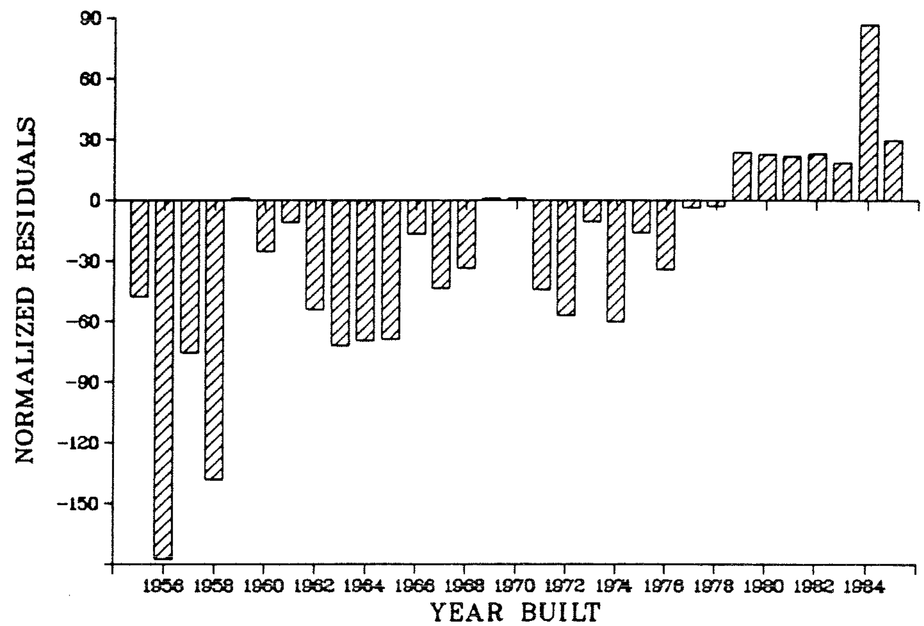


FIGURE 2.7
TREND FOR BHP



TRENDS IN VESSEL DESIGN PARAMETERS

FIGURE 2.8
BHP RESIDUALS

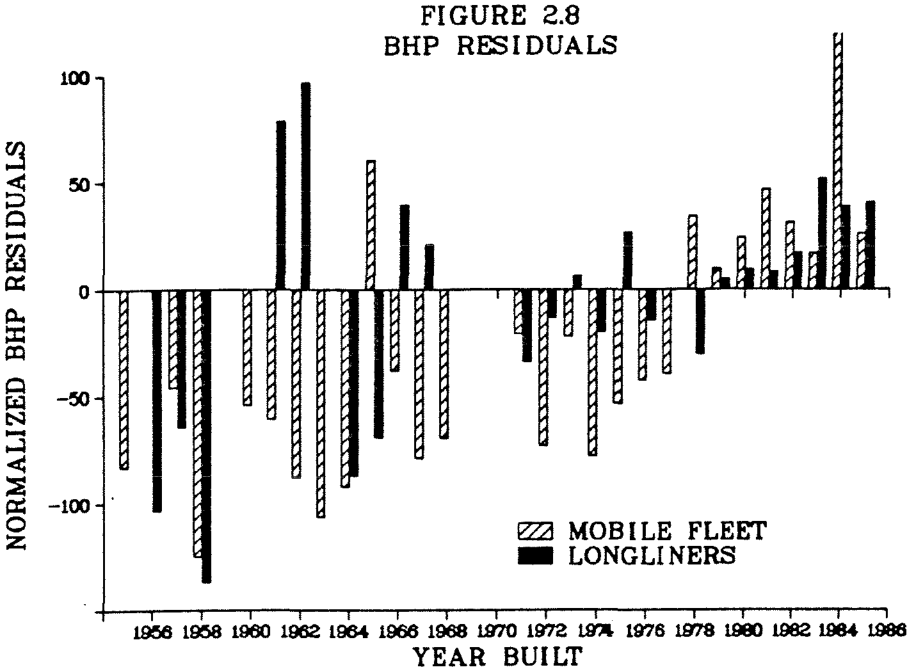


FIGURE 2.9
GROSS TONNEAGE RESIDUALS

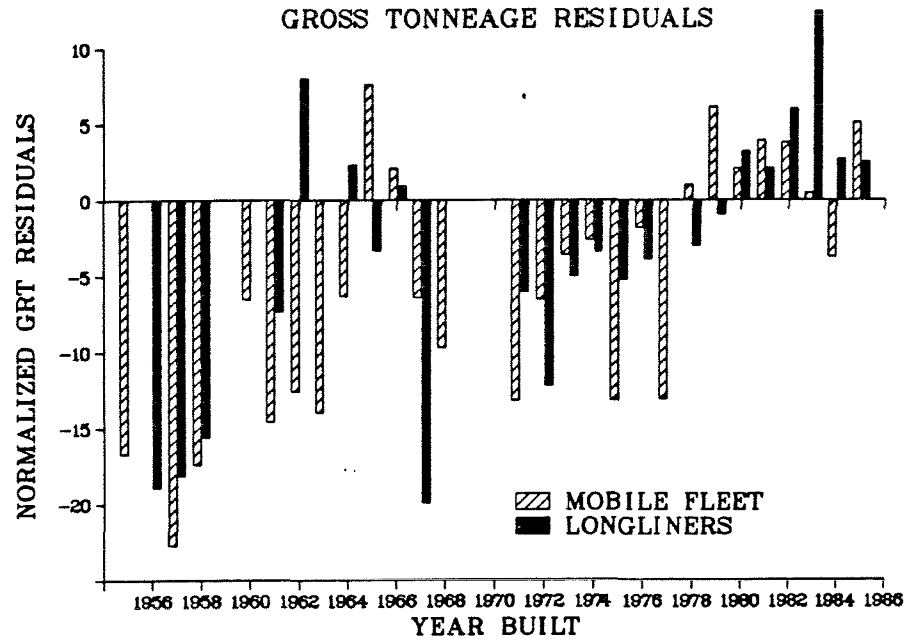


Figure 2.10 shows a plot of the ratio of LOA/breadth as a function of the year of construction of the vessel. Figure 2.11 shows a similar plot but with LOA/depth as the dependent variable. If these fishermen were building vessels with greater breadth or depth while being constrained by the vessel length that was permitted, then a declining relationship as a function of the year of construction should be evident. Figure 2.12 shows a similar plot of LOA^2 divided by the product of vessel depth and breadth as the dependent variable. While there is evidence of some increase in the product of breadth x depth for vessels of similar length over time, all three plots show considerable scatter in the dependent variable for vessels of the same age.

2.6 Age Composition of the Fleet

The age composition of the mobile gear and longline fleet are given in Table 2.7. Mean age is 10.8 years for the mobile fleet and 9.6 years for the longline fleet. Median ages are 7.3 and 6.5 years respectively. Figures 2.13 and 2.14 show the age frequency composition of the fleet for the two gear classes.

Predicting the life expectancy of a vessel is complicated by changes in materials used for their construction, in particular the rapidly increasing use of glass-fibre hulls. As such vessels have not yet begun to be retired from the fleet, no good estimate of the longevity of a glass-fibre hulled boat is yet available. Further, the vessel data record does not indicate the material of hull construction. Many new, larger vessels, I believe, are being built with glass-fibre hulls.

FIGURE 2.10

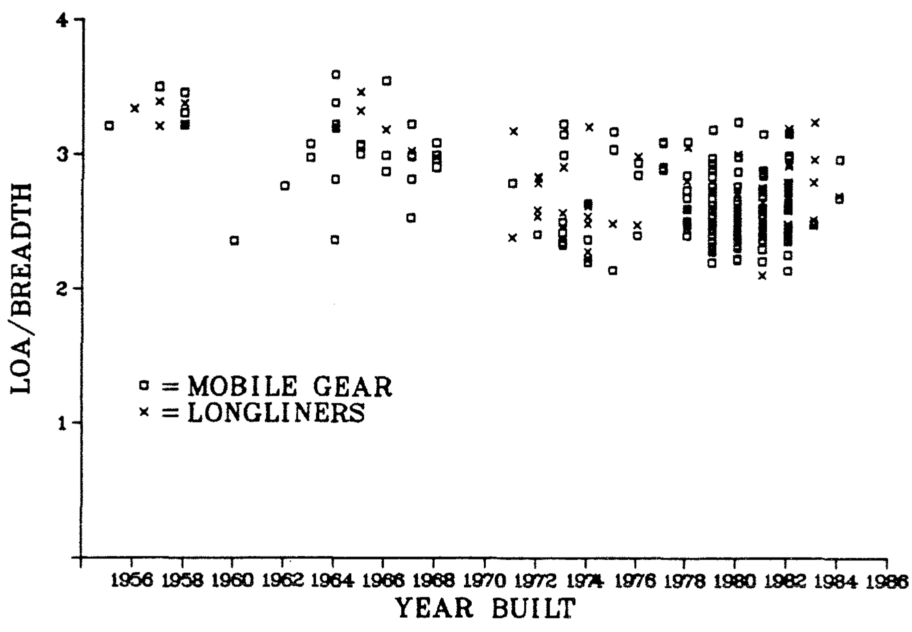


FIGURE 2.11

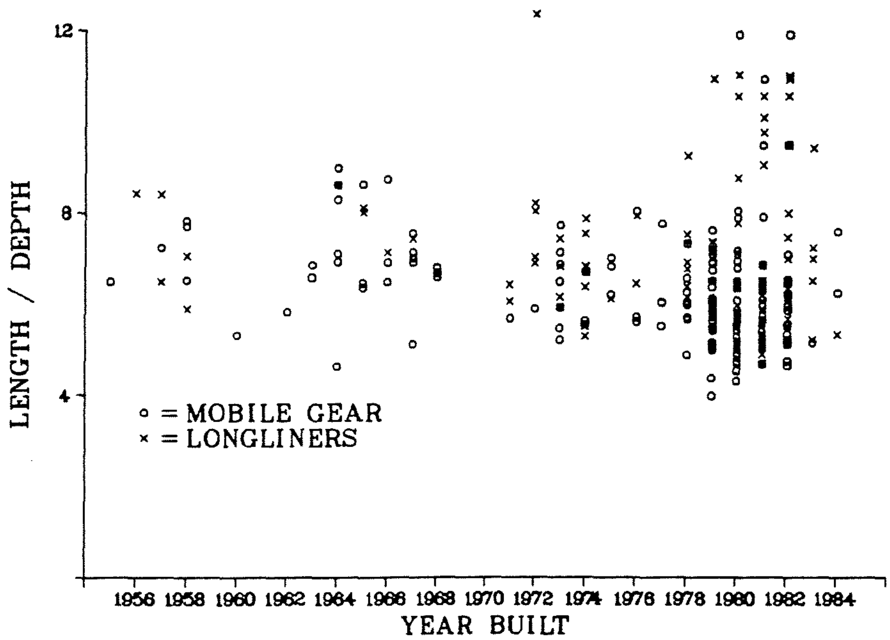
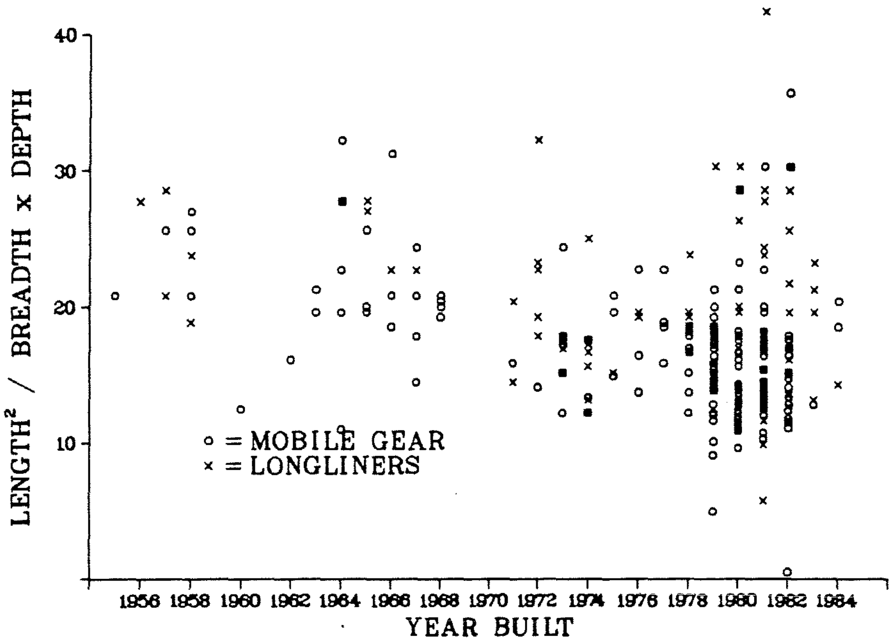


FIGURE 2.12



Figures 2.13 and 2.14 shows a comparative distribution of frequency of vessels by age and a weighted index, obtained from the products of number of vessels built and their LOA. Weighting made only a small difference to shape of the relative frequency distribution of vessel age. Figures 2.15 and 2.16 show the frequency of GT and BHP by vessel age for the two gear types.

Table 2.7
Age Distribution of Study Fleet

Age	Year Built	Mobile Fleet	Longliners
2	1985	2	3
3	1984	2	2
4	1983	1	5
5	1982	19	16
6	1981	26	29
7	1980	35	22
8	1979	33	11
9	1978	8	8
10	1977	5	0
11	1976	3	2
12	1975	3	1
13	1974	3	8
14	1973	8	5
15	1972	1	5
16	1971	1	2
17	1970	0	0
18	1969	0	0
19	1968	5	0
20	1967	5	1
21	1966	6	2
22	1965	3	4
23	1964	7	1
24	1963	3	0
25	1962	1	1
26	1961	2	1
27	1960	1	0
28	1959	0	0
29	1958	3	2
30	1957	2	2
31	1956	0	1
32	1955	1	0
Number of Vessels		189	134
Mean Age		10.8 yrs.	9.6 yrs.
25 percentile		5.9	5.3
Median age		7.3	6.5
75 percentile		13.2	12.2

FIGURE 2.13
MOBILE GEAR (LOA)

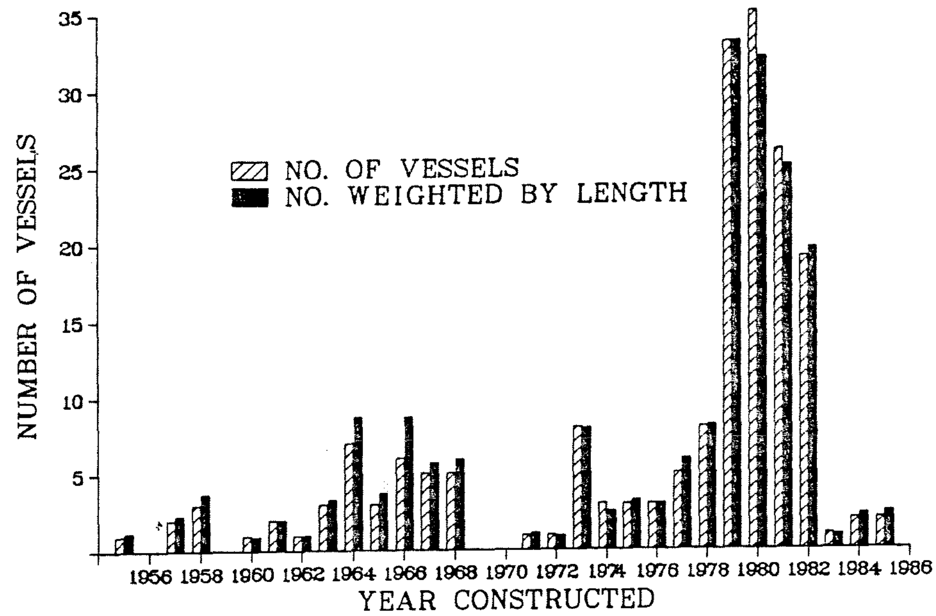


FIGURE 2.14
LONGLINERS (LOA)

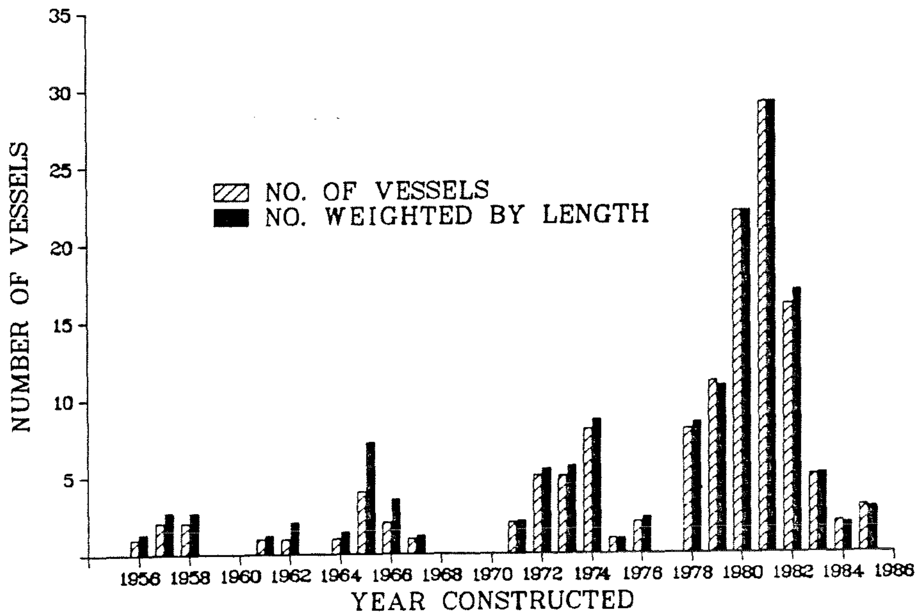


FIGURE 2.15

DISTRIBUTION OF FLEET GRT BY AGE

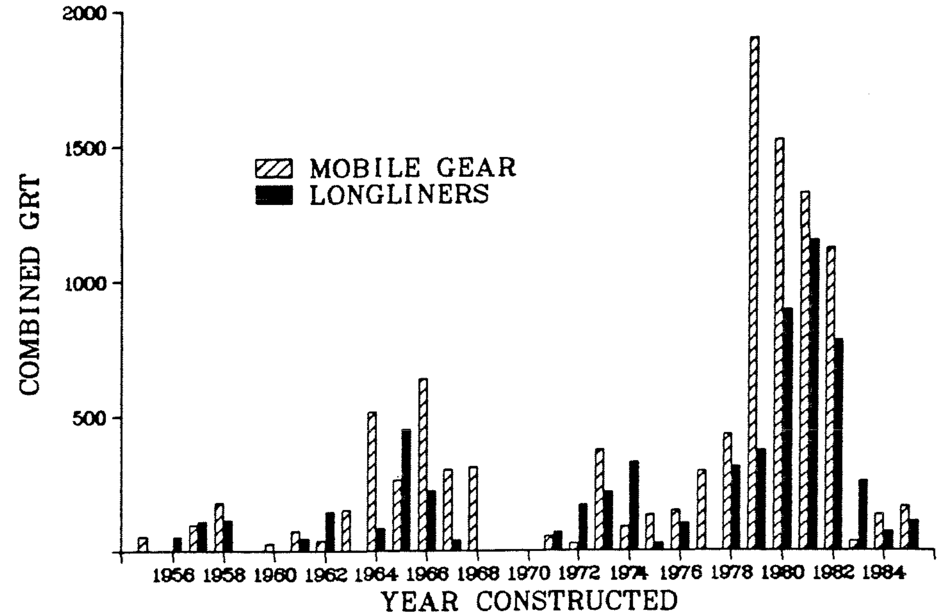
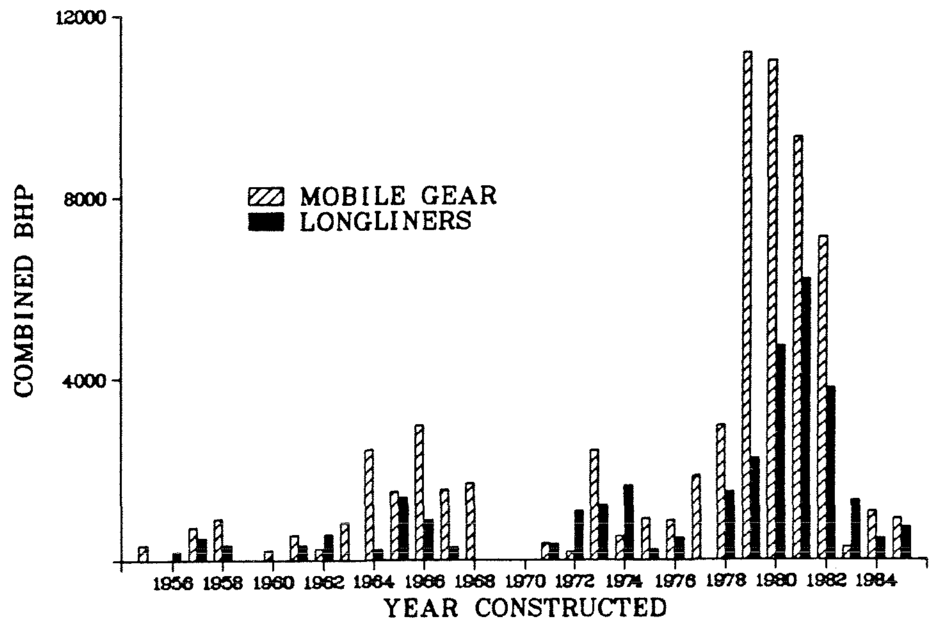


FIGURE 2.16

DISTRIBUTION OF FLEET BHP BY AGE



3. The Data Base

The catch and effort data used in this analysis are those from vessels in tonnage classes two and three. Effort data are not collected for vessels in tonnage class one, and vessels in tonnage classes four and five primarily fish offshore. Of vessels in tonnage classes two and three, only data for which both catch and effort were recorded have been used. These data were further reduced by excluding catch and effort data for those boats for which vessel dimensions were not available. Of particular importance is the manner in which fishing effort is measured; any day on which a vessel fished is counted, no matter what period of time was actually spent fishing.

Catch (main species) and effort expended by the study fleet was:-

	1984	1985
Catch (total)	55 118 t	66 300 t
Catch (main species)	35 864 t	41 494 t
Effort (days)	9 300	9 692

The catch by the two gear types was:-

	1984		1985	
Mobile Gear				
total	36 730	(66.6%)	48 604	(73.3%)
effort avialable:	27 016	(75.3%)	33 385	(80.5%)
Longliners				
total	18 387	(33.4%)	17 695	(26.7%)
effort available:	8 849	(24.7%)	8 109	(19.4%)

The relative effort (fishing days) expended by the two gear types based on available data was-:

	1984		1985	
Mobile Gear	6664	(71.7%)	7206	(74.3%)
Longliners	2636	(28.3%)	2486	(25.7%)

The 4Xq, 4Xr, and 5Y, Cod and Haddock are a mixed fishery and for this reason they were considered as a single fishery. The different stocks, ranked in terms of importance of landings by gear type are as follows:

Mobile Gear

	1984	1985
1.	4VWX+5 Pollock	4VWX+5 Pollock
2.	4Xq+4Xr+5Y Cod & Haddock	4VsW Cod
3.	4X Haddock	4Xq+4Xr+5Y Cod & Haddock
4.	4Vn Cod	5Z Cod
5.	4VsW Cod	4X Haddock
6.	4X Cod	4Vn Cod
7.	4VW Haddock	4X Cod
8.	5Z Cod	4VW Haddock
9.	5Z Haddock	5Z Haddock

Longline Gear

	1984	1985
1.	4VsW Cod	4VsW Cod
2.	5Z Cod	5Z Cod
3.	4X Haddock	4X Haddock
4.	4X Cod	4X Cod
5.	4Vn Cod	4Vn Cod
6.	4VW Haddock	4VW Haddock
7.	5Z Haddock	5Z Haddock
8.	4VWX+5 Pollock	4Xq+4Xr+5Y Cod & Haddock
9.	4Xq+4Xr+5 Cod & Haddock	

The stocks, ranked by the fraction taken by the mobile gear fleet, are as follows:-

	1984	1985
1.	4VWX+5 Pollock	4VWX+5 Pollock
2.	4Xq+4Xr+5Y Cod & Haddock	4Xq+4Xr+5Y Cod & Haddock
3.	4Vn Cod	5Z Haddock
4.	4VW Haddock	4VW Haddock
5.	4X+5Y Haddock	4Vn Cod
6.	5Z Haddock	5Z Cod
7.	4X+5Y Cod	4X+5Y Haddock
8.	4VsW Cod	4X+5Y Cod
9.	5Z Cod	4VsW Cod

The importance, by stock, to the longliners is the reverse of this order. Note that fish in one grouping are not included in another, e.g., cod in the 4Xq and 4Xr catagory are not included in the 4X cod.

Table 3.1 lists the catch by stock for 1984 and 1985 by the study fleet; the fishing effort is listed in Table 3.2. Table 3.3 lists the catch by the mobile gear fleet, and Table 3.4 the fishing effort. Tables 3.5 and 3.6 list the corresponding data for the longline fleet. Table 3.7 lists the relative catch, by stock, taken by the two gear types and Table 3.8, the relative amount of fishing effort they expended.

4. Gear Effects and Annual Differences in Fishing Power

4.1 Introduction

The efficacy of regulations that attempt to control fishing power of vessels by limiting their dimensions will be affected if the fishing power of a vessel differs depending on the type of fishing gear it uses, or if its "apparent" fishing power changes from year to year. In the first case, different regulations may be needed for Longliners relative to 'Mobile gear' vessels. In the second case, changes may be required to account for temporal differences; at least, the weaknesses in any time-invariant regulations should be known.

Table 3.1
Catch by Stock for which Effort was Available, 1984 and 1985

	1984		1985		1984 and 1985	
	t	%	t	%	t	%
4Vn Cod	3 769	10.0	2 784	6.4	6 554	8.1
4VsW Cod	4 558	12.1	9 941	22.8	14 498	17.8
4X Cod	2 055	5.5	2 081	4.8	4 135	5.1
5Z Cod	2 508	6.7	6 551	15.0	9 059	11.2
4VW Haddock	685	1.8	1 168	2.7	1 853	2.3
4X Haddock	6 544	17.4	4 691	10.8	11 235	13.8
5Z Haddock	353	0.9	1 067	2.4	1 20	1.7
4VWX+5 Pollock	9 380	24.9	9 19	22.5	19 198	23.6
4XQ,4XR,5Y Cod+Had	7 809	20.7	5 483	12.6	13 292	16.4

Table 3.2
Fishing Effort Expended by Stock, 1984 and 1985 as Used in this Analysis

	1984		1985		1984 and 1985	
	days	%	days	%	days	%
4Vn Cod	520	5.5	372	3.8	892	4.6
4VsW Cod	925	9.7	1 439	14.5	2 364	12.2
4X Cod	926	9.7	935	9.4	1 861	9.6
5Z Cod	623	6.6	1 364	13.8	1 987	10.2
4VW Haddock	199	2.1	217	2.2	416	2.1
4X Haddock	2 150	22.6	1 633	16.5	3 783	19.5
5Z Haddock	117	1.2	279	2.8	396	2.0
4VWX+5 Pollock	1 267	13.3	1 543	15.6	2 810	14.5
4XQ,4XR,5Y Cod+Had	2 778	29.2	2 130	21.5	4 908	25.3

Table 3.3
Catch by Mobile Gear Fleet for which Effort Data was Available, 1984 and 1985

	1984		1985	
	t	%	t	%
4VN Cod	3 155	11.1	2 309	6.5
4VSW Cod	1 546	5.4	5 650	16.0
4X Cod	1 047	3.7	1 520	4.3
5Z Cod	256	0.9	5 269	14.9
4VW Haddock	504	1.8	975	2.8
4X Haddock	4 666	16.4	3 476	9.8
5Z Haddock	204	0.7	968	2.7
4VWX+5 Pollock	9 274	32.7	9 819	27.7
4XQ,4XR,5Y Cod+Had	7 710	27.2	5 409	15.3

Table 3.4
Fishing Effort for which data was available Expended by Mobile Gear Fleet
1984 and 1985

	1984		1985	
	days	%	days	%
4VN Cod	308	4.5	212	2.9
4VSW Cod	217	3.2	470	6.3
4X Cod	507	7.4	646	8.7
5Z Cod	86	1.3	922	12.4
4VW Haddock	90	1.3	100	1.3
4X Haddock	1 559	22.9	1 164	15.7
5Z Haddock	62	0.9	241	3.3
4VWX+5 Pollock	1 236	18.1	1 543	20.8
4XQ,4XR,5Y Cod+Had	2 750	40.4	2 113	28.5

Table 3.5
Catch for which Effort Data was Available, by Longliners, 1984 and 1985

	1984		1985	
	t	%	t	%
4Vn Cod	614	6.6	475	5.8
4VsW Cod	3 012	32.4	4 291	52.4
4X Cod	1 008	10.8	561	6.8
5Z Cod	2 251	24.2	1 282	15.7
4VW Haddock	181	1.9	193	2.4
4X Haddock	1 879	20.2	1 215	14.8
5Z Haddock	149	1.6	98	1.2
4VWX+5 Pollock	105	1.1	0	0.0
4Xq,4Xr,5Y Cod+Had	99	1.1	74	0.9

Table 3.6
Fishing Effort for which Data was Available Expended by Longliners
1984 + 1985

	1984		1985	
	days	%	days	%
4Vn Cod	212	7.9	160	6.4
4VsW Cod	708	26.3	969	38.7
4X Cod	419	15.6	289	11.6
5Z Cod	537	20.0	442	17.7
4VW Haddock	109	4.1	117	4.7
4X Haddock	591	22.0	469	18.8
5Z Haddock	55	2.0	38	1.5
4VWX+5 Pollock	31	1.2	0	0.0
4Xq,4Xr,5Y Cod+Had	28	1.0	17	0.7

Table 3.7

Relative Catch by Mobile Gear and Longline Fleet for which Effort Data were available, 1984 and 1985

	1984	Mobile	Longline	1985	Mobile	Longline	1984 and 1985	Mobile	Longline
	t	%	%	t	%	%	t	%	%
4Vn Cod	3 769	83.7	16.3	2 784	82.9	17.1	6 554	83.4	16.6
4VsW Cod	4 558	33.9	66.1	9 941	56.8	43.2	14 498	49.6	50.4
4X+5Y Cod	2 055	51.0	49.0	2 081	73.0	27.0	4 135	62.1	37.9
5Z Cod	2 508	10.2	89.8	6 551	80.4	19.6	9 059	61.0	39.0
4VW Haddock	685	73.6	26.4	1 168	83.5	16.5	1 853	79.8	20.2
4X+5Y Haddock	6 544	71.3	28.7	4 691	74.1	25.9	11 234	72.5	27.5
5Z Haddock	353	57.8	42.2	1 067	90.8	9.2	1 420	82.6	17.4
4VWX+5 Pollock	9 380	98.9	1.1	9 819	100.0	0.0	19 198	99.5	0.5
4Xq+4Xr+5Y Cod+Had	7 809	98.7	1.3	5 483	98.6	1.4	13 292	98.7	1.3

Table 3.8

Relative Effort, for which Data was Available, Expended by Mobile Gear and Longline Fleet, 1984 and 1985

	1984	Mobile	Longline	1985	Mobile	Longline	1984 and 1985	Mobile	Longline
	days	%	%	days	%	%	days	%	%
4Vn Cod	520	59.2	40.8	372	57.0	43.0	892	58.3	41.7
4VsW Cod	925	23.5	76.5	1 439	32.7	67.3	2 364	29.1	70.9
4X+5Y Cod	926	54.8	45.2	935	69.1	30.9	1 861	62.0	38.0
5Z Cod	623	13.8	86.2	1 364	67.6	32.4	1 987	50.7	49.3
4VW Haddock	199	45.2	54.8	217	46.1	53.9	416	45.7	54.3
4X+5Y Haddock	2 150	72.5	27.5	1 633	71.3	28.7	3 783	72.0	28.0
5Z Haddock	117	53.0	47.0	279	86.4	13.6	396	76.5	23.5
4VWX+5 Pollock	1 267	97.6	2.4	1 543	100.0	0.0	2 810	98.9	1.1
4Xq+4Xr+5Y Cod+Had	2 778	99.0	1.0	2 130	99.2	0.8	4 908	99.1	0.9

4.2 Methods

Simple comparisons of the CPUE between gear types or between years can not be used to test for differences in fishing power because they will not account for possible different affects of years on gears, or effects from temporal changes in the dimensions of the fleet characteristics being examined. To test for year-gear interactions, a regression technique using "dummy variables" (Draper and Smith 1981) has been used in which gear type or year is considered as an independent or predictor variable, i.e.,

$$CPUE = b_0 + b_1D + b_2Z$$

where D = appropriate vessel dimension
Z = dummy variable

In checking for annual differences, Z is set to one for 1984 data, and zero for 1985 data. For gear differences, Z is set to 1 for one gear type and zero for the other. A large annual or gear effect would result in large increases in R^2 when the second variable was fitted in the regression and b_2 would be significantly different to zero. A measure of the difference tested for is given by b_0-b_2.

4.3 Results

Table 4.1 lists the results from the regression analyses. In no cases did fitting the dummy variable result in other than minor increases in the R^2 values. Surprisingly, (to me) in none of the comparisons could particularly convincing differences be demonstrated between the two gear types. Probabilities of type I errors were in the range 0.12 -0.41. Significant differences were apparent for the Mobile gear groups between 1984 and 1985, but no differences were evident in the longline fleet. The results imply a gear-year interaction. However an F-test for gear-year interaction showed that a model with no such interaction could be accepted (p=0.36 for both LOA and GT).

4.4 Discussion

These analyses show that gear effects in terms of the fishing power of a vessel are unlikely to be significant. Thus different regulations for vessel dimensions should not be necessary for the two gear types. However, for the two years examined there was a temporal difference in the case of the mobile gear fleet with the fleet exhibiting a greater CPUE in 1985 than in 1984 (p=0.02). The logical explanation for this difference is that fish abundance was greater in 1985 than in the preceding year rather than that the difference resulted from a change in the fishing power of the fleet. Note that temporal changes in CPUE from changes in fleet fishing power will be indistinguishable from changes caused by an increase or decrease in fish abundance.

