Sea Fish Industry Authority
Industrial Development Unit

Fish Quality -
A Survey of UK Ports

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Abstract

This report describes the methodology used for the 1985 SeaFish port quality survey; presents a model of fish quality change at varying temperatures; analyses the survey data for the effects of the various handling practices in use aboard vessels and at the ports; and presents an estimate of the UK distribution of the quality of fish at first sale.

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Preface

The duties of the Sea Fish Industry Authority (SeaFish) are detailed in Appendix 1, where the relationship of this project to the overall work of the Authority is also defined.

Some fish processors, when trying to raise quality standards, have experienced difficulty in obtaining raw material of adequate quality from U.K. ports due to fish quality being variable and often mixed. This has to some extent led to these processors substituting imported fish for use in their operations. It should be noted that the handling of fish on vessels and in ports cannot be considered as separate issues, since often the requirements of one area dictates the practices adopted in the other. It should be further noted that fish handling practices in the U.K. are heterogeneous, in that there are a wide range of handling systems employed in the various ports throughout the United Kingdom.

As a result, part of the SeaFish research and development programme for 1984/5 funded by the Ministry for Agriculture, Food and Fisheries (M.A.F.F.) under reference QFA 16(b), was concerned with the technical aspects of improvements in fish quality. A specific project within this area was to survey handling and storage practices, both on board vessels and within the port systems. The results from this survey are intended to form the basis for producing guidelines detailing recommendations for fish handling practices, both on board fishing vessels and at the port of first sale. The production of these guidelines forms part of the internally funded SeaFish programme for 1985/86.

The brief received by the authors in SeaFish project proposal 6058 entitled 'Vessel and Port Handling Practices - Effects on Fish Quality', gave the following description of the current project :

"In the last financial year a field survey was conducted aimed at investigating the handling practices both on board vessels and in the port system, together with observing fish quality and temperature. In order to make this detailed information available to assist in the production of guidelines the data from all areas must be analysed as a totality to highlight and quantify the effects on fish quality of the various handling practices observed, and estimates of the current national distribution of fish qualities based on this model are also needed."

The ideal methodology employed to tackle the overall quality problem outlined above would have been to send SeaFish fish technologists to every fishing port in the United Kingdom, with the objectives of their visits being to observe fish handling practices and to measure the temperatures and freshness of fish as it passes through the vessel and port system from capture to first sale.

However due to financial and manpower constraints this was not possible, so instead a number of ports throughout the U.K. were chosen in order to form as representative a sample as possible of the fish handling practices both on board vessels and at U.K. ports. The procedure by which the sample was selected is detailed in Chapter 1 of this report, together with a summary description of the data collected.

The second chapter discusses the mathematical interpretation of repeated samples, as about a third of the fish sample temperatures taken were repeated over a period of time ranging from discharge through to auction. The information on temperature and quality change derived by these methods is used in later analysis to provide a more complete description of the fish quality at auction than could be obtained by simple consideration of the qualities as sampled.

Introduced in Chapter 3 is the formulation of the six statistical models developed from the collected field data using the Statistical Package for Social Scientists (SPSS/PC) computer software. A detailed analysis of these models and their results is then presented. This shows that the majority of effects on quality and temperature due to different handling practices which might be expected *a priori* are generally substantiated by the data collected.

Chapter 4 contains details of the approach adopted to estimate the current distribution of fish quality in the UK, and shows that, although the majority of fish available at the point of first sale within the UK is of high quality, some is either of poor quality, or does not have sufficient reserve to withstand significant distribution or display times.

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CHAPTER 1

Selection of the Sample and Data Collected

It was an immediate SeaFish management decision that Northern Ireland must be included in the sample. It was decided to include the following three Irish ports because they are the three largest (by value of landings) and furthermore they represent 81.7% of the total landings in Northern Ireland. They are, in order of value of their landings (1982 figures):

1) Kilkeel
2) Portavogie
3) Ardglass

It must be noted that value rather than weight has been used as the chosen statistic to represent landings as fish prices vary widely depending on species.

It is important to stress that the remainder of the ports were not chosen at random but on two numerical criteria; namely the total landings (in value terms) of the port and also the contribution of each of the major fish species to the value of the port landings; together with a judgement as to the regional coverage of each major handling practice anticipated.

Figure 1 contains a histogram which shows the percentage contribution to landings (by value) for each of the main fish species landed by vessels at U.K. ports. Also shown is the cumulative value for these main species. It is clear from both diagrams that different species of fish are more important than others in terms of their contributions to the total value of U.K. landings.

Table 1 lists in greater detail the contribution of each of the most important species to the total value of British landings and also places the species into one of three categories; namely Demersal, Pelagic or Shellfish. Demersal refers to fish with a normal habitat on or close to the sea bed (whitefish), whereas Pelagic refers to fish captured in mid-water (oily fish e.g Herring and Mackerel). Shellfish is a generic term for Molluscs (e.g Oysters) and Crustacia (e.g lobsters). It can be seen from Table 1 that the 17 highest contributers account for 92.3% of the total value of landings. Furthermore we can see that the contributions to this 92.3% of total landings by value are approximately Demersal (69%), Pelagic (10%) and Shellfish (14%). It is very clear from the previous figures that the Demersal category is by far the largest contributer to the value of total landings. Hence more attention has been paid to the Demersal fish category than to the others.

Just as each species of fish differs in its contribution to the total value of landings then so does the value of landings of each port. Table 2 details the largest 27 ports in Great Britain by their value of landings by British vessels. Once again it can be seen that certain ports are far more important than others. Indeed 27 ports realise 80% of the total value of British landings. Table 2 also illustrates that from the 27 largest contributers to total value of landings 16 have been chosen to form part of the sample.

It is possible to detail the contribution of each fish category to total value of landings at each port. Table 3A lists the 27 ports which realise between them 90% of the total value of British Demersal landings. In a similar fashion Table 3B details the 26 ports who between them make up 99% of the total value of British Pelagic landings. Finally Table 3C details the 27 ports which between them constitute 60% of the value of British Shellfish landings.

The species of fish to be sampled were mainly chosen by reference to Figure 1. It was decided that those species whose total landings accounted for one percent or more of total value of British landings should be included in the sample. Hence all of the fish listed in Table 1 were sampled. It was also decided to sample Turbot, Squid and Halibut since all these species have a high price per tonne. Although their respective catches by weight are too small for them to contribute significantly to the value of total British landings, they can form a significant proportion of an individual ports landing.

As Demersal is the most valuable category of fish it was decided to include in the sample the top six Demersal ports, since these collectively contribute 60% of the value of total Demersal landings. Six of the next ten ports were also included in the sample, which means that 12 out of the first 16 contributors by value were included in the sample.

The first 8 ports in Table 3B represent 90% of the value of total pelagic landings, six ports were selected from these eight and included in the sample.

Although Shellfish represent 14% of the total Britsh landings by value, as opposed to only 10% by Pelagic fish, the Pelagic category were given more consideration because of the sheer volume of their landings. (Pelagic landings were nearly 4 times the landings of shellfish by weight in 1982). Furthermore on comparison of Tables 3B and 3C it is clear that Shellfish landings are far less concentrated than Pelagic landings. However ports at which Shellfish landings are very important were included in the sample, e.g. Lochinver where Shellfish landings constitute 83% of total landings (by value).

The small East Sussex ports of Hastings, Rye and Newhaven were visited to gain an impression of the situation at smaller ports and also because their combined contribution is fairly significant. (29th most important by value in 1982)

Due to both financial and manpower constraints it was not possible to include some major ports in the sample e.g. Fleetwood, which by value of landings was the tenth largest port in Great Britain. It was also considered unnecessary to include any Welsh ports in the sample as the only port in Wales which significantly contributes to U.K. landings is Milford Haven.

Table 4 and Figure 2 deal exclusively with the ports which have been selected to be in the sample, giving details of the whether the port is in Scotland, England or Ireland. Furthermore, Table 4 lists the rankings of each port in terms of the contribution which the port made to the value of total landings of each of the three different fish categories. For example it can be seen that the Scottish port of Ullapool is the 4th largest contributor to total landings by value but surprisingly it does not land any significant quantities of Demersal fish at all. Also Ullapool is the largest contributor to total Pelagic landings by value but only the 39th largest contributor to total Shellfish landings. This method of interpretation can be applied to each port shown in Table 4.

It can also be seen that the sample consists of twelve English ports, ten Scottish ports and three ports from Northern Ireland, so the sample is representative of fish handling practices in three different countries.

The sample consists of ports of all sizes, e.g. Peterhead through to Hastings, Rye and Newhaven. Once again this indicates that the sample should be a fair representation of the fish handling practices existing in the U.K. Finally the sample reflects the required bias; namely that more attention has been given to the Demersal category then any other and also that the Pelagic category has been given a greater weighting than the Shellfish category.

The final factor taken into consideration once the ports to be in the sample had been chosen, was when to visit the ports in question? Due to manpower planning all the fieldwork related to this fish handling study had to be undertaken between late June and early November 1985. In deciding the order that the ports would be visited an attempt was made to coincide the visits with a period when the main species of the port was at its peak or at least was being landed.

Table 5 details the seasonal peaks for important species at each of the ports in the sample for Scotland, England and Northern Ireland. A good example of how this information was used can be seen in the timing of the visit to Fraserburgh which took place from 12th-20th August 1985. The visit was organised for these dates in order to insure that SeaFish fish technologists were able to witness Herring landings, this was important as over 40% of Fraserburghs' landings by weight (15% by value) can be attributed to Herring. If the visit had been any later the fish technologists may not have been able to examine any Herring as it can be seen from Table 5A that the

Herring season finishes in early September.

Figure 3 is a histogram showing the distribution of samples taken throughout the period of the survey. This shows that the majority of the temperature and quality measurements were obtained in autumn, when conditions are likely to be less extreme than either summer or winter periods. In that sense the results of the survey may therefore be taken to represent some level around an annual average.

Port and vessel handling practices are heterogeneous, even vessels landing at the same port may vary widely in how they handle the fish whilst at sea. Some ways in which vessel handling practices may differ are immediately obvious even to the 'layman'. The type of vessel and length of voyage are immediate examples (although here the former will more often than not dictate the latter). However less obvious differences in handling practices occur. For example, how is the fish stowed aboard vessels which realise long trip lengths; or in the case of day boats, is the fish left boxed on deck or iced in the hold? The above is not intended as an exhaustive list but emphasises just a few of many different handling practices which can occur at sea.

Handling practices also differ once the fish has been landed at the port(s). For example there are a number of ways in which the fish can be displayed in preparation for sale on the market. A good illustration of this is the container the fish are displayed in, it could generally be a plastic, wooden, or metal fish box, or a metal kit, or no container at all, or etc. Table 7 details the various ways in which fish handling practices can and do differ, for example ten different methods by which fish can be stowed aboard vessels were identified.

Data was collected concerning the species, temperature, and quality of each fish sampled, as well as it's immediate history e.g. source, stowage on ship and the current state of the fish e.g. gutted, boxed etc. Where the fish was iced, the nature and type of ice was noted. Where possible, the fish technologists sampled nine fish from each box; three fish each from the top, middle and bottom. Measurements of the temperature and quality of the fish were taken as soon as possible after landings and the temperature measurements were repeated at intervals until the auction, if possible. Any other changes were also noted e.g. re-icing of fish.

The quality of the fish was measured with reference to the Torry Research Station Quality Index (T.R.S.) or on a "poor" to "excellent" scale which could be converted to the T.R.S. scale. The T.R.S. scale is explained in Appendix 2. An example of the collected data is illustrated in Table 6. This collected data was stored in databases using the computer package "dBase2".

The structure of these databases is shown in Table 7, along with an example of the different attributes of the sample, together with the various possible classifications of each attribute. The temperature for the nine fish sampled are listed with -99 representing any missing observations. These missing observations occur because it was not always possible to sample nine fish or three from the desired box positions, due to various problems including manpower, inaccessibility and size of the fish. Table 8 (which contains the data codes) studied together with the tables contained in Table 7 gives a very clear indication of the structure and content of the data collected.

CHAPTER 2

Information from Repeated Readings.

It was the decided to analyse this collected data using the Statistical Package for Social Scientists (SPSS/PC) in order to achieve the final objective of a prediction of the present level of fish quality and its distribution within the United Kingdom. The repeating of readings after a period of time adds what might be termed a 'third dimension' to the data. Obviously a repeated reading could not be considered to be a separate entity in it's own right as it is not independent of any previous readings, and so it was deemed necessary to remove this ' third dimension ' before the data could be processed using SPSS/PC. Hence a single summary statistic was required to reduce the repeated data on to a single measure.

After consultation with various informed individuals within SeaFish it was decided that a rate of quality deterioration model could most usefully achieve this. After undertaking a literature search the authors discovered the Spencer and Baines linear model relating temperature to the rate of fish spoilage, (see Appendix 3A: extract from "The Effect of Temperature on The Spoilage of Wet Fish."). It is possible to derive from this model an equation relating loss in quality (defined as the fall in the taste panel score) during a time interval for a varying temperature (see Appendix 3B: Spencer's Torry Research Station paper 61/58/2). It was decided that this type of model would be the most appropriate to apply to the problem in question. However a subsequent paper ("Temperature function integration and it's importance in the storage and distribution of flesh foods above the freezing point " by J. Olley and O.A. Ratkowsky) states that:

> *"It appears that c (the temperature coefficent in the Spencer and Baines linear model) is approximately constant at a value of about 0.24, with not too great a standard deviation, at temperatures up to 6°C, but beyond this temperature the value of c increases and becomes more variable."*

This implies that the linearity of the Spencer and Baines model breaks down for temperatures in excess of 6°C. It seems intuitively reasonable that the spoilage rates increase faster at high temperatures than at low temperatures. So it was decided to investigate the fitting of a non-linear model to the data given in the Spencer/Baines paper. This data is displayed in Table 9. The quality observations collected by SeaFish fish technologists are based on the Torry Research Station raw odour and appearance scoring system. Since odour would appear to be the standard measure of quality utilised in the majority of papers, it was thought appropriate to consider only the raw odour spoilage rates (in terms of loss in Taste Panel Units per day) given in the Spencer and Baines paper. It is valid to assume that quality can be determined by raw odour since raw odour is highly correlated to all other measures of quality, e.g. cooked odour and flavour.

A plot of raw odour spoilage rates against temperature was drawn for each of the six batches of fish considered in the Spencer and Baines paper. These plots are illustated in Figure 4. When examined these plots show that at least four batches suggest a non-linear model, hence an exponential model was fitted for all six batches using the linear least squares method with a transformation of log spoilage rate against temperature. It was felt inappropriate at this stage to fit one model to all of the data since the six batches of fish were of different origins, four batches being from Aberdeen and the other two from Hull. Appendix 4 illusrates that the worse fit acheived was one of 80%, whereas four of the models had fits of over 95%. All the models were tested and the hypothesis of no relationship was rejected at at least the 90% significance level for each of the models. A test on the coefficients of the six curves accepted the hypothesis that they could be considered to be coincident. The average of the two coefficients was obtained and this is considered to be a model fitting all six batches of data. It was recognised that this exponential model would give very large spoilage rate estimates for high temperatures but examination of the data suggested that the model need only be accurate for temperatures of up to 20°C and it was felt that this accuracy had been achieved. Appendix 5-1 shows by analysis of variance that the hypothesis of no regression is rejected at the 99.9% level of significance and further shows that a goodness of fit of 90% was also achieved. Having obtained an exponential model relating rate of spoilage (as denoted by raw odour) to temperature, it was decided that because this model was based on data obtained under ideal conditions, it could not be used in its present form on SeaFish port quality data.

A more realistic set of spoilage rate data was obtained from SeaFish Internal Report number 1175 by A. Mills, a fish technologist at SeaFish. This data is contained in Table 10. This data set was plotted against the estimated spoilage rates found by using the authors' own exponential model for equivalent temperatures. This plot, displayed in Figure 5, revealed a linear trend and using the least squares regression procedure a linear model relating the two was obtained. Appendix 5-2 shows that the hypothesis of no relationship was rejected at the 99.9% level of significance and further that a goodness of fit of 93% was achieved. When the linear and exponential models are combined the result is a model that can calculate realistic spoilage rates for given temperatures below 20°C.

Figure 6 and Table 11 detail the exponential spoilage rate model and the linear spoilage rate model plotted for temperatures in the range 0 to 15°C. These show that the authors' exponential model follows the linear model of Spencer and Baines (as amended by A. Mills in the light of experience) closely for temperatures between 3°C and 9°C but for temperatures in excess of 9°C the loss in taste panel units increases faster than for the linear model. This is what one would expect intuitively.

The spoilage rates obtained by this model are for constant temperatures. In the real world however temperature will fluctuate erratically with respect to time and hence it is necessary to incorporate a feature into the model which relates changes in temperature to time. Further it was considered valid to assume that fish obey 'Newtons Law Of Cooling' and hence it was decided that a good model relating fish temperature to time could be obtained from :

$$d\emptyset/dt = -K(\emptyset - \emptyset_T)$$

where : $d\emptyset/dt$= rate of change of temperature with time

K = constant

$\emptyset$ = temperature of the fish

$\emptyset_T$ = 'target' temperature

When the fish had been iced the 'target' temperature ($\emptyset_T$) was considered to be 0°C and when the fish had not been iced the 'target' temperature was considered to be the ambient temperature.

The ambient temperature is defined as:

"The air temperature at a position close to the sample (i.e. within two metres) at approximately one and a half metres above the floor."

Obviously the ambient temperature changes over time so it proved necessary to express the ambient temperature in terms of time. In order to accomplish this a model depicting ambient temperature had to be formed.