Table 4.1
Regression Results from Tests for Gear and Annual Differences in Fishing Power

Model Examined:	b_0	b_1	b_2	p-value for b_2	R^2	R^2 without dummy
1984 and 1985 combined, differences by gear, mobile-longline:						
CPUE v LOA:	-3.366	0.1378	0.4263	0.12	24.0	23.5
CPUE v GT:	0.06270	0.07217	0.3745	0.13	36.1	35.6
Both Gears combined, differences by year, 1984-1985:						
CPUE v LOA:	-3.202	0.1464	-0.5484	0.01	20.6	19.7
CPUE v GT:	0.4057	0.07557	-0.4795	0.02	31.2	30.5
Mobile gear, differences between 1984 and 1985:						
CPUE v LOA:	-4.497	0.1761	-0.7618	0.02	25.5	24.1
CPUE v GT:	-0.2318	0.0972	-0.6593	0.02	39.6	38.6
Longline, differences between 1984 and 1985:						
CPUE v LOA:	1.278	0.04160	-0.1193	0.65	2.3	2.2
CPUE v GT:	2.069	0.02727	-0.1102	0.67	6.0	5.9
Differences between mobile gear and longliners, 1984:						
CPUE v LOA:	-1.954	0.1073	0.2834	0.31	16.7	16.4
CPUE v GT:	0.4816	0.06163	0.2068	0.41	29.3	29.1
Differences between mobile gear and longliners, 1985:						
CPUE v LOA:	-4.887	0.1733	0.5365	0.16	24.1	23.5
CPUE v GT:	-0.3805	0.08500	0.5135	0.15	33.2	32.7

5. Catch-per-Unit-Effort as a Function of Vessel Characteristics

5.1 Introduction

Implicit in regulations that limit the dimensions of fishing vessels to restrict their fishing power (and hence fishing mortality per unit fishing time expended) is the assumption that the fishing power of the vessel is a function of its linear or volumetric dimensions, and/or of its engine power. Although considerable efforts are undertaken tocontrol the LOA of replacement vessels in fishing fleets, no tests of this implicit assumption were done.

In this section, least-squares regression analyses are used to examine the relation between catch-per-unit-effort (CPUE) and vessel dimensions to determine how much of the variation in the fishing power among the different vessels in the fleet can be explained by the differences in the associated vessel dimensions.

CPUE has been calculated as the quotient of total catch and number of days spent fishing for the relevant period, e.g., one year (1984 or 1985), or for a quarter. The catch and effort data used were obtained from the Statistics Division's data base (See Section 2.) Some errors occurred in the vessel dimensions data base which were apparent as outliers. Where possible corrections were made or the entry was dropped. No minimum catch or effort was required for a vessel's data to be included in ths analysis. Arguments can be made for analysing the entire data set or analysing only a selected subset depending on an arbitrarily set minimum level of catch or effort. The appropriate action would depend on the objectives of the analysis (See Section 12).

The values tabulated are the square of the (multiple) correlation coefficient, R^2, which is the amount of the variation of the CPUE that is explained by the regression as a function of the different dependent variables that are examined . Initially it was not intended to focus on R^2 as a prime statistic for analysis. However, because of the large number of data subsets examined and because most of the regression analyses explained little of the variability of CPUE as a function of vessel dimensions, the R^2 value has been used as a convenient first measure in comparative examination of the different possible data subsets.

5.2 Data Aggregated for All Stocks

5.2.1 Methods

In this first analyses, the CPUE for the 'main species' (cod + haddock + pollock), of 'all species', the value of the main species catch, and the value of the total catch (revenue per day), have been regressed as a function of LOA, BHP, GT, and as a stepwise multiple regression on these vessel dimensions. These regressions have been done for the 1984 and 1985 data combined, and for each year separately. All analyses have been done for the total fleet, mobile-gear fleet, and the longline fleet. Further analyses have been done on subsets of the data consisting of the CPUE data for those vessels, ranked in order of importance, which caught 90%, 80% and 50%, respectively, of the fleet catch or of total fleet revenues.

In some instances, to reduce the number of comparison made, the R^2 values within a comparison have been averaged over the 100%, 90% and 80% fleet data subsets. The 50% cumulative catch category was not included as the R^2 value in this case appeared very sensitive to the number of vessels included in that data subset. This mean R^2 value will give a weighting of three to those vessels (ranked in descending order of annual catch) that took 80% of the catch, two to those vessels that took 90% of the catch and one to all vessels in the fleet. Thus this average is a compromise between using results for the total fleet and results for those vessels that took the majority of the catch. Figures 5.1 - 5.3 show cumulative catch and revenue curves for the fleet and the two gear types.

5.2.2 **Results**

5.2.2.1 **Data Aggregated for All Stocks**

Tables 5.1 - 5.9 list the statistics from regression of CPUE, 'main species' on vessel dimensions. Tables 5.10 - 5.18 list similar statistics obtained from stepwise regression of CPUE on vessel dimensions. Tables 5.19 - 5.21 list coefficients of variation (R^2) for regressions using CPUE for "All Species" and Revenue from "Main Species" and "All Species". Tables 5.22 to 5.25 list the R^2 values averaged over subsets of the data categories. Plots of CPUE as a function of LOA, GT, and BHP are shown in Figures 5.4 - 5.12.

FIGURE 5.1
CUMMULATIVE CATCH & REVENUE VERSUS NUMBER OF BOATS
ALL VESSELS

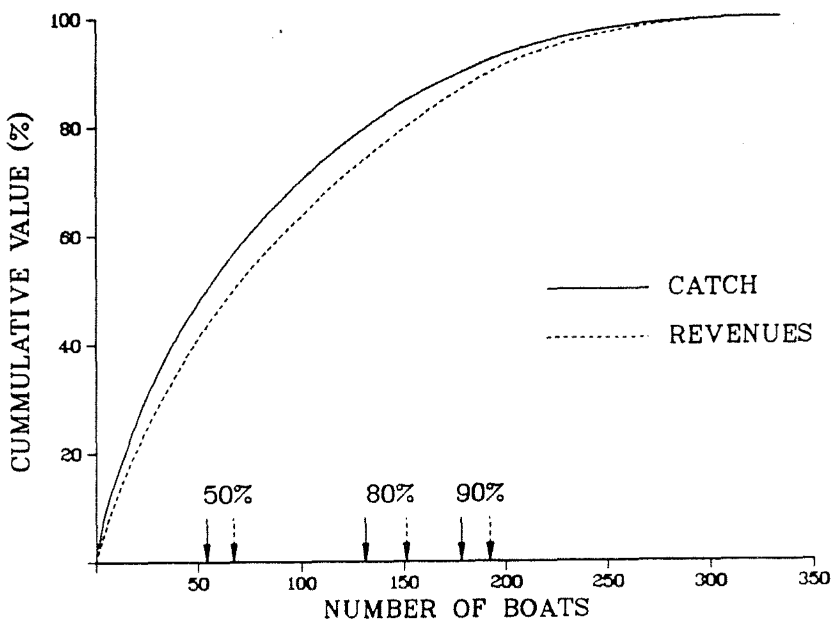


FIGURE 5.2
CUMMULATIVE CATCH & REVENUE VERSUS NUMBER OF BOATS
MOBILE GEAR

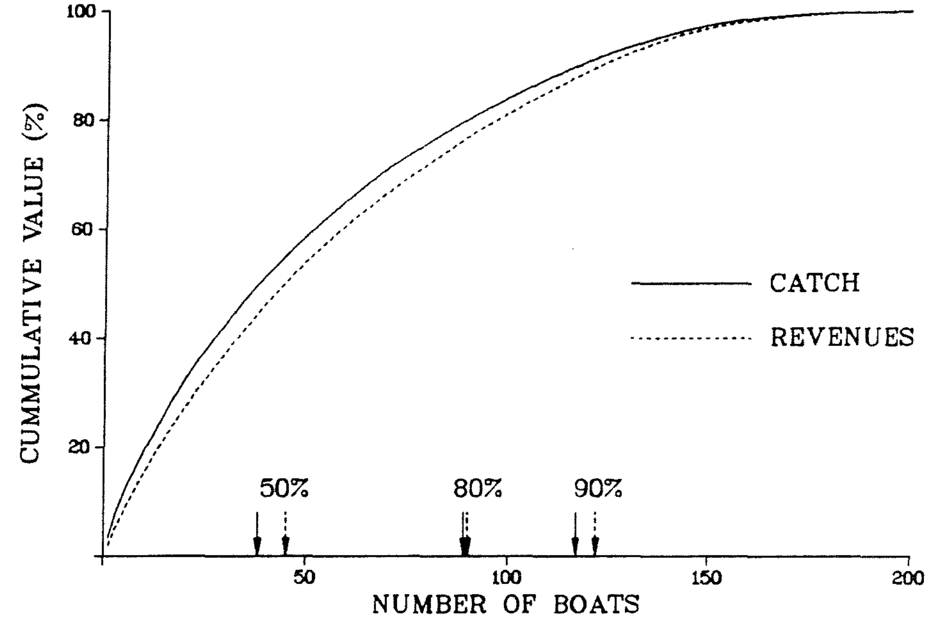


FIGURE 5.3
CUMMULATIVE CATCH & REVENUE VERSUS NUMBER OF BOATS
LONGLINERS

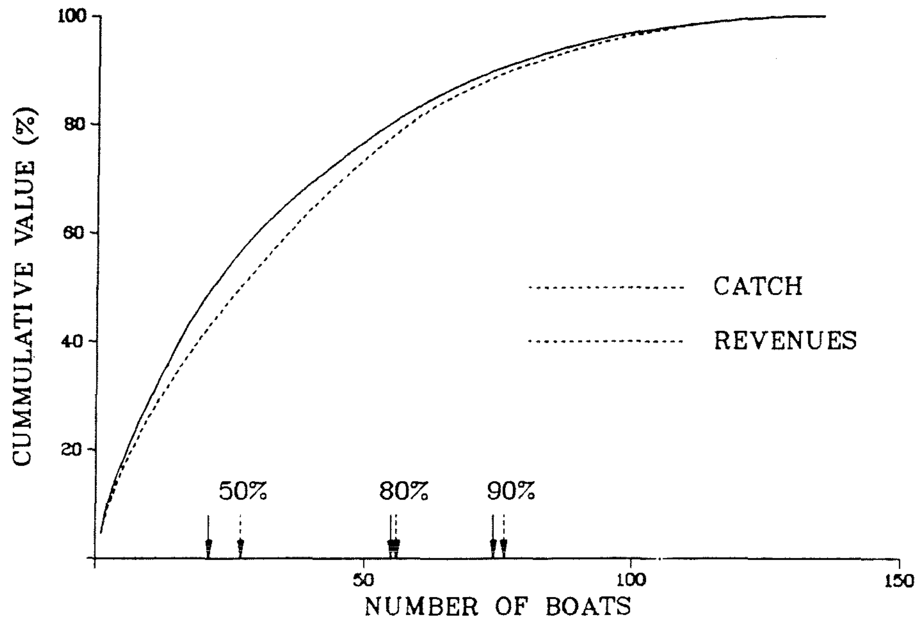


Table 5.1
Statistics from Regression of CPUE (main species) on Vessel Dimensions, All Vessels, 1984 and 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	324	-2.69697	0.12877	26.4
90%	178	-3.16808	0.15052	31.4
80%	131	-2.40589	0.14316	28.4
50%	54	-0.83740	0.13274	12.8
GT				
100%	324	0.70167	0.06245	36.3
90%	178	0.87182	0.07040	42.9
80%	131	1.21260	0.06980	41.3
50%	54	2.10285	0.06711	25.9
BHP				
100%	324	0.26396	0.01234	32.2
90%	178	0.57305	0.01254	31.5
80%	131	1.15869	0.01181	26.2
50%	54	2.72702	0.01015	11.4

Table 5.2
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Mobile Gear, 1984 and 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	189	-4.53498	-0.16785	32.5
90%	117	-3.07086	0.15334	26.8
80%	89	-1.54504	0.13465	19.6
50%	39	1.75885	0.09777	4.5
GT				
100%	189	-0.07420	0.08082	46.4
90%	117	0.79705	0.07519	41.0
80%	89	1.69012	0.06695	33.1
50%	39	3.20222	9.05753	19.1
BHP				
100%	189	-0.42083	0.0140	32.3
90%	117	0.23254	0.01358	25.5
80%	89	1.44169	0.01185	18.8
50%	39	4.43315	0.00746	4.3

Table 5.3
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Longliners, 1984 and 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	135	0.27727	0.06065	11.8
90%	74	0.52889	0.06451	12.3
80%	54	0.29239	0.07392	20.4
50%	21	0.67946	0.08303	39.1
GT				
100%	135	1.88327	0.02932	15.6
90%	74	2.46306	0.02525	13.2
80%	54	2.49277	0.02976	21.4
50%	21	2.86670	0.03966	46.8
BHP				
100%	135	1.01498	0.00974	19.5
90%	74	1.62942	0.00861	23.4
80%	54	1.82018	0.00872	26.6
50%	21	2.18379	0.01064	51.3

Table 5.4
Statistics from Regression of CPUE (main species) on Vessel Dimensions, All Vessels, 1984

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	283	-2.29717	0.11768	21.9
90%	160	-1.6977	0.11809	24.1
80%	118	-1.1272	0.11373	23.0
50%	47	0.7313	0.09944	13.3
GT				
100%	283	0.70167	0.06245	36.3
90%	161	1.31308	0.05810	35.4
80%	118	1.75625	0.05548	33.9
50%	47	3.10418	0.04865	25.5
BHP				
100%	283	0.62405	0.01040	27.3
90%	163	1.1082	0.01023	25.8
80%	120	1.8921	0.00884	19.6
50%	49	4.5000	0.00537	4.5

Table 5.5
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Mobile Gear, 1984

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	167	-3.55126	0.14333	27.7
90%	101	-2.4069	0.1331	24.6
80%	75	-1.3778	0.12178	19.8
50%	32	2.8247	0.07564	3.8
GT				
100%	167	0.08312	0.07250	42.8
90%	101	0.95303	0.06526	37.8
80%	75	1.59920	0.05988	32.3
50%	32	4.00110	0.04316	15.8
BHP				
100%		-0.16213	0.01220	29.4
90%	100	0.44667	0.01179	24.5
80%	75	1.71596	0.00951	14.8
50%	32	7.2323	0.008749	0.0

Table 5.6
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Longliners, 1984

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	115	1.06354	0.04422	3.6
90%	68	1.5484	0.04482	4.7
80%	50	1.2820	0.0580	8.1
50%	20	1.5414	0.06724	29.2
GT				
100%	115	1.99008	0.02702	8.9
90%	68	2.85819	0.01848	5.8
80%	50	2.71128	0.03027	14.4
50%	20	3.30245	0.03169	35.3
BHP				
100%	115	1.29452	0.00849	14.3
90%	68	2.00383	0.00718	15.5
80%	52	1.58789	0.01052	27.8
50%	20	2.87207	0.00813	33.9

Table 5.7
Statistics from Regression of CPUE (main species) on Vessel Dimensions, All Vessels, 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	271	-3.64691	0.15422	24.4
90%	154	-3.94567	0.17509	24.6
80%	112	-2.79978	0.16352	20.3
50%	42	5.28560	0.05515	0.0
GT				
100%	271	0.49486	0.07230	32.0
90%	149	0.51124	0.08548	36.3
80%	108	1.25831	0.08014	31.3
50%	39	3.77092	0.07108	7.1
BHP				
100%		-0.32072	0.01530	31.9
90%	154	0.24906	0.01495	29.2
80%	112	0.94497	0.01422	24.5
50%	42	5.10173	0.00793	2.3

Table 5.8
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Mobile Gear, 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	167	-5.50910	0.19472	29.7
90%	108	-3.63278	0.17552	20.9
80%	81	-2.33715	0.15931	16.2
50%	34	3.73818	0.07712	0.0
GT				
100%	167	0.54520	0.09904	39.8
90%	103	0.85186	0.08468	33.0
80%	77	1.63014	0.07752	26.9
50%	31	3.47060	0.06180	12.3
BHP				
100%	167	-1.18903	0.01746	32.8
90%	108	-0.20275	0.01645	25.6
80%	81	0.52620	0.01549	22.0
50%	34	3.55805	0.01076	4.8

Table 5.9
Statistics from Regression of CPUE (main species) on Vessel Dimensions, Longliners, 1985

% of Fleet	n	b_0	b_1	R^2
LOA				
100%	104	0.25931	0.06317	7.6
90%	62	-2.08370	0.12257	35.2
80%	45	-0.34557	0.09038	11.8
50%	19	-3.59672	0.17981	39.3
GT				
100%	104	1.97267	0.02919	9.5
90%	62	1.97516	0.04925	32.4
80%	45	2.33012	0.03560	13.2
50%	19	0.70948	0.09400	60.3
BHP				
100%	104	0.97326	0.01037	12.4
90%	62	0.36564	0.01508	32.6
80%	45	1.42328	0.01106	20.5
50%	19	0.20217	0.01971	53.8

5.2.2.2 **Effect of Vessel Dimension and Gear Type**

Regression of CPUE (main species) on GT provided the best explanation of the variation of the CPUE for all gears and both years; 40.2%, compared to 30.0% for BHP and 28.7% for LOA. When separated by gear type, there was a slight reduction in the R^2 values for regression of the CPUE, mobile gear, on BHP and GT, and a larger reduction in the R^2 values for the dimensions LOA, BHP and GT for the longliners; 14.8%, 22.9% and 16.7% respectively. Taken overall, BHP provided the best measure of CPUE for the longline fleet. Stepwise regression of CPUE on the three vessel dimensions provided a slight increase in the R^2 values.

Table 5.10
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
1984 and 1985, All Vessels

	$\underline{n}$	$\underline{b_0}$	$\underline{b_1}$	$\underline{b_2}$	$\underline{b_3}$	$\underline{R^2}$
100%						
GT	324	0.70167	0.06245			36.3
GT, BHP		0.11213	0.04203	0.00555		38.7
GT, BHP, LOA		2.5178	0.07077	0.00571	-0.07661	39.9
90%						
GT	178	0.87182	0.07040			42.9
GT, LEN		3.49002	0.10048	-0.08100		43.9
80%						
GT	131	1.21260	0.06980			41.3
GT, LEN		4.78322	0.11167	-0.11124		43.3
50%						
GT	53	2.10285	0.0671			25.9

Table 5.11
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
Mobile Gear, 1984 and 1985

	$\underline{n}$	$\underline{b_0}$	$\underline{b_1}$	$\underline{b_2}$	$\underline{b_3}$	$\underline{R^2}$
100%						
GT	335	-0.14047	0.08286			41.1
GT, LEN		3.40196	0.12327	-0.10886		42.8
GT		2.98261	0.11034	-0.11103	0.00362	
90%						
GT	117	0.79705	0.07519			41.0
GT, LEN		4.80163	0.11923	-0.1207		43.3
80%						
GT	89	1.69012	0.06695			33.1
GT, LOA		6.54081	-0.11734	-0.14251		36.1

Table 5.12

Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions

Longliners, 1984 and 1985

	n	b_0	b_1	b_2	b_3	R^2
100%						
BHP	219	1.13694	0.00941			13.4
90%						
BHP	74	1.62942	0.00861			23.3
80%						
BHP	54	1.82018	0.00872			26.6
50%						
BHP	21	2.18379	0.01064			33.9

Table 5.13

Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions

Both Gears, 1984

	n	b_0	b_1	b_2	b_3	R^2
100%						
GT	283	0.65462	0.06038			34.0
GT, LOA		3.32131	0.09160	-0.08331		35.8
GT, LOA, BHP		3.14949	0.07809	-0.08857	0.00380	37.0
90%						
GT	161	1.31308	0.05810			35.4
GT, LOA		4.13747	0.09133	-0.08842		37.1
80%						
GT	118	1.175625	0.05548			33.9
GT, LOA		5.01473	0.09369	-0.10174		35.9
50%						
GT	47	3.10418	0.04865			25.5

Table 5.14
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
Mobile Gear, 1984

	n	b_0	b_1	b_2	b_3	R^2
100%						
GT	168	0.08312	0.7250			42.8
GT, LOA		3.62849	0.11291	-0.10864		45.2
90%						
GT	101	0.95303	0.6526			37.8
GT, LOA		4.38102	0.10308	-0.10377		39.7
80%						
GT	75	1.59920	0.05988			32.3
50%						
GT	32	4.0110	0.04316			15.8
GT, LOA		12.43326	0.11550			34.2

Table 5.15
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
Longliners, 1984

	n	b_0	b_1	b_2	b_3	R^2
100%						
BHP	115	1.29452	0.00849			14.3
90%						
BHP	68	2.00383	0.00718			15.5
80%						
BHP	50	1.58789	0.01052			27.8
50%						
GT	20	3.30245	0.03169			35.3

Table 5.16
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
Both Gears, 1985

	n	b_0	b_1	b_2	b_3	R^2
100%						
GT	220	1.19931	0.08088			32.6
GT, LOA		5.77071	0.13132	-0.13914		34.6
90%						
GT	154	0.5112	0.08548			36.3
GT, LOA		4.08356	0.12607	-0.11033		37.6
GT, LOA, BHP		3.99347	0.10871	-0.12830	0.00592	38.9
80%						
GT	112	1.25831	0.08014			31.3

Table 5.17
Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions
Mobile Gear, 1985

	n	b_0	b_1	b_2	b_3	R^2
100%						
GT	220	1.21653	0.08049			29.0
GT, LOA		6.82734	0.13766			31.5
90%						
GT	108	0.85186	0.08468			33.0
GT, LOA		6.05832	0.13956	-0.15471		35.1
80%						
GT	81	1.63014	0.07752			26.9
50%						
GT	34	3.47060	0.06180			12.3

Table 5.18

Statistics for Stepwise Multiple Regression of CPUE on Vessel Dimensions

Longliners, 1985

	n	b_0	b_1	b_2	b_3	R^2
100% GT	220	0.80841	0.09069			55.7
90% LOA	62	-2.08370	0.12257			35.2
80% BHP	45	1.42328	0.01106			20.5
50% GT	19	0.70948	0.09400			60.3

Table 5.19
R^2 (%) From Regression of CPUE (for All Species) on Vessel Dimensions

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	26.2	33.7	31.4	15.5	19.7	24.5	22.5	13.9	24.7	27.0	23.2	0.9
Mobile Gear	LOA	34.1	29.4	22.4	7.5	26.2	24.3	20.1	3.7	30.2	22.8	17.7	1.2
Longliners	LOA	10.3	18.3	22.3	30.5	5.3	11.6	14.1	22.7	7.4	35.3	12.2	31.6
All Vessels	BHP	33.2	35.7	32.0	14.8	23.4	27.4	21.4	6.7	36.2	35.2	31.9	4.8
Mobile Gear	BHP	36.3	30.6	24.7	7.8	30.2	27.2	17.6	3.1	37.8	31.9	28.0	6.5
Longliners	BHP	19.2	33.4	29.3	43.4	14.4	21.0	30.6	31.4	15.1	40.6	25.6	51.9
All Vessels	GT	36.6	44.4	43.6	26.9	32.0	35.6	33.0	25.2	32.2	37.2	32.6	6.9
Mobile Gear	GT	47.2	42.7	35.0	20.8	40.2	37.4	32.0	14.2	39.8	33.1	26.3	10.2
Longliners	GT	16.2	22.4	23.4	42.9	13.5	13.6	22.6	33.8	11.2	37.0	20.7	58.5
All Vessels	Multiple Regression	40.1 GT, BHP LOA	45.4 GT, BHP	44.9 GT,LOA	26.9 GT	34.4 GT,LOA	36.6 GT,LOA	34.8 GT,LOA	25.2 GT	39.5 GT,BHP, LOA	40.3 GT,BHP	35.9 GT,BHP	
Mobile Gear	Multiple Regression	48.8 GT,LOA BHP	42.7 GT	35.0 GT	20.8 GT	42.2 GT,LOA	39.2 GT,LOA	32.0 GT	14.2 GT	43.3 GT,BHP	36.6 GT,BHP	30.7 BHP,GT	10.2 GT
Longliners	Multiple Regression	19.2 BHP	33.4 BHP	29.2 BHP	43.4 BHP	17.8 GT	21.0 BHP	30.6 BHP	33.7 GT	15.1 BHP	40.6 BHP	25.5 BHP	58.5 GT

Table 5.20
R^2 (%) From Regression of Revenue (Main Species) per Day Fished on Vessel Dimensions

Sample	Vessel Variable	1984 and 1985				1984				1985			
		All	90%	80%	50%	All	90%	80%	50%	All	90%	80%	50%
All Vessels	LOA	19.5	21.1	20.6	8.5	14.4	10.4	8.7	2.9	24.3	18.3	16.2	1.3
Mobile Gear	LOA	26.0	25.3	17.0	10.5	16.2	15.3	11.2	3.7	26.7	17.8	13.1	2.5
Longliners	LOA	18.9	18.4	19.1	15.9	12.3	17.5	13.8	13.8	16.7	41.9	15.9	28.5
All Vessels	BHP	30.8	19.4	20.0	9.5	34.0	8.8	8.2	2.2	17.8	22.6	22.6	0.8
Mobile Gear	BHP	37.4	28.3	22.6	11.6	26.0	22.4	16.6	2.4	32.1	29.8	25.3	0.2
Longliners	BHP	26.8	25.5	27.4	23.2	20.5	11.4	14.6	12.1	20.3	42.7	31.3	32.8
All Vessels	GT	34.9	29.0	29.5	12.8	23.5	17.9	16.0	7.0	22.6	24.8	22.8	0.8
Mobile Gear	GT	37.7	34.0	26.8	13.6	24.7	24.5	19.3	8.9	29.4	24.8	18.0	0.6
Longliners	GT	28.8	26.1	25.7	31.1	23.9	20.6	18.2	22.4	18.2	42.9	25.5	51.3
All Vessels	Multiple Regression	36.7 GT	29.0 GT	29.5 GT	13.0 GT	19.8 GT,LOA	20.2 GT,LOA	18.9 GT,LOA	7.0 GT	22.6 GT	24.8 GT	25.2 GT,BHP	
Mobile Gear	Multiple Regression	26.5 GT	34.0 GT	26.8 GT	13.6 GT	32.7 GT,LOA, BHP	24.5 GT	19.3 GT	8.9 GT	34.4 BHP,GT	29.8 BHP	25.3 BHP	
Longliners	Multiple Regression		26.1 GT	27.4 BHP	31.1 GT	23.9 GT	20.6 GT	18.2 GT	22.4 GT	20.3 BHP	46.3 GT,BHP	31.3 BHP	51.3 GT

Table 5.21
R^2 Values From Regression of Revenue (All Species) per Day Fished on Vessel Dimensions

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	25.5	27.1	24.0	8.1	7.8	14.8	11.3	3.8	16.7	23.9	21.0	1.3
Mobile Gear	LOA	27.7	25.7	15.6	3.9	17.9	13.4	8.1	1.6	23.1	21.7	14.9	2.6
Longliners	LOA	20.0	19.2	21.0	19.7	8.2	18.1	14.7	31.7	13.2	34.8	13.0	28.9
All Vessels	BHP	15.2	31.7	30.1	17.3	6.3	18.9	16.3	8.5	33.6	31.9	31.9	8.4
Mobile Gear	BHP	29.6	33.8	28.4	12.5	26.6	21.5	13.9	2.4	40.7	39.3	33.0	6.9
Longliners	BHP	21.2	32.7	28.1	25.1	10.9	15.1	21.6	23.5	26.7	39.3	26.2	30.1
All Vessels	GT	28.6	34.5	31.4	11.3	16.7	21.2	16.9	6.8	31.0	30.4	28.4	2.5
Mobile Gear	GT	36.7	32.9	23.9	6.3	28.8	18.6	12.2	1.5	32.9	28.9	20.8	1.1
Longliners	GT	26.5	28.8	30.2	34.6	17.8	21.7	19.3	41.6	24.3	43.1	26.0	58.5
All Vessels	Multiple Regression	38.3 GT,BHP, LOA	36.8 GT,BHP	34.4 GT,BHP	17.3 BHP	26.1 GT,LOA, BHP	21.2 GT	16.9 GT	8.5 BHP	36.5 BHP,GT	34.4 BHP,GT	33.8 BHP,GT	8.4 BHP
Mobile Gear	Multiple Regression	41.6 GT,BHP	37.5 BHP,GT	28.4 BHP	12.5 BHP	27.8 BHP,GT	21.5 BHP	13.9 BHP		41.9 BHP,GT	39.3 BHP	33.0 BHP	
Longliners	Multiple Regression	28.8 GT	32.7 BHP	30.2 GT	34.6 GT	23.9 GT	21.7 GT	21.6 BHP	41.6 GT	26.7 BHP	43.1 GT	26.2 BHP	58.5 GT

Table 5.22
Weighted Mean % Variation (R^2) Explained by Regression
of CPUE on Vessel Dimension
Main Species

These data are the means for the 100%, 90% and 80% vessel data subsets.

	1984 & 1985	1984	1985
LOA			
All Vessels	28.7	23.0	23.1
Mobile	27.0	24.0	22.3
Longline	14.8	5.5	18.2
GT			
All Vessels	40.2	34.2	33.2
Mobile	40.2	37.6	33.5
Longline	16.7	9.7	18.4
BHP			
All Vessels	30.0	24.2	28.6
Mobile	25.5	22.9	26.8
Longline	22.9	19.2	21.8

Table 5.23
Weighted Mean % Variation (R^2) Explained by the Regression
of CPUE on Vessel Dimension
All Species

	1984 & 1985	1984	1985
LOA			
All Vessels	30.4	22.2	25.0
Mobile	28.6	23.5	23.6
Longline	17.0	10.3	18.3
GT			
All Vessels	41.5	33.5	34.0
Mobile	41.6	36.5	33.1
Longline	20.7	16.6	23.0
BHP			
All Vessels	33.6	24.1	25.1
Mobile	30.5	25.0	32.6
Longline	27.3	22.0	27.1

Table 5.24
Weighted Mean % Variation (R^2) Explained by Regression
of CPUE on Vessel Dimension
Revenue per Day, Main Species

	1984 & 1985	1985	1984
LOA			
All Vessels	20.4	11.2	19.6
Mobile	22.8	14.2	19.2
Longline	18.8	14.5	24.7
GT			
All Vessels	31.1	19.1	23.4
Mobile	32.8	22.8	24.1
Longline	26.9	20.9	28.9
BHP			
All Vessels	23.4	17.0	21.0
Mobile	29.4	21.7	29.1
Longline	26.6	15.5	31.4

Table 5.25
Weighted Mean % Variation (R^2) Explained by Regression
of CPUE on Vessel Dimension
Revenue per Day, All Species

	1984 & 1985	1984	1985
LOA			
All Vessels	25.5	11.3	20.5
Mobile	23.0	13.1	19.9
Longline	20.1	13.7	20.3
GT			
All Vessels	31.5	18.3	29.9
Mobile	31.2	19.9	27.5
Longline	28.5	19.6	31.1
BHP			
All Vessels	25.7	13.8	32.5
Mobile	30.6	20.7	37.7
Longline	27.3	15.9	30.7

These data are the means for the 100%, 90% and 80% vessel data subsets.