A major problem in attempting to model ambient temperature was caused by a behavioural aspect of ambient temperature in that it fluctuates up and down rather than being a monotonic increasing or decreasing function. So what are the factors that lead to this behaviour?

It is immediately clear that a major factor that affects the ambient temperature within a market hall is the size, design and the construction materials of the market hall itself. Fish technologists at SeaFish are currently undertaking research with respect to this factor. A second and far less obvious factor affecting ambient temperature is the quantity of fish in the market coupled with the initial temperature of the fish. Obviously the ambient temperature in a market hall which is full of iced fish will *ceteris paribus* be less than the ambient temperature in a market hall which contains a little un-iced fish. A final variable which plays a role in determining the ambient temperature of the market hall is the temperature outside the market place itself.

However due to lack of accurate and quantifiable data it was not possible to develop a model using these variables, even though it is known that these variables affect the ambient temperature within the market hall. The only ambient temperature data available were a few measurements at discrete intervals over a relatively short period of time which meant that it was impossible to model ambient temperature accurately. The authors consider that it is worthwhile to note that current projects being undertaken by SeaFish fish technologists do to some extent consider the factors outlined above.

Consequently it was decided to fit a simple linear 'model' to the ambient temperature data previously obtained i.e. a model of the form :

$$\text{Ø}_{amb} = a + bt$$

where : a and b are parameters and t is time.

The differential equation defined by Newtons Law of Cooling is solved in Appendix 6 for the three cases of: iced fish; un-iced fish with the ambient temperature given by the linear model described above; and un-iced fish with ambient temperature given by the observed average ambient temperature. These three solutions (equations [1a] [1b] and [2] in Appendix 6) give the fish temperatures in terms of a function of elapsed time. It can be noted from these equations that since the relationship between ambient temperature and elapsed time has already been evaluated, the only unknown elements remaining in the two equations are the parameters 'Ø_0' and 'k'. The parameter θ_0 is defined to be the initial temperature reading. This means that 'k' is the only remaining unknown and this can be estimated by fitting a logarithmic model to the temperature and time data.

Also shown in Appendix 6 are the quality loss equations for the iced and un-iced cases. These are based on Spencer's equation as shown in Appendix 3.

These equations can be used to evaluate the quality loss over a period of time for fish that have had their temperature taken at least twice. While the integral for the iced case and the un-iced case using average ambient temperature can be explicitly solved (equations 3b and 3c), it is more feasible to use equation 3a and solve the integral numerically. Equation 4 (the un-iced case with the linear model used for ambient temperature) cannot be solved so numerical analysis must be used.

While it was recognised that a linear model for ambient temperature was generally a more realistic representation than merely considering the average of all times, the question of how beneficial the application of this model was, remained. In order to tackle this problem two sets of data concerning Grimsby landings of Cod and Halibut respectively were analysed to find the difference of the loss in quality using the different models. This analysis is contained in Appendix 7.

Example 1 in Appendix 7 (Cod data from Grimsby) shows that only a 0.1% increase in the loss of T.P.U. is estimated using the more realistic function for ambient temperature, although it should be noted that for this ambient temperature data, the fit of the linear model was only 40%. However the linear model in example 2 acheives a fit of 98% with only a 2.5% increase in the loss of T.P.U. compared with using the average ambient temperature.

This evidence leads to the conclusion that even if a significant linear trend exists for the ambient temperature data there is very little difference in the resulting estimate of quality loss compared with employing the average ambient temperature as an estimator for ambient temperature at any given time. The insignificance of this difference is further highlighted if the quality loss is considered as a percentage of the initial quality. An illustration of this can be found in Example 1 where quality losses of 0.2683 T.P.U. and 0.2686 T.P.U over nearly ten hours is only 3.3% of the initial quality of 8.1667 T.P.U.

In the light of this evidence the linear model ($Ø_{amb}$ = a+bt) was rejected and because of the short time intervals involved the average ambient temperature was considered to be a good estimator of ambient temperature at all times.

Example 1 shows further the inaccuracies of repeated quality measurements over short periods of time. These calculations demonstrate a fall in quality of aproximately 3% in a timespan of ten hours. The quality measurements were repeated after five hours and it was found that the average quality had fallen by approximately 2.25 T.P.U. from 8.1667 T.P.U. to 5.9167 T.P.U. The maximum temperature acheived by any one fish was 8.7°C, the authors own exponential model of the rate of spoilage of fish (Figure 5) suggests a spoilage rate of 1.22 T.P.U. per day or 0.26 T.P.U. in an equivalent five hour period at a constant temperature of 9°C.

It is suggested that the reasons for these inaccuracies in the re-measurement of quality are a combination of the subjective desires of the fish technologists to record a fall in quality between readings and the inflexibility of a ten point scale which has half point increments.

CHAPTER 3

The Effects of Handling Practices on Fish Quality and Temperature

The data collected had been allocated to twenty-four separate databases mounted on the Sirius computer using the software package dBase2. It was desired to analyse this collected data using SPSS/PC but this was not possible on the Sirius as SPSS/PC is only available for IBM compatible machines. It was thus necessary to transfer these twenty-four separate databases to a machine which could operate the SPSS/PC package.

SeaFish were fully aware of this problem and in order to assist the project ordered at very short notice a Victor Vi computer. The Victor Vi is a machine which has the ability to operate as a Sirius (enabling dBase 2 to be used) or as an IBM (enabling SPSS/PC to be used). Unfortunately, although the Victor machine arrived within a very short time of it being ordered, it failed to perform as specified, the consequence being that the authors had to use the IBM computer already owned by SeaFish, and transfer the files from the Sirius to the IBM, using the Victor as an intermediary.

The alphabetical data codes given to the majority of the fields of the databases under dBase2 were unsuitable for SPSS/PC and these had to be re-coded and given numeric values. The twenty-four databases were then transferred to the IBM as separate data files and then amalgamated into a large text file prior to SPSS/PC analysis. This transfer of the data from twenty-four separate databases on the Sirius to one large text file on the IBM took approximately ten working days. This was because programs had to be written in dBase2 to extract the required data and also because these programs required considerable running time. Further time consuming problems arose when data errors were encountered, for example a port code which should have read LI, representing Lochinver, was found to read 88. Faults in the data such as these took a long time to find, as they were created when the collected data was punched into each database. It was not until every data error discovered had been eliminated that the statistical analysis could begin.

After detailed discussions with SeaFish staff the development of five statistical models was envisaged. It was decided that a model detailing the factors which accounted for the quality of the fish (judged on the Torry Scale) as first seen, and a model explaining the variables which affect the quality of the fish at the time of auction would prove to be useful tools. Also, it was thought that a model depicting the within sample standard deviation of the fish quality at auction time (i.e. the quality variation inside a box of fish) would compliment the previous two models very well.

It was a further decision that similar models to the above could be developed for temperature, namely: the temperature of the fish when first examined during the survey, the temperature of the fish at the time of auction, and finally the within sample standard deviation of the temperature of the fish when first examined by the fish technologists (this latter model was subsequently discarded). It should be noted that the models for quality and temperature at time of auction are based on the quality and temperature change models developed in Chapter 2, with the coefficients being obtained from those samples with repeated information. This represents maximum exploitation of the data collected.

These statistical models were developed using the statistical method of analysis of variance (ANOVA). This procedure details how much of the variance in the variable of interest (the dependent or criterion variable, e.g. the quality of the fish when first seen) is explained by the quantifiable factors which may be included in the model. This methodology however requires large amounts of computer memory and because of this the data had to be re-coded again with the aim being to reduce the number of categories to be analysed and hence computer memory requirements.

It was thus necessary to attempt to collect together different values of attributes which were within the same group. This final re-coding is displayed in Table 12, and an example of how the data was reduced when re-coded is that of the collected data regarding species. It can be seen from Table 8 that originally there were twenty-one different attributes within the variable Species. This required too much computer memory when it was included in the analysis and as a consequence the number of categories had to be reduced. Due to the very large number of obsevations concerning Cod and Haddock it was immediately decided that that these two attributes could remain in their prior coded state, that is codes of: Cod = 1 and Haddock = 2. It was then decided to re-code the remaining species into one of four groups according to their species category. Shellfish were given a code of 3, Pelagic fish were allocated a code of 4, and a code of 5 was allocated to the round Demersal fish, whilst the remaining flat Demersal fish were given a code of 6. This method of re-coding which brought together what were thought to be similar attributes was applied to all the other variables contained in Table 8. Obviously certain characteristics of the data were lost and sometimes *ad hoc* methods were used to decide which attributes could be grouped with each other.

One such example of this *ad hoc* grouping can be illustrated with reference to the recoding of the Species attributes. In the original alphabetical coding there is a species attribute 'Mixed', when re-coded it was assumed that this attribute would have mainly consisted of round Demersal fish and, as such, was given a code of 5.

Although certain data characteristics were lost in the data re-coding there were also potential benefits. If possible the attributes which had been observed only a few times were grouped with attributes similar to themselves, and this hopefully means that any statistical analysis applied to these attributes would be less subjective than any analysis applied before the re-grouping.

The statistical analysis was then undertaken and the ANOVA models developed. The results of these models are displayed in Table13.

Table 13A contains the results of the analysis of variance for the within sample average quality of the fish when first seen by the fish technologists. In order to interpret the results, it is necessary to have some understanding of the ANOVA procedure. The ten variables (factors), Port through to Measurement Position were each examined individually (a oneway ANOVA) to discover their relationship with the criterion variable named Torry (the average fish quality as first seen). The ANOVA procedure reveals if the relationship is statistically significant or not, this information is contained in the relevant Appendices. The strength, as opposed to the existence, of the relationship is measured by R^2, which is the proportion of the variance in the criterion variable explained by a knowledge of the corresponding independent variable(s). The factor with the largest R^2 (denoted by *) has been taken into the predictive model and a two way ANOVA performed with the remaining nine variables. A similar procedure was followed for three way, four way and five way analysis of variance, as shown in Table 13A. It should be noted that although often significant, in a statistical sense, interactions between factors were discovered; they were, without exception, of very low explanatory power (increase in R^2).

For example it can be seen in Table 13A that for the one way ANOVA for Torry, all the factors are statistically significant and further that the variable Port had the highest explanatory power and was thus selected as the basis for a two way ANOVA. Further it can be seen that the variables Ice, Presentation, Fishroom and Protection become statistically insignificant in the fourway ANOVA. It is worthy of note that the effect of each factor diminishes as the next factor to be added to the model is considered. Finally it can be seen that the factors Port, Source, Stowage, Species and Container constitute the model derived for Torry. A similar method of analysis was applied to the four remaining models as contained in Tables 13B to 13E.

In the model of the within sample standard deviation of fish quality as first seen, it proved advisable to include a covariate in the statistical analysis. The term covariate is used to designate a metric independent variable (i.e. a factor measurable on a continuous scale) and is included in the model to remove additional variation from the dependent variable, that is increasing the predictive precision of the model derived.

The covariate used in the model of the within sample standard deviation of quality of fish first seen was :

$$Mtorry = Torry*(10-Torry)$$

where Torry is the average quality score given to the fish when first seen. This covariate was used because it was thought that high average quality suggested low dispersion while medium average quality suggested high dispersion, and that this would result in a certain amount of variation in dispersion which arose purely due to the general level of quality. By definition all dispersion measures are zero when average quality is zero or ten. This is simply because average quality cannot, by definition, be less than zero or greater than ten.

The covariate used in an attempted model of the within sample standard deviation of fish temperature first seen was :

$$Mtemp = Tav*(Tmax-Tav)$$

where 'Tav' was the average temperature of the fish first seen and 'Tmax' was the maximum temperature of any one fish in the sample. This covariate was used because it was believed that a similar relationship to that described above also existed between average temperature and dispersion of temperature. However it was subsequently realised that Mtemp was in itself a (rather unusual) measure of dispersion and thus by definition would be highly correlated with the within sample standard deviation. Thus the analysis of variance model derived for temperature dispersion on this basis has been discarded.

The Multiple Classification Analysis (MCA) option within the ANOVA facility of SPSS/PC was also utilised. As explained previously the usual ANOVA table provides only the statistics necessary for significance (hypothesis) testing, however this is not sufficient. For example, the fact that the Port effect in the ANOVA in Table 13A is significant merely indicates that the mean of one port is different from the grand mean, after appropriate adjustments have been made. It is also important to examine the pattern of the relationship of the criterion variable to each category of the factor Port.

The MCA table is to be considered as a method of displaying the results of analysis of variance when there are no important interaction effects. It is particularly useful when the factors examined are attributes which are not experimentally manipulated and therefore may well be correlated. Given two or more interrelated factors, it is valuable to know the net effect of each variable when the differences in the other factors are accounted for.

The results from the MCA for the five models are displayed in Table 14. An illustration of how the the tables of output are interpreted follows. The numbers opposite each category of the factors shown is the mean of the dependent variable expressed as a deviation from the grand mean. Hence in order to predict the effect of specific combinations of attributes, the numbers corresponding to the relevant categories should be added to the grand mean shown.

For example the MCA breakdown contained in Table 14B for the model for the average quality at the time of auction shows that fish landed in Northern Ireland boasts the highest average quality thus defined. This is almost certainly attributable to the very short trip lengths at the Irish ports. At the opposite end of the scale the average quality of the fish landed at Grimsby is of very low quality being almost one and a half Torry units below the grand mean. Once again it is very probable that this is due to the long trip lengths undertaken by Grimsby vessels, because even though the fish is handled well on board this cannot compensate for the quality which is inevitably lost during the period of the voyage.

It can also be seen from this MCA model that wooden boxes appear to maintain the quality of fish better than plastic boxes. This is counter to evidence derived in extensive trials by SeaFish fish technologists which is leading to wooden boxes being phased out. This apparent anomaly may be explained by the suggestion that the fish in plastic boxes, from which the temperature/quality readings were taken, were originally in wooden boxes, and the transfer from wooden to plastic box took place when the fish was landed ready for market.

An examination of the model for the within sample average fish temperature as first seen presented in Table 14D provides a further example of the analysis of MCA output. A breakdown of the effects of the various levels of the factors Port, Stowage, Source, Fishroom and Icing is shown. For example it is clearly illustrated by the Port effect that fish landed in Northern Ireland can be expected to be at least 2°C warmer than fish landed at any other port in the UK. This can be possibly attributed to the auctions in Northern Ireland being held in mid-afternoon and hence the ambient conditions can be expected to be considerably warmer than if the auctions were held around the dawn hours as is the usual procedure at most ports.

The low temperature of the Ullapool fish (two and a half degrees below the grand mean) can almost certainly be attributed to the fact that Ullapool fish is rapidly trans-shipped to Klondykers and so has very little time to increase in temperature in a fashion similar to fish at other ports, which may remain on the market for considerable lengths of time.

The breakdown of the source of fish reveals that fish which have travelled in insulated or refrigerated vans tend, as one would expect, to be very cool. Initially it would appear counter-intuitive that fish which has travelled on open vehicles (e.g. flatbed lorries) would also be very cool but this may occur due to the journeys being of very short distances or time periods, or that additional ice is provided to counter the effects of the journey. A further explanation could be that the fish is very cool when the overland journey is begun.

It can also be seen from the MCA output displayed in Table 14D that the most efficient type of fishroom is of the chilled variety which results in the average fish temperature being 3°C less than fish which is not kept in any type of fishroom and 1.5°C less than fish kept in a non-insulated room.

The analysis of Stowage displays the merits of the different icing methods. It can be seen that boxing with ice keeps the fish approximately 4°C cooler than the best un-iced method of stowage. It is worthy of note that shelving with ice appears to be the optimal method of stowage from a temperature viewpoint. The MCA table also shows that sea water icing is more efficient than fresh water icing, but it must be bourne in mind that this method is used solely in Northern Ireland. Finally it would appear that there is no real advantage apparent between the different methods of fresh water icing.

The three remaining models (Tables 14A, 14C and 14E) should be interpreted in a manner similar to that employed for the two models described in detail above. However an expert in fish technology with a greater knowledge of the fishing industry, the UK ports and their respective handling practices coupled with *a priori* expectations about the possible results, is in a superior position to draw conclusions from the statistical analysis and the respective tables of output than are the authors, whose comments above are to be taken as suggestions rather than definitive interpretations.

In order to assist in this task two graphs showing temperature and quality at auction were constructed. These graphs appear as Figures 7 and 8 respectively.

Figure 7 shows the mean and between sample standard deviation of quality at auction for the ports in the sample. This shows that fish in Northern Ireland has the highest average quality and also a small standard deviation. This is probably due to the fact that most of the Northern Ireland fleet consists of day boats. Grimsby fish have the lowest average quality at auction and this is once again due to the long trip lengths of Grimsby vessels. The large standard deviation is perhaps due to a mixture of day boats landing good quality fish and longer trip length vessels landing poorer quality fish. It is interesting to note that Grimsby average fish quality is more than one and a half Torry units lower than the next worse case, Lowestoft.

Figure 8 displays the mean and between sample standard deviation of temperature for the ports in the sample. The standard deviation is shown as a range either side of the mean. It is apparent from the Figure 8 that fish at auction in Grimsby are warmer than fish at auction in any other port. This is undoubtedly due to fish being kept without ice on the market floor for long periods before sale. The coolest fish at auction are in Whitby. This is probably due to a combination of short trip lengths, good icing practices, and the fact that Whitby market is quite small and so fish are sold relatively quickly. It should also be noted that the standard deviation of temperature of Whitby fish is small, suggesting consistency of temperature. A large temperature standard deviation, such as at Ayr, is probably due to the fleet being a mixture of day boats and longer trip length boats.