FIGURE 5.4

CPUE v LOA, BOTH GEARS, 1984 & 1985

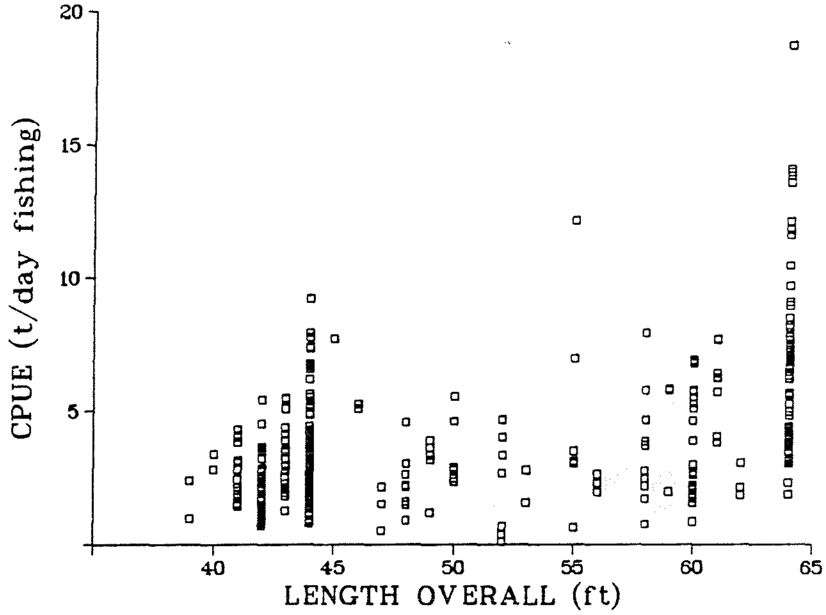


FIGURE 5.5

CPUE v GT, BOTH GEARS, 1984 & 1985

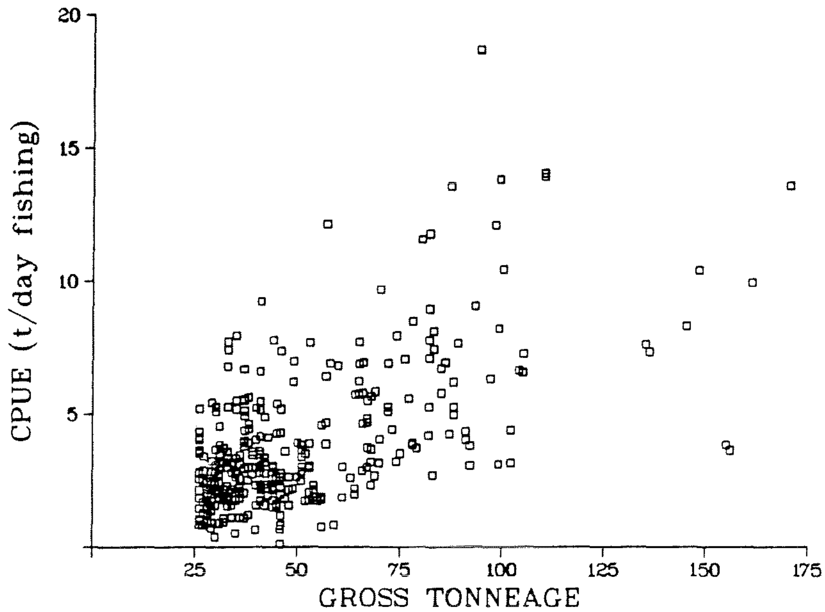


FIGURE 5.6

CPUE v BHP, BOTH GEARS, 1984 & 1985

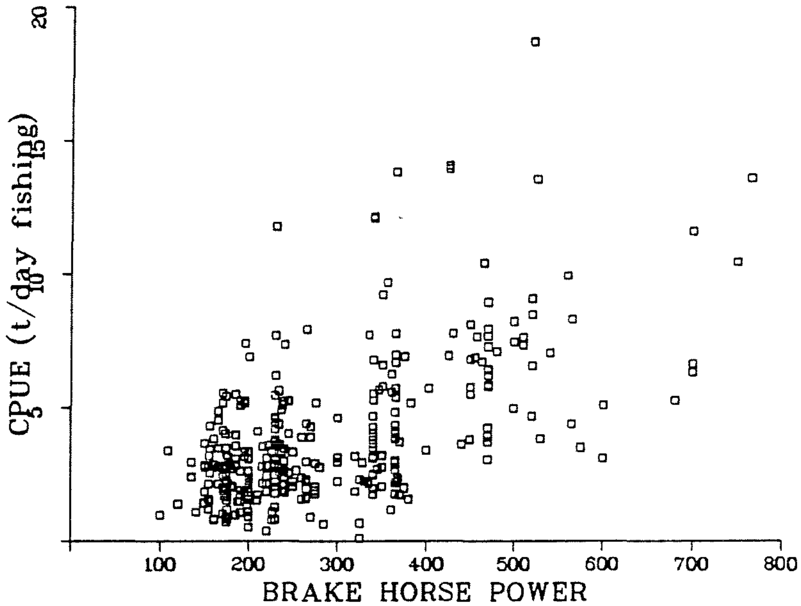


FIGURE 5.7

CPUE v LOA, MOBILE GEAR, 1984 & 1985

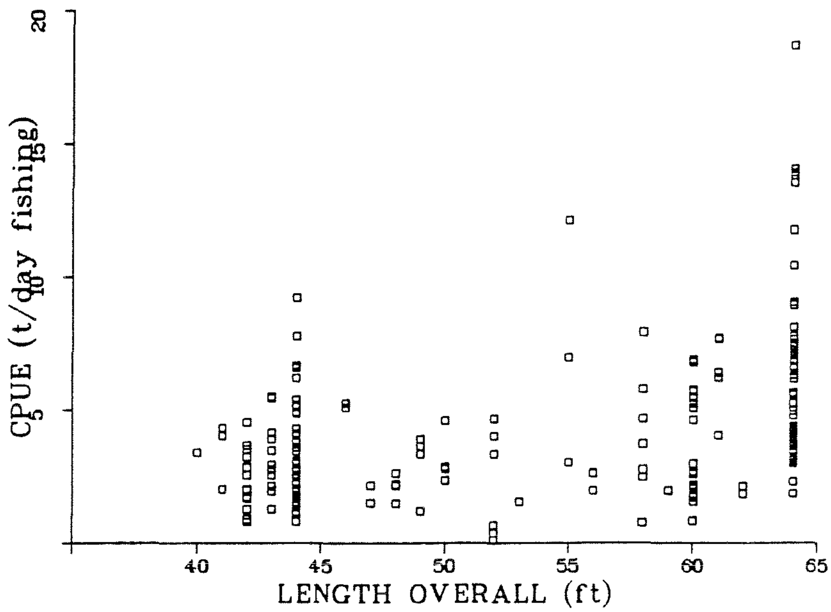


FIGURE 5.8
CPUE v GT, MOBILE GEAR, 1984 & 1985

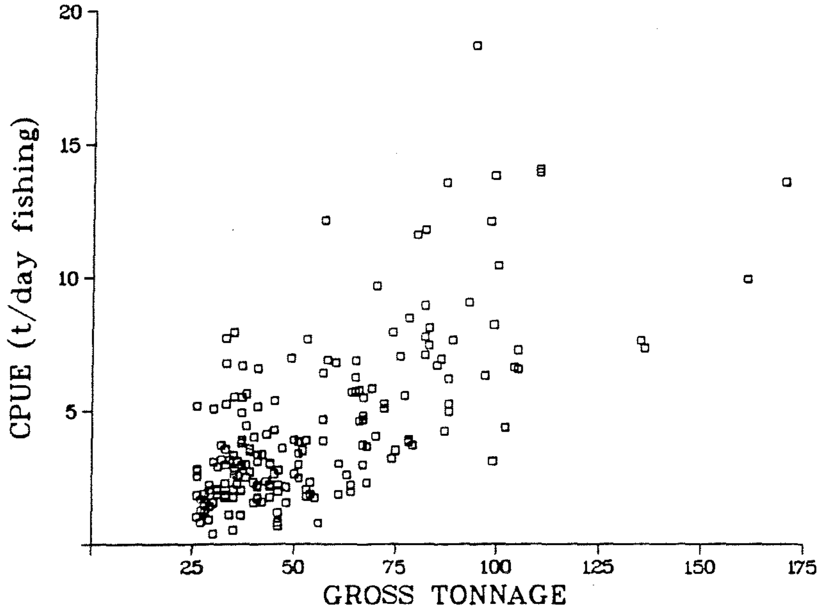


FIGURE 5.9
CPUE v BHP, MOBILE GEAR, 1984 & 1985

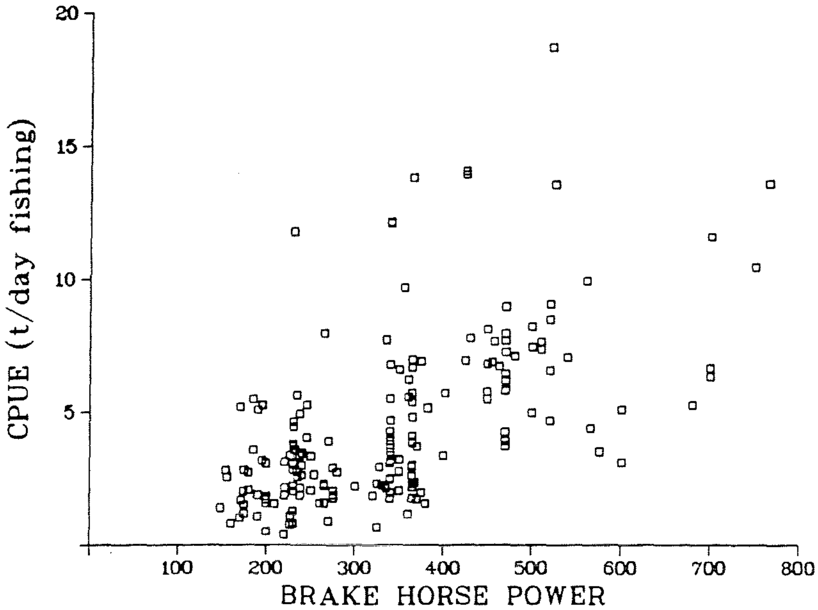


FIGURE 5.10

CPUE v LOA, LONGLINE GEAR, 1984 & 1985

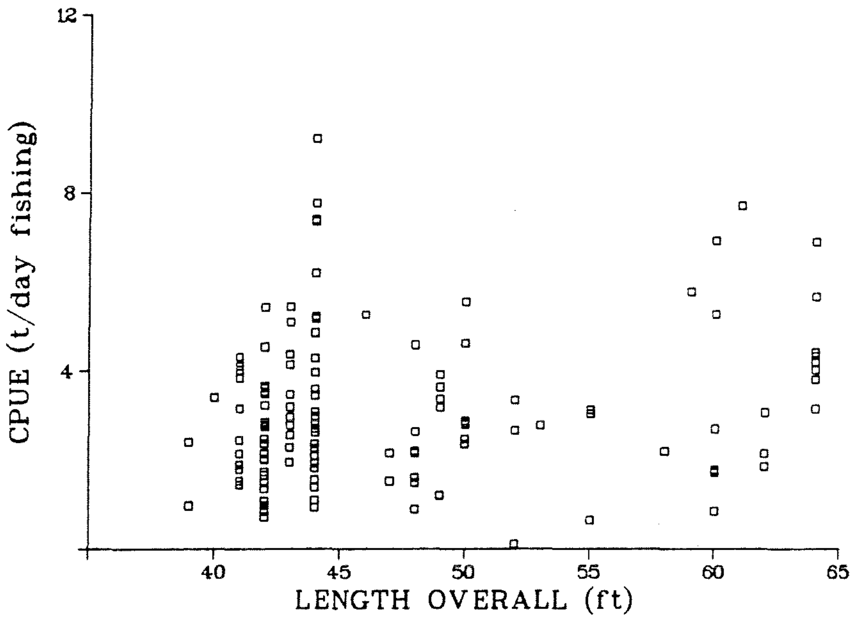


FIGURE 5.11

CPUE v GT, LONGLINERS, 1984 & 1985

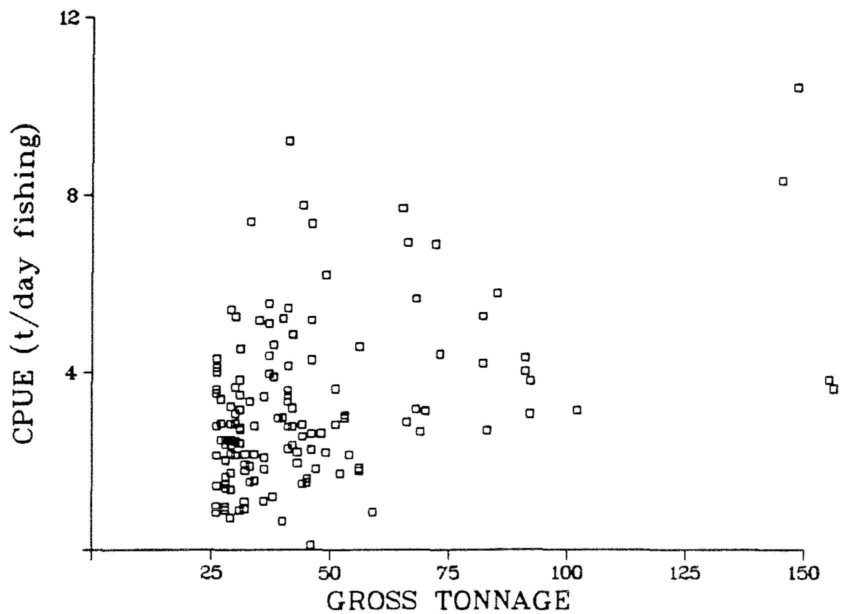
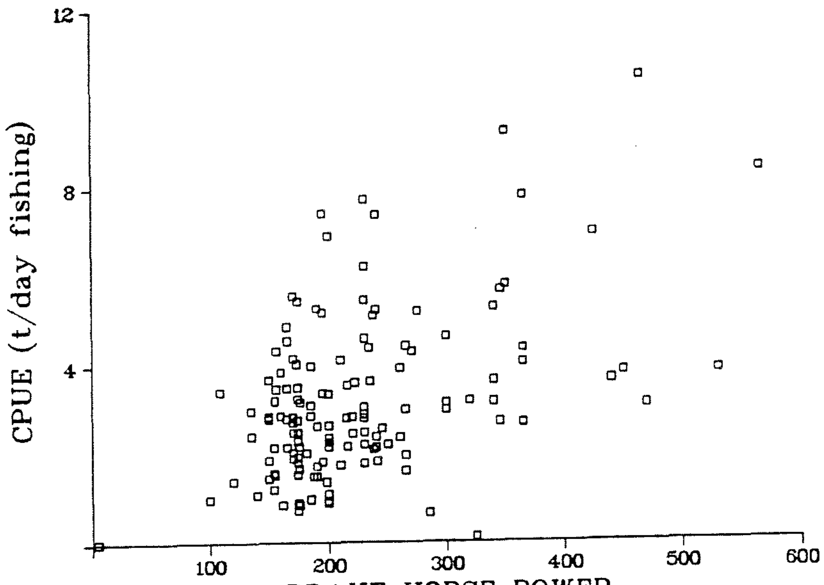


FIGURE 5.12

CPUE v BHP, LONGLINERS, 1984 & 1985



	R^2 values	
	Best Single Dependent Variable	Stepwise Multiple Regression
All Vessels	GT 40.2%	42.4%
Mobile	GT 40.2%	42.4%
Longline	BHP 22.9%	23.2%

The improvement in R^2 from multiple regression was only 5.5% in the case of the total fleet and mobile gear, and 1.3% in the case of the longline fleet. The major point is that in no case is even a majority of the variation on the CPUE of the fleet explained by the vessel dimensions!

5.2.2.3 **Effect of Disaggregation by Year**

Disaggregating the data by year resulted in increases in the R^2 values in only four of the 36 analyses (100%, 90% and 80% fleet categories) in 1984 and in 7 of 36 analyses for the 1985 data. There was no pattern to these differences between 1984 and 1985.

5.2.2.4 **Effect of Fraction of Fleet Size Examined**

No consistent overall pattern was evident in the R^2 values when successively smaller sections of the fleet, ranked by amount of catch, were examined. for example, when both gear types were considered together, R^2 values tended to decrease as the fraction of the fleet examined was reduced. This was more apparent for the mobile gear fleet. The converse was true for the Longline fleet. In this case, reducing the number of vessels examined by dropping the less important vessels resulted in large increases in the R^2 values. The pattern, by gear type, was accentuated when the data were disaggregated by year prior, to analysis as the R^2 values tabulated for GT and the multiple regression below show:

	R^2 Values			
	1984		**1985**	
% of Fleet Analysed	100%	50%	100%	50%
GT				
Mobile	42.8	15.8	40.7	12.3
Longline	8.9	35.3	9.5	60.3
Multiple Regression				
Mobile	45.2	34.2	42.9	23.4
Longline	14.4	35.3	12.4	60.3

Tables 5.26 to 5.28 show which of the data subsets provides the best fit of the regressions in each of the four dependent variable cases.

Table 5.26
Data Category Providing Best Fit

	1984	1985	1984 & 1985
LOA			
All Vessels	90%	100%	90%
Mobile	100%	100%	100%
Longline	50%	50%	50%
GT			
All Vessels	90%	90%	90%
Mobile	100%	100%	100%
Longline	50%	50%	50%
BHP			
All Vessels	100%	100%	100%
Mobile	100%	100%	100%
Longline	50%	50%	50%
Multiple Regression			
All Vessels	90%	90%	90%
Mobile	100%	100%	100%
Longline	50%	50%	50%

Table 5.27
Vessel Subset Providing Best Fit (Revenue per Day - Main Species)

	1984 & 1985	1984	1985
LOA			
All Vessels	90%	100%	100%
Mobile	100%	100%	100%
Longline	80%	90%	90%
BHO			
All Vessels	100%	100%	80/90%
Mobile	100%	100%	100%
Longline	80%	100%	90%
GT			
All Vessels	100%	100%	80%
Mobile	100%	100%	100%
Longline	50%	100%	50%
Multiple Regression			
All Vessels	100%	90%	80%
Mobile	90%	100%	100%
Longline	50%	100%	50%

Table 5.28
Vessel Subset Providing Best Fit (Revenue per Day - All Species)

	1984 & 1985	1984	1985
LOA			
All Vessels	90%	90%	90%
Mobile	100%	100%	100%
Longline	80%	90%	90%
BHP			
All Vessels	90%	90%	100%
Mobile	90%	100%	100%
Longline	90%	50%	90%
GT			
All Vessels	90%	90%	100%
Mobile	100%	100%	100%
Longline	50%	50%	50%
Multiple Regression			
All Vessels	100%	100%	100%
Mobile	100%	100%	100%
Longline	50%	50%	50%

There is little difference between any of dependent variables and that for "CPUE main species" and "all species" is the same.

5.2.2.5 **Effect of Dependent Variables**

Tables 5.19 - 5.21 show the R^2 results obtained when CPUE was taken for 'all species' combined, and when the dependent variable was taken as revenue per day, 'main species' landed, and revenue per day 'all species' landed. When 'all species' was used as the dependent variable rather than 'main species', an increase in the R^2 was obtained in 94 of the 144 cases examined, however, the increase in the R^2 values was generally small (a mean of 3.1 percentage points). When revenue per day fished for 'main species' was regressed on the vessel dimensions, an increase in the R^2 values was obtained in 39 of 144 cases, compared to CPUE of main species. For 28 of the 39 cases it was for Longline vessels. Revenue per day fished for "main species" relative to revenue for all species gave a larger R^2 value in 46 of 144 analyses; 21 cases for Mobile gear and 13 cases for Longliners. These results show that no strong case can be made for using a different measure of vessel fishing power than CPUE for the main species.

5.3 **CPUE (Main Species) Data Aggregated by Quarter**

5.3.1 **Methods**

In these analyses, the CPUE (main species) data calculated on a quarterly basis were examined. A series of analyses similar to those described in Section 3.2.1. were done. The data subset for 1984 and 1985 combined the results for the corresponding quarters in the two years. The objective of this analysis was to determine if seasonal, i.e., quartery differences, were apparent in the R^2 values. In this and subsequent analyses, results are presented for CPUE of the 'main species' (cod+haddock+pollock) only. In this series of analyses, multiple regressions of CPUE on vessel dimensions were not undertaken as little improvement was anticipated in the R^2 values. Regressions also were done on the Vessel Cubic Number (CN)

5.3.2 **Results**

5.3.2.1 **Introduction**

Tables 5.29 to 5.32 list the R^2 values obtained for the four quarters, the different vessel dimensions, gear types' and the four subsets of the fleet examined. These values are summarized in Tables 5.33 to 5.36 in which the R^2 values have been averaged over the 100%, 90% and 80% fleet size subsets. Of principal interest is the large number of analyses in which the amount of variation in the CPUE that is explained by the different vessel dimensions is very low. In only one regression was R^2 greater than 50%, while 36.6% of the regressions had R^2 values less than 10%.

5.3.2.2 **Effect of Vessel Dimension and Gear Type**

The performance of the different dimensions in explaining variation in CPUE by quarter can be summarized as follows.

Table 5.29

R^2 (%) Values from Regression of CPUE (Main Species) on Vessel Dimensions, First Quarter

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	17.9	18.3	15.1	7.9	16.4	25.8	21.1	13.7	17.8	13.0	9.4	3.3
Mobile Gear	LOA	21.3	17.8	11.8	0.7	24.8	28.6	23.0	4.4	18.6	9.7	9.3	2.1
Longliners	LOA	0.8	2.7	1.4	1.4	1.6	8.5	6.8	0.1	0.2	1.1	0.3	0.3
All Vessels	BHP	19.1	17.1	14.9	6.6	13.6	13.8	11.1	8.0	26.1	22.1	19.0	2.5
Mobile Gear	BHP	18.9	11.2	8.1	0.2	14.1	8.6	5.5	1.4	25.4	15.7	8.5	0.3
Longliners	BHP	5.2	3.3	1.4	0.1	4.5	3.1	2.5	8.7	6.5	4.9	3.2	4.9
All Vessels	GT	25.3	18.1	16.3	17.0	25.4	24.3	23.8	26.8	25.8	13.4	10.7	6.0
Mobile Gear	GT	31.4	19.5	16.1	7.6	34.7	30.8	32.3	19.9	28.9	10.4	8.5	2.0
Longliners	GT	1.9	6.5	2.1	5.4	2.3	6.4	2.4	11.3	1.5	2.6	0.4	1.4
All Vessels	CN	20.8	20.0	26.8	15.7	23.7	30.0	25.7	18.2	18.6	13.0	26.8	8.9
Mobile Gear	CN	21.1	28.9	25.6	10.7	28.6	30.3	25.6	9.3	16.6	27.9	17.9	7.1
Longliners	CN	4.2	6.1	2.3	0.0	5.9	9.9	10.9	0.2	2.7	4.3	2.7	0.5

Table 5.30

R^2 (%) Values from Regression of CPUE (Main Species) on Vessel Dimensions, Second Quarter

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	20.9	15.6	14.6	1.9	19.7	12.2	12.2	2.8	23.1	20.0	17.8	3.2
Mobile Gear	LOA	21.8	13.4	11.0	0.5	20.8	10.8	10.4	1.5	24.0	16.6	10.9	0.0
Longliners	LOA	3.6	3.8	7.5	35.5	6.6	6.6	6.1	32.3	1.8	2.8	8.6	33.7
All Vessels	BHP	30.7	24.6	22.8	10.5	28.2	24.0	19.3	8.1	35.3	31.5	29.8	16.3
Mobile Gear	BHP	30.7	21.9	18.1	11.0	30.4	21.8	17.0	2.8	34.1	28.7	24.1	12.1
Longliners	BHP	10.9	10.5	18.7	36.9	12.9	9.8	15.9	13.8	9.5	13.6	22.9	25.6
All Vessels	GT	28.4	28.2	23.5	8.0	26.3	27.9	20.1	4.2	31.4	32.7	28.5	15.1
Mobile Gear	GT	31.1	24.3	19.4	7.9	30.4	21.8	17.0	2.8	34.6	30.4	25.3	7.2
Longliners	GT	7.2	23.4	33.1	43.8	10.2	36.8	51.7	45.6	5.2	10.0	8.5	23.6
All Vessels	CN	23.5	14.3	18.9	11.2	28.8	19.6	13.0	6.5	23.3	29.8	24.7	14.9

Table 5.31
R^2 (%) from regression of CPUE (main species) on Vessel Dimensions, Third Quarter

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	19.0	15.7	14.1	17.0	12.2	9.9	6.5	11.1	23.9	21.9	20.4	12.2
Mobile Gear	LOA	15.8	14.9	13.2	11.6	13.3	10.5	4.3	7.8	18.1	19.8	15.2	6.7
Longliners	LOA	31.5	21.2	25.7	31.9	10.4	19.7	23.4	43.1	10.3	4.9	9.9	9.1
All Vessels	BHP	15.1	9.9	8.3	5.4	14.8	8.3	5.6	1.6	15.9	13.3	9.7	4.6
Mobile Gear	BHP	15.3	10.4	6.4	1.9	17.4	10.4	4.8	0.1	14.5	10.1	5.7	0.7
Longliners	BHP	24.3	23.3	31.9	36.3	19.7	24.9	24.7	41.5	42.3	29.8	30.1	34.5
All Vessels	GT	24.9	23.7	23.4	18.7	24.5	16.7	14.2	1.8	24.6	28.7	29.0	31.1
Mobile Gear	GT	23.3	24.8	24.7	17.3	27.6	20.1	17.4	0.2	27.3	29.3	33.1	16.0
Longliners	GT	31.5	11.8	9.8	10.7	18.8	12.4	10.9	6.4	36.7	12.7	11.3	3.3
All Vessels	CN	15.3	11.6	7.7	20.4	19.3	16.8	10.7	14.2	12.9	7.4	14.6	18.1
Mobile Gear	CN	15.1	11.9	5.6	19.6	25.4	23.1	12.7	13.7	20.6	31.3	30.3	22.7
Longliners	CN	13.4	15.5	11.6	25.5	4.2	4.3	6.8	26.8	23.9	23.3	34.2	38.6

Table 5.32
R^2 from regression ofCPUE (main species) on Vessel Dimensions, Fourth Quarter

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	14.4	11.6	9.4	2.9	13.3	9.4	0.6	2.9	11.4	0.5	16.1	19.9
Mobile Gear	LOA	13.4	6.4	3.2	0.7	11.2	4.3	0.9	0.3	17.2	17.2	14.3	32.7
Longliners	LOA	14.2	20.2	24.1	23.3	17.9	17.5	10.6	6.5	12.7	1.8	3.5	26.4
All Vessels	BHP	13.2	10.4	7.5	2.9	0.3	3.6	3.4	1.0	6.3	9.7	2.3	17.9
Mobile Gear	BHP	10.0	3.7	2.6	2.3	9.8	1.7	3.2	0.0	9.2	3.4	1.1	15.6
Longliners	BHP	29.9	32.7	40.4	51.0	7.6	11.9	9.8	39.2	8.4	22.1	31.9	46.6
All Vessels	GT	18.5	25.5	23.9	37.0	17.4	17.3	14.0	24.1	14.1	8.3	12.0	17.5
Mobile Gear	GT	18.0	28.3	32.4	41.9	15.5	12.4	28.0	7.6	23.2	18.1	15.9	16.2
Longliners	GT	15.9	11.8	14.1	37.8	23.1	28.9	29.3	28.6	11.8	1.8	1.6	14.8
All Vessels	CN	7.7	4.7	7.1	6.8	6.7	4.3	0.8	1.4	6.4	0.3	5.9	7.4
Mobile Gear	CN	4.9	1.9	3.6	2.0	10.1	10.5	24.4	47.5	9.6	0.5	10.5	18.3

Table 5.33

R_2 (%), 'Main Species', First Quarter.
Data averaged for vessels taking 100%, 90% and 80% of cummulative catch.

	1984 & 1985	1984	1985
LOA			
All Vessels	17.1	21.8	13.4
Mobile	16.9	25.5	12.5
Longline	1.6	5.6	0.5
GT			
All Vessels	19.9	24.5	16.6
Mobile	22.3	32.6	15.9
Longline	3.5	3.7	1.5
BHP			
All Vessels	17.0	12.8	22.4
Mobile	12.7	9.4	16.5
Longline	3.3	3.4	4.9

Table 5.34

R^2 (%) 'Main Species', Second Quarter

	1984 & 1985	1984	1985
LOA			
All Vessels	17.0	14.7	20.3
Mobile	15.4	14.0	17.2
Longline	14.9	6.4	4.4
GT			
All Vessels	26.7	24.8	21.5
Mobile	24.9	23.1	30.1
Longline	21.2	32.9	7.9
BHP			
All Vessels	26.0	23.8	32.2
Mobile	23.6	23.1	29.0
Longline	13.4	12.9	15.3

Table 5.35

R^2 (%), 'Main Species', Third Quarter

	1984 & 1985	1984	1985
LOA			
All Vessels	16.3	9.5	22.1
Mobile	14.6	9.4	17.7
Longline	26.1	17.8	8.4
GT			
All Vessels	24.0	10.3	27.4
Mobile	24.3	21.7	29.9
Longline	17.7	14.0	20.2
BHP			
All Vessels	11.1	9.6	13.0
Mobile	10.7	10.9	10.1
Longline	12.2	23.1	34.1

Table 5.36

R^2 (%), 'Main Species', Fourth Quarter

	1984 & 1985	1984	1985
LOA			
All Vessels	11.8	11.0	25.2
Mobile	7.7	5.9	23.9
Longline	19.5	18.7	17.4
GT			
All Vessels	22.6	16.2	33.8
Mobile	26.2	18.6	45.2
Longline	13.9	27.1	5.1
BHP			
All Vessels	10.4	12.8	9.7
Mobile	5.4	7.0	10.0
Longline	34.3	44.4	25.2

Vessel Dimension Providing Most Explanation of Variation in CPUE determined on a quarterly basis

	1984 & 1985	1984	1985
All Vessels			
LOA	0	0	0
GT	4	4	2
BHP	0	0	2
Mobile Gear			
LOA	0	0	0
GT	4	$2\frac{1}{2}$	3
BHP	0	$1\frac{1}{2}$	1
Longliners			
LOA	1	1	0
GT	2	1	0
BHP	1	2	4

When both gears are considered together, GT provides the most frequent, best predictor of CPUE for all time periods. This is also true for the mobile gear fleet though BHP performs well in two cases in 1984. In 1985, BHP performed equally well for the both-gear catagories; GT performed better for the mobile gear and BHP for longliners.

5.3.2.3 Results

Table 5.37 shows the results of averaging the R^2 values for each quarter and the corresponding values for the full year. Taken across all comparisons, aggregating by quarter resulted in greater R^2 values (averaged over the four quarters) in only 4 of 27 comparisons; longline LOA 1984 and LOA 1985; longline GT for 1984 and 1985 separately. When the comparisons are made on a quarterly basis the number of comparisons with larger R^2 values than the corresponding regression for that data aggregated over the year are as follows:

	1984 & 1985	1984	1985
LOA			
All Vessels	0	0	0
Mobile	0	1	0
Longline	3	3	1
BHP			
All Vessels	0	0	1
Mobile	0	1	1
Longline	1	2	2
GT			
All Vessels	0	0	0
Mobile	0	0	0
Longline	2	3	2

Table 5.37

R^2 values for CPUE 'main species' averaged over the four quarters
Values in parentheses are the corresponding R^2 values for the data combined over the whole year.

	1984	1985	1984 & 1985
All Vessels:			
LOA	15.6 (28.7)	14.3 (23.0)	20.3 (23.1)
GT	23.2 (40.2)	14.8 (34.2)	19.3 (33.2)
BHP	14.9 (30.0)	14.8 (24.2)	19.3 (28.6)
Mobile gear:			
LOA	13.7 (27.0)	13.7 (24.0)	15.3 (22.3)
GT	24.4 (40.2)	12.6 (37.6)	16.4 (33.5)
BHP	13.1 (25.5)	12.6 (19.2)	16.4 (26.8)
Longliners:			
LOA	15.5 (14.8)	12.1 (5.5)	8.8 (18.2)
GT	14.1 (16.7)	21.0 (9.7)	19.9 (18.4)
BHP	15.8 (22.9)	12.1 (19.2)	7.7 (21.8)

These results indicate a more pronounced quarterly effect in the R^2 values for the longline fleet, and for regressions on their LOA and GT. Regressions using these independent variables gave better descriptions of the data in 7 out of 12 possible cases. However, in no gear-type/vessel-dimension combination does stratifying by season result in larger R^2 values in all quarters.

5.3.3 CPUE as a Function of Cubic Number

Because GT and cubic number (CN) are both volumetric measures, it is of interest which is the better predictor of CPUE. In 144 possible comparisons for the quarterly data, regressing on GT rather than CN resulted in larger R^2 values in 92 cases or 64% of the regressions undertaken. When examined on a gear basis, the percentages were 73% and 52% respectively for mobile and longline gear respectively. These results indicate the GT is the better independent variable for the mobile gear fleet, but that either variable (GT or CN) performs about equally well for the longline fleet.

5.4 Data Aggregated by Stock

5.4.1 Methods

In these analyses, CPUE data were stratified depending on stock and CPUE as a function of vessel dimensions was then examined on a stock basis. R^2 values were calculated for 1984, 1985, and for both years together, as well as for the four fleet size selections, i.e., those vessels taking 100%, 90%, 80%, and 50% respectively, of the catch.

5.4.2 Results

Tables 5.38 to 5.46 list the R^2 values from the regression analyses for the different categories. These data have been summarized in Tables 5.47, 5.48 and 5.49, in which the R^2 values have been averaged over the 100%, 90% and 80% fleet subsets. There are clear differences in the R^2

Table 5.38
R^2 (%) from Regression of CPUE on Vessel Dimensions: 4Vn Cod

Sample	Vessel Variable	1984 and 1985 All	90%	80%	50%	1984 All	90%	80%	50%	1985 All	90%	80%	50%
All Vessels	LOA	50.2	45.3	35.6	72.5	55.0	62.5	59.8	-	46.4	32.9	34.7	-
Mobile Gear	LOA	38.6	21.2	62.8	71.4	51.1	45.1	54.0	-	30.0	5.6	29.8	-
Longliners	LOA	4.2	0.3	0.3	-	1.2	0.1	0.0	0.5	10.8	6.8	9.0	-
All Vessels	BHP	57.0	50.5	41.9	32.1	59.7	61.9	42.0	-	54.9	43.1	73.2	-
Mobile Gear	BHP	39.5	45.0	42.5	71.4	43.4	23.3	39.4	-	37.1	54.9	36.3	-
Longliners	BHP	38.9	27.6	30.4	53.7	42.0	41.7	42.4	73.3	35.2	8.4	7.9	-
All Vessels	GT	59.5	52.2	43.0	68.5	70.4	73.6	74.4	-	50.4	35.2	43.2	-
Mobile Gear	GT	43.8	32.3	63.5	71.4	63.6	66.9	74.2	-	29.3	13.8	38.7	-
Longliners	GT	33.8	25.5	19.4	36.1	24.2	24.8	23.4	59.4	47.5	45.8	44.9	-
All Vessels	CV	21.5	28.9	17.9	65.5	18.0	23.1	7.9	-	25.7	37.3	40.8	-
Mobile Gear	CV	12.7	2.7	16.5	-	5.2	1.2	-	-	23.9	3.3	1.8	-
Longliners	CV	3.1	5.3	0.3	90.9	1.9	0.0	45.1	-	5.0	35.8	63.1	-

Table 5.39
R^2 (%) from Regression of CPUE on Vessel Dimensions: 4VsW Cod

Sample	Vessel Variable	1984 and 1985 All	90%	80%	50%	1984 All	90%	80%	50%	1985 All	90%	80%	50%
All Vessels	LOA	17.0	13.7	14.7	6.8	21.6	23.1	40.0	30.1	16.2	12.6	22.6	13.7
Mobile Gear	LOA	8.2	0.3	2.3	6.6	20.5	0.3	18.2	-	9.9	0.1	0.6	1.5
Longliners	LOA	8.5	26.6	24.5	62.8	5.4	25.5	44.7	82.8	12.1	11.3	9.2	53.8
All Vessels	BHP	37.5	41.2	43.4	42.7	22.7	23.9	43.9	40.7	42.5	46.5	57.3	47.7
Mobile Gear	BHP	21.5	17.5	15.5	12.8	7.1	1.9	2.9	-	28.3	27.4	34.9	5.5
Longliners	BHP	17.9	24.9	32.8	54.2	22.9	29.2	47.1	58.1	13.6	15.9	20.1	92.0
All Vessels	GT	18.1	17.0	18.8	14.8	26.7	30.5	51.5	50.0	16.6	13.0	26.1	18.5
Mobile Gear	GT	9.1	0.1	1.1	0.5	29.3	7.9	3.1	-	10.3	1.2	1.2	0.0
Longliners	GT	9.2	25.2	35.0	58.0	6.7	21.9	49.6	76.1	11.9	11.7	19.5	75.1
All Vessels	CN	22.5	19.7	25.0	18.7	8.6	11.3	7.3	5.5	26.8	19.5	30.9	36.0
Mobile Gear	CN	17.2	20.9	24.7	36.0	18.4	54.9	47.5	-	16.8	16.2	14.9	21.3

Table 5.40

R^2 (%) from Regression of CPUE on Vessel Dimensions: 4X+5Y Cod

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	9.5	11.5	15.1	21.2	8.6	15.5	15.0	50.4	10.5	8.4	18.7	11.8
Mobile Gear	LOA	13.5	15.9	26.4	27.7	20.3	34.7	35.8	66.2	10.5	8.0	19.1	12.4
Longliners	LOA	0.8	0.6	1.8	9.5	0.6	0.3	0.1	17.7	1.1	1.0	3.6	3.8
All Vessels	BHP	12.2	12.7	14.2	14.5	6.4	10.4	8.8	28.8	18.7	13.6	17.5	8.2
Mobile Gear	BHP	15.3	14.2	18.6	12.9	15.3	19.1	17.9	50.3	16.8	12.3	12.8	5.6
Longliners	BHP	8.9	13.1	14.2	33.5	7.3	6.9	4.0	38.8	12.7	31.9	46.6	39.9
All Vessels	GT	12.9	18.1	22.3	30.5	12.9	25.4	25.6	65.9	13.0	13.2	26.2	18.2
Mobile Gear	GT	17.7	23.4	35.4	39.4	26.6	51.1	53.1	78.1	13.4	11.4	23.0	23.4
Longliners	GT	2.7	5.4	7.8	27.3	2.2	1.8	1.1	39.7	3.3	17.4	33.4	24.9
All Vessels	CN	2.0	1.2	0.8	2.3	4.6	7.8	7.5	0.5	0.8	0.0	0.0	4.5
Mobile Gear	CN	0.8	0.0	0.5	3.6	4.9	4.0	3.4	5.7	0.1	1.4	1.5	29.6
Longliners	CN	6.1	16.3	24.5	42.6	8.1	4.6	9.6	3.3	4.6	12.3	12.6	4.3

Table 5.41

R^2 (%) from Regression of CPUE on Vessel Dimensions: 5Z Cod

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90	1985 80%	1985 50%
All Vessels	LOA	4.1	14.1	23.6	20.7	4.6	3.4	0.1	10.9	8.9	13.4	23.9	22.9
Mobile Gear	LOA	2.1	6.0	16.3	3.3	6.2	3.2	2.6	29.7	5.4	7.8	11.6	2.7
Longliners	LOA	1.3	3.0	0.0	3.0	4.5	0.1	0.4	14.0	0.2	6.3	0.3	40.5
All Vessels	BHP	7.6	20.4	39.9	44.5	1.5	2.1	0.4	0.6	11.8	20.4	41.3	45.5
Mobile Gear	BHP	4.5	8.7	29.0	19.3	0.2	2.3	2.8	0.7	6.5	17.7	23.9	19.0
Longliners	BHP	3.8	5.6	5.9	0.3	9.0	0.4	2.6	0.1	1.0	25.9	40.6	36.0
All Vessels	GT	5.7	17.0	28.1	25.5	1.4	12.0	8.4	0.2	10.6	15.5	25.3	23.0
Mobile Gear	GT	3.4	7.8	18.4	5.2	1.6	0.0	0.5	23.4	6.5	8.9	13.5	6.6
Longliners	GT	4.0	14.0	13.6	0.0	4.9	8.4	9.9	0.1	2.4	32.6	33.0	55.0
All Vessels	CN	7.2	19.4	18.5	19.6	0.2	7.8	4.4	0.5	12.0	22.1	18.1	23.1
Mobile Gear	CN	6.1	11.7	14.3	6.1	4.0	2.3	1.6	8.6	9.6	8.2	13.7	1.7

Table 5.42

R^2 (%) from Regression of CPUE on Vessel Dimensions: 4VW Haddock

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	14.3	14.5	23.8	23.8	15.2	24.6	50.1	60.2	15.9	6.4	16.7	5.0
Mobile Gear	LOA	1.2	0.5	4.8	12.6	3.4	23.5	29.3	32.6	0.3	0.9	1.0	0.8
Longliners	LOA	28.3	28.2	16.6	65.2	38.1	59.7	50.6	-	20.9	9.6	2.3	51.7
All Vessels	BHP	34.1	35.4	41.3	12.9	38.0	53.7	48.9	67.0	39.5	36.3	38.1	0.1
Mobile Gear	BHP	16.3	7.9	12.0	2.4	26.0	33.7	52.0	69.7	16.7	9.7	10.7	0.1
Longliners	BHP	13.6	21.1	11.1	46.8	22.9	50.9	40.8	-	6.3	1.0	19.2	18.8
All Vessels	GT	13.7	14.8	19.7	5.0	17.2	25.6	54.0	43.6	13.9	6.3	12.2	2.7
Mobile Gear	GT	1.8	0.0	3.1	5.7	5.2	32.8	35.5	8.5	0.6	0.1	1.2	0.0
Longliners	GT	26.5	18.6	6.2	94.6	59.6	77.1	65.4	-	5.4	0.3	22.9	34.8
All Vessels	CN	21.3	12.8	11.5	0.2	29.4	54.2	56.3	63.0	18.9	5.6	3.9	3.1
Mobile Gear	CN	9.0	14.8	12.8	16.2	18.1	3.9	8.8	44.9	5.9	5.7	3.9	10.3
Longliners	CN	23.1	43.4	32.6	28.5	33.1	32.4	39.2	-	9.9	1.6	1.9	16.8

Table 5.43

R^2 (%) from Regression of CPUE on Vessel Dimensions:4X+5Y Haddock

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	11.6	11.7	8.7	22.7	9.4	13.7	13.9	26.1	14.2	11.2	7.5	33.2
Mobile Gear	LOA	13.2	12.0	14.2	26.6	12.2	17.9	17.9	46.3	14.2	7.8	4.6	33.2
Longliners	LOA	3.5	5.4	5.7	13.3	3.4	7.5	3.9	9.5	2.4	5.6	5.5	12.0
All Vessels	BHP	19.6	20.3	20.1	35.1	15.6	19.1	23.5	40.7	24.6	23.0	19.9	38.3
Mobile Gear	BHP	25.8	29.9	30.8	43.2	27.0	40.8	37.7	48.5	25.1	20.6	18.0	39.2
Longliners	BHP	4.7	4.9	4.2	9.7	2.1	2.5	0.8	7.8	9.4	16.9	12.7	21.3
All Vessels	GT	14.1	13.5	10.7	23.1	11.4	14.3	13.6	24.0	17.3	13.9	9.5	32.2
Mobile Gear	GT	16.3	17.2	17.3	24.7	14.1	22.4	20.9	35.3	18.8	12.3	8.2	32.8
Longliners	GT	5.0	3.2	2.6	10.0	5.2	3.1	1.4	6.6	3.9	5.1	3.6	13.5
All Vessels	CN	14.0	11.6	14.7	15.0	18.8	17.8	15.9	24.5	10.5	9.5	14.0	13.6
Mobile Gear	CN	13.7	19.8	12.3	11.1	23.2	24.0	21.6	34.7	8.1	8.8	21.9	23.8

Table 5.44
R^2 (%) from Regression of CPUE on Vessel Dimensions: 5Z Haddock

Sample	Vessel Variable	1984 and 1985 All	90%	80%	50%	1984 All	90%	80%	50%	1985 All	90%	80%	50%
All Vessels	LOA	0.8	1.3	1.9	13.5	5.2	1.6	1.8	45.7	3.7	1.2	1.5	14.3
Mobile Gear	LOA	0.0	0.3	1.1	13.8	7.1	2.0	7.3	18.7	1.0	0.0	0.1	14.5
Longliners	LOA	1.2	4.6	1.7	-	11.6	4.9	53.2	-	2.8	46.7	26.1	-
All Vessels	BHP	6.0	4.9	3.3	12.3	1.8	8.9	11.9	37.8	8.1	2.9	1.2	13.9
Mobile Gear	BHP	3.0	2.0	0.7	8.6	1.3	4.8	11.7	18.7	3.7	0.5	0.0	13.2
Longliners	BHP	0.0	1.7	1.6	-	6.1	12.9	2.1	-	8.1	36.7	17.0	-
All Vessels	GT	2.9	1.7	2.2	11.5	0.7	0.9	2.3	41.9	6.5	1.9	1.4	12.6
Mobile Gear	GT	1.3	0.9	1.3	11.1	1.1	1.5	6.9	27.2	3.3	0.4	0.1	13.9
Longliners	GT	0.0	1.3	0.6	-	3.8	8.6	7.4	-	9.6	4.2	25.4	-
All Vessels	CN	2.6	4.8	7.2	22.8	0.2	7.2	5.6	48.7	5.8	4.9	7.8	40.4
Mobile Gear	CN	1.6	0.8	8.3	15.0	0.6	3.3	7.4	35.4	3.7	11.5	10.1	35.1
Longliners	CN	0.5	0.5	1.9	-	2.7	2.7	15.5	-	0.5	2.7	9.1	-

Table 5.45
R^2 (%) from Regression of CPUE on Vessel Dimensions: 4VWX+5 Pollock

Sample	Vessel Variable	1984 and 1985 All	90%	80%	50%	1984 All	90%	80%	50%	1985 All	90%	80%	50%
All Vessels	LOA	20.7	16.0	15.8	1.4	24.2	14.6	8.5	1.1	18.1	16.3	25.8	1.8
Mobile Gear	LOA	20.5	16.2	16.6	1.4	23.9	14.6	8.5	1.1	18.1	16.3	25.8	1.8
Longliners	LOA	-	-	-	-	-	-	-	-	-	-	-	-
All Vessels	BHP	29.3	20.5	25.9	7.3	37.7	22.7	16.0	6.3	23.2	20.4	38.6	15.3
Mobile Gear	BHP	28.9	20.6	25.3	7.3	36.8	22.3	14.8	6.3	23.2	20.4	38.6	15.3
Longliners	BHP	-	-	-	-	-	-	-	-	-	-	-	-
All Vessels	GT	23.7	18.0	18.9	2.6	28.6	16.9	7.4	2.1	20.2	18.6	30.8	6.9
Mobile Gear	GT	23.5	18.1	18.2	2.6	28.1	16.6	7.5	2.1	20.2	18.6	30.8	6.9
Longliners	GT	-	-	-	-	-	-	-	-	-	-	-	-
All Vessels	CN	11.3	10.2	8.0	3.1	15.4	12.1	5.5	3.4	9.0	10.7	8.1	2.7
Mobile Gear	CN	11.1	6.4	4.9	27.1	14.9	15.8	34.9	9.0	10.7	8.1	2.7	-

Table 5.46

R^2 (%) from Regression of CPUE on Vessel Dimensions: 4XQ+4XR+5Y Cod + Haddock

Sample	Vessel Variable	1984 and 1985 All	1984 and 1985 90%	1984 and 1985 80%	1984 and 1985 50%	1984 All	1984 90%	1984 80%	1984 50%	1985 All	1985 90%	1985 80%	1985 50%
All Vessels	LOA	20.0	30.5	29.5	19.3	18.7	21.7	19.6	14.1	21.6	40.2	47.4	51.4
Mobile Gear	LOA	26.0	31.7	29.4	20.8	22.2	20.8	21.7	14.1	30.9	39.9	46.6	46.1
Longliners	LOA	28.3	17.3	25.3	50.3	23.8	22.7	24.1	-	27.4	47.1	45.2	-
All Vessels	BHP	21.4	25.4	24.6	16.1	21.7	25.3	22.9	14.7	21.3	27.6	22.6	27.6
Mobile Gear	BHP	30.0	25.4	24.7	15.4	27.0	25.2	23.4	14.7	33.7	26.4	21.6	23.2
Longliners	BHP	24.2	10.7	18.0	17.0	22.3	21.1	21.6	-	21.0	53.0	53.0	-
All Vessels	GT	23.3	31.1	30.9	28.7	22.2	25.4	23.2	21.2	25.0	40.9	42.0	46.8
Mobile Gear	GT	29.6	32.0	31.0	28.4	25.9	24.9	24.4	21.2	34.7	40.0	41.1	42.4
Longliners	GT	35.7	24.7	30.6	65.8	15.7	14.6	15.8	-	56.5	2.1	15.3	-
All Vessels	CN	4.2	7.0	4.6	1.7	5.9	14.9	14.7	4.8	2.9	1.0	2.1	5.2
Mobile Gear	CN	5.5	6.2	3.3	31.5	7.0	15.5	10.6	14.2	4.2	1.6	0.5	34.9
Longliners	CN	6.9	2.2	3.0	16..2	5.3	83.7	-	-	10.0	51.3	-	-

Table 5.47

R^2 Values by Stock, Averaged Over the 100%, 90% and 80% Cumulative Catch, Fleet Data, 1984 and 1985.

Stock	1	2	3	4	5	6	7	8	9
LOA									
All Vessels	43.7	15.1	12.0	13.9	17.5	10.7	1.3	17.5	26.7
Mobile	40.9	3.6	18.6	8.1	2.2	11.3	0.5	17.8	29.0
Longline	1.6	19.9	1.1	1.4	24.4	4.9	2.5	-	23.6
BHP									
All Vessels	49.8	40.7	13.0	22.6	36.9	20.0	4.7	25.2	23.8
Mobile	42.3	18.2	16.0	14.1	12.1	28.8	1.9	24.9	26.7
Longline	32.3	25.2	12.1	5.1	15.3	4.6	1.1	-	17.6
GT									
All Vessels	51.6	18.0	17.8	16.9	16.1	12.8	2.3	20.2	28.4
Mobile	46.5	3.4	25.5	9.9	1.6	16.9	1.2	19.9	30.9
Longline	26.2	23.1	5.3	10.5	17.1	3.6	0.6	-	30.3

1 4Vn cod
2 4VsW cod
3 4X + 5Y cod
4 5Z cod
5 4VW haddock
6 4X + 5Y haddock
7 5Z haddock
8 4VWX + 5 pollock
9 4Xq + 4Xr + 5Y cod + haddock

Table 5.48
R^2 Values by Stock, 1984 CPUE Data.
Averaged Over the 100%, 90% and 80% Data Subsets

Stock	1	2	3	4	5	6	7	8	9
LOA									
All vessels	59.1	28.2	13.0	2.7	30.0	12.3	2.9	15.8	20.0
Mobile	50.1	13.0	30.3	4.0	18.7	16.0	5.5	15.8	21.6
Longline	0.4	25.2	0.3	1.7	49.5	4.9	23.2	-	23.5
BHP									
All Vessels	54.5	30.2	8.7	3.3	46.9	19.4	25.5	27.4	23.3
Mobile	35.4	4.0	17.4	1.8	37.2	35.2	24.6	27.4	25.2
Longline	42.0	33.1	6.1	4.0	38.2	1.8	-	-	21.7
GT									
All Vessels	72.8	36.2	21.3	7.3	32.3	13.1	17.6	23.2	23.6
Mobile	68.2	13.4	43.6	0.7	24.5	19.1	17.4	23.2	25.1
Longline	24.1	26.1	1.7	7.7	67.4	3.2	-	-	15.4

Table 5.49
R^2 Values by Stock, 1985 CPUE Data
Averaged Over the 100%, 90% and 80% Fleet Data Subsets

Stock	1	2	3	4	5	6	7	8	9
LOA									
All Vessels	38.0	17.1	12.5	15.4	13.0	11.0	2.1	20.1	36.4
Mobile	21.8	3.5	13.2	8.3	0.7	8.9	0.4	20.1	39.1
Longline	8.9	10.9	4.9	2.3	10.9	4.5	25.2	-	39.9
BHP									
All Vessels	57.1	48.8	16.6	24.5	38.0	22.5	4.1	27.4	23.8
Mobile	42.8	30.2	14.0	16.0	12.4	21.2	1.4	27.4	27.2
Longline	17.2	16.5	30.4	22.5	8.8	13.0	20.6	-	42.3
GT									
All Vessels	42.9	18.6	17.5	17.1	10.8	13.6	3.3	23.2	36.0
Mobile	27.3	4.2	15.9	9.6	0.6	13.1	1.3	23.2	38.6
Longline	46.1	14.4	18.0	22.7	9.5	4.2	25.8	-	24.6

values between the stocks. When the data are considered for both gear types combined, the nine stocks examined can be ranked in terms of the R^2 values. These data are shown in Tables 5.50-5.52. The highest ranked stock in all three time periods was 4Vn cod; 4VsW cod ranked second for 1984 and 1985; and ranked third for 1985. 4VWX+5 pollock and 4VW haddock ranked next. The ranks for the other stocks depended on the time period chosen.

When the R^2 results for the separate stocks are compared with the results for all stocks together for 1984 and 1985 combined, one stock, 4Vn cod, had a higher R^2 values in the regressions on LOA; three had higher R^2 values with regressions on BHP and one stock had a higher R^2 values with regregessions on GT. When the data were examined on an annual basis, for LOA, larger R^2 values were obtained for six stocks in 1984 and for seven stocks in 1985; seven and four stocks, respectively, had higher R^2 values for BHP. For regressions using GT, improvements occurred in seven and six stocks respectively.

5.5 Data Aggregated by Stock and Quarter

5.5.1 Methods

In this series of analyses, the CPUE data were analyised by stock and quarter to determine if seasonal effects could be identified on a stock basis. Should there be a strong seasonal affect in the CPUE-vessel dimension relationships on a stock basis, then disaggregating should result in larger R^2 values. To determine if this is so, the average of the quarterly R^2 values should be compared with R^2 values obtained from analysis of the year's data, all combined.

5.5.2 Results

Tables 5.53 - 5.79 summarize the R^2 values obtained for the individual calculations. Some care must be taken in the interpretation of the R^2 values for data cells containing few observations. In many cases large R^2 values occurred when the number of observations were few.

No clear pattern in the R^2 values was evident for all stocks. For 4Vn cod, 4VWX+5 pollock and 4X+5Y cod and haddock, better fits were obtained with the annual data rather than when disaggregated by quarter. The opposite was the case for 4VW haddock and 5Z haddock. Results for the other stocks depended on whether the data was considered for 1984 and 1985 together, or for each year separately.

Two stocks showed rather remarkably high R^2 values in the third quarter - that for 4VW haddock and for 4VWX+5 pollock. Their R^2 values are summarized as follows for the 1984 and 1985 data combined.

Table 5.50
Stocks Ranked by R^2 Values; 1984, Both Gears Combined

Rank	LOA	R^2	BHP	R^2	GT	R^2
1	4Vn Cod	59.1	4Vn Cod	54.5	4VN Cod	72.8
2	4VW Had	30.0	4VW Had	46.9	4VSW Cod	36.2
3	4VSW Cod	28.2	4VsW Cod	30.2	4VW Had	32.3
4	4Xs5Y Cod+Had	20.0	4VWX+5 Poll	27.4	4X+5Y Cod+Had	23.6
5	4VWX+5 Poll	15.8	5Z Had	25.5	4VWX+5 Poll	23.2
6	4X+5Y Cod	13.0	4X+5Y Cod+Had	23.3	4X+5Y Cod	21.3
7	4X+5Y Had	12.3	4X+5Y Had	19.4	5Z Had	17.6
8	5Z Had	2.9	4X+5Y Cod	8.7	4X+5Y Had	13.1
9	5Z Cod	2.7	5Z Cod	3.3	5Z Cod	7.3

Table 5.51
Stocks Ranked by R^2, 1985, Both Gear Types

Rank	LOA	R^2	BHP	R^2	GT	R^2
1	4Vn Cod	38.0	4Vn Cod	57.1	4VN Cod	42.9
2	4X+5Y Cod+Had	36.4	4VsW Cod	48.8	4X+5Y Cod+Had	36.0
3	4VWX+5Y Poll	20.1	4VW Had	38.0	4VWX+5Y Poll	23.2
4	4VsW Cod	17.1	4VWX+5 Poll	27.4	4VSW Cod	18.6
5	5Z Cod	15.4	5Z Cod	24.5	4X+5Y Cod	17.5
6	4VW Had	13.0	4X+5Y Cod+Had	23.8	5Z Cod	17.1
7	4X+5Y Cod	12.5	4X+5Y Had	22.5	4X+5Y Had	13.6
8	4X+5Y Had	11.0	5X+5Y Cod	16.6	4VW Had	10.8
9	5Z Had	2.1	5Z Had	4.1	5Z Had	3.3

Table 5.52
Stocks Ranked by R^2, 1984 and 1985, Both Gear Gears Combined

Rank	LOA	R^2	BHP	R^2	GT	R^2
1	4Vn Cod	43.7	4Vn Cod	49.8	4VN Cod	51.6
2	4X+5Y Cod+Had	26.7	4VsW Cod	40.7	4X+5Y Cod+Had	28.4
3	4VW Had	17.5	4VW Had	36.9	4VWX+5 Poll	20.2
4	4VWX+5 Poll	17.5	4VWX+5 Poll	25.2	4VSW Cod	18.0
5	4VsW Cod	15.1	4X+5Y Cod+Hadd	23.8	4X+5Y Cod	17.8
6	5Z Cod	13.9	5Z Cod	22.6	5Z Cod	16.9
7	4X+5Y Cod	12.0	4X+5Y Had	20.0	4VW Had	16.1
8	4X+5Y Had	10.7	4X+5Y Cod	13.0	4X+5Y Had	12.8
9	5Z Had	1.3	5Z Hadd	4.7	5Z Had	2.3

Table 5.53
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
1984 and 1985, 4Vn Cod

LOA	Q1	Q2	Q3	Q4	**Mean**	**Annual**
All Vessels	27.2	13.8	56.1	28.6	31.4	43.7
Mobile	22.3	14.2	29.4	17.2	15.8	40.9
Longline	-	6.9	20.7	12.5	10.0	1.6
BHP						
All Vessels	30.4	36.3	64.0	33.6	41.1	49.8
Mobile	26.3	31.3	26.1	25.1	20.2	42.3
Longline	-	55.7	6.5	29.8	23.0	32.3
GT						
All Vessels	22.9	18.9	54.6	49.9	31.6	51.6
Mobile	17.7	19.4	25.9	41.5	26.1	46.5
Longline	-	38.9	0.0	29.2	17.0	26.2

Table 5.54
1984 and 1985, 4VsW Cod

LOA	Q1	Q2	Q3	Q4	**Mean**	**Annual**
All Vessels	6.8	11.7	25.3	8.8	13.2	15.1
Mobile	17.6	2.8	0.8	2.3	5.9	3.6
Longline	0.6	11.9	37.7	8.7	14.7	19.9
BHP						
All Vessels	7.5	35.0	32.1	26.6	25.3	40.7
Mobile	5.2	15.8	11.7	9.5	10.6	18.2
Longline	1.6	23.0	38.1	30.9	23.4	25.2
GT						
All Vessels	9.6	12.4	32.4	15.8	17.6	18.0
Mobile	18.5	2.4	17.7	7.3	11.5	3.4
Longline	1.3	15.1	38.1	8.2	15.7	23.1

Table 5.55
1984 and 1985, 4X+5Y Cod

LOA	Q1	Q2	Q3	Q4	**Mean**	**Annual**
All Vessels	11.2	10.4	13.3	3.1	9.5	12.0
Mobile	15.7	10.5	13.0	3.0	10.6	18.6
Longline	0.1	0.0	19.2	5.7	6.3	1.1
BHP						
All Vessels	22.9	14.9	6.7	7.1	10.4	13.0
Mobile	23.5	11.3	5.9	5.9	9.2	16.0
Longline	4.2	10.2	4.4	29.1	12.0	12.1
GT						
All Vessels	13.8	13.6	17.1	5.6	10.0	17.8
Mobile	20.7	12.5	16.9	2.3	13.1	25.5
Longline	0.7	7.6	12.2	24.7	11.3	5.3

Table 5.56
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
1984 and 1985, 5Z Cod

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	0.3	4.1	17.4	18.5	10.1	13.9
Mobile	-	0.1	10.3	8.2	4.7	8.1
Longline	0.3	0.3	0.4	0.4	0.4	1.4
BHP						
All Vessels	4.4	9.1	27.1	26.7	14.8	22.6
Mobile	-	0.7	17.7	15.4	6.0	14.1
Longline	4.4	1.8	0.6	8.7	3.9	5.1
GT						
All Vessels	2.8	6.7	20.2	18.5	9.6	16.9
Mobile	-	0.5	11.9	6.2	2.2	9.9
Longline	2.8	6.5	2.9	4.5	4.2	10.5

Table 5.57
1984 and 1985, 4VW Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	8.4	1.5	63.7	1.4	18.8	17.5
Mobile	0.2	0.9	72.4	-	18.4	2.2
Longline	39.3	32.9	32.2	5.9	27.6	24.4
BHP						
All Vessels	13.8	41.8	64.7	0.4	30.2	36.9
Mobile	0.3	26.8	92.4	-	29.9	12.1
Longline	9.3	32.6	6.6	1.9	12.6	15.3
GT						
All Vessels	4.3	3.2	74.9	2.2	21.2	16.1
Mobile	0.1	0.7	84.7	-	21.4	1.6
Longline	22.3	32.3	36.0	3.5	23.5	17.1

Table 5.58
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
1984 and 1985, 5X+5Y Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	15.2	6.1	0.3	1.2	5.9	10.7
Mobile	17.4	5.6	0.2	4.3	6.9	11.3
Longline	1.8	22.2	5.1	0.4	7.4	4.9
BHP						
All Vessels	23.6	20.6	3.6	4.6	13.1	20.0
Mobile	32.9	20.0	2.5	6.7	15.5	28.8
Longline	2.2	10.1	20.4	18.2	12.7	4.6
GT						
All Vessels	13.2	12.6	0.9	5.1	8.0	12.8
Mobile	17.7	11.4	0.5	3.2	8.2	16.9
Longline	0.5	5.0	8.4	9.4	5.8	3.6

Table 5.59
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
1984 and 1985, 5Z Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	37.1	17.6	1.6	6.1	15.6	1.3
Mobile	-	16.4	3.9	4.2	6.1	0.5
Longline	37.1	8.8	3.6	34.5	21.0	2.5
BHP						
All Vessels	50.4	6.6	1.2	18.3	19.1	4.7
Mobile	-	2.1	0.8	13.9	4.2	1.9
Longline	50.4	4.9	1.0	28.1	21.1	1.1
GT						
All Vessels	31.1	11.9	0.6	14.6	14.6	2.3
Mobile	-	11.1	2.3	10.4	6.0	1.2
Longline	31.1	21.6	0.1	27.9	20.2	0.6

Table 5.60
1984 and 1985, 4VWX+5 Pollock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	4.2	14.9	56.1	5.3	7.5	17.5
Mobile	4.2	14.9	29.4	5.4	13.5	17.8
Longline	-	-	20.7	-	5.2	-
BHP						
All Vessels	7.8	17.5	64.0	13.8	25.8	25.2
Mobile	7.8	17.5	26.1	6.7	14.5	24.9
Longline	-	-	6.5	-	1.6	-
GT						
All Vessels	4.7	15.0	54.6	3.1	19.4	20.2
Mobile	4.7	15.0	25.9	3.2	12.2	19.9
Longline	-	-	0.0	-	0.0	-

Table 5.61
1984 and 1985, 4X Cod+Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	9.0	11.3	15.6	10.0	11.5	26.7
Mobile	11.9	13.0	15.6	10.0	12.6	29.0
Longline	8.5	31.3	-	-	10.0	23.6
BHP						
All Vessels	3.8	4.0	21.1	4.1	8.3	23.8
Mobile	7.2	5.4	21.1	4.1	9.5	26.7
Longline	1.6	34.4	-	-	9.0	17.6
GT						
All Vessels	5.4	8.0	22.4	14.0	12.5	28.4
Mobile	12.8	8.9	22.4	14.0	14.5	30.9
Longline	25.2	22.4	-	-	11.9	30.3

Table 5.62

Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets

4Vn Cod, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	27.0	14.0	68.0	0.8	27.5	59.1
Mobile	17.7	12.2	75.7	0.8	26.6	50.0
Longline	-	11.0	18.8	-	14.9	0.4
BHP						
All Vessels	26.4	37.0	83.5	2.8	38.4	54.5
Mobile	19.3	3.2	83.6	2.8	27.4	35.4
Longline	-	39.3	12.7	-	26.0	42.0
GT						
All Vessels	28.2	30.1	80.9	4.4	35.9	72.8
Mobile	22.6	12.0	85.0	4.4	31.0	68.2
Longline	-	14.1	3.7	-	8.9	24.1

Table 5.63

4VSW Cod, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	19.0	41.9	35.1	21.9	29.5	28.2
Mobile	42.7	15.8	29.5	15.9	26.0	13.0
Longline	36.1	28.2	47.6	2.9	28.7	25.2
BHP						
All Vessels	19.2	37.9	37.5	29.6	31.1	30.2
Mobile	47.1	8.9	33.4	9.7	24.8	4.0
Longline	29.8	34.6	47.9	0.8	28.3	33.1
GT						
All Vessels	22.9	42.6	43.6	25.2	33.6	36.2
Mobile	54.0	14.0	67.0	17.3	38.1	13.4
Longline	33.5	25.4	46.5	6.7	28.0	26.1

Table 5.64

4X Cod, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	13.6	0.1	17.2	7.0	9.5	13.0
Mobile	22.2	18.8	16.4	2.6	15.0	30.3
Longline	0.6	0.3	0.7	2.5	1.0	0.3
BHP						
All Vessels	26.2	0.2	10.0	20.2	14.2	8.7
Mobile	28.9	42.9	8.1	15.1	23.8	17.4
Longline	1.4	19.9	11.4	20.3	13.3	6.1
GT						
All Vessels	14.8	3.0	23.2	12.4	13.4	21.3
Mobile	23.9	51.0	21.6	9.8	26.6	43.6
Longline	0.5	6.9	3.0	-	3.5	1.7

Table 5.65
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
5Z Cod, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	4.4	5.0	5.0	2.0	3.7	2.7
Mobile	-	72.3	6.0	-	39.2	4.0
Longline	4.4	0.4	3.9	2.0	2.7	1.7
BHP						
All Vessels	14.0	1.7	1.6	4.5	5.5	3.3
Mobile	-	15.0	27.1	-	14.0	1.8
Longline	14.0	1.7	0.2	4.5	5.1	4.0
GT						
All Vessels	13.0	6.9	1.9	11.7	8.4	7.3
Mobile	-	48.2	14.1	-	31.2	0.7
Longline	13.0	5.4	1.7	11.7	8.0	7.7

Table 5.66
4VW Haddock, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	25.9	12.5	16.4	10.0	16.2	30.0
Mobile	1.0	4.5	82.5*	6.1	23.5	18.7
Longline	48.9	-	55.5*	48.1*	50.8	49.5
BHP						
All Vessels	31.4	42.2	23.2	7.5	26.1	46.9
Mobile	24.4	30.9	-	2.4	19.2	37.2
Longline	10.1	-	19.0	87.1*	38.7	38.2
GT						
All Vessels	7.4	17.7	1.8	3.4	7.6	32.3
Mobile	5.3	9.1	-	0.5	5.0	24.5
Longline	22.2	-	89.7*	16.7	42.9	67.4

* Few observations.

Table 5.67
4X Haddock 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	25.8	5.8	2.4	8.7	10.7	12.3
Mobile	40.6	4.0	3.0	8.5	14.0	16.0
Longline	1.7	4.0	1.4	2.4	2.4	4.9
BHP						
All Vessels	29.3	23.4	1.5	20.2	18.6	14.4
Mobile	48.6	19.6	0.6	21.0	22.5	35.2
Longline	0.8	13.8	27.6	7.6	12.5	1.8
GT						
All Vessels	20.7	11.5	0.2	9.1	10.4	13.1
Mobile	37.3	8.7	0.5	11.2	14.4	19.1
Longline	0.8	0.6	21.9	0.3	5.9	3.2

Table 5.68
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
5Z Haddock, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	-	3.7	2.2	-	3.0	2.9
Mobile	-	16.1	5.8	-	11.0	5.5
Longline	-	24.9	7.2	-	16.1	23.2
BHP						
All Vessels	-	0.3	13.2	-	6.8	25.5
Mobile	-	0.1	9.3	-	4.7	34.6
Longline	-	11.1	5.1	-	8.1	-
GT						
All Vessels	-	0.1	3.2	-	1.6	17.6
Mobile	-	5.5	3.2	-	4.3	17.4
Longline	-	19.7	1.8	-	10.8	-

Table 5.69
4VWX+5 Pollock, 1984

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	9.5	10.5	16.7	5.0	10.4	15.8
Mobile	9.5	10.5	14.7	5.0	10.4	15.8
Longline	-	-	-	-	-	-
BHP						
All Vessels	12.4	13.6	26.7	9.2	15.5	15.8
Mobile	12.4	13.6	24.6	9.2	15.5	15.8
Longline	-	-	-	-	-	-
GT						
All Vessels	6.3	10.4	21.8	6.6	11.3	27.4
Mobile	6.3	10.4	20.1	6.6	11.3	27.4
Longline	-	-	-	-	-	-

Table 5.70
4X+5Y Cod/Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	11.5	13.6	14.2	10.0	12.3	20.0
Mobile	15.7	17.6	14.2	27.0	18.6	21.6
Longline	47.8	1.4	-	-	-	23.5
BHP						
All Vessels	1.9	16.8	22.0	6.9	11.9	23.2
Mobile	3.3	5.7	22.0	22.7	13.4	25.2
Longline	40.2	0.4	-	-	20.3	21.7
GT						
All Vessels	5.6	15.4	18.1	6.4	11.4	23.6
Mobile	9.1	17.9	18.1	24.5	17.4	25.1
Longline	35.6	2.8	-	-	19.2	15.4

Table 5.71
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
4Vn Cod, 1985

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	0.8	12.1	58.6	44.0	28.9	38.0
Mobile	0.8	24.1	21.8	27.7	18.6	21.8
Longline	-	11.9	23.7	43.6	26.4	8.9
BHP						
All Vessels	2.8	41.9	61.5	57.9	41.0	57.1
Mobile	2.8	58.0	28.2	41.3	32.6	42.8
Longline	-	67.7	4.8	34.3	35.6	17.2
GT						
All Vessels	4.4	18.5	45.4	63.1	32.9	42.9
Mobile	4.4	12.5	26.1	51.0	23.5	27.3
Longline	-	68.0	34.5	57.5	53.3	46.1

Table 5.72
4VsW Cod, 1985

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	21.9	17.1	22.8	21.8	20.9	17.1
Mobile	15.9	3.6	10.9	4.2	8.7	3.5
Longline	2.9	11.9	32.9	26.3	18.5	10.9
BHP						
All Vessels	29.6	44.3	33.9	51.8	39.9	48.8
Mobile	9.7	25.1	25.7	55.8	29.1	30.2
Longline	0.8	14.5	36.6	46.8	24.7	16.5
GT						
All Vessels	25.2	19.0	28.8	27.6	25.2	18.6
Mobile	17.3	5.1	25.3	17.0	16.2	4.2
Longline	6.7	10.8	35.0	25.2	19.4	14.4

Table 5.73
4X+5Y Cod, 1985

	Q1	Q2	Q3	Q4	mean	Annual
LOA						
All Vessels	7.0	16.0	18.8	19.4	15.3	12.5
Mobile	5.9	12.0	18.2	25.9	15.5	13.2
Longline	2.5	0.6	-	2.4	1.8	4.9
BHP						
All Vessels	20.2	26.3	9.6	21.8	19.5	24.5
Mobile	15.2	21.0	7.7	17.5	15.4	16.0
Longline	20.3	14.4	-	34.8	23.2	22.5
GT						
All Vessels	12.4	16.2	19.4	25.6	18.4	17.1
Mobile	9.8	11.9	18.2	21.9	15.5	9.6
Longline	14.5	34.6	-	22.2	23.8	22.7

Table 5.74
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
5Z Cod, 1985

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	-	3.4	21.3	21.0	15.2	15.4
Mobile	-	0.4	11.4	4.7	5.5	8.3
Longline	-	0.8	6.4	4.7	4.0	2.3
BHP						
All Vessels	-	7.2	31.6	25.8	21.5	24.5
Mobile	-	1.4	19.2	9.2	9.9	16.0
Longline	-	3.5	6.6	27.2	12.4	22.5
GT						
All Vessels	-	3.0	17.8	17.9	12.9	17.1
Mobile	-	1.1	12.3	2.3	5.2	9.6
Longline	-	12.1	7.1	11.2	10.1	22.7

Table 5.75
4VW Cod, 1985

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	10.0	6.0	73.8	4.6	23.6	13.0
Mobile	6.1	5.2	-	-	3.8	0.7
Longline	48.1*	-	15.6	7.2	23.6	10.9
BHP						
All Vessels	7.5	28.8	80.5	2.0	29.7	38.0
Mobile	2.4	26.7	-	-	14.6	12.4
Longline	87.1*	-	2.0	0.9	30.0	8.8
GT						
All Vessels	3.4	1.5	83.9	3.0	23.0	10.8
Mobile	0.5	2.5	-	-	1.5	0.6
Longline	98.1*	-	37.3	3.0	46.1	9.5

Table 5.76
5X+5Y Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	8.7	8.8	36.1	11.6	16.3	11.0
Mobile	8.5	7.2	36.6	20.6	18.2	8.9
Longline	2.4	23.4	3.7	8.5	9.5	4.5
BHP						
All Vessels	20.8	19.4	52.7	18.9	28.0	22.5
Mobile	21.0	17.2	53.2	4.8	24.1	21.2
Longline	7.6	3.9	-	50.1	20.5	13.0
GT						
All Vessels	9.1	14.7	58.7	19.3	25.5	13.6
Mobile	11.2	12.8	61.9	18.3	26.1	13.1
Longline	0.3	40.2	-	41.1	27.2	4.2

Table 5.77
Mean R^2 Values for 100%, 90% and 80% Fleet Data Subsets
5Z Haddock, 1985

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	-	75.4	2.2	5.6	27.7	2.1
Mobile	-	50.7*	3.6	4.2	19.5	0.4
Longline	-	26.2*	-	34.4	30.3	25.2
BHP						
All Vessels	-	70.3	0.8	9.8	27.0	4.1
Mobile	-	48.0*	0.9	9.2	19.4	1.4
Longline	-	35.3*	-	-	17.7	20.6
GT						
All Vessels	-	74.4	1.7	9.0	28.4	3.3
Mobile	-	52.6	2.3	10.4	21.8	1.3
Longline	-	67.7	-	0.2	34.0	25.8

Table 5.78
4VWX+5 Pollock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	5.0	13.9	27.4	35.6	20.5	20.1
Mobile	5.0	13.9	27.4	35.6	20.5	20.1
Longline	-	-	-	-	-	-
BHP						
All Vessels	9.2	13.4	20.4	13.3	14.1	27.4
Mobile	9.2	13.4	20.4	13.3	14.1	27.4
Longline	-	-	-	-	-	-
GT						
All Vessels	6.5	19.3	24.7	19.3	17.5	23.2
Mobile	6.5	19.3	24.7	19.3	17.5	23.2
Longline	-	-	-	-	-	-

Table 5.79
4X and 5Y Cod/Haddock

	Q1	Q2	Q3	Q4	Mean	Annual
LOA						
All Vessels	10.0	12.4	25.8	35.6	21.0	36.4
Mobile	27.0	13.2	25.8	35.6	25.4	39.1
Longline	-	21.0	-	-	21.0	39.9
BHP						
All Vessels	6.9	5.1	22.1	13.3	11.9	23.8
Mobile	22.7	7.0	22.1	13.3	16.3	27.2
Longline	-	18.4	-	-	18.4	42.3
GT						
All Vessels	6.4	6.0	29.8	19.3	15.4	36.0
Mobile	24.5	7.3	29.8	19.3	20.2	38.6
Longline	-	27.8	-	-	27.8	24.6

R^2 Values for

	4VW Haddock		4VWX+5 Pollock	
	Mean of 1st, 2nd and 4th Quarter	3rd Quarter	Mean of 1st, 2nd and 4th Quarter	3rd Quarter
LOA				
All	3.8	63.7	8.1	56.1
Mobile	0.6	72.4	8.2	29.4
Longline	26.0	32.2	5.2	20.7
BHP				
All	18.7	64.7	13.0	64.0
Mobile	13.6	92.4	10.7	26.1
Longline	14.6	6.6	1.6	6.5
GT				
All	3.2	74.9	7.6	54.6
Mobile	0.4	84.7	7.6	25.9
Longline	19.4	36.0	0.0	0.0

5.6 Discussion

Figures 5.4 - 5.12 clearly show the large variation in CPUE that occurs for vessels of similar dimensions measured either as LOA, GT, or BHP. These large variations will cause low R^2 values in the regressions that will not be reduced by transformation of the dependant variables. This is confirmed by examination of plots of the residuals (Figures 5.13 - 5.21). In the case of CPUE versus LOA, for both gears combined, and for the mobile gear, (Figures 5.13 and 5.14), there is some indication of an increase in the residuals with increasing LOA but it is not especially marked. In the case of the longline fleet there is an indication of the reverse effect. In neither case are the trends of the residuals marked. In the case of CPUE versus GT, the residuals appear reasonably well distributed for all gear catagories. When CPUE is regressed on BHP, as for GT, no marked trend is apparent in the distribution of the residuals.