Comparing Figures 7 and 8 it is clear that warm fish at auction does not necessarily mean that the fish are of poor quality. In the case of Northern Ireland the fish at auction are cool and the quality is good, but Scarborough on the other hand has the second warmest fish of any port in the sample, but it's fish is of the second highest quality. This is because the Scarborough fleet consists mainly of day boats but their icing practices are poor which results in high temperatures. However these high temperatures are not sustained for a long enough period to have a significant effect on quality. This emphasises the fact that quality is a function of temperature and time, so relatively high temperatures over a short period will not have a serious effect on quality, except that fish will have to be cooled after auction to allow distribution to the consumer at acceptable quality levels.

CHAPTER 4

The Distribution of Fish Quality Within the United Kingdom

To enable one of the required objectives of the project to be met, that is estimating the current national distribution of fish qualities, it was decided to further consider the 73 ports which realise 95% of the total value of UK landings. The remaining 5% of total value of landings being by numerous small ports which individually are far too insignificant to be considered in detail in the analysis.

Questionnaires regarding these seventy-three ports were distributed both to SeaFish Senior Marine Surveyors, situated throughout the UK and to the IDU fish technologists. The objective was to classify each port with respect to three factors, namely the nature of the fleet, the fleet handling practices and the port handling practices; and a grade of 'good', 'medium' or 'poor' was allocated to each of these factors. The exact format, may be clearly seen in Appendix 8, where a copy of the questionnaire is displayed.

Because the project has been primarily concerned with demersal landings, ports who land similar amounts of Demersal fish (by value of landings) were first allocated to groups. Due to the previous work indicating that the trip length of the vessel was a particularly important factor, this was given priority over the fleet and port handling practices when considering the results of the questionnaire. Thus the ports were arranged within their previously determined size grouping according to the length of the vessels voyage. This procedure was then adopted for the vessel and port handling with vessel practices being given priority over port practices. Employing this methodology enabled non-sampled ports to be grouped along with similar sampled ports. For example the Lancashire port of Fleetwood was considered to be comparable with the North-Eastern port of North Shields in terms of demersal landings, sea trip lengths and the handling practices at sea and at the port.

It is suggested that the distribution of fish quality at comparable ports would be similar. That is the proportion of fish in each quality range (given in Torry units) at say Fleetwood would not be significantly different from the proportion of fish in that range at North Shields for example. Employing this argument for all ports and quality ranges; the proportions of each quality, when multiplied by the total value of Demersal landings, would describe the total value of fish in each of the quality ranges.

The very small ports were grouped together on the assumption that they share similar fish quality distributions to the small ports selected to be in the sample. This assumption would appear to be valid as the landings at small ports are mainly by day boats and further that the Demersal handling practices at these small ports will be very similar.

Northern Ireland, as described in Chapter 1, was considered to be very well represnted by the ports of Ardglass, Kilkeel and Portavogie, which were included in the sample.

The initial step was to estimate the distribution of fish at auction for the sampled ports using the results obtained from the statistical models. The following information was utilised: the average quality of the fish first seen, the average quality of the fish at auction, the standard deviation of quality within samples and the standard deviation of fish quality between samples (see Chapter 3). Note that the standard deviation within samples measures the dispersion of fish in any one box, and the standard deviation between samples measures the dispersion between the box averages for each port.

Mathematical intuition coupled with a knowlege of the sample ports would suggest that the quality distribution function is unimodal and negatively skewed. This suggests a Beta distribution but, as the cumulative distribution function for the Beta distribution cannot be expressed in closed form, a truncated Logistic distribution was employed instead. By definition all quality measurements must lie between 0 and 10 and as such it was necessary to truncate the logistic distribution at quality scores of 0 and 10. In order to estimate the parameters of the Logistic distribution it is required to calculate the average and the standard deviation of fish quality at auction for each of the ports. The average fish quality at auction was found using the rate of quality loss model which featured in Chapter 2

The standard deviation of fish quality at auction is a combination of the within sample standard deviation (i.e. in box variation) and the between sample standard deviation (i.e. between different boxes at the port) at auction. These two quantities can be calculated using the first seen within sample and across sample deviations coupled with consideration of the fall in quality from the time first seen to auction time.

Appendix 9 contains the mathematical proof which shows that the standard deviation of quality at auction is equal to the square root of the sum of the squares of the average of within sample standard deviations and the between sample standard deviation. That is the variance at auction is equal to the sum of the within sample variance and the between sample variance.

A spreadsheet (Multiplan model) was then utlised to calculate the UK distribution of Demersal fish quality at auction. This spreadsheet is displayed in Table 15, and the formulae employed therein are given in Appendix 10.

The results are summarised in Figure 9, which shows that although most of the fish available at first sale in the UK is of high quality (54.5% over Torry score 8), some (4.4%) is of unacceptable quality (less than Torry score 6), and the remainder (41.1% between 6 and 8) has little reserve for quality degredation through the processing and distribution chain.

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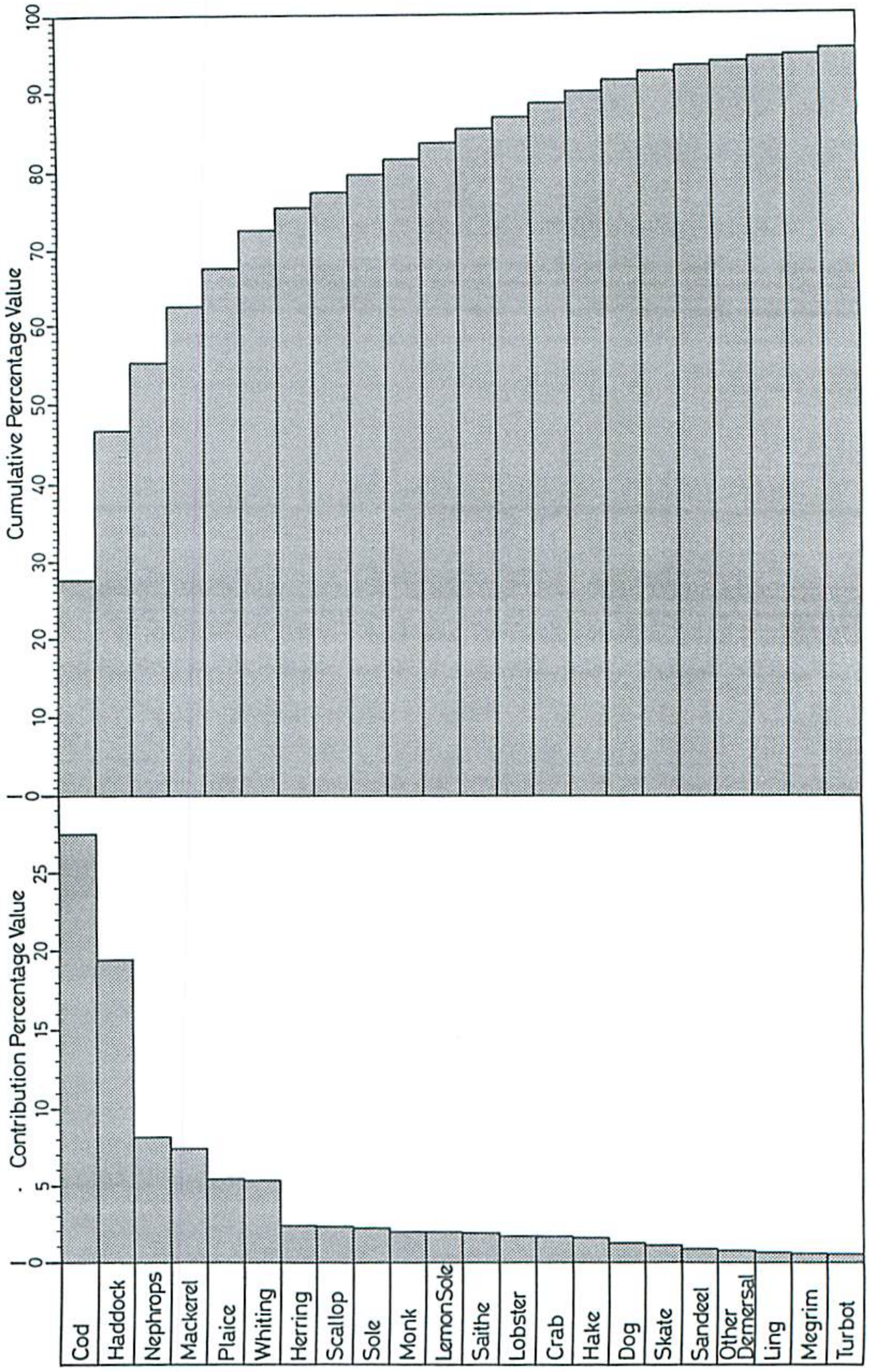
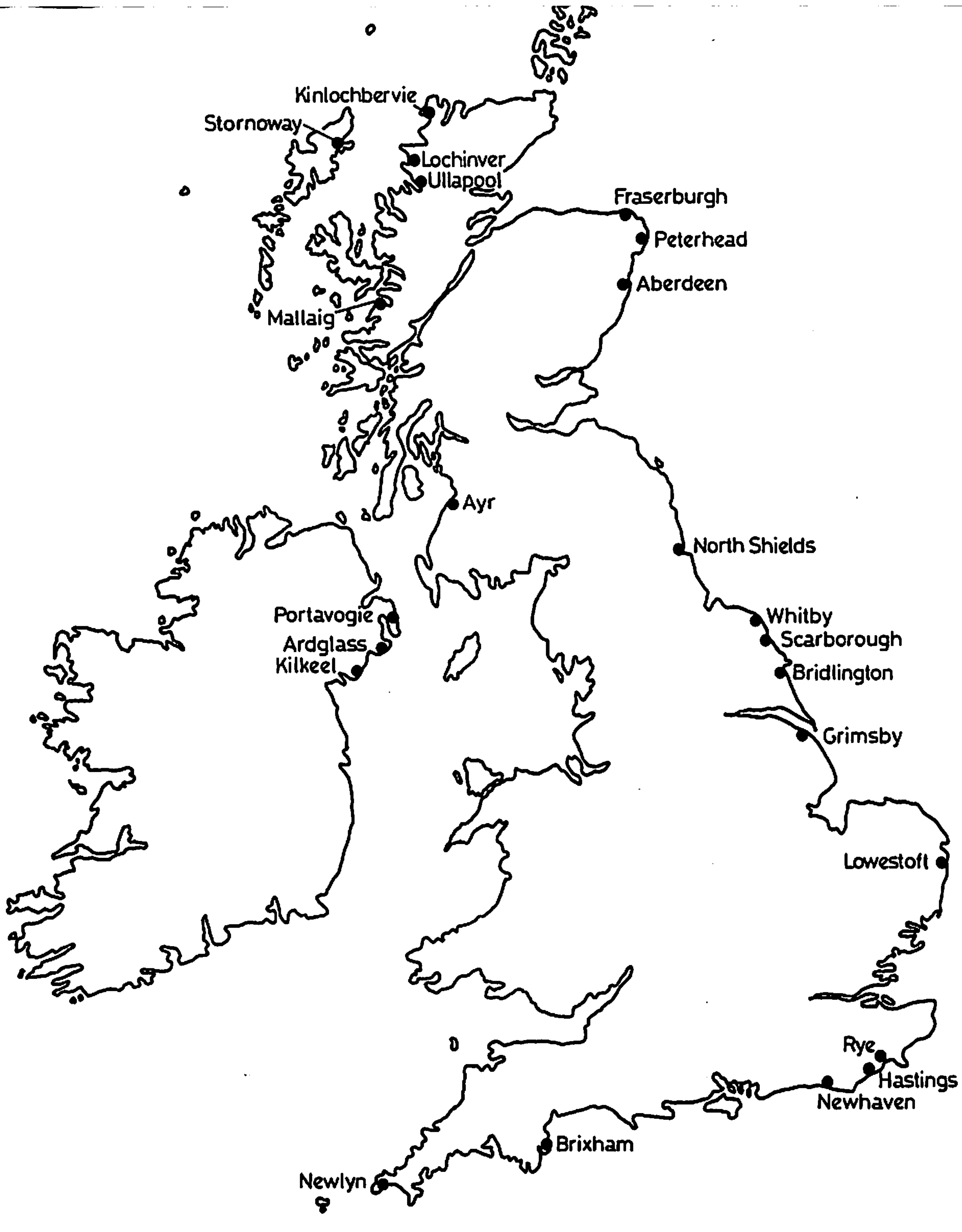
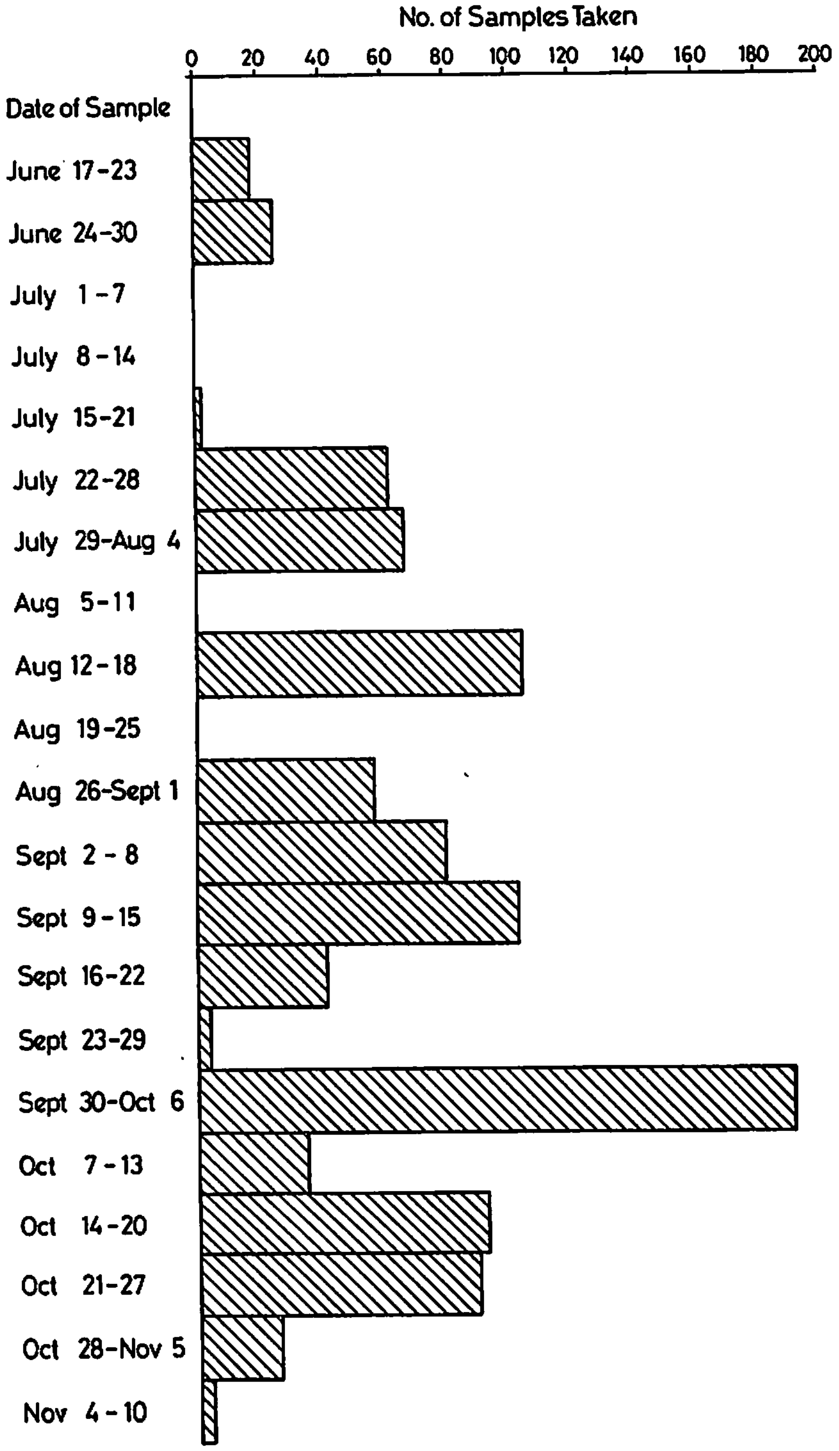


Contribution to the Total Value of Landings (1982) for Each of the Main Fish Species Fig.1