These results indicate that a linear first-order regression model, particularly in the case of GT and BHP, will perform as well (or as poorly) as a nonlinear or higher-order model in describing CPUE as a function of vessel dimensions.

5.7 Allocation Based on CPUE

In developing future policies, allocations based on a CPUE-vessel dimension function may be considered. If so, it is relevant to know what the consequences of such a policy might be. Vessels that had had a high CPUE would be penalized if their future "rights" were based on an overall fleet model while those vessels that had previously performed poorly would benefit.

Regression analyses of CPUE and vessel LOA and GT were done for the whole fleet, mobile gear and longliners. In each analysis the maximum penalty and benefit, median penalty and benefit and mean penalty and benefit were determined and the fraction of fishermen who would be

FIGURE 5.13
RESIDUALS FROM REGRESSION OF CPUE v LOA
BOTH GEARS, 1984 & 1985

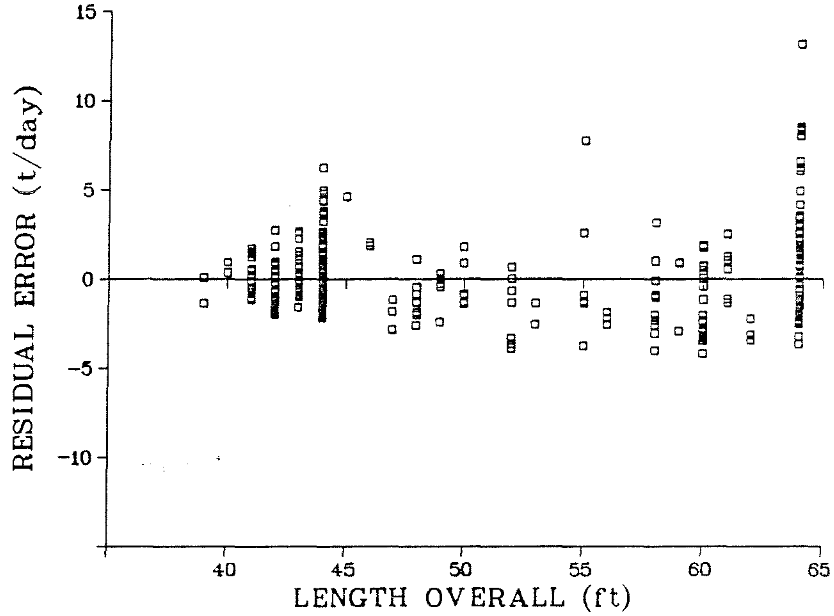


FIGURE 5.14
RESIDUALS FROM REGRESSION OR CPUE v LOA
MOBILE GEAR, 1984 + 1985

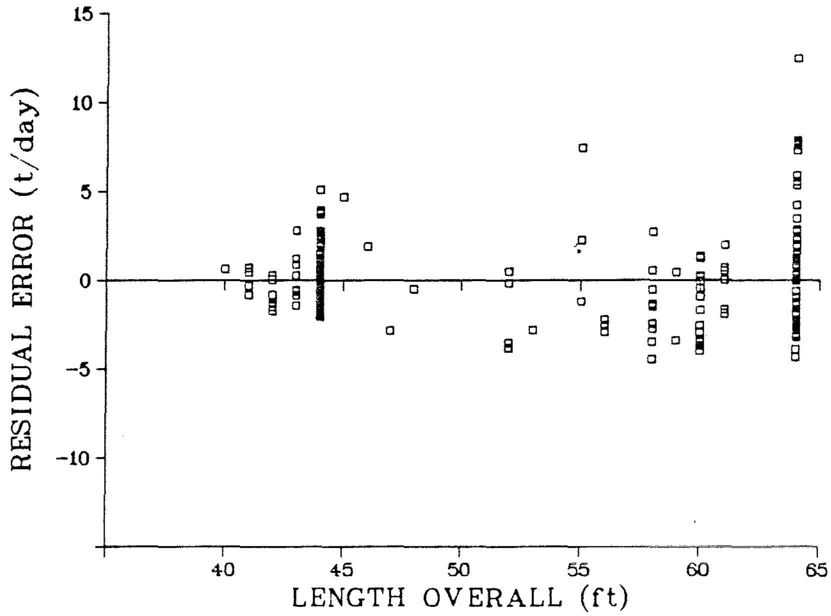


FIGURE 5.15
RESIDUALS FROM REGRESSION CPUE v LOA
LONGLINE GEAR, 1984 + 1985

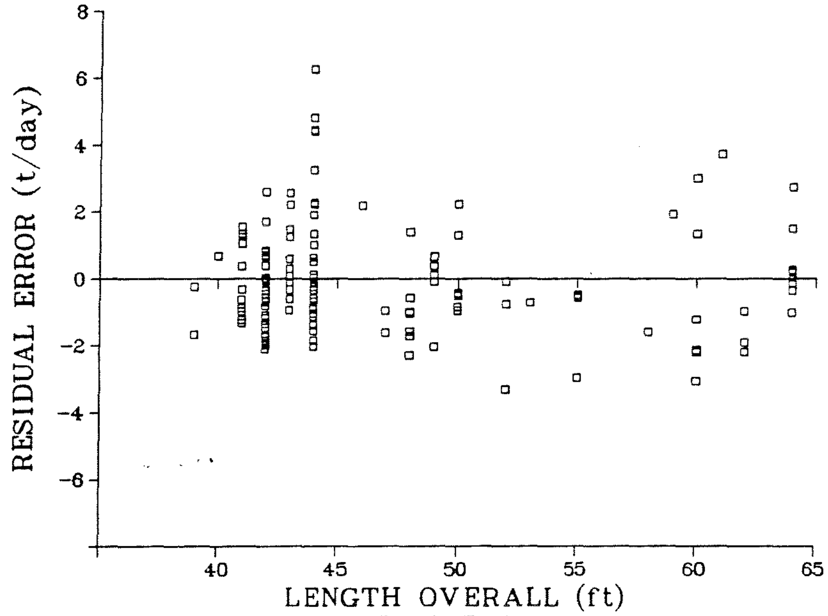


FIGURE 5.16
RESIDUALS FROM REGRESSION CPUE v GT
BOTH GEARS, 1984 + 1985

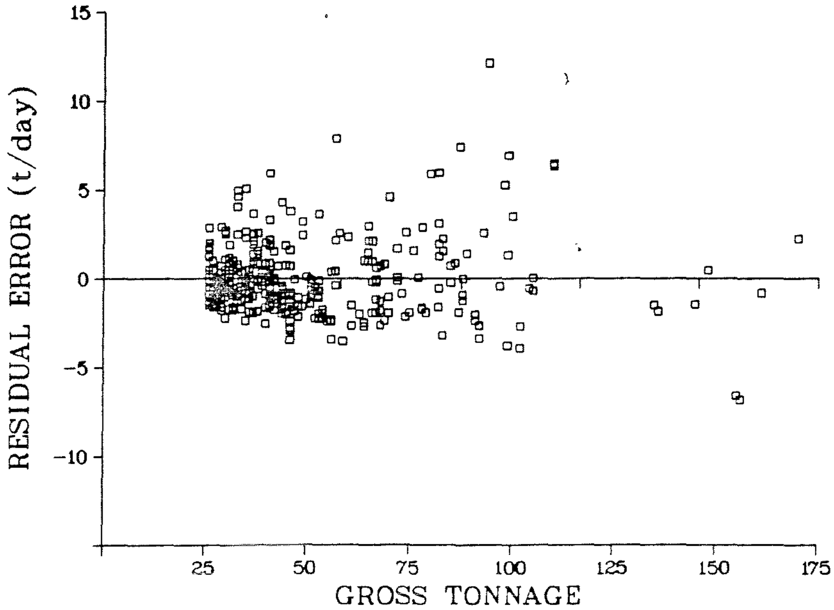


FIGURE 5.17
RESIDUALS FROM REGRESSION OF CPUE v GRT
MOBILE GEAR, 1984 +1985

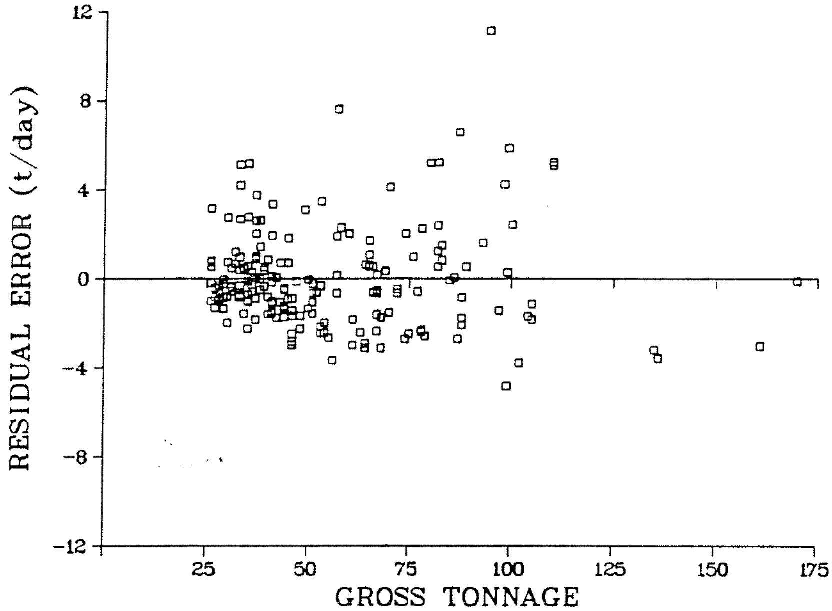


FIGURE 5.18
RESIDUALS FROM REGRESSION OF CPUE v GRT
LONGLINE GEAR, 1984 + 1985

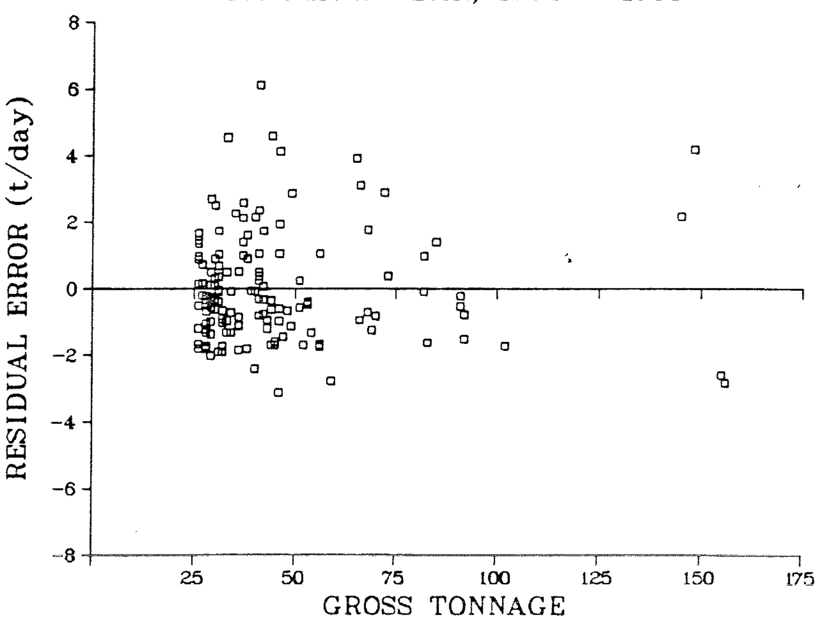


FIGURE 5.19
RESIDUALS FROM REGRESSION OF CPUE v BHP
BOTH GEARS, 1984 & 1985

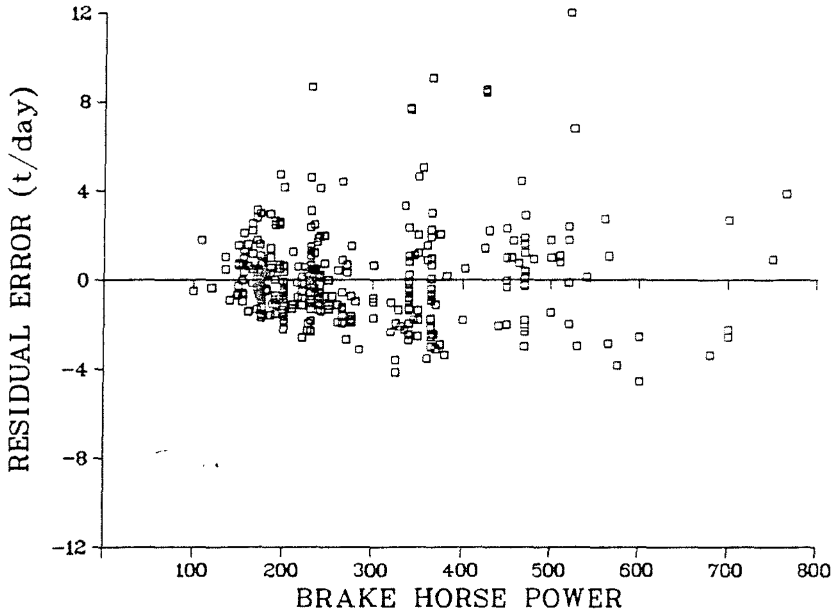


FIGURE 5.20
RESIDUALS FROM REGRESSION OF CPUE v BHP
MOBILE GEAR, 1984 +1985

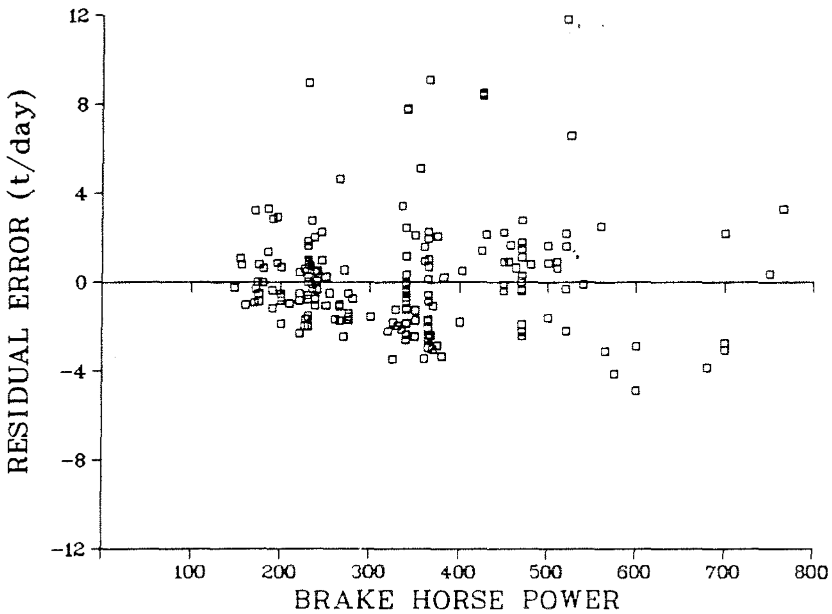
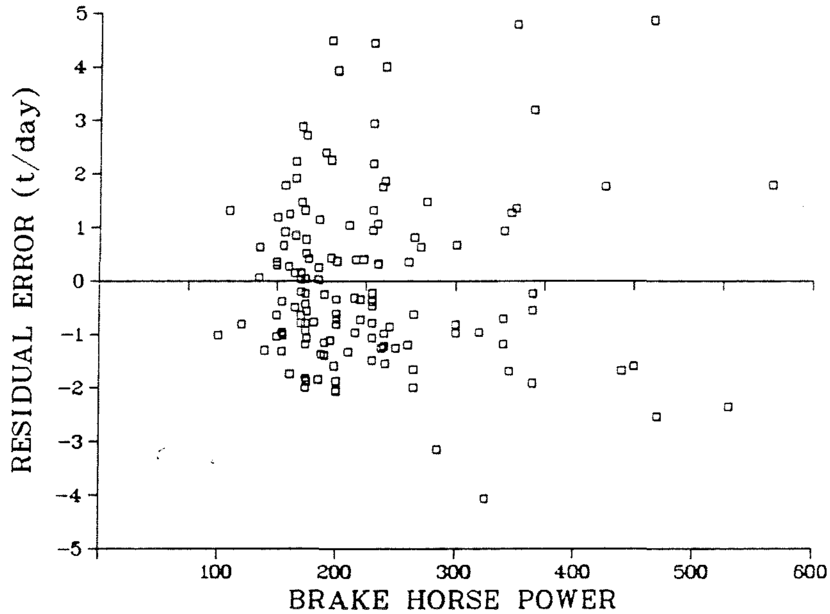


FIGURE 5.21
RESIDUALS FROM REGRESSION OF CPUE v BHP
LONGLINE GEAR, 1984 + 1985



penalized or benefited.

The results of these analyses are listed in table 5.80. It is apparent that the CPUE-GT function slightly reduces the maximum penalty in terms of CPUE that would be incurred relative to that resulting from a CPUE-LOA function. Although the results are not consistent in all data sets, use of GT rather than LOA as the predictor variable results in slightly smaller median and mean penalties and benefits. In all cases the ratio of penalized to benefitted operators is about 2:3.

Although the vessel performance differences from the CPUE-LOA function are greater than those given by the CPUE-GT function, the differences are sufficiently small that if there were administrative conveniences in using a CPUE-LOA function, that would probably be sufficient to warrant its use in preference to a CPUE-GT function.

Table 5.80
'Penalties' and 'Benefits' from Use of a Vessel
Dimension Function for Allocation of "Rights" Quotas

CPUE - LOA

	All vessels	Mobile gear	Longliners
Maximum 'penalty'' (t/day)	12.9	12.3	6.2
Maximum 'benefit' (t/day)	4.4	4.5	3.2
Mean penalty/benefit (t/day)	0.82	1.8	1.3
Median 'penalty'	1.13	1.12	1.29
Median 'benefit'	1.25	1.26	0.90
% Penalized	43.8%	44.9%	39.2%

CPUE - GT

	All vessels	Mobile gear	Longliners
Maximum 'penalty' (t/day)	11.5	10.7	6.1
Maximum 'benefit' (t/day)	4.6	5.3	3.1
Mean penalty/benefit (t/day)	1.5	0.81	0.62
Median 'penalty'	1.15	1.09	1.05
Median 'benefit'	1.13	1.11	0.96
% Penalized	43.2%	42.7%	40.0%

6. Fishing Power as a Function of Gross Tonnage and Brake Horsepower

6.1 Introduction

One assumption in the multiple regressions described in the previous section is that the effects of vessel dimensions (LOA, GT, BHP) are additive and can be varied independently, i.e., for vessels of the same length, the effect of GT or BHP can be examined separately. An alternate and empirical approach is to first combine the vessel dimensions and examine the relation of the result with the vessel's fishing power. This approach has been taken in the Northern Australian Prawn fishery where the fishing power of a vessel is taken as the sum of the maximum rated power of the vessel's engine and a measure of the vessel's gross tonnage.

In this section the CPUE and catch of the study fleet have been examined as a function of the sum, and the product, of a vessel's GT and its BHP.

6.2 Methods

Vessel CPUE is estimated as:-

$$CPUE_i = \frac{{}_{84}C_i + {}_{85}C_i}{{}_{84}E_i + {}_{85}E_i}$$

where: C_i = catch of cod, haddock and pollock of the i^{th} vessel in 1984 and 1985,
E_i = number of days spent fishing by i^{th} vessel in 1984 or 1985 respectively.

Vessel catch is estimated by,

$$C_i = \frac{{}_{84}C_i + {}_{85}C_i}{2}$$

The linear regressions evaluated are:

CPUE = a + b (LOA)
CPUE = a + b (LOA + BHP)
CUPE = a + b (GT)
CUPE = a + b (GT + BHP)

Similar analyses were done using catch as the dependent variable, and with regressions on the product of the vessel dimensions, i.e.,

CPUE = a + b (LOA x BHP),

Catch = a + b (GT x BHP).

6.3 **Results**

Tables 6.1 and 6.2 list the results from the regression analyses. Figures 6.1 - 6.6 show plots of CPUE on vessel dimensions for the corresponding analyses.

With LOA summed with BHP as the independent variable, in both the regression for CPUE and for catch, there is an increase in the R^2 values for all gear catalogues compared with that solely for the regression on LOA. When GT is summed with BHP, regression with CPUE shows a slight increase in R^2 for the "Both gear" and Longline categories, and a slight decrease for the Mobile Gear category. In the case of mean annual catch, regressing on GT + BHP results in a slight decrease in the R^2 for "both gears", and a substantial decrease in the case of the Mobile gear. Despite this, GT + BHP still remains a relatively good predictor of mobile-gear vessel catch.

Tables 6.3 and 6.4 list the regression results when the independent variable is product form. With CPUE as the dependent variable, in the case of GT x LOA, a considerable increase in R^2 is apparent for the Mobile gear group, from 29.5% for the sum to 43.7% for the product. The results for GT x BHP are comparable whether a sum or product form is used as the independent variable. With catch as the dependent variable, no major differences were obtained for either the LOA or GT form, or when the sum or product form was used as the independent variable.

6.4 **Discussion**

A fishing power measure that depends on the sum (or product) of a number of vessel dimensions is attractive from the point of view of controlling fleet capacity. When only one vessel dimension is controlled, e.g., LOA, other dimensions, e.g. GT and/or BHP can be increased without limitation; when the regulated measure consists of several factors, any increase in one vessel dimension, e.g. in GT, must be compensated by a reduction in BHP. Obviously there will be severe selection against building large vessels with low-power engines or small vessels with powerful engines.

In the Australian Northern Prawn fishery management plan, the fleet capacity was fixed at a specified number of units, where a "unit" is a measure of fishing capacity. The fishing power (in units) of a vessel is the sum of the "under-deck volume" and the engine power.

The under-deck volume (UDV) is given by:-

$$UDV = \frac{L \times B \times D \times 0.6}{2.83}$$

where, L = length (m),
B = maximum breadth (m),
D = moulded depth amidships (m).

This will give a measure that is approximatly 25% larger than the approximate tonnage under-deck measure given in 6.4 of Appendix 1.

Table 6.1
CPUE Vessel Dimension/Regression Statistics for GT and LOA

	LOA			LOA 7 bhp		
	a	b	R^2	a	b	R^2
Both Gears (n = 315)	-3.470	0.145	23.5	-0.005	0.011	28.9
Mobile Gear (n = 185)	-5.052	0.178	29.0	-0.699	0.013	29.5
Longliners (n = 130)	1.072	0.044	3.4	0.992	0.008	12.3

	GT			GT and BHP		
	a	b	R^2	a	b	R^2
Both Gears	0.175	0.074	35.6	0.174	0.011	31.1
Mobile Gear	-0.547	0.091	44.8	0.524	0.0112	32.4
Longliners	1.934	0.028	8.2	1.223	0.007	12.8

Table 6.2
Catch - Vessel Dimension Regression Statistics for GT and BHP

	LOA			LOA & BHP		
	a	b	R^2	a	b	R^2
Both Gears (n = 315)	-250.39	7.443	21.4	-92.54	0.6362	32.1
Mobile Gear (n = 185)	-291.05	8.693	24.4	-99.62	0.6750	29.2
Longliners (n = 130)	21.60	0.923	0.8	10.29	0.2062	4.2

	GT			GT and BHP		
	a	b	R^2	a	b	R^2
Both Gears	-49.97	3.554	28.1	-78.10	0.5962	33.1
Mobile Gear	-64.39	4.298	35.4	-86.55	0.6402	31.2
Longliners	43.79	0.5025	1.4	18.33	0.1791	4.0

Table 6.3
CPUE - Vessel Dimension Regression Statistics
1984 & 1985

GT x LOA

	a	b	R^2
Both Gears	1.2475	0.00098	35.1
Mobile Gear	0.792	0.00118	43.7
Longliners	2.377	0.00035	6.8

GT x BHP

	a	b	R^2
Both Gears	1.231	0.00017	31.2
Mobile Gear	0.820	0.00019	32.8
Longliners	1.960	0.00011	10.0

Table 6.4
Catch - Vessel Dimension Regression Statistics
1984 & 1985

GT x LOA

	a	b	R^2
Both Gears	0.379	0.09442	28.1
Mobile Gear	-0.898	0.1112	34.3
Longliners	104.76	0.01210	

	a	b	R^2
Both Gears	-38.58	0.01871	33.2
Mobile Gear	-27.69	0.01923	30.7
Longliners	65.80	0.00608	4.0

FIGURE 6.1

CPUE v GT + BHP, 1984 & 1985, ALL VESSELS

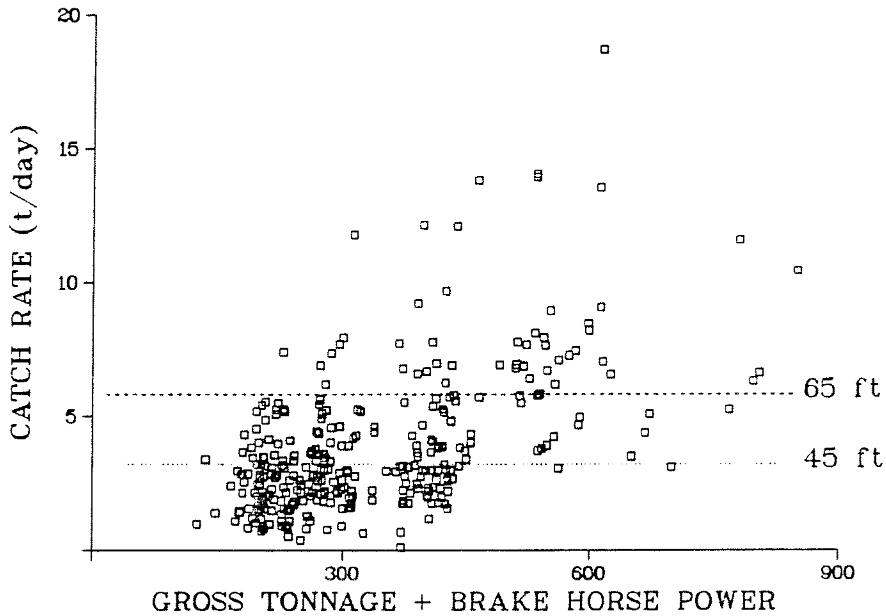


FIGURE 6.2

CPUE v GT + BHP, 1984 & 1985, MOBILE GEAR

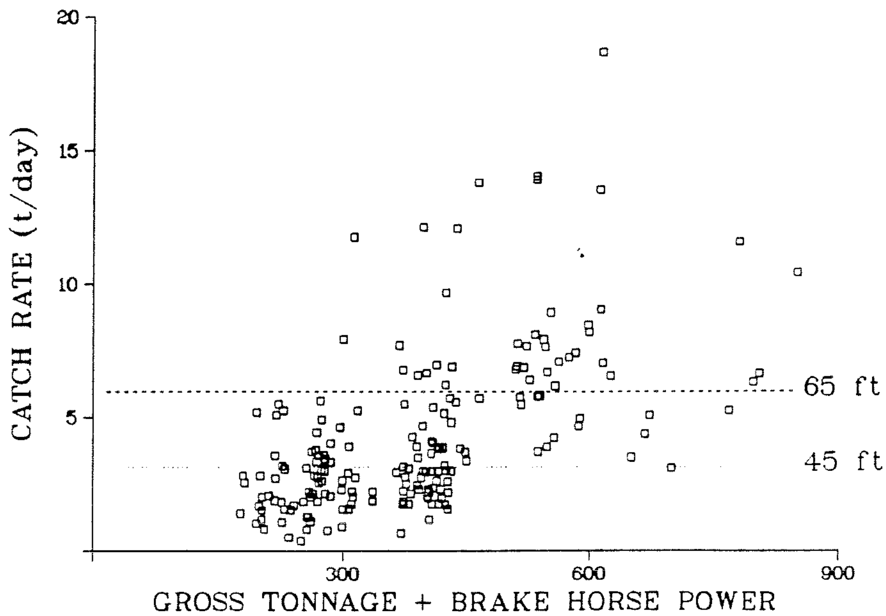


FIGURE 6.3

CPUE V GT + BHP, 1984 & 1985, LONGLINERS

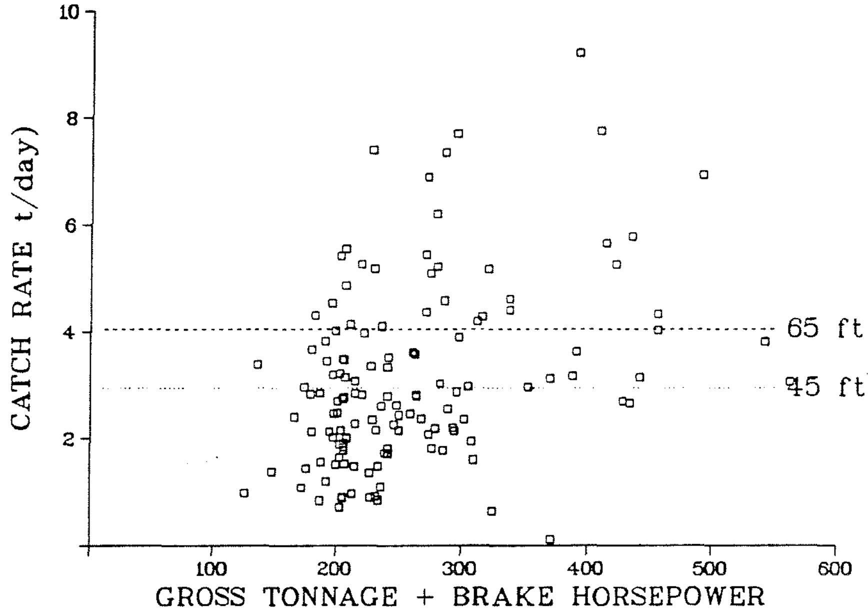


FIGURE 6.4

CATCH V GT + BHP, 1984 & 1985, ALL VESSELS

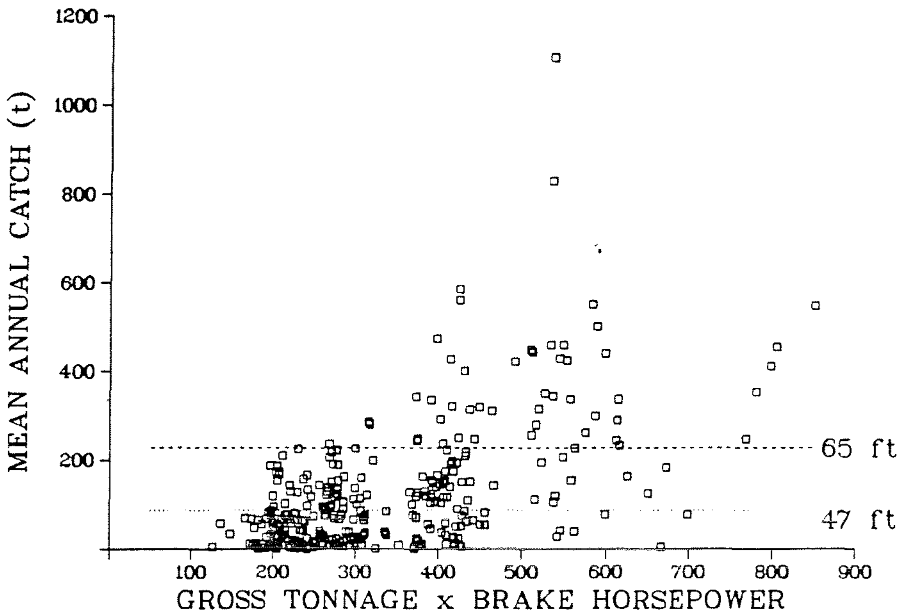


FIGURE 6.5

MEAN ANNUAL CATCH V GT x BHP, 1984 & 1985, MOBILE GEAR

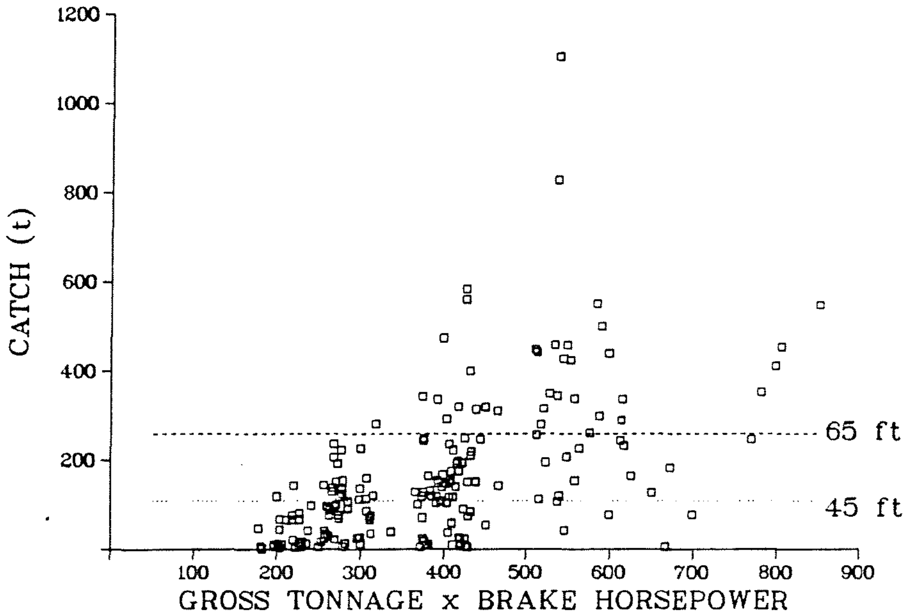
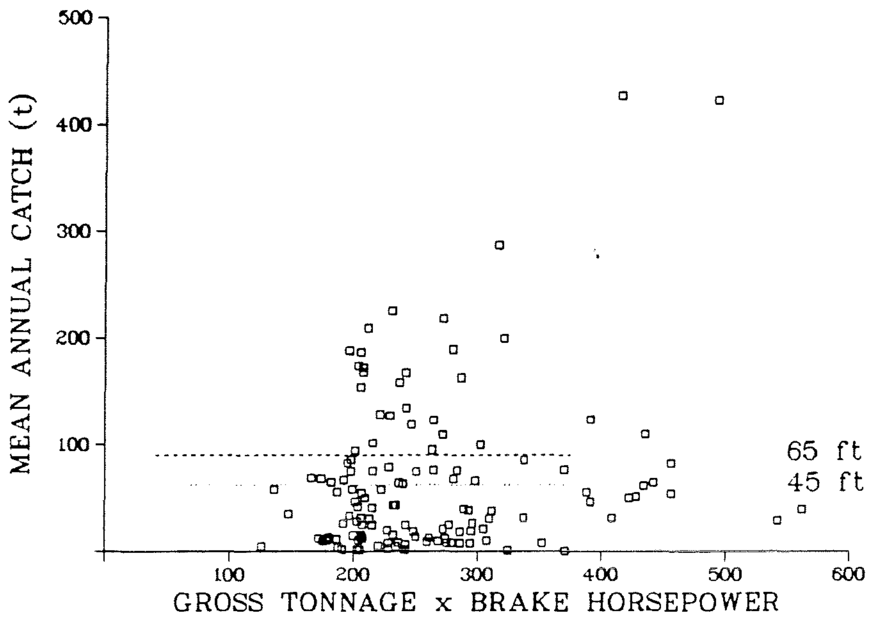