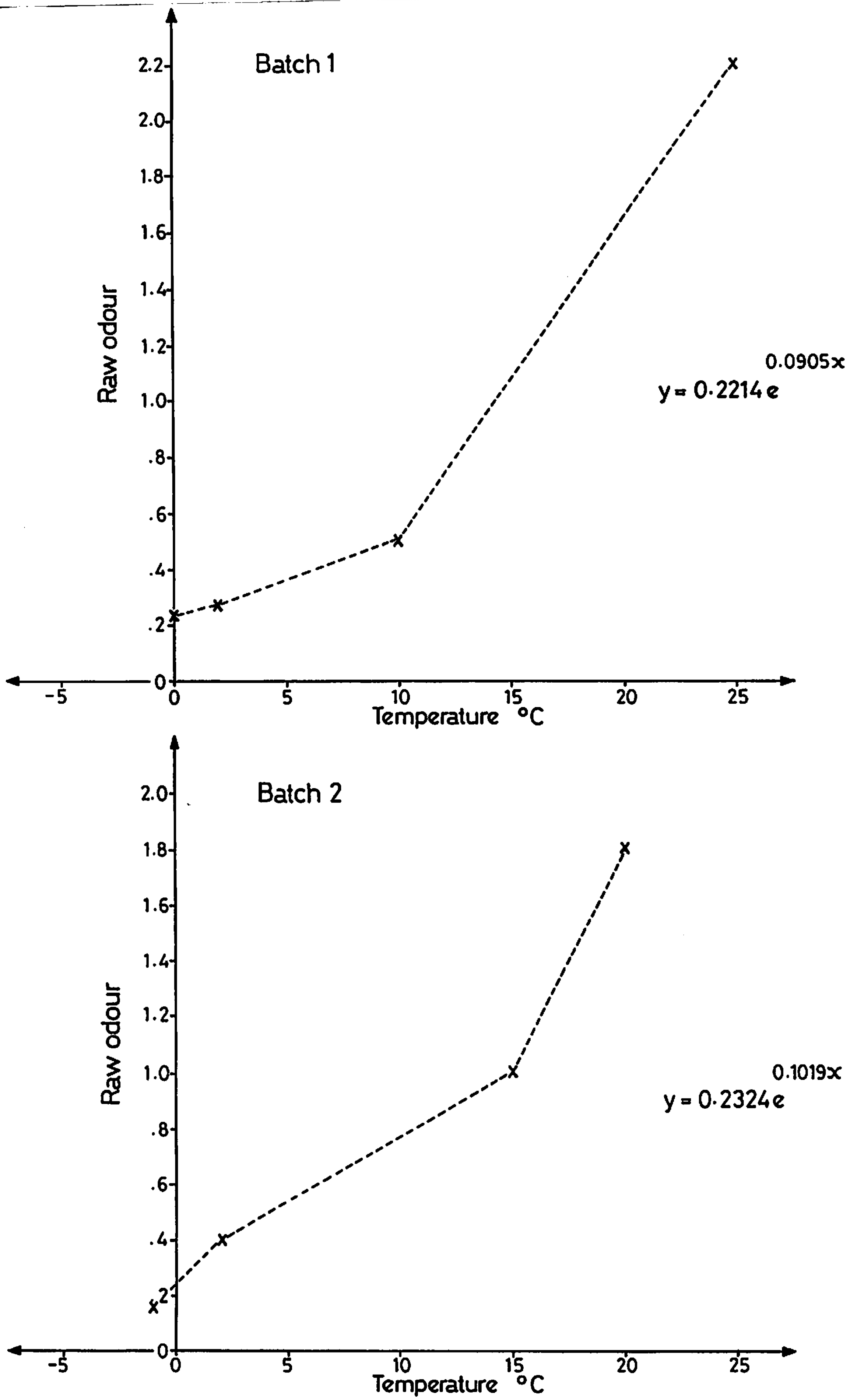


The Geographical Location of the Sampled Ports

Fig. 2



Distribution of Number of Samples Taken During the Survey Fig.3



Plots of the Data from the Spencer and Baines Paper Fig. 4

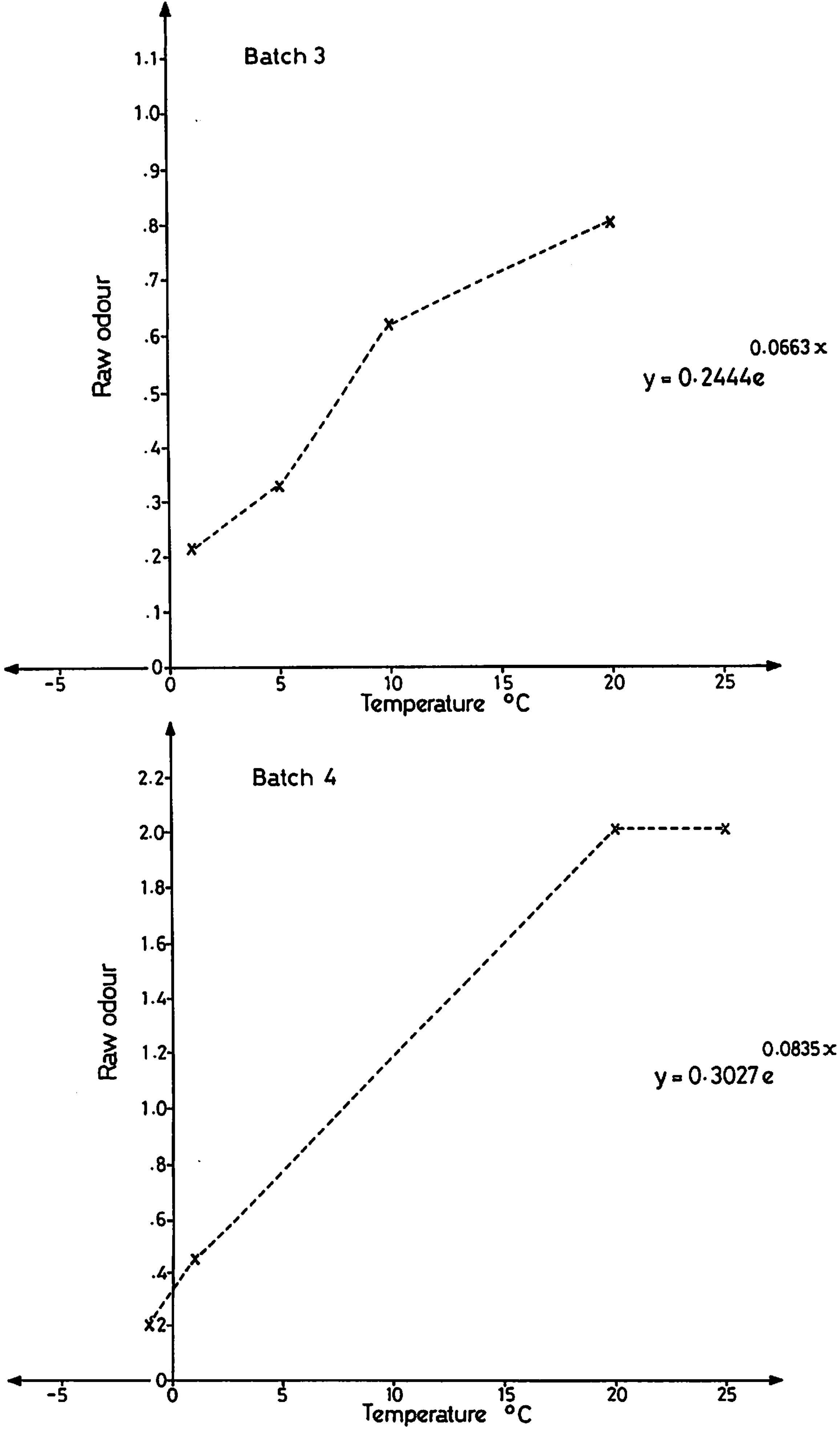
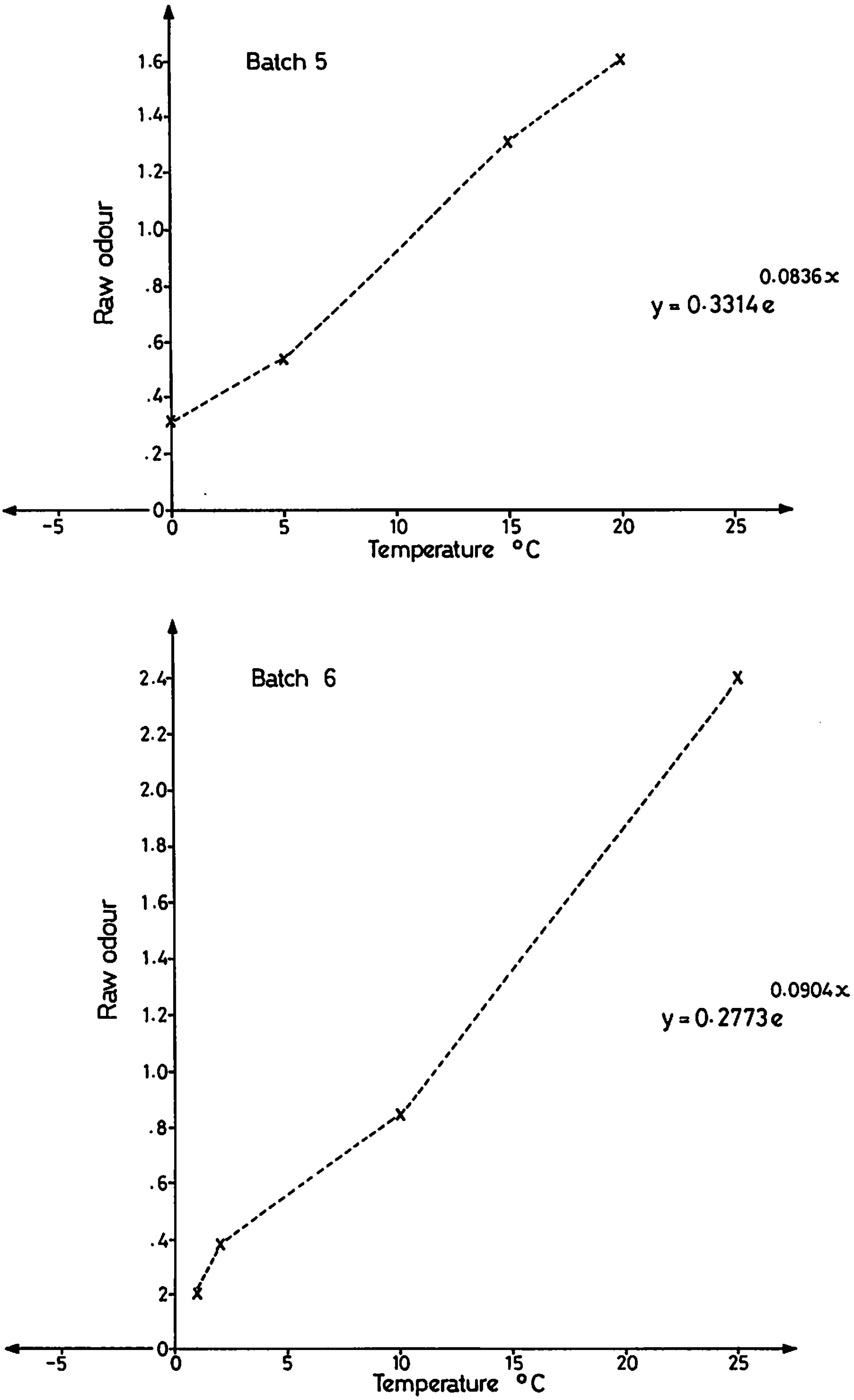

Batch 3
Raw odour
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
-5
0
5
10
15
20
25
Temperature °C
y = 0·2444e 0.0663 x
Batch 4
Raw odour
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
-5
0
5
10
15
20
25
Temperature °C
y = 0·3027e 0.0835 x

Fig. 4a


Batch 5
Raw odour
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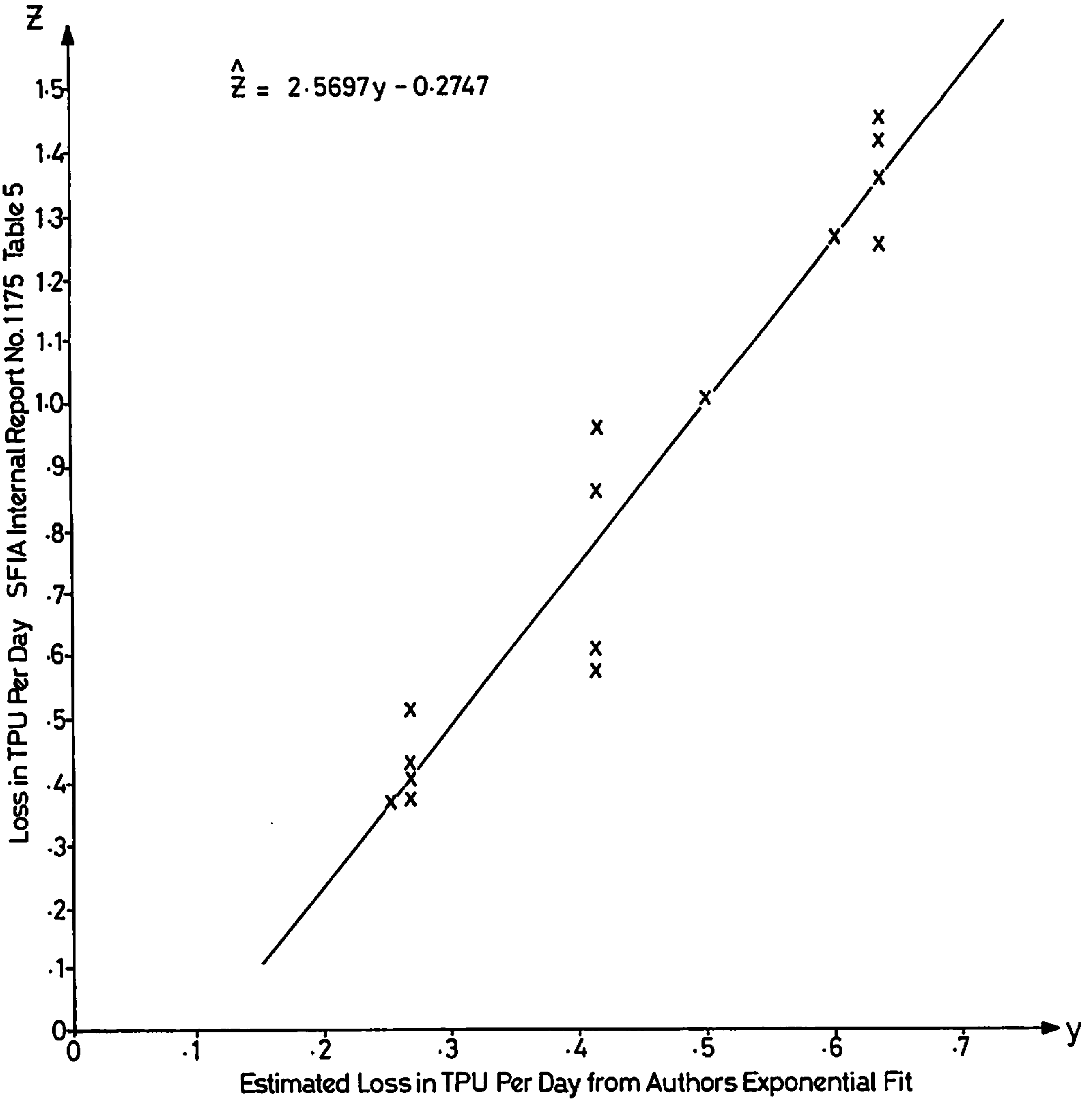
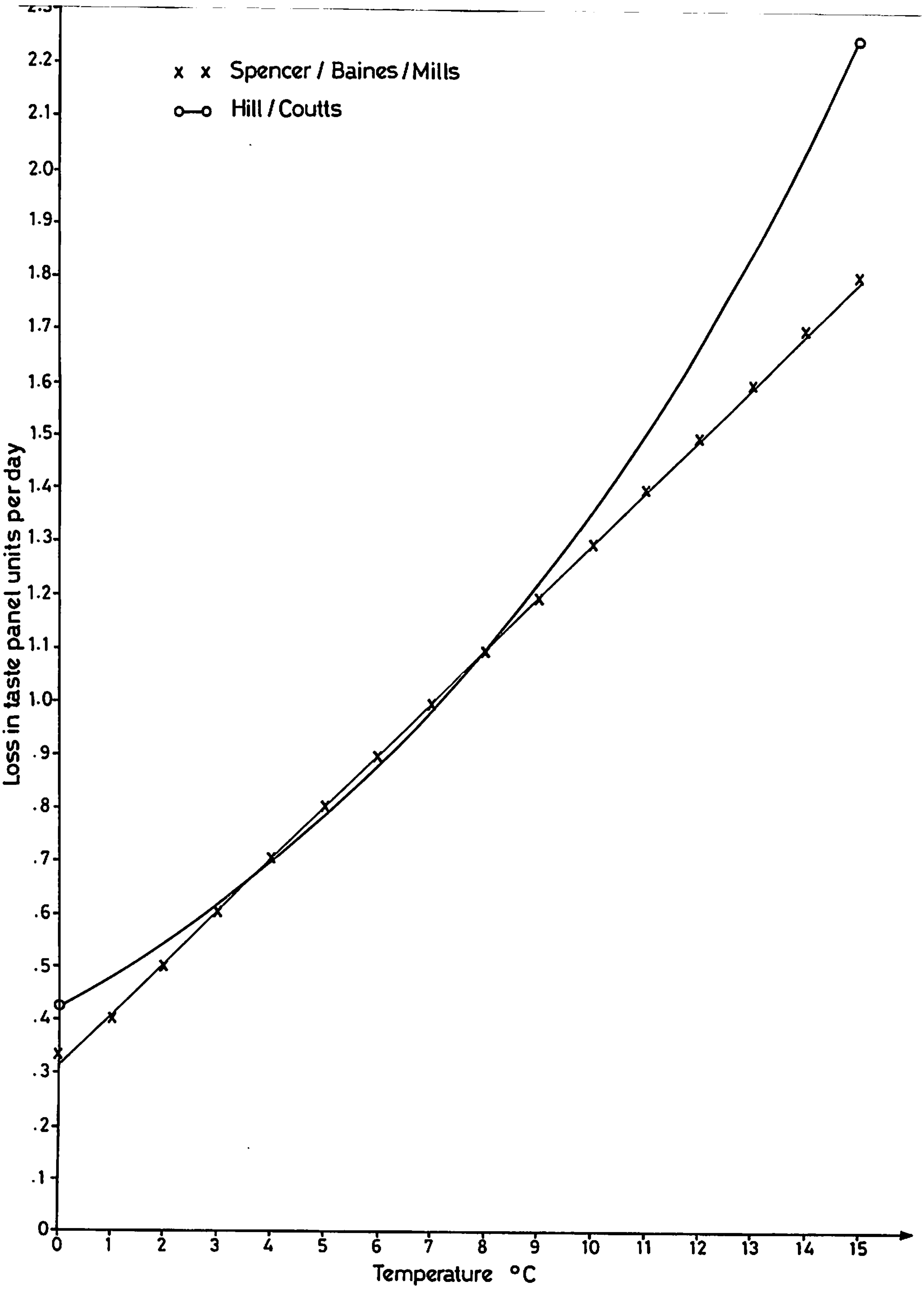
1.4
1.2
1.0
.8
.6
.4
.2
0
-5
0
5
10
15
20
25
Temperature °C
$y = 0.3314e^{0.0836x}$
Batch 6
Raw odour
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
2
0
-5
0
5
10
15
20
25
Temperature °C
$y = 0.2773e^{0.0904x}$

Fig.4b



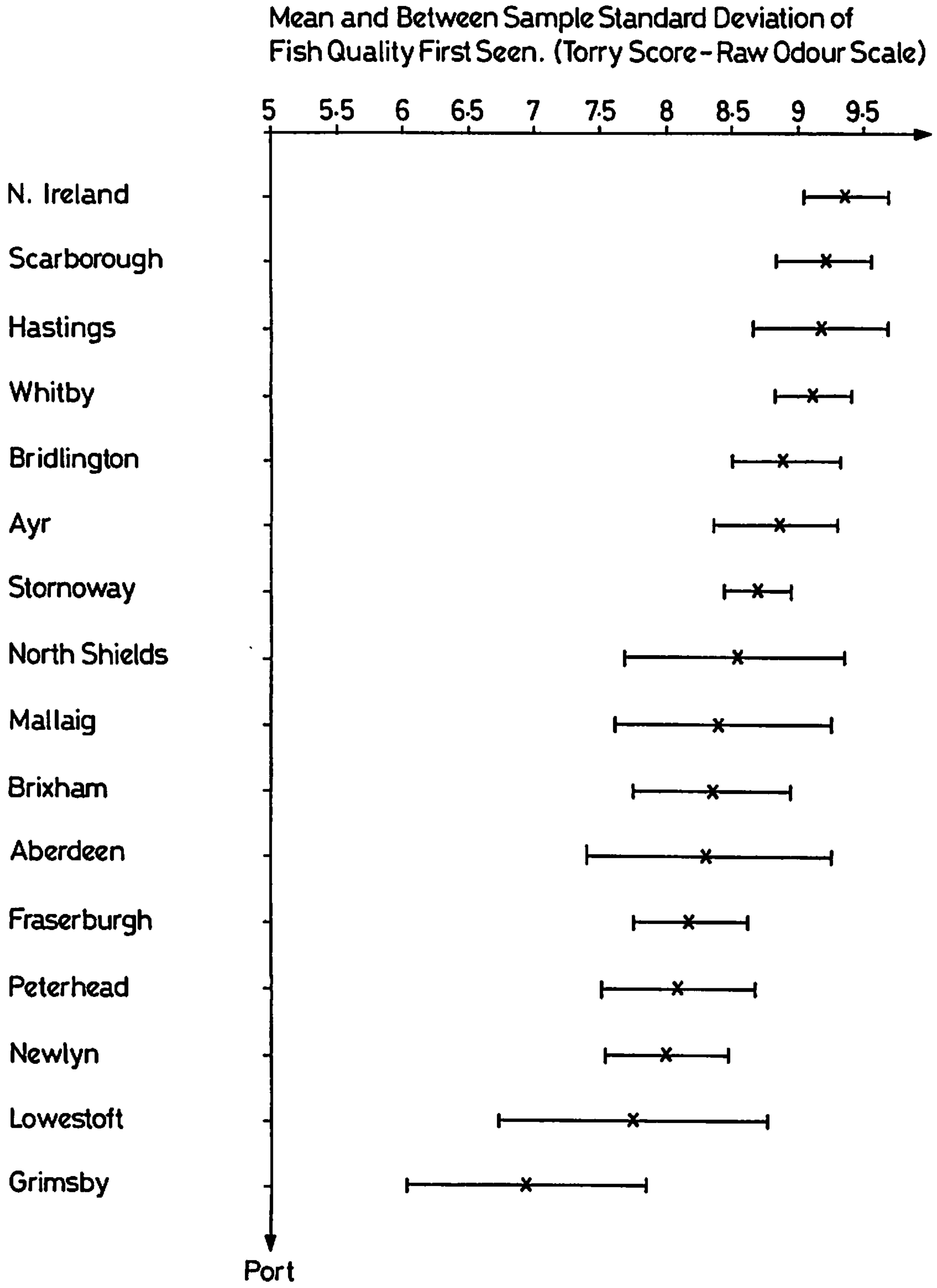
Estimated Spoilage Rates from Authors Exponential Model Plotted Against Practical Spoilage Rates.

Fig. 5



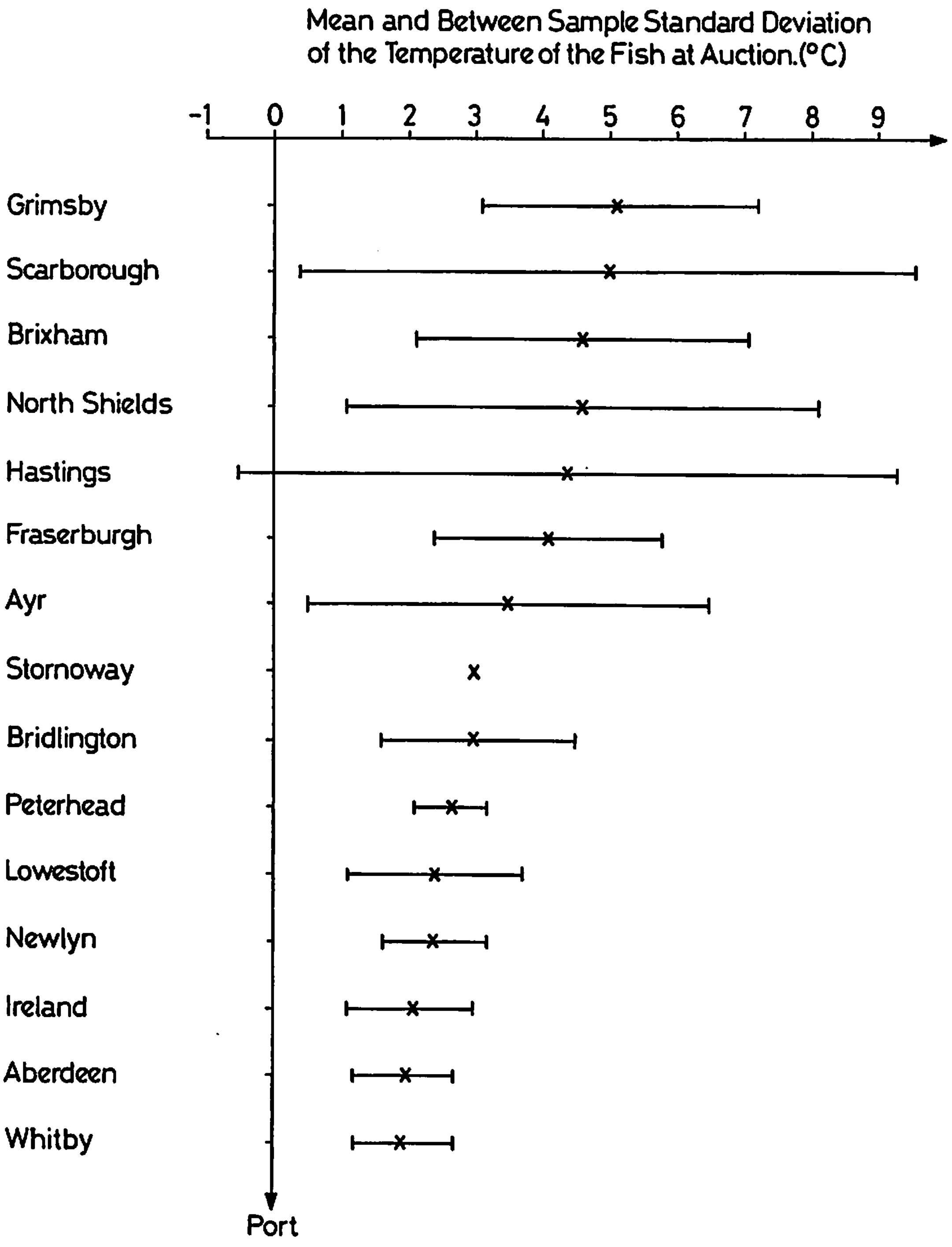
A Comparison of the Authors Model with the
Spencer Baines Model Implemented by A. Mills

Fig.6



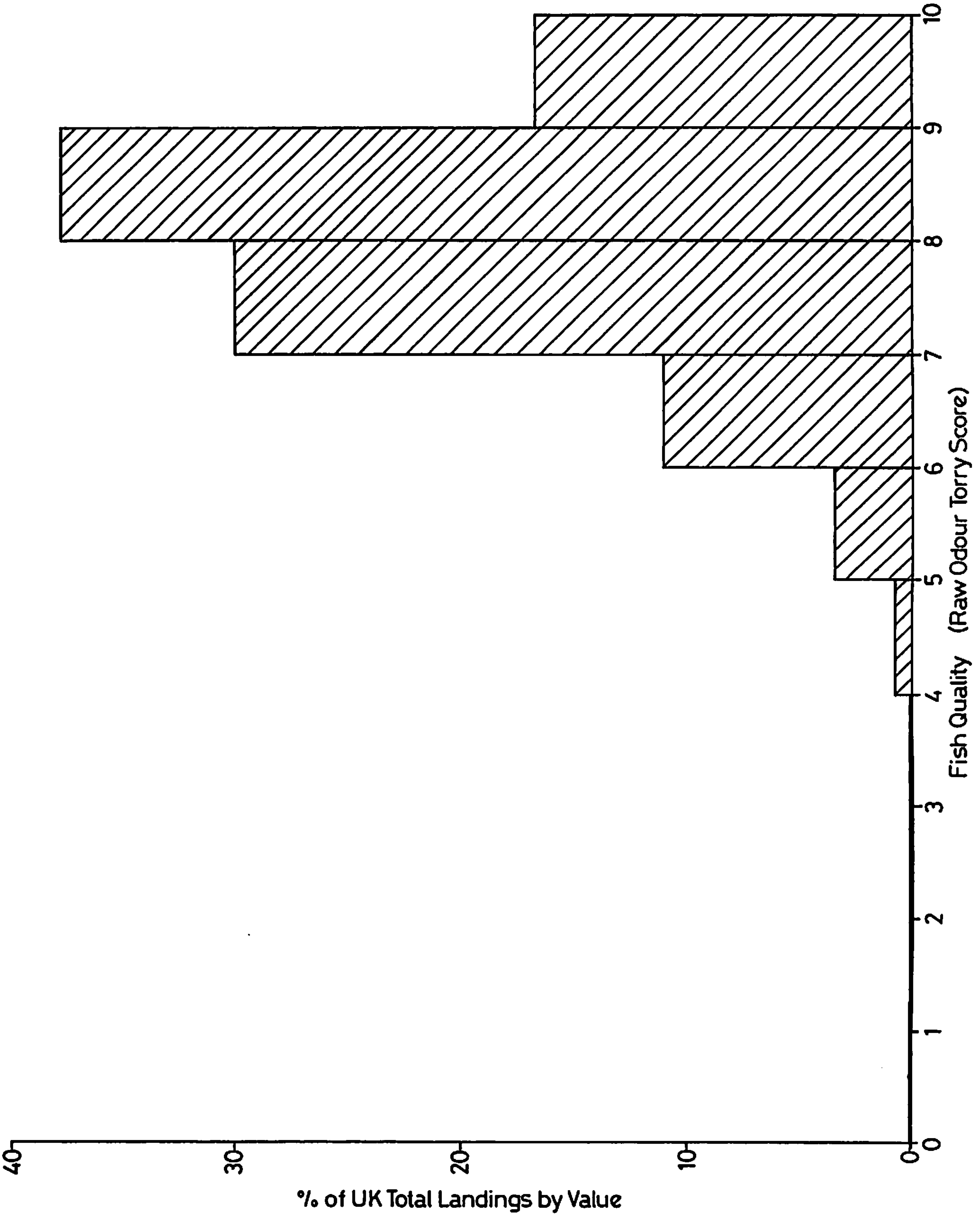
Sampled Fish Qualities at Each Port

Fig. 7



Sampled Fish Temperatures at Each Port

Fig. 8



Estimated Distribution of Fish Quality at First Sale in the UK Fig. 9

TABLE 1

Contribution of Major Fish Species to Total Value of Landings for Great Britain (1982).

Species	**Category**	**Percentage of G.B. landings (by value)**
Cod	Demersal	27.5
Haddock	Demersal	19.4
Nephrops	Shellfish	8.2
Mackerel	Pelagic	7.4
Plaice	Demersal	5.4
Whiting	Demersal	5.2
Herring	Pelagic	2.4
Scallops	Shellfish	2.2
Sole	Demersal	2.0
Monk	Demersal	1.9
Lemon	Demersal	1.9
Saithe	Demersal	1.8
Lobster	Shellfish	1.6
Crab	Shellfish	1.6
Hake	Demersal	1.6
Dog	Demersal	1.2
Skate	Demersal	1.0
		92.3

Note : All of the above species contribute at least one percent to the total value of landings.

TABLE 2

Contribution of Ports to the Value of Total Landings (1982)

Port	**County/Region**	**Contribution (%)**	**Cumulative Total (%)**
* Peterhead	Grampian	17.9	17.9
* Grimsby	Humberside	8.5	26.4
* Aberdeen	Grampian	8.2	34.6
* Ullapool	Highland	6.1	40.7
* Lowestoft	Suffolk	3.8	44.5
* Fraserburgh	Grampian	3.5	48.0
* North Shields	Tyne and Wear	3.0	51.0
Hull	Humberside	2.5	53.5
* Newlyn	Cornwall	2.4	55.9
Fleetwood	Lancashire	2.1	58.0
* Brixham	Devon	1.9	60.0
Eyemouth	Borders	1.9	61.9
* Mallaig	Highland	1.8	63.7
* Kinlochbervie	Highland	1.8	65.5
Falmouth	Cornwall	1.7	67.2
Lerwick	Shetland	1.4	68.6
Plymouth	Devon	1.3	69.6
* Ayr	Strathclyde	1.2	71.1
* Scarborough	N. Yorkshire	1.2	72.3
* Bridlington	Humberside	1.2	73.5
Milford Haven	Dyfed	1.1	74.6
Pittenweem	Fife	1.1	75.7
# Oban	Strathclyde	1.0	76.7
* Whitby	N. Yorkshire	0.9	77.5
* Stornaway	Western Isles	0.9	78.4
Buckie	Grampian	0.8	79.2
Scalloway	Shetland	0.7	79.2

* Indicates that this port is included in the sample

Note : # Oban was visited but due to very bad weather no fish were landed and hence no data collected.

TABLE 3A

Contribution of Ports to the Value of Demersal Landings (1982)

Port	County/Region	Contribution (%)	Cumulative Total(%)
* Peterhead	Grampian	24.0	24.0
* Grimsby	Humberside	11.5	35.5
* Aberdeen	Grampian	11.1	46.6
* Lowestoft	Suffolk	5.1	51.7
* Fraserburgh	Grampian	3.9	55.6
* North Shields	Tyne and Wear	3.5	59.1
Hull	Humberside	3.2	62.3
* Newlyn	Cornwall	2.7	65.0
Fleetwood	Lancashire	2.5	67.5
Eyemouth	Borders	2.5	70.0
* Kinlochbervie	Highland	2.3	72.3
* Brixham	Devon	2.3	72.3
Lerwick	Shetland	1.9	76.5
* Scarborough	N.Yorkshire	1.6	78.1
* Bridlington	Humberside	1.5	79.5
* Whitby	N.Yorkshire	1.1	80.7
Pittenweem	Fife	1.1	81.8
Scalloway	Shetland	1.0	82.8
* Ayr	Strathclyde	0.9	83.7
Plymouth	Devon	0.9	84.6
Milford Haven	Dyfed	0.9	85.5
* Mallaig	Highland	0.7	86.2
# Oban	Strathclyde	0.7	86.9
Seahouses	Northumberland	0.7	87.6
Arbroath	Tayside	0.7	88.2
Macduff	Grampian	0.5	88.7
Scrabster	Highland	0.5	89.3
Whitehills	Grampian	0.5	89.0
Looe	Cornwall	0.5	90.2

* Indicates that this port is included in the sample

Oban was visited but due to very bad weather no fish were landed and hence no data collected.