FIGURE 6.6

CATCH V GT X BHP, 1984 & 1985, LONGLINERS



The vessel engine power is the (maximum) continuous kilowatts brake power specified by the manufacturer, i.e., if an owner chooses to derate an engine's power, this does not affect the specified engine power. As one horse power = 0.75kW, by specifying the power in kW, the relative contribution of vessel power is reduced by 25%.

On a numerical basis, vessels have a larger engine power than their gross tonnage. Vessel GT is approximately 14% of vessel BHP in numerical terms (14.4% mobile gear, 18.0% longliners). Thus for a capacity unit defined as the sum of GT and BHP, a 10% reduction in BHP would enable a vessel of 288 BHP (fleet mean) to increase its GT from 48.6 to 77.4 GT, a 59% increase. Obviously, excessive trades between BHP and GT will be unfeasible as an large trade between these variables will compromise the fishing power of the replacement vessel. Figure 6.7 shows how vessel GT and BHP vary as a function of length overall.

An alternative to a fishing power measure determined by the sum of vessel dimensions is one based on a product, e.g., GT x BHP. In this case a fractional decrease of X in BHP would permit a fractional increase of 1/X in GT, e.g., a 10% decrease in BHP permits an 11% increase in GT (cf 59% under the summation formula); a 20% decrease in BHP, a 25% increase in GT. Thus, in the "sum" case, there would be more incentive to switch power units for tonnage, as a larger tonnage is possible for a given power reduction. Figure 6.8 shows how the product of GT and BHP varies as a function of length overall.

Table 5.1 shows that the CPUE relation is much steeper when a function of GT than of BHP (regression coefficients of 0.06245 cf 0.01234). Thus from a capacity point of view in the summation case, at least on a quid pro quo basis, operators should not be allowed to swap power units for those of GT. This is not a major problem as it can be resolved by scaling the power, e.g., measuring in kW rather than BHP will scale the power units down by 25%.

The large variation in engine power for vessels of the same size (Figure 6.9) indicates that some operators may choose to substitute power for tonnage, to the benefit of their fishing power. The corresponding plot showing the variation of GT as a function of length overall is shown in Figure 6.10.

FIGURE 6.7
SUM OF GT & BHP VERSUS LOA

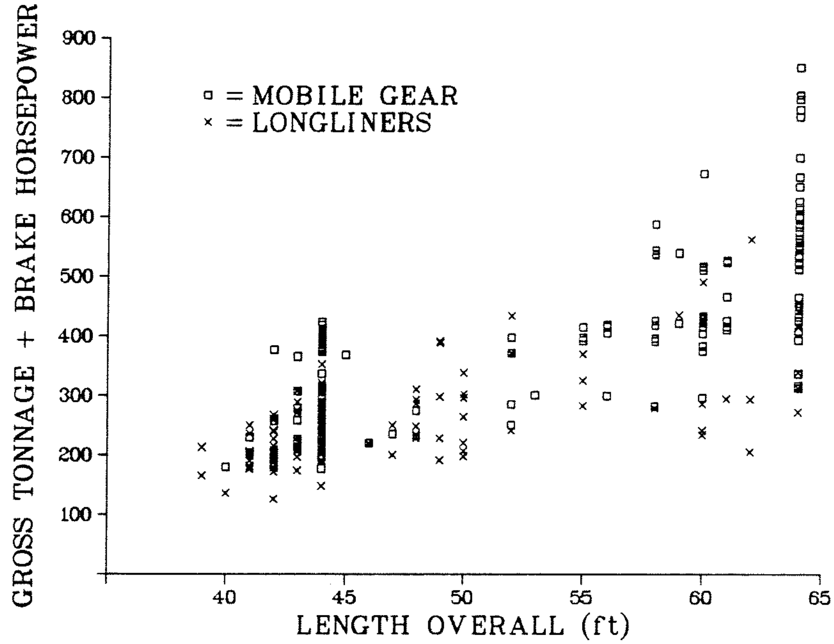


FIGURE 6.8
PRODUCT OF GT & BHP VERSUS LOA

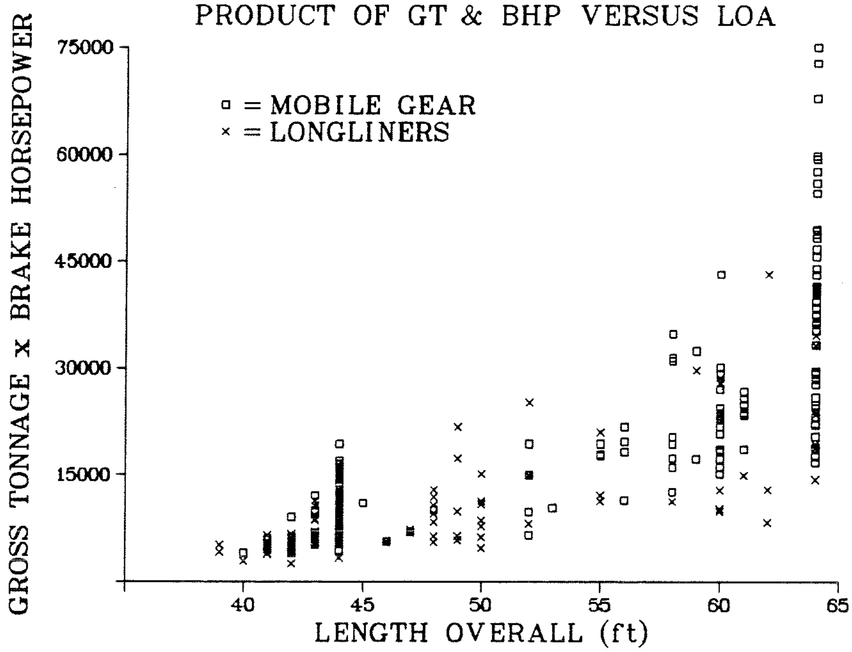


FIGURE 6.9

BRAKE HORSE POWER VERSUS LENGTH OVERALL

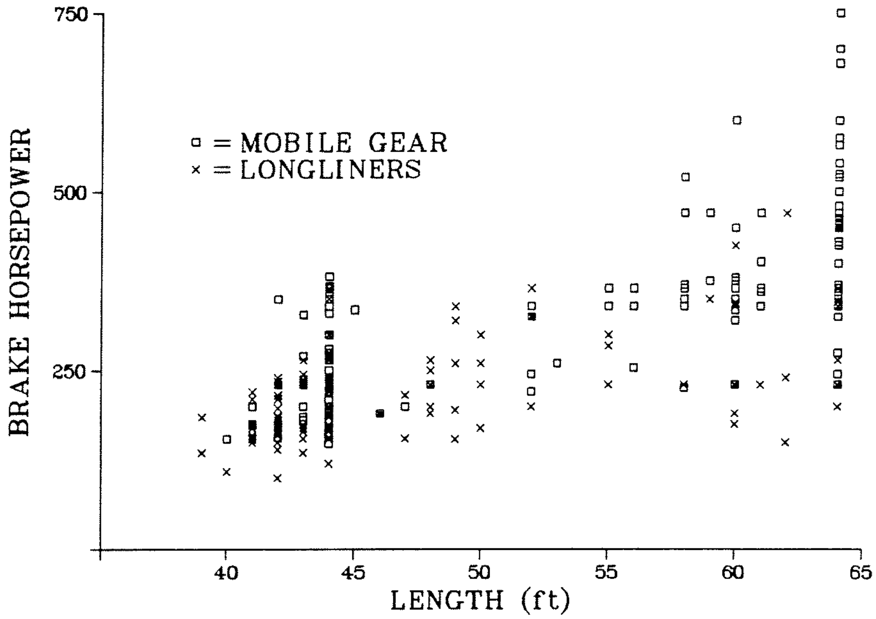
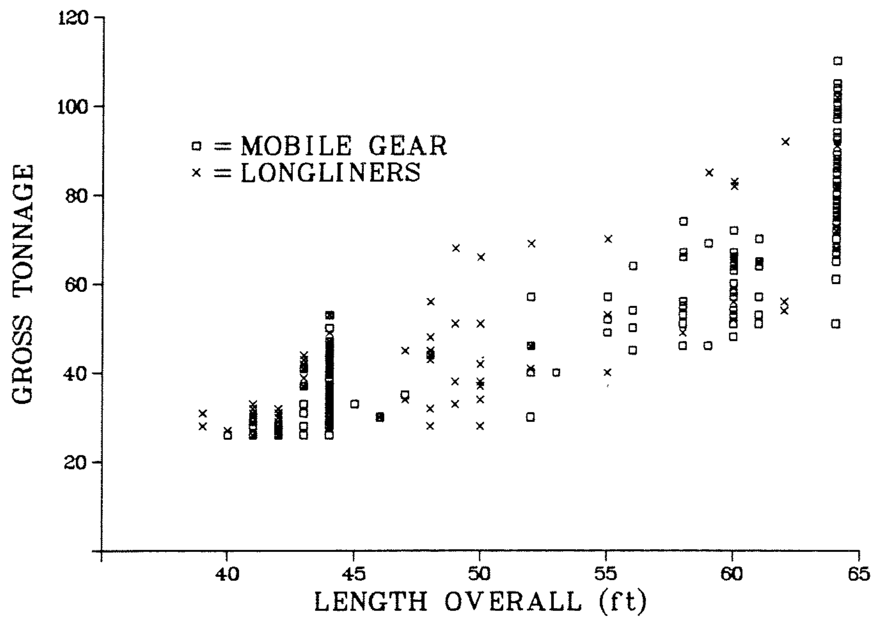


FIGURE 6.10

GROSS TONNAGE v LENGTH OVERALL



7. Changes in the Relative Performance of Vessels

7.1 Introduction

Implicit in the control of vessel dimensions to regulate CPUE is that the relative performance of vessels should not change significantly from one year to another, at least for vessels of different size, nor when the fleet switches from one stock to another. One way to investigate the affect of year or stock on the fishing power of vessels in a fleet is to rank their performance (i.e. their CPUE) and compare the ranks between years or stocks. If there is little annual or 'stock-affect' and little noise in the data, there should be a high degree of correlation between-years and/or between-stocks of the vessel fishing power ranks.

7.2 Relative Performance Between Stocks

7.2.1 Methods

Catch and effort were summed over 1984 and 1985 by stock, and CPUE estimated for each vessel by gear type. For each stock, those vessels were identified that exploited a particular stock and each of the other stocks. The ranksof the vessel's CPUE for each comparison of two stocks were determined and the Spearman rank correlation and Pearson product-moment correlation coefficient determined. At least three vessels in common must have exploited each pair of stocks compared. Data analyses were restricted to those cases where the number of vessels exploiting in common two stocks exceeded 40% of the number of vessels fishing each stock.

7.2.2 Results

Table 7.1 lists the results of these analyses. The Pearson correlation coefficients are not tabulated. With few exceptions they were slightly lower than the Spearman coefficient. In nearly all cases, the correlation coefficients were highly significant. Relatively high correlations were obtained between the ranks of vessels fishing the 4Vn Cod and 4VsW Cod (r_s=0.74), between 4VsW Cod and 4VW Haddock (r_s = 0.71) and 4VW Haddock and 4X+5Y Haddock (r_s = 0.68). Although the Spearman rank correlation coefficient cannot be strictly interpreted in the same manner as the Pearson correlation coefficient, they are highly correlated, and the square of r_s will give some indication of the variation in one rank that can be explained by the variation in the other. In this case, the most variation that can be explained by correlation between rankings is (for 4Vn and 4VSW Cod) 54.8%, or only about half!

In the largest data set, that between 4X Cod and 4X Haddock, where 87.4% of the vessels in the latter fishery also exploited the former, r_s = 0.40, i.e. only 16% of the variation could be explained by the two sets of vessel CPUE rankings.

7.2.3 Discussion

The rather low correlation coefficients given by the different data sets imply that large effects on vessel fishing power arise from fishing the different stocks, i.e., the relative (or apparent) fishing power between a set of vessels changes considerably when the vessels exploit different stocks.

Table 7.1
Spearmen Rank Correlation Coefficients Between Vessels
Fishing Different Stocks, Both Gear Types

Stock	Number of Vessels in Common	% of Vessels	r_s	P-Value
4Vn Cod				
4VSW Cod	31	67.4	0.74	0.01
4VsW Cod				
4X Cod	72	53.3	0.46	0.01
4VW Haddock	59	43.7	0.71	0.01
4VWX+5 Pollock	57	42.3	0.32	0.01
4X Cod				
5Z Cod	108	52.4	0.37	0.01
4X Haddock	180	83.4	0.40	0.01
4VWX+5 Pollock	105	51.0	0.45	0.01
4Xq+4Xr+5Y Cod	113	54.9	0.50	0.01
5Z Cod				
4VSW Cod	54	41.9	0.53	0.01
4X Cod	108	83.7	0.37	0.01
4X Haddock	121	93.8	0.45	0.01
4VWX+5 Pollock	89	69.0	0.41	0.01
4VW Haddock				
4X Cod	56	73.7	0.43	0.01
5X Cod	39	51.3	0.25	0.06
4X Haddock	66	86.8	0.68	0.01
4VWX+5 Pollock	50	65.8	0.26	0.04
4Xq+4Xr+5Y Cod+ Haddock	37	48.7	0.47	0.01
4X Haddock				
5Z Cod	121	52.4	0.45	0.01
4VWX+5 Pollock	127	55.0	0.48	0.01
4Xq+4Xr+5Y Cod+Haddock	123	53.2	0.54	0.01
5Z Haddock				
4VSW Cod	34	42.7	0.43	
4X Cod	64	78.0	0.07	0.28
5Z Cod	71	86.6	0.41	0.01
4X Haddock	79	96.3	0.37	0.01
4VWX+5 Pollock	60	73.2	0.22	0.04

7.3 Relative Performance of Vessels During 1984 and 1985

7.3.1 Methods

The CPUE of 'main species' for vessels in 1984 and 1985 was determined. The vessels were ranked by their CPUE. Their performance in 1984 and 1985 was compared by calculating the Spearmen rank correlation coefficient. Comparisons were done for all stocks combined, both gear types; for all stocks combined separately by gear type; by stock for both gear types, and by stock for the mobile and longline gear separately.

7.3.2 Results

Table 7.2 lists the correlation coefficients of vessel CPUE between 1984 and 1985 for the respective data comparisons. Taken across all stocks, the mobile gear showed a slightly better correlation between years, but even so, the 'variation explained by the correlation' was only 59.3%; the corresponding value for longline gear was 43.6%.

When the inter-annual comparison is considered on a stock basis, moderately large correlation coefficients occur for the 4Vn and 4Vs cod and the 4X haddock. No significant relation occurred for the 5Z cod, only a low value was obtained for the 4X cod. When considered on a gear basis; 'significant' correlations were obtained only for the 4Vs cod and 4VW haddock in the case of the mobile gear. All tests were significant in the case of the longline fleet. However, in all of these comparisons the maximum R^2 value was only 51.8%, in the case of both gears combined; 50.4% in the case of the mobile gear (best comparison, 4Vs cod) and 51.8% for the longliners (best comparison 4Vn cod).

7.3.3 Discussion

These results indicate that considerable variation occurred in the relative fishing power of the vessels in the study fleet between 1984 and 1985. For some gear stock combinations, there was no apparent correlation (ie. 4Vn cod, 4X+5Y cod and 5Z cod/mobile gear). It is of interest the different apparent behavior of the mobile and longline gear fleets in the relative inter-annual fishing power rankings.

8. Relative Fishing Power When Exploiting Different Stocks

8.1 Introduction

Estimates of the relative fishing power of vessels are needed for evaluating replacement policies, especially where licences of two or more vessels may be combined. The comparability of estimates of fishing power based on different dimensions are also of relevance. If the different dimensions perform relatively similarly, then either could be used for regulatory purposes. If they differ in their relative values or when they are exploiting different stocks, care must be taken to determine the consequences of using one dimension instead of another.

8.2 Methods

CPUE was regressed on the vessel dimensions of LOA, GT and BHP for the data subsets comprising each stock for all vessels, Mobile gear and Longliners. In the case of LOA to obtain a relative measure for illustrative purposes, the fishing power of a 65' vessel is expressed in terms of that for a 45 using the ratio:

Table 7.2
Spearmen Rank Correlation Coefficient of Vessel CPUE
Between 1984 and 1985

All Stocks	Correlation Coefficient	Number ofvessels compared	P-Value
All Gear	0.73	230	0.01
Mobile	0.77	146	0.01
Longline	0.66	84	0.01
All Gear			
4Vn Cod	0.68	18	0.01
4Vs Cod	0.72	42	0.01
4X Cod	0.26	82	0.02
5Z Cod	0.21	39	0.11
4X haddock	0.60	132	0.01
4VWX + 5 Pollock	0.55	89	0.01
4Xq,4Xr + 5Y cod and haddock	0.58	95	0.01
Mobile Gear			
4Vn Cod	0.20	10	0.58
4Vs Cod	0.71	16	0.01
4X Cod	0.19	43	0.23
5Z Cod	0.04	22	0.87
4X haddock	0.64	82	0.01
4VWX + 5 Pollock	0.55	89	0.01
4Xq,4Xr + 5Y cod and haddock	0.58	93	0.01
Longline			
4Vn Cod	0.72	10	0.02
4Vs Cod	0.65	26	0.01
4X Cod	0.37	39	0.02
5Z Cod	0.66	17	0.01
4X haddock	0.57	50	0.01

$$\frac{a + b \times 45}{a + b \times 65},$$

where a and b are the corresponding coefficients from the regressions. CPUE was also regressed as a function of GT and BHP. GT and BHP were then regressed as a function of LOA, and the estimated GT and BHP for a 45' and 65' vessel determined. The fishing powers, as a function of GT and BHP, were then determined for 45' and 65' vessels using these values. Finally, for each stock, the fishing power of a 65' vessel in terms of the GT and BHP measures were expressed as a percentage of the fishing power based on the CPUE-LOA relation.

8.3 **Results**

Tables 8.1 - 8.3 list the regression coefficients obtained from regressing CPUE on LOA, GT, and BHP respectively. Table 8.4 lists the relative fishing powers for the different stocks and gear types. In the case of LOA, the relative power of a 65' to that for a 45' ranges from 1.28 to 2.15 depending on stock; for GT, from 1.38 to 2.05, and for BHP from 1.25 to 2.77. When only the mobile gear fleet is considered, the ranges for LOA, GT and BHP are 1.17-2.01, 1.29-2.09 and 1.18-2.17 respectively. For the longline fleet, the relative range for LOA is 0.73-3.51, or 0.73-2.93 if the regressions with a poor fit are ignored; 0.77-4.70 (0.77-2.30) for GT and 0.88-4.02 (0.88-1.73) for BHP.

The mean differences between the relative fishing powers are as follows:

	LOA and GT	LOA and BHP	GRT and BHP
All Vessels	0.05	0.24	0.26
Mobile	0.06	0.17	0.22
Longline	0.31	0.38	0.35

For all vessels combined, LOA and GT track relatively closely compared to the comparisons for LOA and BHP, and for GT and BHP. For the mobile gear fleet, LOA and GT also track most closely, with greater differences between the two other comparisons. For the longline fleet, all relative comparisons are greater, but differences between the three comparisons are about the same.

8.4 **Discussion**

Taken together, or for the Mobile gear alone, using LOA or GT, gives a relatively close index of the relative power of a 65' boat to that of a 45' when compared for nine different stocks in the study area. When the CPUE/vessel-dimension relation is considered for all stocks combined and the relative fishing power of a 45' vessel is compared to that of a 65' vessel, then LOA as a measure of the fishing power results in greater relative fishing powers for the larger vessels than is obtained when a CPUE - GT regression is used. When a CPUE-BHP relation is used, the relative fishing power of a 45' and 65' is greater than that indicated by a regression on LOA in the case of both gears combined and for longliners, but it is smaller in the case of the mobile gear fleet.

Table 8.1
Coefficients from regression of CPUE on LOA by stock

All gear

Stock	a	b	R^2(%)	p-Value
All stocks combined	-2.697	0.129	26.6	0.01
4Vn Cod	-68.90	2.497	58.7	0.01
4VsW Cod	-31.99	2.012	14.7	0.01
4X Cod	-15.57	0.809	12.8	0.01
5Z Cod	-9.241	1.117	8.8	0.01
4VW Haddock	-55.54	2.107	16.0	0.01
5X Haddock	-6.925	0.750	16.1	0.01
5Z Haddock	13.04	0.481	3.5	0.10
4VWX+5 Pollock	44.03	1.920	25.2	0.01
4Xq+4Xr+5Y Cod+Pollock	-6.933	0.685	19.1	0.01

Mobile gear

Stock				
All stocks combined	4.535	0.168	32.9	0.01
4Vn Cod	-40.28	2.164	53.1	0.01
4VsW Cod	-1.341	1.974	9.2	0.01
4X Cod	-24.94	0.989	16.7	0.01
5Z Cod	1.658	0.965	6.1	0.02
4VW Haddock	33.14	0.813	2.0	0.32
5X Haddock	-11.21	0.837	18.0	0.01
5Z Haddock	23.82	0.333	1.6	0.32
4VWX+5 Pollock	44.22	1.922	25.1	0.01
4Xq+4Xr+5Y Cod+Pollock	16.12	0.834	28.4	0.01

Longline gear

Stock	a	b	R^2(%)	p-Value
All stocks combined				
4Vn Cod	10.55	0.536	2.4	0.50
4VsW Cod	7.720	0.661	8.5	0.02
4X+5Y Cod	12.23	0.220	1.1	0.34
5Z Cod	1.396	0.747	3.1	0.30
4VW Haddock	-54.05	1.559	30.5	0.06
5X Haddock	-7.852	0.432	5.9	0.02
5Z Haddock	37.39	-0.264	1.5	0.65
4VWX+5 Pollock	-287.4	7.759	31.2	0.62
4Xq+4Xr+5Y Cod+Pollock	69.16	0.586	26.4	0.09

Table 8.2
Coefficients from regression of CPUE on BHP by stock.
Vessel Dimensions by Stock

Stock	a	b	R^2(%)	p-Value
All stocks	0.264	0.012	32.4	0.01
4Vn Cod	-4.446	0.229	63.9	0.01
4VsW Cod	-23.73	0.314	38.4	0.01
4X Cod	-3.947	0.073	14.4	0.01
5Z Cod	16.91	0.099	11.9	0.01
4VW Haddock	-37.41	0.275	38.9	0.01
5X Haddock	-9.087	0.074	24.8	0.01
5Z Haddock	18.69	0.058	9.0	0.01
4VWX+5 Pollock	-13.74	0.201	36.8	0.01
4Xq+4Xr+5Y Cod+Pollock	11.77	-0.051	19.6	0.01

Mobile Gear

Stock	a	b	R^2(%)	p-Value
All stocks	-0.074	0.014	32.7	0.01
4Vn Cod	14.58	0.197	47.9	0.01
4VsW Cod	-1.573	0.283	23.0	0.01
4X Cod	-4.140	0.092	16.1	0.01
5Z Cod	21.12	0.090	7.9	0.01
4VW Haddock	-24.67	0.251	20.4	0.01
5X Haddock	-0.750	0.096	23.5	0.01
5Z Haddock	24.81	0.046	5.1	0.01
4VWX+5 Pollock	13.25	0.200	36.2	0.01
4Xq+4Xr+5Y Cod+Pollock	4.548	0.067	32.6	0.01

Longline Fleet

Stock	a	b	R^2(%)	p-Value
All stocks	1.015	0.010	20.1	0.01
4Vn Cod	4.696	0.158	43.0	0.01
4VsW Cod	5.034	0.146	19.9	0.01
4X+5Y Cod	8.721	0.063	9.2	0.01
5Z Cod	16.31	0.090	5.9	0.15
4VW Haddock	-2.838	0.091	14.5	0.07
5X Haddock	-20.51	0.036	3.8	0.07
5Z Haddock	24.76	0.001	0.0	0.98
4VWX+5 Pollock	-70.40	0.423	94.4	0.15
4Xq+4Xr+5Y Cod+Pollock	50.16	-0.040	19.8	0.14

Table 8.3
Coefficients from regression of CPUE on BHP by stock.
Vessel Dimensions by Stock

Stock	a	b	R^2(%)	p-Value
All stocks	0.264	0.012	32.4	0.01
4Vn Cod	-4.446	0.229	63.9	0.01
4VsW Cod	-23.73	0.314	38.4	0.01
4X Cod	-3.947	0.073	14.4	0.01
5Z Cod	16.91	0.099	11.9	0.01
4VW Haddock	-37.41	0.275	38.9	0.01
5X Haddock	-9.087	0.074	24.8	0.01
5Z Haddock	18.69	0.058	9.0	0.01
4VWX+5 Pollock	-13.74	0.201	36.8	0.01
4Xq+4Xr+5Y Cod+Pollock	11.77	-0.051	19.6	0.01

Mobile Gear

Stock	a	b	R^2(%)	p-Value
All stocks	-0.421	0.014	32.7	0.01
4Vn Cod	14.58	0.197	47.9	0.01
4VsW Cod	-1.573	0.283	23.0	0.01
4X Cod	-4.140	0.092	16.1	0.01
5Z Cod	21.12	0.090	7.9	0.01
4VW Haddock	-24.67	0.251	20.4	0.01
5X Haddock	-0.750	0.096	23.5	0.01
5Z Haddock	24.81	0.046	5.1	0.01
4VWX+5 Pollock	13.25	0.200	36.2	0.01
4Xq+4Xr+5Y Cod+Pollock	4.548	0.067	32.6	0.01

Longline Fleet

Stock	a	b	R^2(%)	p-Value
All stocks	1.015	0.010	20.1	0.01
4Vn Cod	4.696	0.158	43.0	0.01
4VsW Cod	5.034	0.146	19.9	0.01
4X+5Y Cod	8.721	0.063	9.2	0.01
5Z Cod	16.31	0.090	5.9	0.15
4VW Haddock	-2.838	0.091	14.5	0.07
5X Haddock	-20.51	0.036	3.8	0.07
5Z Haddock	24.76	0.001	0.0	0.98
4VWX+5 Pollock	-70.40	0.423	94.4	0.15
4Xq+4Xr+5Y Cod+Pollock	50.16	-0.040	19.8	0.14

Table 8.4
Relative Fishing Power of a 65' Vessel to that of a 45' Vessel.
GT and BHP Measures in Parenthesis Expressed as a % of the LOA Index

All Vessels

Stock	LOA	GT	%	BHP	%
All stocks	1.83	1.36	(74.3)	1.30	(71.0)
4Vn Cod	2.15	1.96	(91.2)	1.69	(78.6)
4VsW Cod	1.69	1.64	(97.0)	1.97	(116.6)
4X Cod	1.78	1.83	(102.8)	1.50	(84.3)
5Z Cod	1.54	1.58	(102.6)	1.34	(87.0)
4VW Haddock	2.07	2.05	(99.0)	2.77	(133.8)
5X Haddock	1.56	1.54	(98.7)	1.39	(89.1)
5Z Haddock	1.28	1.38	(107.8)	1.25	(97.7)
4VWX+5 Pollock	1.91	1.76	(97.9)	1.93	(101.0)
4Xq+4Xr+5Y Cod+Haddock	1.57	1.57	(100.0)	1.30	(82.8)

Mobile Gear

Stock	LOA	GT	%	BHP	%
All stocks	2.11	1.45	(68.7)	2.34	(110.9)
4Vn Cod	1.76	1.65	(93.8)	1.46	(83.0)
4VsW Cod	1.45	1.41	(97.2)	1.61	(111.0)
4X Cod	2.01	2.09	(104.0)	1.80	(89.6)
5Z Cod	1.43	1.46	(102.1)	1.29	(90.2)
4VW Haddock	1.23	1.31	(106.5)	2.17	(176.4)
5X Haddock	1.63	1.66	(101.8)	1.65	(101.2)
5Z Haddock	1.17	1.29	(110.3)	1.18	(100.9)
4VWX+5 Pollock	1.91	1.86	(97.4)	1.91	(100.0)
4Xq+4Xr+5Y Cod+Pollock	1.78	1.74	(97.8)	1.45	(82.6)

Longliners

Stock	LOA	GT	%	BHP	%
All stocks	1.40	1.18	(84.3)	1.13	(80.7)
4Vn Cod	1.31 [1]	2.04	(168.6)	1.56	(119.1)
4VsW Cod	1.35	1.35	(100.0)	1.54	(114.1)
4X Cod	1.20 [2]	1.27	(105.8)	1.38	(115.0)
5Z Cod	1.43 [3]	1.57	(109.8)	1.33	(93.0)
4VW Haddock	2.93	2.30	(77.2)	1.73	(59.0)
5X Haddock	1.32	1.35	(102.3)	1.17	(88.6)
5Z Haddock	0.79 [1]	1.05	-	1.01	-
4VWX+5 Pollock	3.51 [1]	4.70	-	4.02	-
4Xq+4Xr+5Y Cod+Pollock	0.73	0.77	(105.5)	0.88	(120.5)

[1]/ Regression coefficients of CPUE on LOA not significantly different to zero.

[2]/ p-value = 0.17; [3]/ p-value = 0.15

9. Analysis of Time Spent at Sea and Time Spent Fishing

9.1 Introduction

Larger fishing vessels may generate greater fishing mortalities, because in addition to their greater fishing power they can fish in less clement conditions and so fish more days per year than can smaller boats. Because larger boats are likely to steam greater distances to fishing grounds than do smaller boats, larger boats may spend a smaller fraction of time-at-sea fishing than do smaller boats. However, as larger vessels make longer trips overall, this will mitigate the effect of greater steaming distances. This section examines the hypotheses that larger boats spend more time at sea and that the fraction of their time-at-sea spent fishing differs to that for smaller boats.