TABLE 3B

Contribution of Ports to the Value of Pelagic Landings (1982)

Port	County/Region	Contribution (%)	Cumulative Total (%)
* Ullapool	Highland	57.7	57.7
Falmouth	Cornwall	13.2	70.8
Milford Haven	Dyfed	4.6	75.4
* Fraserburgh	Grampian	4.0	79.4
Plymouth	Devon	3.3	82.7
* Ayr	Strathclyde	2.8	85.4
* Stornaway	Western Isles	1.8	87.3
* Newlyn	Cornwall	1.8	89.1
* Mallaig	Highland	1.6	90.7
Tarbet	Strathclyde	1.3	92.0
Hull	Humberside	1.3	93.3
Westbay	Dorset	0.8	94.1
* Brixham	Devon	0.7	94.8
Lymington	Hampshire	0.6	95.4
Torquay	Devon	0.5	96.0
Looe	Cornwall	0.4	96.5
Mevagissy	Cornwall	0.4	96.9
* Kinlochbervie	Highland	0.4	97.3
Colchester	Essex	0.2	97.6
Scabster	Highland	0.2	97.9
Gt. Wakering	Essex	0.2	98.1
* Grimsby	Humberside	0.2	98.3
Polperro	Cornwall	0.2	98.4
Penbirth	Cornwall	0.2	98.6
Boston	Lincolnshire	0.2	98.8
* Lowestoft	Suffolk	0.2	98.9

* Indicates that this port is included in the sample

TABLE 3C

Contribution of Ports to the Value of Shellfish Landings (1982)

Port	County/Region	Contribution (%)	Cumulative Total (%)
* Mallaig	Highland	7.3	7.3
West Loch	Strathclyde	4.0	11.4
* Lochinver	Highland	3.1	14.4
# Oban	Strathclyde	3.0	17.5
Buckie	Grampian	3.0	20.5
Cromer	Norfolk	2.9	23.4
* North Shields	Tyne and Wear	2.6	25.9
* Stornaway	Western Isles	2.5	28.5
Whitehaven	Cumbria	2.5	30.9
Gairloch	Highland	2.4	33.3
Kikudbright	Dumfries	2.0	35.3
Blyth	Northumberland	2.0	37.3
Holyhead	Gwynedd	1.7	40.7
* Hastings	East Sussex	1.7	42.4
Wyke/Regis	Dorset	1.7	44.1
* Ayr	Strathclyde	1.6	44.1
Plymouth	Devon	1.6	47.3
Cambletown	Strathclyde	1.6	48.9
Pittenweem	Fife	1.4	50.3
Amble	Northumberland	1.4	51.6
Tobermory	Strathclyde	1.3	52.9
* Fraserburgh	Grampian	1.3	54.2
Snizort	Highland	1.3	55.5
Fleetwood	Lancashire	1.3	56.8
* Newlyn	Cornwall	1.3	58.1
Port Ellen	Strathclyde	1.2	59.3

* Indicates that this port is included in the sample

\# Oban was visited but due to very bad weather no fish were landed and hence no data collected

<u>Note</u> : Cromer denotes Cromer, B.Wells, Gt. Yar'mth, Sheringham, Winterton and Brantr.

Hastings denotes Hastings, Rye, Eastbourne and Newhaven.

TABLE 4

The Ports in the Sample and their British Ranking (by value) of their Catches (1982).

Port	Country	Total	Demersal	Pelagic	Shellfish
Aberdeen	Scotland	3	3	58	186
Ayr	Scotland	18	19	6	17
Bridlington	England	20	15	77	51
Brixham	England	11	12	13	32
Fraserburgh	Scotland	6	5	4	23
Grimsby	England	2	2	22	216
Hastings	England	29	31	29	15
Kinlochbervie	Scotland	14	11	18	95
Lochinver	Scotland	33	53	*	3
Lowestoft	England	5	4	26	201
Mallaig	Scotland	13	22	9	1
Newlyn	England	9	8	8	26
North Shields	England	7	6	56	7
#Oban	Scotland	23	23	*	4
Peterhead	Scotland	1	1	71	55
Scarborough	England	19	14	92	85
Stornoway	Scotland	25	35	7	8
Ullapool	Scotland	4	*	1	39
Whitby	England	24	16	70	67

Note : Detailed statistics for Northern Ireland are not available.

Hastings denotes Hastings, Rye, Eastbourne, and Newhaven.

* Indicates that the category of fish is not landed here in significant quantities.

\# Oban was visited but due to very bad weather no fish were landed and hence no data collected.

TABLE 5A

The Scottish ports in the Sample and their Main Seasonal Species.

Port	Main Seasonal Species	Season
Aberdeen	Haddock	Jan-mar
	Whiting	Jan-Mar
	Saithe	Jan-Mar
	Cod	Apr-May
Ayr	Cod	Feb-Apr
	Herring	May-Aug
Fraserburgh	Herring	Jun-Sept
Kinlochbervie	Haddock	Jun-Augt
	Whiting	Jun-Augt
	Cod	Jun-Augt
Lochinver	Whitefish	Apr-July
Mallaig	Nephrops	Mar-Sept
Oban	*	*
Peterhead	Haddock	Jul-Oct
	Cod	Apr-July
Stornaway	Herring	Jul-Nov
	Mackerel	Sep-Feb
	Lobster	Aug-Nov
	Nephrops	Jun-Sep
Ullapool	Haddock	Apr-Aug
	Whiting	Apr-Aug
	Cod	Apr-Aug

* Indicates lack of seasonality of species or lack of data

TABLE 5B

The English Ports in the Sample and their Main Seasonal Species

Port	Main Seasonal Species	Season
Bridlington	Whiting	Nov-May
	Cod	May-Sep
Brixham	Monk	Jul-Aug
Grimsby	Haddock	Mar-Jul
	Plaice	Apr-Oct
	Cod	Feb-Apr
Hastings	*	*
Lowestoft	Plaice	Feb-May
Newhaven	*	*
Newlyn	Monk	Mar-Aug
North Shields	Cod	Jul-Sep
Scarborough	Haddock	Aug-Nov
	Cod	August
Whitby	Haddock	Aug- Nov
	Cod	Aug-Nov

* Indicates lack of seasonality of species or lack of data.

TABLE 5C

The Northern Ireland Ports in the Sample and their Main Seasonal Species.

Port	**Main Seasonal Species**	**Season**
Kilkeel	Nephrops	Jun-Aug
	Whiting	Jan-April
	Cod	Feb-Apr
Portavogie	Herring	May-Sep
	Whiting	Sep-Dec
	Dog	Aug-Dec
Ardglass	Herring	Jun-Aug
	Whiting	Sep-Dec

TABLE 6

Summary of Collected Data for Temperature and Quality

```
0: 0 PCE GUT VES BOX UNK WDN NON NON VAN 1/1  13.0 —  0.6 11.1  1.7 10.6 11.4 11.3  ——   —— Q3..........................
0: 0 HLB GUT VES BOX UNK WDN NON NON VAN 1/1  14.0 —  0.2  8.4  0.6  ——   ——   ——   ——   —— 4 SAMPLES ONLY..................
0: 0 HAD GUT RFG BXI UNK WDN PLS TOP HFL 1/1  13.0 —  0.1  0.6  5.2  -.0  1.9  0.0  ——   —— X A TO FR AUCT Q4Q6Q8A 2LBICE l
0: 0 HAD GUT VES BXI UNK WDN PAP TOP HFL 1/1  13.0 —  0.1  -.0  1.0  0.3  -.2  -.1  8.5  1.5 X A TO FR AUCT Q4Q6Q8A 2LBICE l
0: 0 COD GUT RFG BOX UNK WDN NON NON HFL 1/1  13.0 —  0.1  2.4  1.1  2.3  2.7  2.3  9.0  0.0 X A TO FR AUCT Q3 ULD U21......
0: 0 COD GUT RFG BXI UNK WDN PLS TOP HFL 1/1  13.0 —  0.1  -.0  0.6  0.0  -.1  -.1  8.1  1.0 X A TO FR AUCT V.WELL ICED-SLB.
0: 0 HHK GUT VES BXI BAR WDN NON TOP HFL 1/1  14.0 —  0.2  0.0  1.4  ——   ——   —— -1.0  0.0 BF378 U1V1 LN 0000 5LBICE BERT
1:17 HHK GUT VES BXI BAR WDN NON TOP HFL 1/1  13.0 —  0.3  -.3  1.2  ——   ——   ——   ——   —— (18/08/85)....................
0: 0 HHK GUT VES BXI BAR WDN NON TOP HFL 1/1  14.0 —  0.2  1.2  3.2  ——   ——   —— -1.0  0.0 BF 378 U1V1LND 0600 1LBICE BER
1:20 HHK GUT VES BXI BAR WDN NON TOP HFL 1/1  13.0 —  0.3  1.9  3.5  ——   ——   ——   ——   —— (18/08/85)....................
0: 0 HAD WHO VES BXI BAR WDN NON TOP HFL 1/2  14.0 —  0.4  2.2  3.1  1.2  2.3  3.1  7.8  1.0 BF25 U1V1 LND 610 1LB ICE.....
1:15 HAD WHO VES BXI BAR WDN NON TOP HFL 1/2  14.0 —  2.1  3.7  4.7  5.9  2.4  2.8  ——   —— NO ICE LEFT 730...............
```

TABLE 7

Structure of the Databases

```
STRUCTURE FOR FILE:   PTBYQUAL.DBF
NUMBER OF RECORDS:    00261
DATE OF LAST UPDATE:  01/01/80
PRIMARY USE DATABASE
FLD      NAME       TYPE WIDTH   DEC
001      PORT         C    002
002      IDNUM        N    008
003      REPEAT       N    001
004      DDAY         N    002
005      DMON         N    002
006      DYEAR        N    002
007      THOUR        N    002
008      TMIN         N    002
009      DSCRPTN      C    029
010      AMBTEMP      N    005     001
011      HUMID        N    002
012      AIRFLO       N    004     001
013      T1           N    005     001
014      T2           N    005     001
015      T3           N    005     001
016      T4           N    005     001
017      T5           N    005     001
018      T6           N    005     001
019      T7           N    005     001
020      T8           N    005     001
021      T9           N    005     001
022      TEMPCODE     L    001
023      Q1           N    004     001
024      Q2           N    004     001
025      Q3           N    004     001
026      Q4           N    004     001
027      Q5           N    004     001
028      Q6           N    004     001
029      Q7           N    004     001
030      Q8           N    004     001
031      Q9           N    004     001
032      COMMENTS     C    036
** TOTAL **              00180
```

```
. list dscrptn, ambtemp, humid, airflo fot_r £ < 15
00001  CODGUTVESBLKCINPLSNONNONMFL13   16.0  -9  -9.0
00002  CODGUTVESBLKCINPLSNONNONMFL13   14.0  -9  -9.0
00003  CODGUTVESBLKCINPLSNONNONMFL13   12.6  -9  -9.0
00004  CODGUTVESBLKCINPLSNONNONMFL13   11.7  -9  -9.0
00005  CODGUTVESBLKCINPLSNONNONMFL13   12.5  -9  -9.0
00006  CODGUTVESBLKCINPLSNONNONMFL13   12.6  -9  -9.0
00007  CODGUTVESBLKCINPLSNONNONMFL13   16.0  -9  -9.0
00008  HADGUTVESBLKCINPLSNONNONMFL13   15.3  -9  -9.0
00009  HADGUTVESBLKCINPLSNONNONMFL13   14.0  -9  -9.0
00010  HADGUTVESBLKCINPLSNONNONMFL13   12.6  -9  -9.0
00011  HADGUTVESBLKCINPLSNONNONMFL13   11.7  -9  -9.0
00012  HADGUTVESBLKCINPLSNONNONMFL13   12.0  -9  -9.0
00013  HADGUTVESBLKCINPLSNONNONMFL13   13.2  -9  -9.0
00014  PCEGUTCONUNKUNKPLSPAPTOPMFL13   16.3  -9  -9.0
```

TABLE 8

Port Quality Study - Data Codes

Port	
Aberdeen	-A
Ayr	AR
Ardglass	AS
Bridlington	BR
Brixham	BM
Fraserburgh	FR
Grimsby	GY
Hastings	HT
Kilkeel	KL
Kinlochbervie	KB
Loch Inver	LI
Lowestoft	LT
Mallaig	MG
Newhaven	NN
Newlyn	NY
North Shields	SN
Peterhead	PD
Portavogie	PV
Rye	RX
Scarborough	SH
Shoreham	SM
Stornoway	SY
Ullapool	UL
Whitby	WY

Container (as seen)	
Plastic Box	PLS
Wooden Fish Box	WDN
Metal Kit	KIT
Expd. Polystyrene Box	EPX
Metal Fish Box	MET
Wax Cardboard Carton	WAX
Bulk Container	BLK
None (Individual Fish)	NON

Quality Comments	
Overfilled Box	Q1
Crushed Fish	Q2
Poor Gutting	Q3
Good Gutting	Q4
Poor Washing	Q5
Good Washing	Q6
Belly Burst	Q7
Market Grading	Q8
Poor Grading	Q9
No Grading	Q10
Legs Pressent	Q11
Freezing	Q12
Less Ice in Lower Boxes	Q13
Melt Water around Fish	Q14

Quality Scores		
Torry Scores (where defined)		
	from:-	0.5
	to :-	9.5
Otherwise:		
	Excellent	-1
	Good	-1.5
	Medium	-2
	Low	-2.5
	Poor	-3

Species	
Cod	COD
Crab	CRB
Dogfish	DOG
Haddock	HAD
Hallibut	HLB
Hake	HKE
Herring	HRG
Lemon Sole	LEM
Lobster	LOB
Mackerel	MAC
Monk & Angler	MNK
Nephrops	NEP
Plaice	PCE
Saithe (Coley)	STH
Scallops	SCP
Skates & Rays	RAY
Sole (Dover)	SOL
Squid	SQD
Turbot	TUR
Whiting	WHG
Mixed	MIX

Stowage (on Vessel)	
Bulked with Ice	BLK
Bulked No Ice (Industrial)	IND
Shelved with Ice	SVI
Shelved without Ice	SLV
RSW Tanks	RSW
CSW Tanks	CSW
Boxed with Ice	BXI
Boxed without Ice	BOX
On Deck with Ice	DWI
On Deck without Ice	DCK
Unknown	UNK

Box (Container) Icing	
No Ice	NON
F.W. Ice Top only	TOP
F.W. Ice Top & Bottom	TAB
F.W. Ice Mixed	MIX
F.W. Ice Bottom only	BOT
S.W. Ice Top only	SWT
S.W. Ice Top & Bottom	STA
S.W. Ice Mixed	SMI
S.W. Ice Bottom only	SBO

Vessel Type Comments	
Stern Trawler	V1
Side Trawler	V2
Beam Trawler	V3
Seine Netter	V4
Purse Seiner	V5
Liner (Hand or Long)	V6
Gill/Tramel Netter	V7
Wreck Netter	V8
Shellfish (Trawl/Pot)	V9
Pair Trawler	V10

Stack Position - Number of Boxes counting from Top of Stack

Stack Height -Number of Boxes

Presentation	
Whole	WHO
Gutted	GUT
Mixed Whole & Gutted	WTD
Headed	HED
Skinned	SKI
Gutted & Skinned	GAS
Gutted,Skinned&Headed	GSH
Fillets	FIL
Live	LIV
Unshelled	UNS
Shelled	SHD
Tails only	TAO
Wings & Patches	WNG

Source	
Landed ex Fishing Vessel	VES
Ovind- Open Vehicle	OPN
Ovind- Tarpaulin Cover	TRP
Ovind- Non Insulated Van	VAN
Ovind- Insulated Van	INS
Ovind- Refrigerated Van	RFG
Ovind- Non Ref. Container	CON
Ovind- Refrigerated Cont.	CNF

Fishroom	
Insulated	INS
Insulated & Chilled	CIN
Non-Insulated (Bare)	BAR
Non-Insl. but Chilled	CHL
None (Fish on Deck)	NON
Unknown	UNK

Protection (of Container)	
None (No Cover)	NON
Paper Cover Sheet	PAP
Plastic Cover Sheet	PLS
Tarpaulin	TRP

Measurement Position	
Vessel Fish Hold	HLD
On Vessel's Deck	DCK
Before Sorting/Grading	BFS
After Sorting/Grading	ASG
Market Floor	MFL
(Un-)Loading Bay	BAY
On (In) Road Transport	VAN
Chill Room Facility	CRF
In Container	CON
Jetty/Staithe	JTY

Discharge Gang Comments	
Vessel Crew	U1
Casual Labour	U2
Port Labour	U3
Vehicle Driver (& Mate)	U4
Owners Shore Gang	U5

Missing Value Codes	
Humidity, Air Flow	-9
Temperatures.	-99
Qualities	0

Tempcode -True if 9 temperatures taken in ordered groups of 3 at Top, Middle And Bottom of box
-False otherwise

TABLE 9

Individual Spoilage Rates, in Spoilage Units/Day.*

Batch	Temperature	Appearance	Raw odour	Cooked odour	Flavour
1	0	0.22	0.23	0.34	0.29
	2	0.27	0.27	0.43	0.37
	10	0.65	0.50	1.1	0.98
	25	1.7	2.2	2.9	****
2	-1	0.16	0.16	0.17	0.19
	2	0.37	0.40	0.40	0.42
	15	1.2	1.0	2.0	2.3
	20	1.7	1.8	3.4	3.7
3	1	0.23	0.22	0.40	0.39
	5	0.38	0.35	0.62	0.68
	10	0.75	0.63	1.3	1.0
	20	0.80	0.80	2.1	1.7
4	-1	0.22	0.20	0.18	0.17
	1	0.46	0.45	0.33	0.35
	20	2.1	2.0	3.0	3.4
	25	2.3	2.0	3.0	3.3
5	0	0.31	0.31	0.28	0.29
	5	0.45	0.53	0.64	0.66
	15	1.3	1.3	1.6	1.5
	20	1.4	1.6	2.3	2.2
6	1	0.22	0.20	0.18	0.19
	2	0.36	0.38	0.45	0.48
	10	0.81	0.84	0.87	0.94
	25	2.3	2.4	2.0	2.1

*Extract from table 2, "The effect of Temperature on the Spoilage of Wet White fish" by R.Spencer and C.R.Baines

TABLE 10

*Spoilage Rate Data from SeaFish Internal Report Number 1175.

		March	**July**
		Loss in T.P.U. per day	Loss in T.P.U. per day
Raw Odour			
Gutted fish	in Ice	-0.504	-0.412
	at 5°C	-0.957	-0.604
	at 10°C	-1.35	-1.45
Ungutted Fish	in Ice	-0.436	-0.387
	at 5°C	-0.860	-0.587
	at 10°C	-1.42	-1.25

* Extract from Table 5, "A Comparison Of The Storage Properties Of Gutted Versus Ungutted White Fish In Good Intrinsic Condition". SeaFish Internal Report Number 1175.

TABLE 11

Rates of Spoilage per Day at Varying Temperatures for the Authors' Model compared with the linear model of Spencer, Baines and Mills

°C	loss in T.P.U per day*	loss in T.P.U. per day**
0	0.33	0.4147
1	0.40	0.4766
2	0.50	0.5441
3	0.60	0.6177
4	0.70	0.6978
5	0.80	0.7852
6	0.89	0.8803
7	0.99	0.9840
8	1.09	1.0971
9	1.19	1.2203
10	1.29	1.3456
11	1.39	1.5009
12	1.49	1.6609
13	1.59	1.8341
14	1.69	2.0235
15	1.79	2.2299

* Indicates the values suggested by the linear model of Spencer and Baines, as modified by A. Mills.

** Indicates the values suggested by the authors' exponential model.

Note : T.P.U. denotes Taste Panel Units.

TABLE 12

Port Quality Study - Re-coded data

Port	Code
Aberdeen	1
Ayr	2
Kinlochbervie	2
N. Ireland	3
Bridlington	4
Brixham	5
Fraserburgh	6
Grimsby	7
Hastings	8
Newhaven	8
Rye	8
Shoreham	8
Lochinver	9
Mallaig	9
Lowestoft	10
Newlyn	11
North Shields	12
Peterhead	13
Scarborough	14
Stornaway	15
Ullapool	16
Whitby	17

Container	
Plastic Box	1
Wooden Fish Box	2
Polystyrene Box	3
Wax Carton	3
Bulk Container	3
Individual Fish	4

Species	Code
Cod	1
Haddock	2
Shellfish	
Crab	3
Lobster	3
Nephrops	3
Scallops	3
Squid	3
Pelagic	
Herring	4
Mackerel	4
Round Demersal	
Dogfish	5
Hallibut	5
Hake	5
Monk & Angler	5
Saithe	5
Whiting	5
Mixed	5
Flat Demersal	
Lemon Sole	6
Skates & Rays	6
Dover Sole	6
Turbot	6

Stowage	Code
Bulked With Ice	1
Shelved With Ice	2
RSW Tanks	3
Boxed With Ice	4
Boxed No Ice	5
On Deck With Ice	6
On Deck No Ice.	

Icing	
No Ice	1
FW Top Ice	2
FW Ice Top/Botom	3
FW Bottom Only	3
FW Ice MIxed	4
SW Ice Mixed	5
SW Ice Only	6
SW Bottom Only	6

Presentation	
Whole	1
Headed	1
Gutted	2
Whole & Gutted	2
Live	3
Tails Only	4

Protection	
None	1
Paper Sheet	2
Plastic Sheet	3
Tarpaulin	4

Source	**Code**	**Fishroom**	**Code**	**Meas Pos**	**Code**
Fishing Vessel	1	Insulated	1	Fish Hold	1
Open Vehicle	2	Ins. Or Chd.	2	On Deck	2
Tarpaulin Cover	2	Non Insulated	3	Pre Grading	3
Non Insulated Van	3	Non Ins. & Chd.	3	Post Grading	4
Non Ref. Van	3	Non	4	Market Floor	5
Insulated Van	4	Unknown	5	Loading Bay	6
Refrigerated Van	5			On The Road	7
				Chill Room	8
				In Container	9
				Jetty/Staithe	10

TABLE 13A

Analysis of Variance for Within Sample Average Fish Quality as First Seen.

	Oneway	Twoway	Threeway	Fourway	Fiveway
Port	0.493*	****	****	****	****
Species	0.013	0.511	0.550	0.575*	****
Container	0.066	0.514	0.543	0.567	0.584*
Stowage	0.239	0.522	0.556*	****	****
Ice	0.026	0.505	0.538	0.562✱	0.580✱
Pres	0.025	0.493	0.530	0.557✱	0.578✱
Source	0.081	0.529*	****	****	****
Fishroom	0.029	0.507	0.541	0.562✱	0.580✱
Protection	0.019	0.496	0.530	0.558✱	0.576✱
Meas Pos	0.069	0.510	0.543	0.566	0.583✱

Note : The figures denote the proportion of the variance explained by the variable(s) (i.e. R^2)

✱ denotes the variable is not significant at the 5% level.

* denotes the variable has been added to the model.

Interactions between variables have been suppressed.

TABLE 13B

Analysis of Variance of the Average Quality of Fish at Auction.

	Oneway	**Twoway**	**Threeway**	**Fourway**	**Fiveway**
Port	0.503*	****	****	****	****
Container	0.081	0.524	0.551	0.572	0.590*
Species	0.013#	0.521	0.559	0.581*	****
Stowage	0.235	0.529	0.562*	****	****
Icing	0.030	0.512	0.545	0.567#	0.586#
Pres	0.031	0.503	0.537	0.562#	0.585#
Source	0.084	0.537*	****	****	****
Fishroom	0.022	0.514	0.548	0.567#	0.586#
Protection	0.017	0.507#	0.538#	0.564#	0.582#
Meas pos	0.067	0.519	0.552	0.573	0.589#

Note : The figures denote the proportion of the variance explained by the variable(s) (i.e. R^2)

# denotes the variable is not significant at the 5% level.

* denotes the variable has been added to the model.

Interactions between variables have been suppressed.

TABLE 13C

Analysis of Variance for the Within Sample Standard Deviation of Fish Quality First Seen.

	Oneway	Twoway	Threeway	Fourway
Port	0.321*	****	****	***
Container	0.226	0.332	0.355	0.371
Species	0.223#	0.335	0.369*	****
Stowage	0.222	0.331	0.360	0.377
Ice	0.223	0.329#	0.359	0.376#
Presentation	0.224	0.328	0.365	0.381*
Source	0.262	0.353*	****	****
Fishroom	0.235#	0.334	0.363	0.377
Protection	0.240	0.322#	0.355#	0.371#
Meas pos	0.226#	0.333#	0.359#	0.377#

Note : The figures denote the proportion of the variance explained by the variable(s) (i.e. R^2)

# denotes the variable is not significant at the 5% level.

* denotes the variable has been added to the model.

Interactions between variables have been suppressed.

TABLE 13D

Analysis of Variance for Within Sample Average Fish Temperature at First Seen.

	Oneway	Twoway	Threeway	Fourway	Fiveway
Port	.0274	0.564	0.670*	****	****
Species	0.110	0.524	0.608✱	0.678	0.691
Container	0.135	0.536	0.622	0.678	0.690
Stowage	0.519*	****	****	****	****
Ice	0.280	0.606*	****	****	****
Pres	0.114	0.541	0.630	0.682	0.694
Source	0.046	0.558	0.629	0.683	0.697*
Fishroom	0.206	0.546	0.629	0.683*	****
Protection	0.034	0.527	0.609	0.670✱	0.683✱
Meas Pos	0.071	0.540	0.610✱	0.673✱	0.685✱

Note : The figures denote the proportion of the variance explained by the variable(s) (i.e. R^2)

✱ denotes the variable is not significant at the 5% level.

* denotes the variable has been added to the model.

Interactions between variables have been suppressed.

TABLE 13E

Analysis of Variance for the Within Sample Average Fish Temperature at Auction.

	Oneway	**Twoway**	**Threeway**	**Fourway**
Port	0.228	0.820	0.846*	****
Species	0.135	0.797	0.827	0.846✱
Container	0.055	0.796	0.826✱	0.847✱
Stowage	0.792*	****	****	****
Ice	0.312	0.810	0.833	0.857*
Pres	0.008✱	0.794	0.824✱	0.846✱
Source	0.038	0.796	0.829	0.850
Fishroom	0.232	0.795	0.826	0.847
Protection	0.055	0.792✱	0.824✱	0.847
Meas Pos	0.051	0.824*	****	****

Note : The figures denote the proportion of the variance explained by the variable(s) (i.e. R^2)

✱ denotes the variable is not significant at the 5% level.

* denotes the variable has been added to the model.

Interactions between variables have been suppressed.

TABLE 14A

M.C.A. Table for Within Sample Average Fish Quality First Seen.

Grand Mean = 8.324

Port	Adjusted * Deviation
N. Ireland	0.93
East Sussex	0.92
Bridlington	0.79
Whitby	0.67
Scarborough	0.62
Ayr/Kinlochbervie	0.54
Stornaway	0.46
Brixham	0.32
Aberdeen	0.11
North Shields	0.08
Mallaig/Lochinver	-0.03
Fraserburgh	-0.19
Newlyn	-0.20
Peterhead	-0.32
Lowestoft	-0.45
Grimsby	-1.26

Source	
Open Vehicle	0.30
Fishing Vessel	0.04
Non Insulated Van	-0.19
Refrigerated Van	-0.29
Insulated Van	-1.20

Stowage	Adjusted * Deviation
Shelved with Ice	0.51
On Deck without Ice	0.38
Boxed without Ice	0.23
Boxed with Ice	-0.05
Bulked with Ice	-0.23

Species	
Cod	0.19
Flat Demersal	0.03
Round Demersal	-0.05
Haddock	-0.14
Pelagic	-0.44

Container	
None	0.12
Wooden Box	0.11
Plastic Box	-0.12
Other	-0.71

* Denotes the deviation from the grand mean after the effect of other factors has been considered.

TABLE 14B

MCA table for the Average Quality of Fish at the Time of Auction

Grand Mean = 8.094

Port	**Adjusted* Deviation**
N. Ireland	1.00
East Sussex	0.97
Whitby	0.73
Scarborough	0.67
Ayr/Kinlochbervie	0.59
Stornaway	0.50
Brixham	0.29
Aberdeen	0.15
North Shields	0.12
Mallaig/Lochinver	0.03
Newlyn	-0.18
Fraserburgh	-0.19
Peterhead	-0.27
Lowestoft	-0.42
Grimsby	-1.29

Source	
Open Vehicle	0.38
Vessel	0.03
Non Insulated Van	-0.16
Refrigerated Van	-0.19
Insulated van	-1.20

Stowage	**Adjusted * Deviation**
Shelved with Ice	0.54
On Deck Without Ice	0.29
Boxed Without Ice	0.23
Boxed With Ice	-0.03
Unknown	-0.03
Bulked With Ice	-0.21

Species	
Cod	0.18
Flat Demersal	0.10
Round Demersal	-0.05
Haddock	-0.14
Pelagic	-0.43

Container	
None	0.14
Wooden Box	0.11
Plastic Box	-0.13
Other	-0.73

* denotes the deviation from the grand mean after the effect of the other factors has been considered.

SCORE	EYES	SKIN	TEXTURE AND EFFECT OF RIGOR MORTIS	FLESH AND BELLY FLAPS	KIDNEY AND BLOOD	GILLS		SCORE
						APPEARANCE	ODOUR	
10	Bulging, convex lens, black pupil, crystal-clear cornea	Bright, well-differentiated colours, glossy, transparent slime.	Flesh firm and elastic. Body pre-rigor or in rigor	Cut surface stained with blood. Bluish translucency around backbone. Fillet may have rough appearance due to rigor mortis contraction.	Bright red, blood flows readily	Glossy, bright red or pink; clear mucus.	Initially very little odour increasing to sharp, iodine, starchy, metallic odours, changing to less sharp seaweedy, shellfish odours.	10
9	Convex lens, black pupil with slight loss of initial clarity.		Flesh firm and elastic. Muscle blocks apparent. In or just passing through rigor.	White with bluish translucency, may be corrugated due to rigor mortis effect.	Bright red, blood does not flow.			9
8	Slight flattening or plane, loss of brilliance.	Loss of brilliance of colour.	Firm, elastic to the touch.	White flesh with some loss of bluish translucency. Slight yellowing of cut surfaces of belly flaps.	Slight loss of brightness of blood.	Loss of gloss and brightness, slight loss of colour.	Freshly cut grass. Seaweedy and shellfish odours just detectable.	8
7							Slight mousy, musty, milky or caprylic.	7
6	Slightly sunken, slightly grey pupil, slight opalescence of cornea.	Loss of differentiation and general fading of colours; overall greyness. Opaque and somewhat milky slime.	Softening of the flesh, finger indentations retained, some grittiness near tail.	Waxy appearance of the flesh, reddening around the kidney region. Cut surfaces of the belly flaps brown and discoloured.	Loss of brightness, some browning.	Some discoloration of the gills and cloudiness of the mucus.	Bready, malty, beery, yeasty	6
5							Lactic acid, sour milk or oily.	5
4	Sunken, milky white pupil, opaque cornea.	Further loss of skin colour. Thick yellow knotted slime with bacterial discoloration. Wrinkling of skin on nose.	Softer flesh, definite grittiness.	Some opacity reddening along backbone and brown discoloration of the belly flaps.	Brownish kidney blood.	Slight bleaching and brown discoloration with some yellow bacterial mucus.	Lower fatty acid odours (eg acetic or butyric acids), composted grass, 'old boots', slightly sweet, fruity or chloroform-like.	4
3							Stale cabbage water, stale turnips, 'sour sink', wet matches.	3

APPENDIX 3

A Extract from "The Effect of Temperature on the Spoilage of Wet White Fish" by R. Spencer and C.R. Baines.

"The effect of temperature ($\varnothing$) on the rate of spoilage (U) of white fish stored at a constant temperature between -1°C and 25°C was found to be approximately linear and expressible in the form

$$U = V(1+c\varnothing)$$

where : V is the spoilage rate at 0°C

c is a constant"

B Extract from "The Effect of the Time/Temperature Conditions of Distribution on land on the quality of Wet White Fish." by R.Spencer.

"The effect of temperature on the rate of spoilage of fish.

The relationship between temperature and rate of spoilage can be expressed by the linear relationship

$$U = U_0 + KT \qquad \text{('Spencer / Baines' model)}$$

where : U = rate of spoilage at a temperature T°C

U_0 = rate of spoilage at temperature 0°C

K = a constant, the temperature coefficient

It follows that the loss in quality, S, defined as the fall in the taste panel score, during time interval t, is :

$$S = tU + KtT$$

or for a varying temperature :

$$S = tU_0 + K.{}_0\int^t T.dt \quad "$$

APPENDIX 4

The Exponential Fits to the Six Data Sets from "Spencer and Baines".

Y = rate of spoilage, X = temperature °C

Batch 1

Fitted model : $Y = 0.2214 \exp(0.0905X)$ $R^2 = 0.9971$

The hypothesis of 'no relation' is rejected at the 99.5% level.

Batch 2

Fitted model : $Y = 0.2327 \exp(0.1018X)$ $R^2 = 0.9868$

The hypothesis of 'no relation 'is rejected at the 99% level.

Batch 3

Fitted model : $Y = 0.2444 \exp(0.0663X)$ $R^2 = 0.8051$

The hypothesis of 'no relation' is rejected at the 90% level.

Batch 4

Fitted model : $Y = 0.3027 \exp(0.0835X)$ $R^2 = 0.8699$

The hypothesis of 'no relation' is rejected at the 90% level.

Batch 5

Model fitted : $Y = 0.3314 \exp(0.0836X)$ $R^2 = 0.9852$

The hypothesis of 'no relation' is rejected at the 97.5% level.

Batch 6

Model fitted : $Y = 0.2773 \exp(0.09042X)$ $R^2 = 0.9682$

The hypothesis of 'no relation' is rejected at the 97.5% level.

APPENDIX 5

1. A Combined Exponential Model for all Six Data Batches in the 'Spencer and Baines' paper.

$Y = 0.2683 \exp(0.086X)$ $R^2 = 0.9036$

where : Y = rate of quality loss per day measured by raw odour

X = temperature in degrees centigrade (°C).

Analysis of Variance:

due to	d.f	s.s.	m.s.	F-ratio
regression	1	11.1989	11.1989	206.172
residual	22	1.195	0.0543	
total	23	12.3939		

From tables of the F distribution with 1 and 22 degrees of freedom :

$$\Pr(F_{1,22} > 14.4) = 0.001$$

Hence the hypothesis of 'no relation' is rejected at the 99.9% level of significance.

2. Linear model relating the data of 'Spencer and Baines' to the data contained in S.F.I.A Internal Report number 1175.

$Z = -0.2747 + 2.5687Y$ $R^2 = 0.9272$

where : Z = rate of quality loss in raw odour, taken from SeaFish I.R. 1175

(See also Table 10 and Figure 5)

Analysis of Variance:

due to	d.f.	s.s	m.s.	F-ratio
regression	1	1.7928	1.7928	127.1489
residual	10	0.1407	0.0141	
total	11	1.9335		

From tables of the F distribution with 1 and 10 degrees of freedom

$$Pr(F_{1,10} > 21) = 0.001$$

Hence the hypothesis of 'no relation' is rejected at the 99.9% level of significance.

<u>Combining the two above models:</u>

Rate of Quality Loss per day at constant temperature $\emptyset$

$$dQ/dT = 0.6895e^{0.086\emptyset} - 0.2747$$

or equivalently:

Rate of Quality Loss per hour at constant temperature $\emptyset$

$$dQ/dt = 0.0288e^{0.086\emptyset} - 0.0114$$

APPENDIX 6

Derivation of Equation relating Fish Temperature to Time

Newtons' Law of Cooling suggests the following relationship:

$$\frac{d\theta}{dt} = -k(\theta - \theta_T)$$

where θ = temperature of fish
t = elapsed time
$\theta_T = 0$ if the fish is iced
$\theta_T = \theta_{amb}$ if the fish are un-iced.