Only data for which both catch and effort were available have been included in this analysis. Therefore, this section can only be considered as "exploratory". Any differential behavior between larger and smaller boats in the way that complete their logs will bias the results and may invalidate the conclusions.

9.2 Methods

The number of days at sea, the number of days spent fishing and the fraction of the time at sea spent fishing have been regressed as a function of the vessels dimensions of LOA, GT and BHP. These regressions have been done for both gears combined, for 1984 and 1985 combined, for the Mobile and Longline fleets separately for 1984 and 1985 combined, and by gear for each year separately.

9.3 Results

9.3.1 Days at Sea as a Function of Vessel Dimensions

Figures 9.1 and 9.3 show the relation of days spent at sea as a function of LOA for the two gear types. Clearly there is a large amount of variation for vessels of the same size in the data examined. The results of the regression analyses are shown in Table 9.1. In all but two cases (for Longliners) significant regression coefficients were obtained. The one significant relation for the Longline gear showed a negative relation between time spent at sea and vessel LOA, i.e., smaller longliners spent more days at sea than did larger ones! However, in all cases the R^2 values were small. The best descriptions were obtained for the Mobile gear fleet.

If the amount of time spent at sea by a 65' vessel is expressed in terms of that for a 45' vessel, the results are as follows:

		65'/45'
1984 and 1985:		
	All Gear	1.37
	Mobile	1.36
	Longline	0.92
1984		
	All Gear	1.34
	Mobile	1.31
	Longline	1.15
1985		
	All Gear	1.25
	Mobile	1.31
	Longline	0.74

FIGURE 9.1
1984 & 1985, MOBILE GEAR

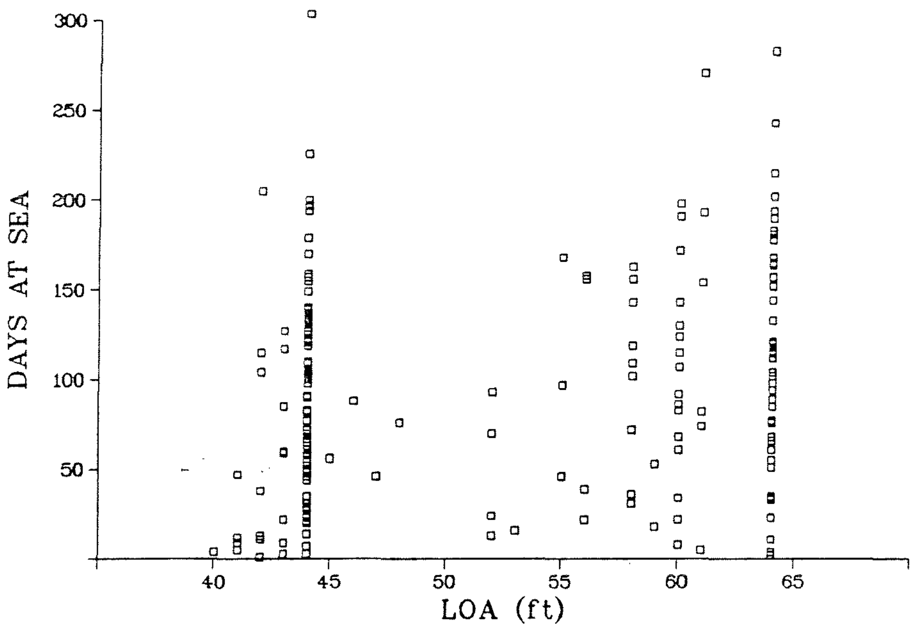


FIGURE 9.2
1984 & 1985, MOBILE GEAR

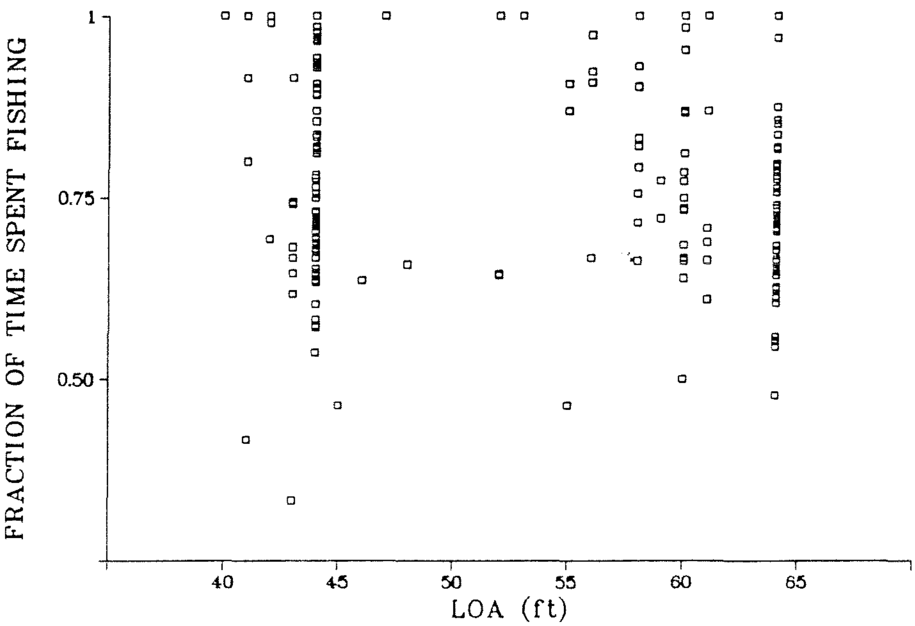


FIGURE 9.3
1984 & 1985, LONGLINE GEAR

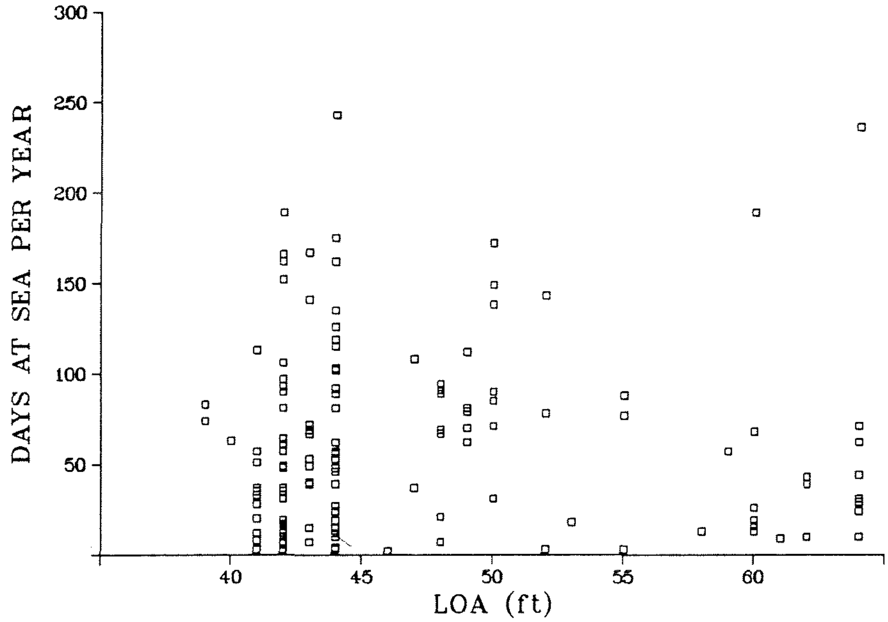


FIGURE 9.4
1984 & 1985, LONGLINE GEAR

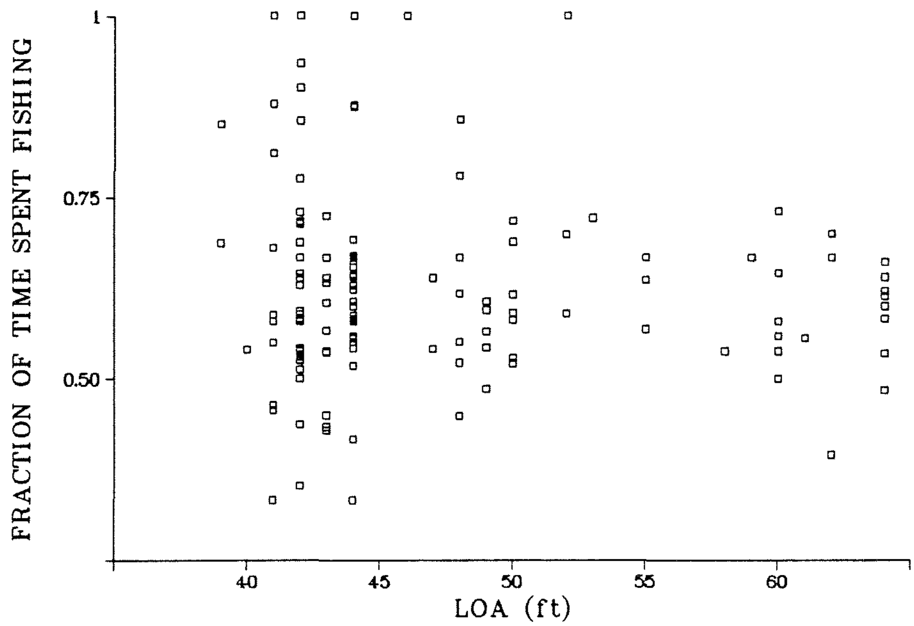


Table 9.1
Regression results for Days at Sea v LOA

Regression on...	a	b	R^2	p-Value
1984 + 1985				
All Gear	13.13	1.408	7.8	0.01
Mobile	17.13	1.548	12.4	0.01
Longline	75.37	0.2567	0.1	0.69
1984				
All Gear	9.772	0.7174	6.0	0.01
Mobile	13.88	0.7213	6.9	0.01
Longline	24.7	0.2704	0.6	0.39
1985				
All Gear	20.8	0.6019	6.4	0.01
Mobile	15.42	0.8333	14.1	0.01
Longline	64.59	-0.5290	4.1	0.04

Table 9.2
Fraction of time at sea spent fishing v LOA

Regression ... on	a	b	R^2	p-Value
1984 + 1985				
All Gear	0.7815	-0.0012	0.8	0.11
Mobile	0.8708	-0.0017	2.9	0.02
Longline	0.7441	-0.0024	1.1	0.18
1984				
All Gear	0.7735	-0.0009	0.3	0.37
Mobile	0.9384	-0.0027	4.6	0.01
Longline	0.7295	-0.0020	1.2	0.25
1985				
All Gear	0.7838	-0.0016	1.8	0.03
Mobile	0.8739	-0.0022	5.0	0.01
Longline	0.6745	-0.0013	1.0	0.30

9.3.2 Fraction of Time at Sea Spent Fishing

Figures 9.2 and 9.4 show plots of the fraction of time at sea spent fishing as a function of vessel LOA. The results of the regression analyses are shown in Table 9.2. In all cases, the fraction of time at sea that was spent fishing declined as the vessel size increased. Significant regressions in all time periods were only obtained for the Mobile gear fleet. No relation could be confidently claimed in the case of the Longliners. Again, only small R^2 values were obtained from the regression.

9.4 Discussion.

The data suggest that at least in the case of the Mobile gear, a CPUE-vessel dimension relation is insufficient to describe the impact of a vessel in terms of the fishing mortality that it generates. Its CPUE/vessel dimension may need to be weighted by the apparent ability of larger mobile gear vessels to spend more time at sea. Although the fraction of time at sea spent fishing does decrease as vessel size increases, at least for the data set examined, it is not sufficient to compensate for the increased time spent at sea.

For the Longline fleet, as larger vessels may spend less time at sea than smaller vessels, the decreased fraction of time spent fishing while at sea has the effect of further diminishing the relative fishing mortality caused by the larger vessels. The caveat noted in the introduction regarding the limitation of the data set used here must be kept in mind in interpreting the results of this section.

10. Effect of Vessel Age on Fishing Power

10.1 Introduction

The age of a fishing vessel may affect its fishing power in several ways. Newer vessels, if less prone to mechanical failure, should be able to spend more time fishing. If more recent vessel designs enable construction of more seaworthy vessels, then newer vessels should be able to spend more time fishing than older vessels. These factors would enable more catch per year, but may not result in an increase in the catch per day fished.

Newer vessels may have more efficient equipment, both deck gear (e.g. net drums, automatic baiters, etc.) and electronic equipment. Such gear may permit an increase in the fishing power of a new vessel relative to an older vessel of the same length. In Section 2 it is shown that there is a trend over time in the dimensions of GT and BHP for vessels of the same LOA. Thus an analysis of CPUE as a function of LOA and vessel age should indicate a positive effect of age, in that the age will be correlated with GT and BHP. To determine if an "age effect" is present its effect must be determined independently of the effect of vessel dimensions, particularly those for which there is colinearity with age.

10.2 Methods

The following regressions were done:

1) CPUE as a function of LOA, GT and vessel age.
2) CPUE as a function of LOA, BHP and vessel age.

The data analized were:

1) All stocks, both gears, 1984 and 1985 combined.
2) All stocks, Mobile gear, 1984 and 1985 combined.
3) All stocks, Longline fleet, 1984 and 1985 combined.

In all cases, the age of the vessel has been calculated in terms of the year of construction, with the year of construction of the oldest vessel in the fleet (1955) set equal to one. Because vessels of 44' and 64' LOA were particulary frequent, regression of GT as a function of year-built was done for the vessels in these length classes.

10.3 **Results**

Table 10.1 shows the results of the regression analyses. When CPUE is considered in terms of vessel age, in addition to LOA, relatively large improvements in the fit of the regression relation are obtained. When both gear types are considered together, the effect of one year of vessel age is equivalent to 0.59'. In terms of the overall fleet relation, if a vessel 20 years old was replaced with a vessel of the same length, the CPUE - LOA/YB relation implies it would improve the fishing power of a vessel by 5.9'. When analized by gear type, replacement of a vessel of the median age in the Mobile fleet would result in an equivalent length increase of 7.8' (10.8 yr. x 0.1548/0.2135), and for longliners, 10.7' (9.6 yr. x 0.1031/0.0926).

Much of the increase in fishing power of newer vessels can be explained in terms of the increased GT of newer vessels of the same length. Figures 10.1 and 10.2 show a plot of GT/LOA^3 as a function of the year of construction of the vessel. When the whole fleet is considered, stepwise regression of CPUE on LOA, GT and year built (YB) shows that GT explained most of the variation in CPUE (35.6%), then year built (3.6%), and LOA least, 0.2%. Similar results were obtained when the fleet was stratified by gear type prior to analysis. When GT is regressed on LOA and YB (see Table 10.2), on a vessel-gear type basis, the affect of age on CPUE was significant in both cases, resulting in an R^2 contribution of 3.1% and 4.5% for the Mobile and Longline fleet respectively. Equivalent analyses can be done for BHP as have been done with the GT - LOA relationships.

Based on these regressions, replacement of the oldest 25% in the Mobile-gear fleet would result in an increase in the capacity of this fleet of 3.9% and 2.9% in the case of the Longline fleet. The increases in fishing power in terms of the vessels replaced, would be 13.5% and 10.4% respectively.

Table 10.3 lists the results from regressing GT on year-of-vessel-contruction. Significant regression coefficients were obtained in all cases except for the 44' Longliners. The greatest predicted increase in GT among the 64' vessels was for the Longline fleet, equivalent to 129 ft^3/year; among the 44' vessels, Mobile gear boats were predicted to increase the most rapidly, equivalent to 57.1 ft^3/year. In each length class, the rates of increase are comparable. Figures 10.3-10.6 show plots of GT as a function of year of construction for the two gear types and length classes.

Table 10.1
Coefficients from Regression of CPUE on Vessel Dimensions
and Year Vessel Constructed (1955 as Year 1)

Independent Variables	b_0	b_1	b_2	b_3	R^2 (%)
All Vessels					
LOA	-3.470	0.1448			23.5
LOA, YB	-9.162	0.1898	0.1498		35.3
Mobile Gear					
LOA	-5.052	0.1782			29.0
LOA, YB	-10.36	0.2135	0.1548		40.1
Longliners					
LOA	-1.072	0.0435			3.4
LOA, YB	-3.095	0.0926	0.1031		13.0
All Vessels					
GT	0.175	0.0744			35.6
GT, YB	-1.709	0.0771	0.07637		39.3
GT, LOA	2.060	0.09598	0.05845		36.5
GT, YB, LOA	-3.138	0.06511	0.09009	0.00206	39.4
				(p=0.95)	
Mobile Fleet					
GT	-0.5472	0.09076			44.7
GT, YB	-2.363	0.09170	0.07889		47.9
GT, LOA	2.054	0.1193	-0.0786		46.0
GT, YB, LOA	-1.992	0.0949	0.07563	-0.0090	47.9
				(p=0.85)	
Longliners					
GT	1.934	0.0280			8.2
GT, YB	0.3270	0.03215	0.06020		12.8
			(p=0.11)		
GT, LOA	-3.643	0.04688	-0.05325		9.6
GT, YB, LOA	-2.053	0.01510	0.08554	-0.05301	13.3
			(P=0.21)	(p=0.37)	
All Vessels					
BHP, LOA	-1.822	0.008302	0.06421		30.5
BHP, LOA, YB	-7.314	0.004136	0.1415	0.1228	36.7
Mobile Gear					
LOA, BHP	-3.821	0.1068	0.007419		33.3
LOA, YB, BHP	-9.601	0.1918	0.1420	0.001945	40.3
Longliners					
BHP, LOA	1.541	0.009199	-0.009586		12.7
BHP, YB, LOA	-1.833	0.006078	0.0986	0.04171	16.0

NORMALIZED TREND IN VESSEL VOLUMES
FIGURE 10.1
MOBILE GEAR

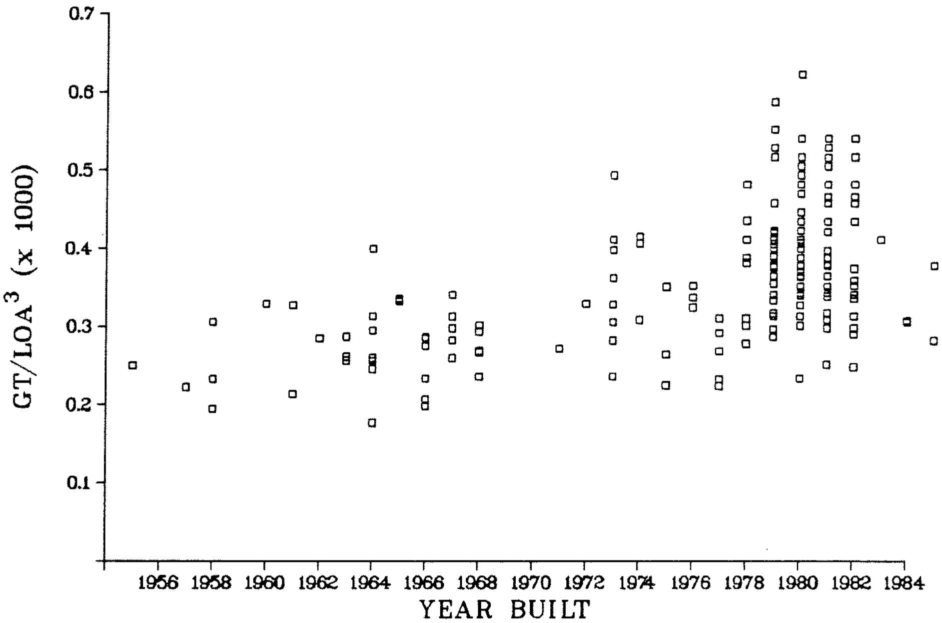


FIGURE 10.2
LONGLINERS

Table 10.2
Coefficients of Regression of GT on LOA and Year Vessel Built (1955 as Year 1)

Independent Variables	b_0	b_1	b_2	R^2 (%)
All Vessels				
GT, LOA	-57.68	2.120		78.0
LOA, YB	-57.77	2.103	0.01542 (P=0.19)	78.1
Mobile Gear				
GT, LOA	-59.58	2.153		78.0
LOA, YB	-88.19	2.344	0.8339	83.9
Longliners				
GT, LOA	-54.84	2.064		73.1
LOA, YB	-108.6	2.618	1.1631	84.7

Table 10.3
Results from Regression of GT on Year Vessel Constructed (1955 as Year 1)

Independent Variables	b_0	b_1	p-value	R^2 (%)
All Vessels				
44'	23.55	0.5773	0.01	12.9
66'	62.90	1.046	0.01	36.3
Mobile Gear				
44'	23.24	0.5705	0.01	15.7
64	63.25	1.016	0.01	32.2
Longliners				
44'	26.35	0.5079	0.22	5.5
66'	61.30	1.290	0.01	75.8

FIGURE 10.3
GROSS TONNAGE v YEAR BUILT
MOBILE GEAR – 44 ft

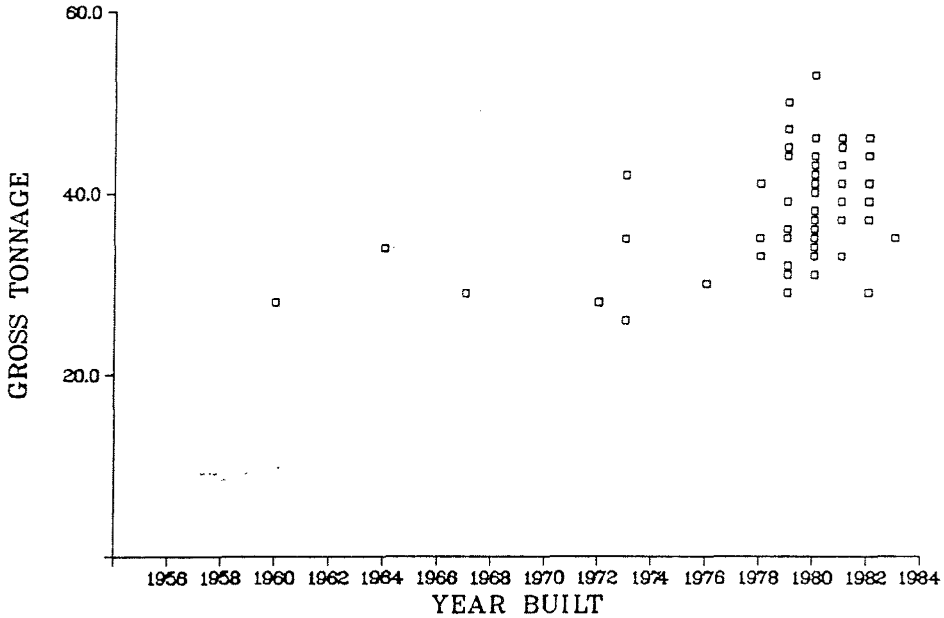


FIGURE 10.4
MOBILE GEAR – 65 ft

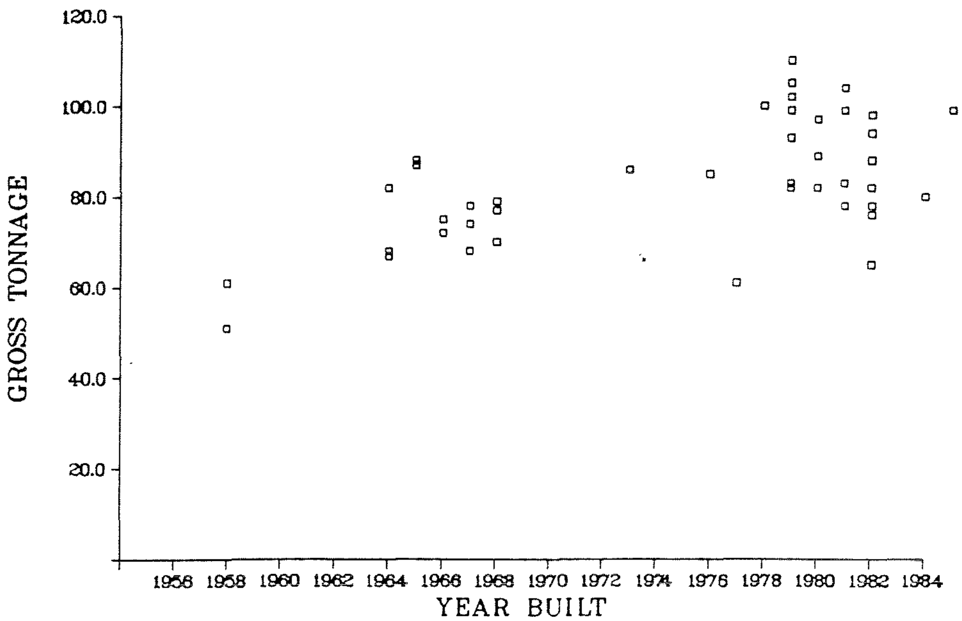


FIGURE 10.5
GT v YEAR BUILT
LONGLINERS – 44 ft

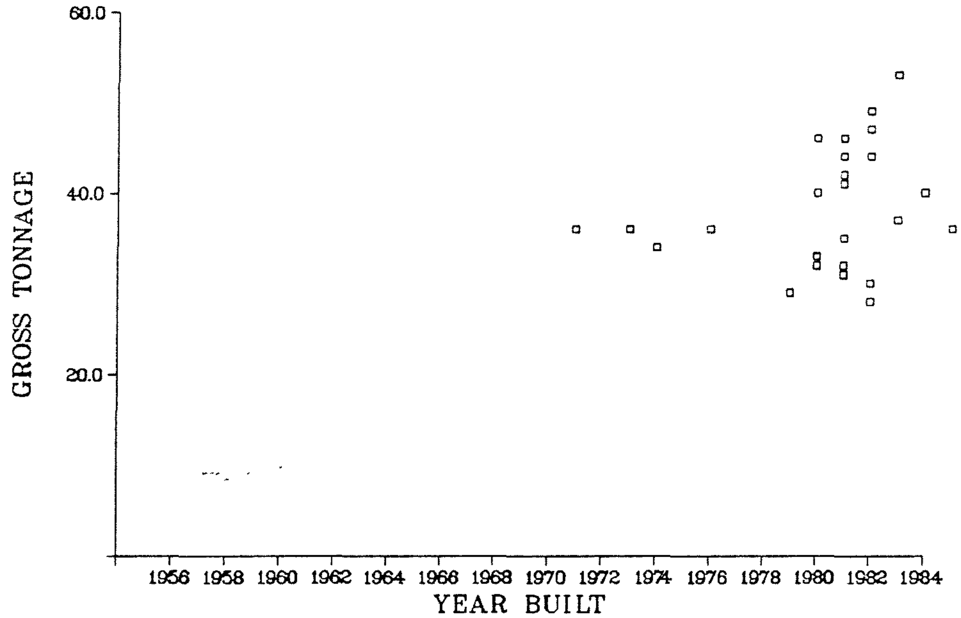
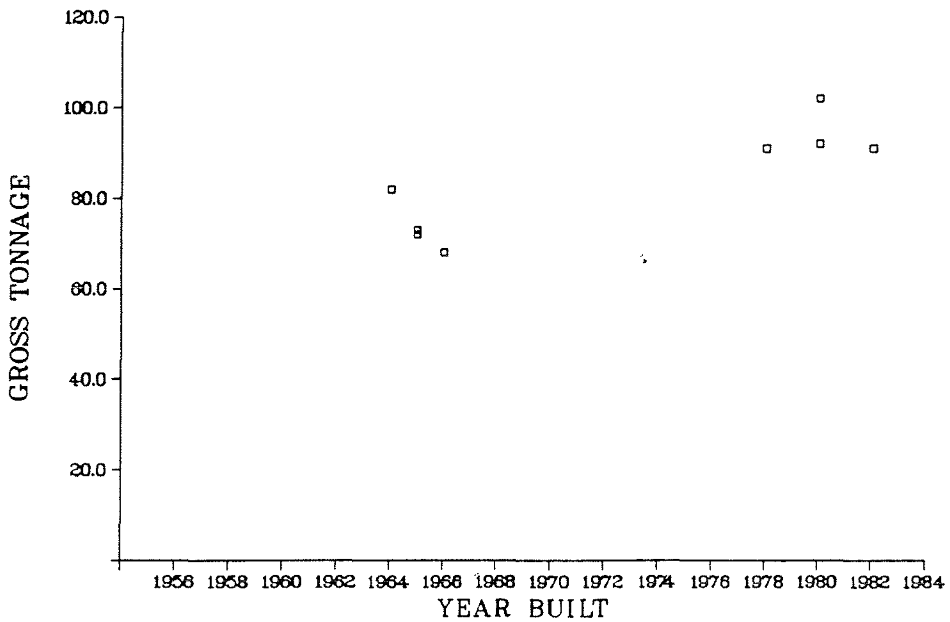


FIGURE 10.6
LONGLINERS – 65 ft



10.4 Discussion

This analysis does not enable prediction of how GT of future replacement vessels may increase. If an upper limit exists to GT that is feasible for a vessel of a given length, one would expect future increases in the fishing power from increased GT to reach an asymptote. Clearly, the "age effect" is resulting in an increase in the fleet capacity, despite restrictions on the length of replacement vessels.

It is noteworthy that after the trend in GT has been accounted for in the regression, only a small additional residual is explained by the age of the vessel. This residual could account for factors such as innovations in equipment that cannot be, or is not, installed on older vessels.

11. Total Catch and Vessel Dimensions

11.1 Introduction

This report has examined the relation between CPUE and vessel dimensions. In this section total catch, rather than CPUE, is investigated as the response variable. If there are major differences in the relative amount of effort expended by vessels of different size, then a catch/vessel-size function may be more useful in determining the effect on fishing mortality by vessels of a particular size. Further, it is total mortality which is of relevance in investigation of fleet capacity rather than CPUE.

11.2 Total Catch as a Function of Vessel Dimensions

11.2.1 Methods

Summed catch of cod, haddock and pollock was regressed on vessel LOA, GT and BHP. The catch of a 65' vessel relative to a 45' boat is calculated based on the regression model results. The results are compared with those obtained using CPUE as the response variable.

11.2.2 Results

Figures 11.1 - 11.9 show plots of catch as a function of vessel dimensions for the different data subsets. Table 11.1 lists the regression results and the comparisons with the corresponding regressions using CPUE as the response variable. GT and BHP performed practically identically in terms of the R^2 values, the R^2 for LOA being noticeably lower. In all cases the R^2 values obtained using catch were lower than when CPUE was used as the response variable.

Comparison of the relative fishing power (using a 65' and a 45' vessel) showed a similar relation for both catch and CPUE. Use of GT as the measure of fishing power results in the greatest difference in the relative fishing power, i.e., it gives the steepest fishing-power/vessel -dimension curve. A fishing power curve based on LOA gives an estimate for a 65' vessel that is 8.2% lower than that when GT is used as the predictor variable in the case of catch, and 13.7% lower in the case of CPUE.

11.2.3 Discussion

Because GT provides a better predictor of both CPUE and the catch taken by vessels than does LOA, and because the relation based on GT indicates a steeper response of fishing power as vessel dimensions increase, a licence combination policy, or vessel replacement policy based

FIGURE 11.1

CATCH v LOA, TOTAL FLEET, 1984 + 1985

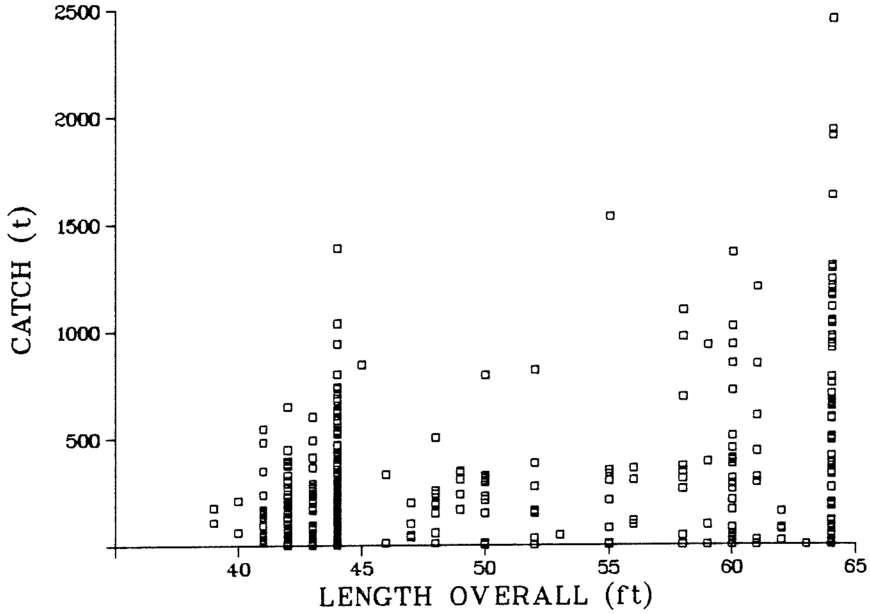


FIGURE 11.2

CATCH v GT, TOTAL FLEET, 1984 + 1985

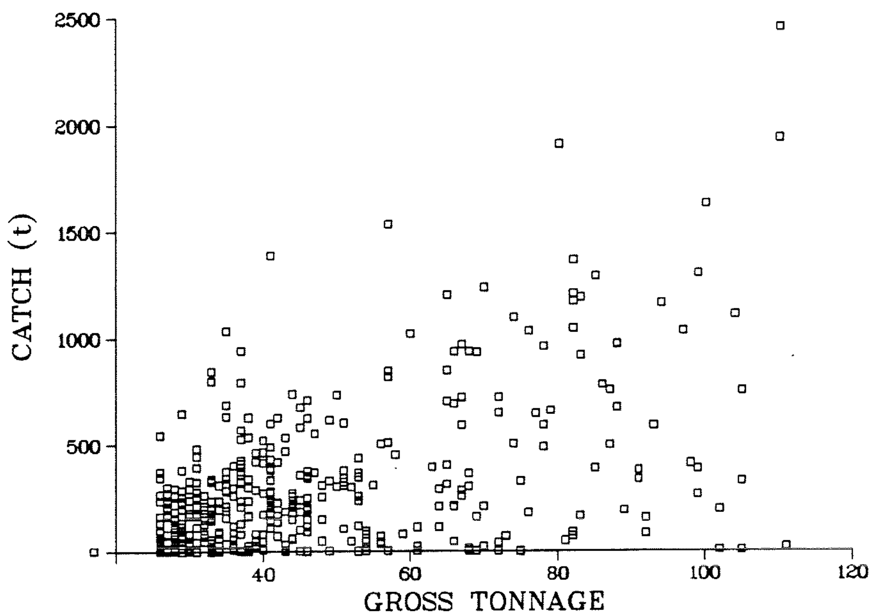


FIGURE 11.3

CATCH v BHP, TOTAL FLEET, 1984 + 1985

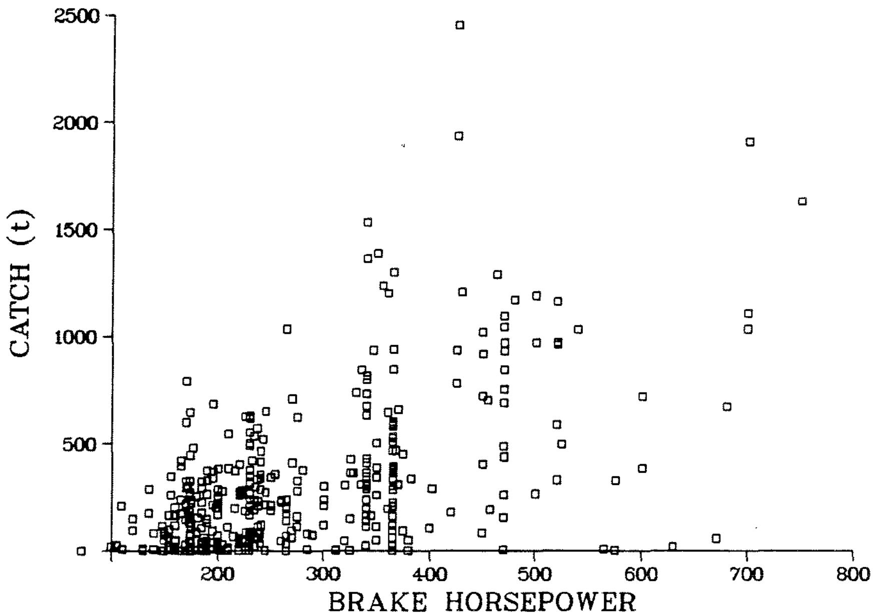


FIGURE 11.4

CATCH v LOA, MOBILE GEAR, 1984 & 1985

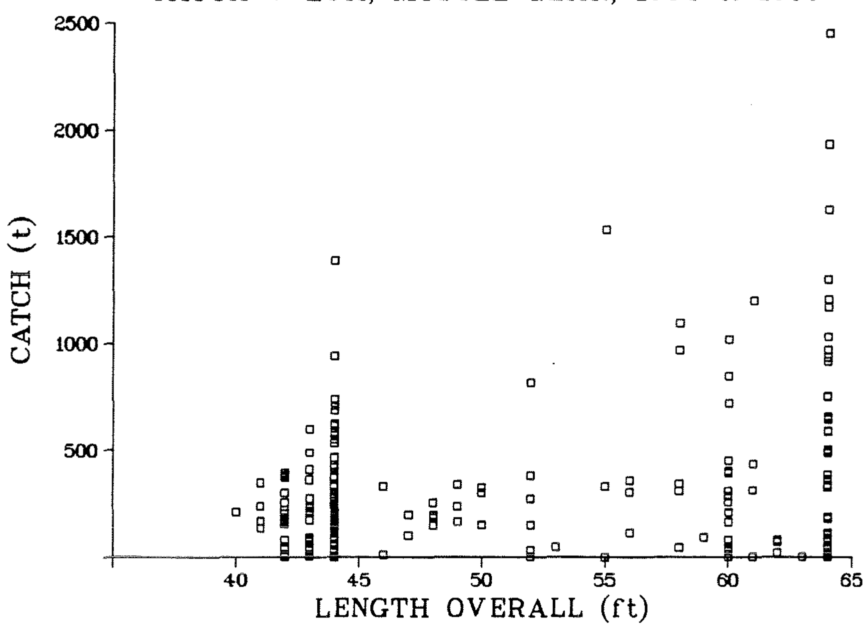


FIGURE 11.5

CATCH v GT, MOBILE GEAR, 1984 + 1985

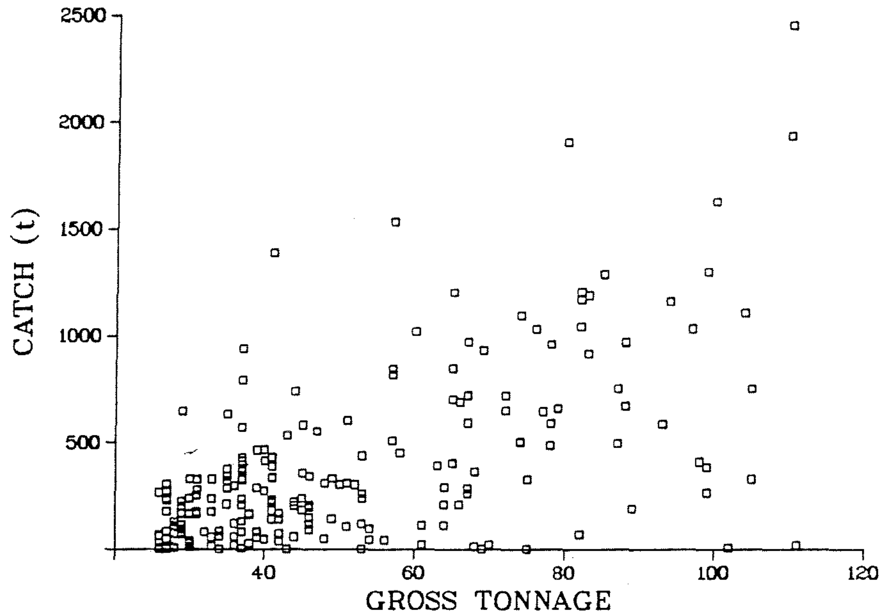


FIGURE 11.6

CATCH v BHP, MOBILE GEAR, 1984 + 1985

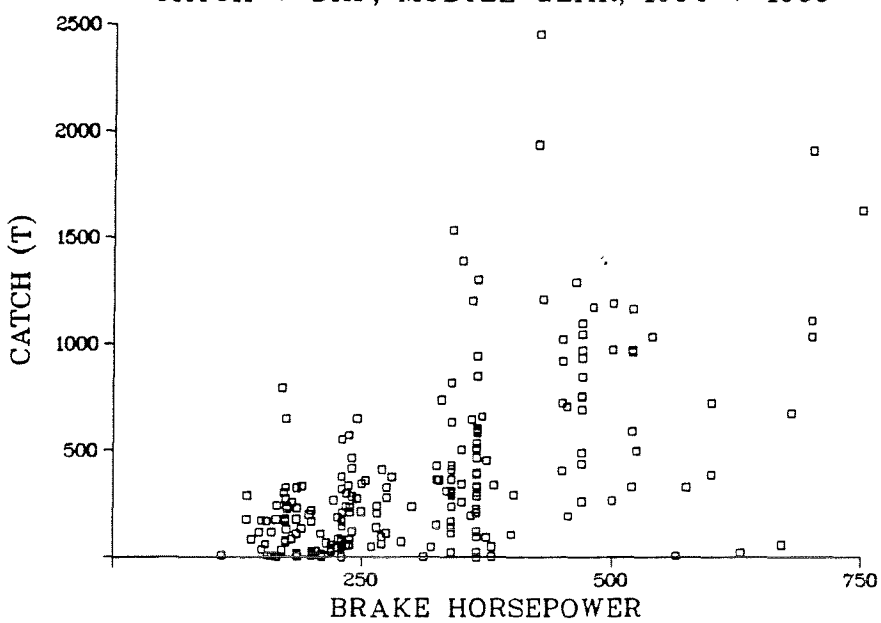


FIGURE 11.7

CATCH v LOA, LONGLINERS

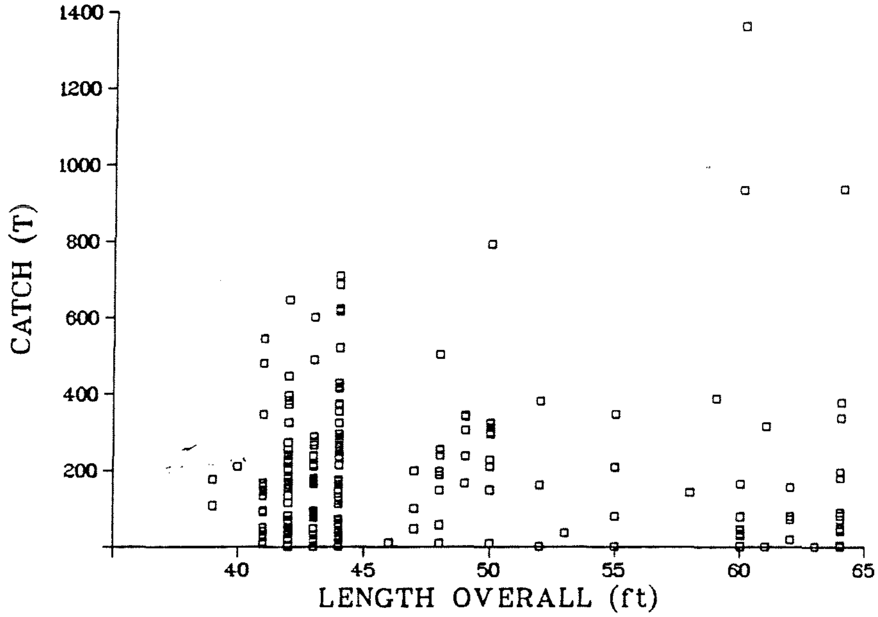


FIGURE 11.8

CATCH v GT, LONGLINERS, 1984 + 1985

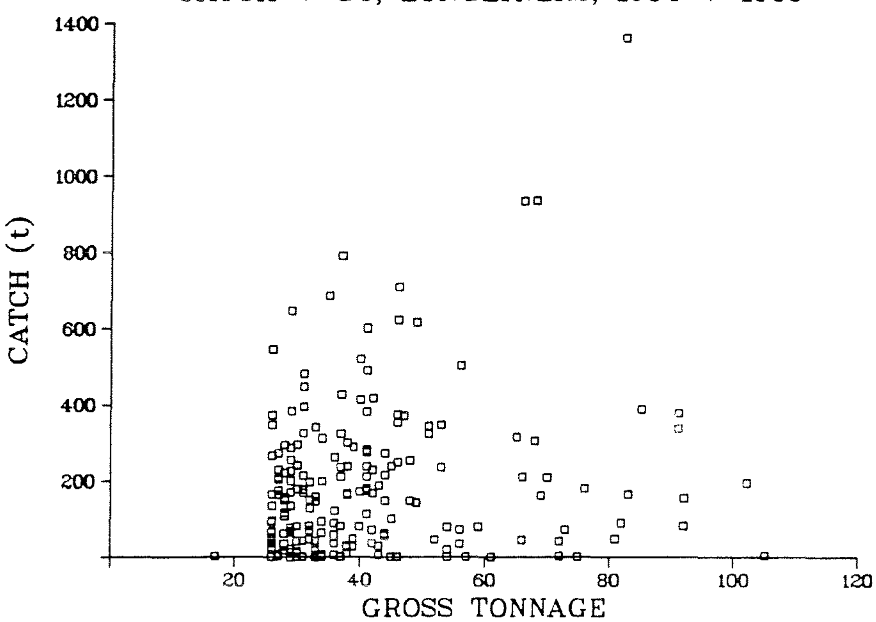
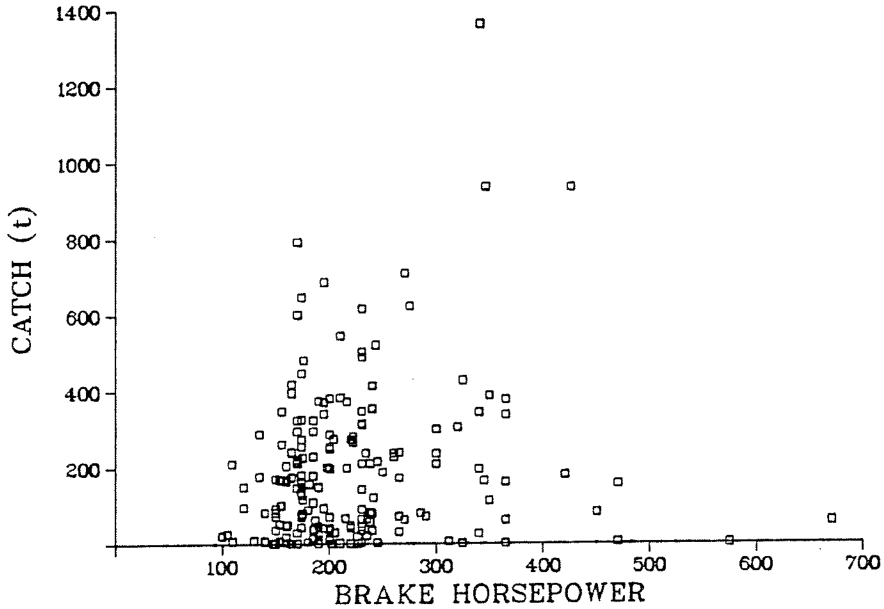


FIGURE 11.9

CATCH v BHP, LONGLINERS, 1984 + 1985



on regulation of vessel length will underestimate the fishing 'capacity' that is being added to the fleet.

Results in Table 11.1 show that fishing power (in the case of CPUE) curves are steeper than fishing 'capacity' (as in the case of catch), i.e., the differential between large and small boats is less when catch is taken as the response variable than when CPUE is used. This implies that smaller boats exert relatively more effort than larger boats.

11.3 The Effect of Vessel Age on Total Catch

11.3.1 Introduction

As in Section 10 for CPUE, it is relevant to know if vessel age affects the total annual catch by a boat; newer vessels may generate more fishing mortality than older vessels of the same size. If this is the case (and ignoring limitations that might be imposed by catch quotas) replacement of older vessels by newer vessels of the same size would result in an increase in the "fleet capacity".

11.3.2 Methods

Catch has been regressed as a function of LOA, GT and BHP, and the age of the vessel. Two data bases have been used: (1) total catch for each year separately, 1984 and 1985; and (2) the mean catch for 1984 and 1985. Several boats operated in only one of these two years. In any event, the results for the two data bases were quite similar. The p-value

Table 11.1

Results of Regression of Annual Catch on Vessel Dimensions

	a	b	p-value (b=0)	R^2 (catch)	R^2 (CPUE)	65-45' (catch)	65-45' (CPUE)
Both Gears:							
LOA	-45.87	4.543	0.01	9.5	26.6	1.57	1.83
GT	-9.903	3.975	0.01	22.5	36.4	1.71	2.12
BHP	-26.96	0.738	0.01	26.3	32.4	1.60	1.81
Mobile Gear:							
LOA	-29.19	5.122	0.01	10.8	32.9	1.51	2.11
GT	-6.863	4.619	0.01	26.4	46.6	1.67	2.15
BHP	-27.82	0.798	0.01	26.0	32.7	1.55	1.72
Longliners:							
LOA	55.65	1.170	0.04	1.3	12.5	1.21	1.40
GT	59.70	1.228	0.01	4.3	16.3	1.14	1.12
BHP	59.50	0.234	0.01	3.5	20.1	1.01	1.05

listed for the first case will underestimate the probability of type I errors as an F test for one numerator degree of freedom has been used. This will not consider the replicated observations when the same vessel fished in both years. As almost all p-values were less than 0.01, this is unlikely to be a serious problem.

An additional set of regressions were done with an added term to describe an age-dimension effect

$$\text{Catch} = b_0 + b_1, D + b_2 \text{ age} + b_3 (D \times \text{Age})$$

A strong age-dimension effect could imply that the age effect depended on the vessel dimension.

11.3.3 Results

Table 11.2 lists the regression analyses results. Regression on LOA and age shows a significant age effect (p 0.01) that implies an annual effect equal to 0.80' - 0.83'. A new vessel that replaced a 15 year old vessel of the same LOA, has a fishing power of a vessel 12.0' - 12.45' greater than the vessel it replaced. When considered by gear, this effect was greatest for longliners. Based on these relations, the increased catch that would be taken by new vessels relative to one 15 years old would be as follows:

Based on LOA (65' LOA)	% Increase
All Vessels	149 - 150%
Mobile Gear	156 - 161%
Longliners	
Based on GT (65' LOA)	
All Vessels	138 - 140%
Mobile Gear	144 - 148%
Longliners	139 - 143%

When an age-dimension interactive term was included in the regression, a significant coefficient (p 0.05) was obtained for a LOA x age interaction for the total fleet but when the analysis was done by gear type, there was little indication of such an interaction. When GT was the dimension analyzed, an interactive term was likely ($p = 0.06$), but again this did not hold when the two fleet components were analyzed separately by gear type. Vessel BHP behaves a little differently to vessel LOA and GT, a significant interactive term is obtained for the whole fleet, and a significant term also occurs for the Mobile fleet ($p = 0.09$) though the increase in the R^2 values is only minor.

11.3.4 Discussion

The simple models, in most cases, show a clear age effect on annual catch, and if an important objective in a vessel replacement policy is to prevent an increase in fishing power, the dimensions of the replacement vessel will have to be reduced accordingly. The evidence for an age-dimension interactive effect is less clear. In all cases a negative coefficient was obtained, and in most cases, the interactive term was

Table 11.2

Coefficients from Regression of Catch on Vessel Dimensions and Vessel Age. Data for 1984 and 1985 are Treated as Separate Points (1) and Averaged for the Two Years (2)
(Where no p-value is given p 0.01)

Independent Variables	b_0	b_1	b_2	b_3	R^2	Length Effect/ Year (ft)
All Vessels						
(1) LOA	-253.9	8.606			15.9	
(2) LOA	-198.6	7.066			12.9	
(1) LOA, Age	-336.6	11.83	-9.491		27.1	0.80
(2) LOA, Age	-286.0	10.33	-8.538		25.7	0.83
(1) LOA, LOA x Age, Age	-500.3	14.91	-0.4200	13.94	28.1	
				(p=0.06)		
(2) LOA, LOA x Age, Age	-473.6	13.90	-0.4508	16.50	27.3	
			(p=0.04)	(p=0.06)		
Mobile Gear						
(1) LOA	-315.4	10.45			18.6	
(2) LOA	-273.6	9.212			17.4	
(1) LOA, Age	-359.5	13.32	-12.17		30.8	0.91
(2) LOA, Age	-341.2	12.59	-12.01		32.1	0.95
(1) LOA, LOA x Age, Age	-467.6	15.28	-0.2689	3.154	31.1	
			(p=0.19)	(p=0.79)		
(2) LOA, LOA x Age, Age	-461.1	14.77	-0.2916	4.665	32.5	
			(p=0.24)	(p=0.74)		
Longliners						
(1) LOA	58.79	1.105			0.5	
		(p=0.18)				
(2) LOA	82.24	0.2920			0.0	
		(p=0.77)				
(1) LOA, Age	-22.68	3.526	-4.219		7.3	1.20
(2) LOA, Age	8.698	2.506	-3.656		7.5	1.46
		(p=0.03)				
(1) Age, LOA, LOA x Age	-92.79	4.807	4.921	-1.661	7.8	
		(p=0.51)		(p=0.21)		
(2) Age, LOA, LOA x Age	-68.54	5.439	4.052	-0.1682	8.0	
		(p=0.55)	(p=0.03)	(p=0.31)		

Table 11.2 Continuied

Independent Variables	b_0	b_1	b_2	b_3	R^2	Length Effect/ Year (ft)
All Vessels:						
(1) GT	-39.43	4.499			25.1	
(2) LOA	-38.55	4.082			24.3	
(1) GT	-6.423	4.757	-5.526		29.5	0.43
(2) GT, Age	-5.017	4.367	-5.322		30.2	0.45
(1) GT, GT x Age, Age	-49.70	5.635	-0.1212	0.7174	30.1	
			(p=0.02)	(p=0.80)		
(2) GT, GT x Age, Age	-47.09	5.931	-0.2261	6.1925	38.5	
			(p=0.06)	(p=0.24)		
Mobile Gear:						
(1) GT	-55.33	5.399			29.9	
(2) GT	-61.12	5.132			31.8	
(1) GT, Age	2.241	5.527	-7.416		34.9	0.48
(2) GT, Age	-5.612	5.343	-7.395		38.2	0.50
(1) GT, GT x Age, Age	-36.58	6.242	-0.9659	-2.0976	35.1	
			(p=0.22)	(p=0.64)		
(2) GT, GT x Age, Age	-47.46	5.931	-0.0767	0.5569	9.3	
			(p=0.18)	(p=0.85)		
Longliners:						
(1) GT	60.91	1.203			3.6	
(2) GT	56.04	0.9607			2.7	
(1) GT, Age	72.50	1.507	-3.161		8.8	0.86
(2) GT, Age	69.38	1.273	-3.054		9.5	0.88
(1) GT, GT x Age, Age	47.02	2.072	-0.0767	0.5569	9.3	
			(p=0.18)	(p=0.85)		
(2) GT, GT x Age, Age	47.73	4.361	1.641	-0.1301	10.0	
		(p=0.56)		(p=0.32)		
All Vessels:						
(1) BHP	-61.35	0.8421			29.6	
(2) BHP	-59.00	0.7734			28.5	
(1) BHP, Age	-32.40	0.8383	-3.401		31.3	0.20
			(p=0.03)	(p=0.57)		

fitted before age in the stepwise regression, the Longliners being in most cases, the exception. This may only reflect the dominant influence of the dimension variable.

11.4 Catch Allocations

11.4.1 Introduction

Catch quotas issued to particular vessels may be derived from a function based on the fleet characteristics and its past catch history, e.g.,

$$\text{allocation} = a + b \times D$$

where D = vessel dimensions,
a, b = coefficients derived from a regression analysis of past fleet catch results.

In this case particular vessel allocations will depend not on on the past results of the individual vessels, but on the fleet as a whole, in relation to vessel size. Vessels of a particular length which in the past performed well will be penalized by such a scheme, those with a poor past catch record will benefit. Thus it is relevant to know the nature of the benefits and penalties that individual vessel operators may receive.

11.4.2 Methods

Average catch for 1984 and 1985 has been regressed as a function of LOA and GT for the total fleet, Mobile gear and Longliners. The maximum and minimum residuals (i.e., penalty in the case of a boat which catches more than that predicted by the fleet model, and benefit in the case of a vessel catching less than the fleet model) are determined by:-

$$\text{Residual} = C_i - C_1$$

where, C_i = catch (main species) of the i^{th} vessel,
C = predicted catch of i^{th} vessel,
$= a + b \times D_i$,
where, D_i = dimension of vessel, LOA at GT.

The mean and median penalty and benefit and the number that would be penalized and benefitted are also determined.

11.4.3 Results

Tables 11.3 and 11.4 list the statistics obtained. When a single fleet model is used, rather than separate models for the Mobile gear and Longliners, the maxiumum and mean penalty are minimized, both when catch is regressed on LOA and on GT. As expected, use of a GT based function resulted in a smaller maximum penalty, mean penalty/benefit, median penalty and median benefit.

11.4.4 Discussion

The results in Tables 11.3 and 11.4 show that if vessel allocations are base on a catch/vessel dimension relation, about 40% of operators will be penalized and 60% rewarded, relative to their past catch history. Use of a GT-based relation will reduce the differences, relative to use of a LOA-based catch function. But in either case important differences exist between past and "predicted" catch.

Table 11.3
Catch Allocation Results - Catch = a + b x LOA

	Total Fleet	Mobile Gear	
Longliners			
a	-212.7	-566.7	192.8
b	7.352	18.82	
0.7844			
R^2%	1.36	17.3	0.1
Maximum penalty (t)	967.0	181.2	116.2
Maximum benefit (t)	257.8	637.7	202.7
% Penalized	39.1	41.3	38.9
Mean penalty/benefit	56.5	137.0	71.7
Median penalty	92.2	270.5	114.0
Median benefits	77.5	183.2	129.9

Table 11.4
Catch Allocation Results - Catch = a + b x GT

	Total Fleet	Mobile Gear	
Longliners			
a	-42.19	-122.6	107.7
b	4.153	10.27	1.984
R^2%	24.3	30.6	2.8
Maximum penalty (t)	810.2	1442.6	1092.1
Maximum benefit (t)	409.0	977.7	312.3
% Penalized	42.4	43.2	41.1
Mean penalty/benefit	53.1	123.1	71.3
Median penalty	75.3	185.2	111.8
Median benefits	69.1	153.6	132.3

12. Discussion

12.1 Unexplained Variation in the Regressions

The outstanding feature of the analyses of CPUE as a function of vessel dimensions is the large variation in CPUE unexplained by the regression analyses. This could be for several reasons.

(1) Inadequate model parameterization:

All analyses were done using a linear regression model. However, multiple regression on more than one vessel dimension, also using linear models, did not provide much improvement. This was not unexpected given the relatively high colinearity among the vessel dimensions of LOA, GT and BHP. However, there is no fundamental basis on which to assume that a linear model is appropriate, and polynomials of a form such as

$$CPUE = b_0 + b_1 L^a + b_2\ GT^b + b_3\ BHP^c$$

may provide a better relationship between CPUE and the vessel dimensions. Figures 5.1 - 5.9 of the distribution of residuals from fitting the linear models show that first order models do produce reasonable distributions of the residuals. Thus higher order models are unlikely to greatly reduce the unexplained variation.

(2) Missing or unknow independent variables:

Catch success has been ascribed to factors other than vessel dimensions. These may be technically related, e.g., deck gear (e.g. net drums), fish finding equipment, and navigation equipment. Catch success may also be a function of skipper and crew skills. Because data are not available to quantify these characteristics, it is not possible to include them in a functional relationship. If these factors were uniform over the range of vessel dimensions in the fleet, then the CPUE-vessel dimension relation should be constent whether or not these factors were included in the regression. If factors such as skipper ability, or the calibre of vessel electronics, depend on the size of boats, and were highly correlated with them, then the vessel dimensions should provide a satisfactory description of vessel's fishing power. This would be the case if more skillful skippers and crews operate larger, better equipped vessels. Should the skipper's ability, or the amount of vessel equipment that augments catch success, not be related to the size of the boat, then the effects of these factors will be apparent as unexplained variation in the regression model. Undoubtedly, some unexplained variation will arise from this cause but it can only be speculated as to how much.

12.2 Error Caused by the Nature of the Data Base

CPUE has been calculated as the quotient of catch and days spent fishing. A day spent fishing is defined as any day on which there is fishing activity. Data entries consisting of one day, could represent any period of time up to 24 hours; for two days, a period of time from, say, two hours (2300-0100), upto 48 hours. Clearly, considerable error will arise from 'rounding up' the time spent fishing to a number of days. If the times of starting and stopping fishing occur with uniform probability throughout the day (0000-2400) then the relative error will depend on the length of the trip. The shorter the trip, the greater the potential bias, and hence under estimation of the actual catch rate. Thus, as smaller vessels have shorter trips, their CPUE relative to larger vessels will be underestimated. Hence the fishing power of larger vessels in relation to smaller vessels will be overestimated. For this reason, correction for the actual error in using "days fished" rather than hours fished may provide the greatest reduction in the unexplained variation in the CPUE - vessel dimension functional relationships.

12.3 What is the Appropriate Data Base?

There are two considerations in evaluating the fishing power of the fleet: the analysis may have a "technical" emphasis, i.e., what are the determinants of fishing power of vessels in the fleet as a whole? In this case the appropriate data base is the entire fleet. Alternatively, the analysis may have a management objective, i.e., knowledge of what determines fishing power is needed so that actions can be taken to modify the fleet characterisitics, e.g., to reduce the fishing mortality that it generates. In this case a different data base ought be used as the study fleet is characterised by a small number of vessels that take most of the catch. Approximately 20% of the top vessels take 80% of the catch (see Figures 5.1 - 5.3) and many of the boats in the fleet contribute little to the total fishing mortality generated by the fleet.

Future analyses may be modified in two ways: vessels that catch little, could be dropped from the data base, or vessel data could be weighted by the vessel's catch prior to (regression) analysis. The second method, which may be nearly equivalent to the first, would avoid problems arising from subjectively deciding which vessels should be included or excluded from the analysis.

13. Literature Cited

Draper, N. and H. Smith, 1981. Applied Regression Analysis. John Wiley and Sons. 709pp.

APPENDIX I

Terms Used in Relation to Fishing Vessel Dimensions

1. **Length**

1.1 **Length Overall (LOA)**

This is the distance from the extreme fore-end of the vessel to the extreme after-end of the main hull structure.

1.2 **Length Between Perpendiculars (LBP)**

This is the distance between two reference perpendicular lines defined as follows: (1) Forward perpendicular (F.P.), a perpendicular line erected where the designed load waterline crosses the stem; (2) After perpendicular (A.P.), a perpendicular line erected at the after end of the rudder post, or, if a rudder post is not fitted, at the centreline of the rudder stock.

1.3 **Length on the Waterline (LWL)**

This refers to the vessel hull length at a given draft and load condition. LWL is normally used by designers and builders, and is specifically identified as the waterline at which the vessel floats in a 2/3 full load condition.

1.4 **Discussion**

The relevant length is the waterline length as it is this length that carries the load. The Department of Fisheries' length is the Length Overall, and as most of the older vessels have vertical stems, there was very little difference between the Length Overall and the Waterline Length. In order to shed water in heavy weather and reduce pitching, new vessels may have flared bows. The Length Overall is therefore substantially increased, but the waterline length and the carrying capacity is unchanged. The raised focsle design makes the Length Overall even longer, and again without any change in the carrying capacity. This length restriction may only cause the fishermen to request designs with increased beam to maintain the same capacity as their older vessel.

2. **Breadth**

This is the greatest hull width of the vessel. Generally speaking this width occurs amidships. Moulded breadth is the distance between the inside of the shell plate on metal hull vessels and the outside of the planking on wooden vessels.

3. **Depth**

Depth is usually the height measured from the underside of the keel structure to the top of the deck beam on the centreline, amidships. Various agencies have their own definitions for their particular purposes.

4. **Draft**

Draft (or draught) is the distance measured vertically from the underside of the keel to the waterline at which the vessel freely floats in a given load condition. If the vessel has a designed drag to the keel the depth will vary depending upon where it is measured along the hull length.

5. Cubic Number

The cubic number of a vessel is the volume divided by 100 of a box with sides equal to the length, breadth, and depth.

$$CN = \frac{L \times B \times D}{100}$$

6. Tonnage Measures

6.1 Introduction

Many different specific forms of tonnage exist; gross tonnage, registered tonnage, net tonnage, underdeck tonnage, etc. Essentially, tonnage is a measurement of the volume contained within a vessel's hull and superstructure, where 100 cubic feet of volume constitute 1 ton. Tonnage is primarily used by regulatory bodies to ensure safety regulations, to levy harbour dues, etc.

6.2 Gross Tonnage (GT)

Generally, GT is the sum of the following items:-

1. Cubic capacity below tonnage deck (this deck is the upper deck in vessels with less than three decks and the second from below in others),
2. Cubic capacity of each space between decks above tonnage deck,
3. Permanent enclosed spaces on the upper deck available for cargo, stores, passengers or crew, and,
4. Excess of hatchways - this is the cubic capacity of the upper deck hatchways in excess of 1/2% of gross tonnage of the vessel.

Certain spaces are not measured:-

1. Shelter deck space provided that there is a permanent deck opening between 1/5th length from forward and 1/20th the length from aft. Shelter deck space must have no permanent transverse closures (i.e. for bulkheads, there is a special type of tonnage opening allowed),
2. Double bottom tanks used solely for water ballast, and,
3. Certain closed-in spaces on the upper deck, e.g.
   a. machinery spaces
   b. wheelhouse
   c. cookhouse
   d. condenser space

6.3 Net Tonnage (NT)

Generally, NT is tonnage on which port and harbour dues are paid (tonnage of deck cargo, if any, is in addition). It is a measure of a vessel's earning power, not just its cargo carrying capacity. NT is the gross tonnage less certain deductions and is also the "registered tonnage." Deducted space is that which is first included in gross tonnage and then deducted to obtain the net tonnage.

The principal deductions are as follows:-

1. Allowance for propelling power which depends on size of engine room. There is a maximum deduction for propelling power of 55% of gross tonnage remaining after deductions for crew and water ballast spaces,

2. Crew spaces,
3. Chart room, wireless room and boatswains stores, and,
4. Water ballast spaces other than double bottoms.

Net tonnage is not an accurate indicator of the cargo carrying capabilites of a ship since it takes no account of the capability of the ship to safely carry cargo from the reserve buoyancy, stability, or freeboard point of view.

Note that:-

(i) Tonnage cannot be legally known until the vessel is built and surveyed.

(ii) The most economic way to reduce net tonnage on an existing ship is to reduce cargo volume.

(iii) The obvious way of doing this is to raise the bottom of the hold as you cannot economically lower the deck once the ship is built.

(iv) The tonnage computation procedure requires the depth for calculation purposes be measured from the deck down, not the bottom up.

Methods exist to reduce the net tonnage of a vessel of fixed cubic number. This can be achieved by the use of deep tonnage frames and deep bottom floors. Deep frames protrude into the fish hold and even though they reduce the tonnage they have very little effect in reducing the cargo capacity. The other structural modification is to increase the height of the bottom floors. This reduces the cargo capacity but raises the centre of gravity and reduces vessel stability.

The tonnage depth is measured from the top of the floors to the underside of the steel deck. For example, if there are 2 ft. deep floors and 6" deep deck head insulation and the inside clear head room is 7 ft., the tonnage depth is measured as 7'-6". Maintaining the same fish hold volume, the floors could be 6" deep and the deck head insulation 2 ft. deep. This would have a very significant effect on the vessel's stability, lowering the center of gravity 1.5 ft. Unfortunately the tonnage depth in this instance would be 9 ft. and the actual tonnage would be greatly increased.

6.4 Approximate Tonnage Under Deck

The UK Department of Trade and Industry gives the following rule for determining the "tonnage" of "sea fishing boats",

$$\text{approximate tonnage under deck} = \frac{L \times B \times D \times 0.45}{100}$$

where

$$\frac{L \times B \times D}{100} = \text{cubic number.}$$

This is only an approximate estimate of tonnage. In some reports gross tonnage is estimated as CN x 0.55. The dimensions are defined as follows:

L (Length): The length from fore-part of the head of the stem to the after part of the head of the stern-post, or after-part of the transom or tuck, in case of a transom or tuck stern without a post on same at the upper part.

B (Breadth): Extreme breadth of vessel to the outside of outer planking, whether the boat is clinker or carvel built. This breadth must not include the thickness of any moulding or rubbing strake which may be fitted in the way of such a measurement.

D (Depth): depth is measured amidships from the underside of deck, or from the upper strake of planking in open boats, to the upper side of floor timbers at side of the keelson, deducting the ceiling thickness. If this depth cannot be taken owing to fixed ballast, measure the depth down the pump well and deduct one inch per foot from same on account of depth of floors and thickness of ceiling.

In the case of a break or breaks above the deck line, multiply the inside mean length, breadth and depth of the space or spaces, divide each product by 100, and add to the tonnage under-deck. As regards the depth, this must be measured from the underside of the break deck to the top of the upper deck beams. All measurements are in feet and tenths of a foot. Further details are given in the UK Circular 1664 (Revised 1973) on "Instructions Relating to the Tonnage Measurement of Sea Fishing Boats."