Case 1: $\theta_T = m$ (where m is the average ambient temperature observed if the fish are un-iced or $m=0$ if the fish are iced.)

i.e. $$\frac{d\theta}{dt} = -k(\theta - m)$$

hence $$\int \frac{1}{\theta - m} d\theta = \int -k \, dt$$

this implies $\log_e(m - \theta) = -kt + c$ where c is a constant and $\theta < m$

therefore $$\theta = m - Re^{-kt}$$ where $R = e^c$

at $t=0$, $\theta=\theta_0$ (the initial temperature reading) so $R = m - \theta_0$

therefore $$\theta = m - (m - \theta_0)e^{-kt} \quad \text{if } \theta < m \qquad [1a]$$

and $$\theta = m + (\theta_0 - m)e^{-kt} \quad \text{if } \theta > m$$
$$\theta = \theta_0 e^{-kt} \quad \text{if fish are iced } [1b]$$

Case 2: $\theta_T = \theta_{amb} = a+bt$ (see Appendix 7)

i.e. $$\frac{d\theta}{dt} = -k(\theta - a - bt)$$

equivalently,

$$\frac{d}{dt}(\phi e^{kt}) = k(a + bt)e^{kt}$$

hence

$$\phi e^{kt} = \int (a + bt)ke^{kt}\,dt$$

therefore

$$\phi = a + \frac{b}{k}(kt-1) + Pe^{-kt} \quad \text{where P is constant}$$

at $t=0$, $\phi=\phi_0$

so

$$P = \phi_0 + \frac{b}{k} - a$$

therefore

$$\phi = (a - \frac{b}{k}) + bt + (\phi_0 - a + \frac{b}{k})e^{-kt} \qquad [2]$$

Derivation of Quality Loss

Case 1: $\phi_T = m$

It has already been shown that $dQ/dt = Ae^{B\phi} + C$ (A,B,C are known.)

$$\text{Quality Loss } \Delta Q = \int_0^t \frac{dQ}{dt}\,dt = \int_0^t (Ae^{B\phi} + C)\,dt$$

$$= \int_0^t \left\{C + A\exp(B(m - \phi_0)e^{-kt})\right\}dt \quad \text{(using [1])}$$

[3a]

$$\Delta Q = Ct + Akt + AB(m - \phi_0)\sum_{n=1}^{\infty}\frac{1}{nn!}(1 - e^{-knt}) \quad \text{if } m > \phi$$

[3b]

$$= Ct + Akt + AB(\phi_0 - m)\sum_{n=1}^{\infty}\frac{1}{nn!}(1 - e^{-knt}) \quad \text{if } m < \phi$$

If fish are iced $m=0$,

$$\Delta Q = Ct + Akt + AB\phi_0 \sum_{n=1}^{\infty}\frac{1}{nn!}(1 - e^{-knt}) \qquad [3c]$$

Case 2: Fish Un-iced, $\emptyset_T = \emptyset_{amb} = a + bt$

Quality loss in time t

$$\Delta Q = \int_0^t \left\{ C + A\exp B\left[\left(a - \frac{b}{k}\right) + bt + \left(\emptyset_0 - a + \frac{b}{k}\right)e^{-kt}\right]\right\} dt \qquad [4]$$

This integral cannot be solved and must be evaluated using numerical methods.

APPENDIX 7

The benefit of a linear ambient model.

It was decided to investigate the difference between using a linear model for ambient temperature (i.e.$\emptyset_{amb} = a + bt$) and taking the ambient temperature as being equal to the average of the ambient temperature over a given period of time.

To illustate this idea two sets of data were considered, concerning; Cod landed at Grimsby which contains five 'repeat readings' (Example1), and Halibut also landed at Grimsby which contains two 'repeat readings', (Example 2).

The following data concerns the calculated loss in quality until the commencement of the the auction at the fish market for the two opposing cases.

Case 1 incorporates the average ambient temperature ($\emptyset_{amb}$) whilst Case 2 fits a linear model to the observed ambient temperature data.

Example 1

Elapsed Time t	Average Temperature ($\emptyset$)	Ambient Temperature ($\emptyset_{amb}$)	Case1 $\emptyset_{amb}-\emptyset$	Case 2 $\emptyset_{amb}-\emptyset$
0	0.4667	16	12.76666	14.4747
2.4667	2.311	14	10.9222	11.6733
3.55	4.3	12.6	8.9333	9.2642
4.8833	3.6222	11.7	9.6111	9.4247
7.1333	4.7333	12.5	8.5	7.4407
8.3833	6.411	12.6	6.8222	5.2779

Case 1 :

$$\varnothing_T = \varnothing_{amb} = 13.2333$$

$$\log(\varnothing_{amb} - \varnothing) = 2.533 - 0.0662t$$

$$\varnothing = 13.2333 - 12.5913e^{-0.0662t}$$

Quality loss until start of auction $= \int_0^T \frac{dQ}{dt}\,dt$

substituting for Ø $= \int_0^t (0.0288e^{0.086\varnothing} - 0.0114)\,dt$

$$= \int_0^T [0.0288\exp(1.1381 - 1.0829e^{-0.0662t}] - 0.0114)\,dt$$

where :

T = Time of Market - Initial Time = 7.30 - 21.37 = 9.8833 hours

using 'Simpsons Rule' with five intervals to evaluate the integral :

Quality Loss = 0.2683 Taste Panel Units

Case 2 :

$$\varnothing_T = \varnothing_{amb} = 14.9414 - 0.3879t \qquad (R^2 = 0.4022)$$

$$\mathrm{Log}\,(\varnothing_{amb} - \varnothing) = 2.6986 - 0.1106t$$

$$\varnothing = 14.9414 - 0.3879t - 14.8591e^{-0.1106t}$$

As in Case 1

Quality loss up to market time:

$$\int_0^T (0.0288\exp[1.2849 - 0.0334t - 1.2779e^{-0.1106t}] - 0.0114)dt$$

Using 'Simpsons Rule' with five intervals :

Quality Loss = 0.2686 Taste Panel Units.

Hence it can be seen that assuming the ambient temperature is a linear function of the initial ambient temperature and time leads to a 0.1% increase in the estimated loss in quality.

Example 2

Elapsed Time t	Average Temperature (θ)	Ambient Temperature (θ_{amb})	Case 1 $\theta_{amb}-\theta$	Case 2 $\theta_{amb}-\theta$
0	7.26	13.4	5.307	6.122
6.5	11.32	12.2	1.2467	0.0718
8.0833	10.66	12.1	1.9067	1.3662

Case 1 :

$$\theta_T = \theta_{amb} = 12.5667$$

$$\log(\theta_{amb} - \theta) = 1.5963 - 0.1546t$$

$$\theta = 12.5667 - 4.9346e^{-0.1546t}$$

Loss in quality up to market time =

$$\int_0^T (0.0288\exp[1.08007 - 0.4244e^{-0.1546t}] - 0.0114)\,dt$$

Using 'Simpsons Rule' with five intervals :

Quality Loss = 0.432 Taste Panel Units

Case 2 :

$$Ø_{amb} = 13.382 - 0.1677t \qquad (R^2 = 0.9864)$$

$$\text{Log}(Ø_{amb} - Ø) = 1.7381 - 0.2139t$$

$$Ø = 13.382 - 0.1677t - 5.6868e^{-0.2139t}$$

Loss in Quality up to market time =

$$\int_0^T (0.0288\exp\{1.1509 - 0.0144t - 0.4891e^{-0.2139t}\} - 0.0114)\,dt$$

Using 'Simpsons Rule' with five intervals :

Quality Loss up to market = 0.0445 Taste Panel Units

Hence it can be seen that assuming the ambient temperature to be a linear function of the initial ambient temperature and time, leads to a 0.1% increase in the estimated quality loss when compared with the estimated quality loss resulting from the authors' model. (i.e. the model contained in Appendix 6).

APPENDIX 8

Questionnaire

Assessment and Classification of Port

The ports are to be classified according to three factors:

1. Nature of Fleet * (length of trip of vessels):

a) One Day
b) Two or three days **
c) One Week ***
d) Two weeks or more

*Assume overland and containerised fish not included.
**Assume related to volume of fish and not number of vessels.
***Assume 1-2 weeks.

2. Fleet Handling Practices:

a) Good - well iced and good stowage
b) Medium - inadequate icing or poor stowage ****
c) Poor - insignificant icing

****Assume method of icing as opposed to amount of ice.

3. Port Handling Practices:

a) Good - short time delays and insulated/chilled environment. Possible re-icing.
b) Medium - partial cover or average time delays
c) Poor - long time delays or inadequate buildings with no protection from the elements.

APPENDIX 9

Decomposition of Total Variance into Within and Between Sample Variance

Proof of $\Omega_T^2 = \frac{1}{m}\sum_{j=1}^{m}\Omega_{Fj}^2 + \Omega_Q^2$

where Ω_T^2 = Variance of fish quality at auction.
Ω_{Fj}^2 = Within sample variance of jth sample.
Ω_Q^2 = Between sample variance of fish at auction.

Suppose there are m samples (boxes) each containing n fish.

Hence the within sample variance is given by:

$$\Omega_{Fj}^2 = \frac{1}{n}\sum_{i=1}^{n} x_{ij}^2 - \frac{1}{n^2}\left[\sum_{i=1}^{n} x_{ij}\right]^2$$

Similarly the between sample variance is given by:

$$\Omega_Q^2 = \frac{1}{n^2 m}\sum_{j=1}^{m}\left[\sum_{i=1}^{n} x_{ij}\right]^2 - \left[\frac{1}{nm}\sum_{j=1}^{m}\sum_{i=1}^{n} x_{ij}\right]^2$$

The global variance $\Omega_T^2 = \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} x_{ij}^2 - \left[\frac{1}{nm}\sum_{j=1}^{m}\sum_{i=1}^{n} x_{ij}\right]^2$

Therefore

$$\Omega_Q^2 + \frac{1}{m}\sum_{j=1}^{m}\Omega_{fj}^2 = \frac{1}{n^2 m}\sum_{j=1}^{m}\left[\sum_{i=1}^{n} x_{ij}\right]^2 - \frac{1}{n^2 m^2}\left[\sum_{j=1}^{m}\sum_{i=1}^{n} x_{ij}\right]^2$$

$$+ \frac{1}{m}\sum_{j=1}^{m}\left[\frac{1}{n}\sum_{i=1}^{n} x_{ij}^2 - \left[\frac{1}{n}\sum_{i=1}^{n} x_{ij}\right]^2\right]$$

$= \Omega_T^2$ as required.

APPENDIX 10

Formulae used to construct the Multiplan Spreadsheet

Standard deviation within sample at auction

$$\Omega_{WA} = P_{WF}[Q_A(10 - Q_A) - Q_F(10 - Q_F)] + \Omega_{WF}$$

where P_{WF} = within sample standard deviation versus mean quality parameter. [Equal to the coefficient of the covariate in the ANOVA model for within sample quality deviation.]

Q_A = average quality at auction.

Q_F = average quality first seen.

Ω_{WF}= standard deviation within sample first seen.

Standard deviation between sample at auction

$$\Omega_{BA} = P_B[Q_A(10 - Q_A) - Q_F(10 - Q_F)] + \Omega_{BF}$$

where Q_A and Q_F are as before and

P_B = between sample standard deviation versus Mean Quality parameter. [Found by regressing between sample standard deviation against $Q_F(10 - Q_F)$.]

Ω_{BF} = standard deviation between sample first seen.

Logistic distribution parameter $k = (\sqrt{3}/\pi)\Omega_{TA}$

where Ω_{TA} = standard deviation of quality at auction.

TABLE 14C

MCA Table of the Within Sample Standard Deviation of Quality of Fish First Seen.

Covariate Coefficient = 0.021*

Grand Mean = 0.443

Port	**Adjusted* Deviation**
Ayr/Kinlochbervie	0.16
N. Ireland	0.10
Whitby	0.10
Lowestoft	0.06
Scarborough	0.04
East Sussex	0.03
Mallaig/Lochinver	0.03
Bridlington	0.03
North Shields	0.03
Stornaway	0.02
Aberdeen	-0.02
Brixham	-0.02
Fraserburgh	-0.05
Newlyn	-0.05
Grimsby	-0.06
Peterhead	-0.08

Source	**Adjusted * Deviation**
Non Insulated Van	0.16
Overland Vehicle	0.01
Fishing Vessel	0.00
Insulated Van	-0.05
Refrigerated Van	-0.07
Species	
Flat Demersal	0.04
Cod	0.02
Haddock	0.01
Round Demersal	-0.04
Pres	
Tails Only	0.46
Gutted	0.00
Whole	-0.01

* denotes the deviation from the grand mean after the effect of the other factors has been considered.

* Covariate is given by Torry*(10-Torry).

TABLE 14D

M.C.A. Table for the Within Sample Average Fish Temperature as First Seen.

Grand Mean = 3.995

Port	**Adjusted* Deviation**
N.Ireland	2.84
Fraserburgh	0.83
Scarborough	0.76
Stornaway	0.45
Brixham	0.44
Ayr/Kinlochbervie	0.32
Whitby	0.31
Lowestoft	0.16
Mallaig/Lochinver	0.14
Bridlington	0.06
East Sussex	-0.17
Peterhead	-0.59
Aberdeen	-0.60
Newlyn	-1.55
Grimsby	-1.90
Ullapool	-2.54

Source	
Non Insulated Van	1.22
Fishing Vessel	0.06
Open Vehicle	-0.23
Insulated Van	-1.92
Refrigerated Van	-2.21

Stowage	**Adjusted * Deviation**
On Deck Without Ice	4.15
On Deck With Ice	3.72
Boxed Without Ice	2.83
Unknown	0.33
Boxed With Ice	-0.97
Bulked With Ice	-1.71
RSW Tanks	-1.73
Shelved With Ice	-2.66

Fishroom	
Non	1.89
Non Insulated	0.45
Unknown	0.40
Insulated & Chilled	-0.83
Chilled	-0.90

Icing	
Non	1.39
Fresh Water Top	-1.31
Fresh Water Mixed	-1.41
Fresh Water Bottom	-1.82
S. W. Top & Bottom	-2.43
S. W. Mixed	-2.55

* denotes the deviation from the grand mean after the effect of the other factors has been considered.

TABLE 14E

MCA Table for the Average Temperature of the Fish at Auction.

Grand Mean = 8.665

Stowage	Adjusted* Deviation
On Deck With Ice	5.49
On Deck Without Ice	5.24
Unknown	5.20
Bulked With Ice	4.41
Bulked No Ice	3.76
Boxed Without Ice	3.75
RSW Tanks	3.57
Boxed With Ice	-5.73

Port	Adjusted * Deviation
Newlyn	3.21
N. Ireland	1.83
Aberdeen	0.58
Brixham	0.39
Fraserburgh	0.39
Lowestoft	0.26
Scarborough	0.14
Peterhead	0.06
Mallaig/Lochinver	-0.04
Ayr/Kinlochbervie	-0.35
East Sussex	-0.45
Grimsby	-0.67
Whitby	-1.10
Stornaway	-1.38
North Shields	-2.58

Meas Pos	
Unloading Bay	1.56
After Sorting	1.12
On Deck	0.85
Market Floor	0.09
Before Sorting	-0.36
Jetty/Staithe	-0.66
On Road Transport	-1.10
Vessel Fish Hold	-3.98
In Container	-7.05

Icing	
SW Ice Mixed	0.99
No Ice	0.79
F.W. Ice Top Only	-0.48
S.W. Ice Top & Bottom	-0.59
F.W. Ice Mixed	-0.73
S.W. Ice Top Only	-1.73

* denotes the deviation from the grand mean after the effect of the other factors has been considered

ESTIMATE OF THE DISTRIBUTION OF DEMERSAL FISH QUALITY WITHIN THE UNITED KINGDOM

Within sample Std.Devn versus Mean Quality parameter	0.021
Between sample Std.Devn versus Mean Quality parameter	0.038

PORT		Average Quality first seen	Average Quality at auction 'a'	Std.Devn within sample first seen	Std.Devn between sample first seen	Std.Devn within sample at auction	Std.Devn between sample at auction	Std.Devn total at auction	Logistic Distrbn parameter 'k'	Proprtn within range 0-10	Proportion of Truncated Logistic Distribution Within quality range 0 4	4 5	5 6	6 7	7 8	8 9	9 10	Value of Demersal landings 1982(000's)	Estimated Value of Demersal Landings 1982 (000's) Within quality range 0 4	4 5	5 6	6 7	7 8	8 9	9 10
Aberdeen		8.380	8.193	0.397	0.807	0.423	0.915	1.008	0.556	0.963	0.001	0.003	0.016	0.039	0.321	0.412	0.158	20962	12	58	344	1866	6737	8628	3319
Ayr/Kinlochbervie		8.870	8.680	0.540	0.439	0.570	0.565	0.803	0.443	0.952	0.000	0.000	0.002	0.021	0.163	0.521	0.293	6183	0	1	14	128	1008	3223	1809
Northern Ireland		9.362	9.177	0.425	0.355	0.458	0.494	0.674	0.371	0.902	0.000	0.000	0.000	0.003	0.042	0.380	0.575	4460	0	0	1	13	186	1695	2565
Bridlington		8.900	8.900	0.388	0.391	0.388	0.391	0.551	0.304	0.974	0.000	0.000	0.000	0.002	0.048	0.547	0.403	2757	0	0	0	5	134	1507	1111
Brixham		8.366	8.121	0.411	0.532	0.444	0.722	0.848	0.467	0.932	0.000	0.001	0.009	0.074	0.359	0.440	0.117	4349	1	5	41	322	1560	1913	503
Fraserburgh		8.271	8.038	0.399	0.393	0.430	0.522	0.676	0.373	0.995	0.000	0.000	0.004	0.054	0.418	0.457	0.066	7394	0	2	29	402	3094	3381	493
Grimsby		6.963	6.702	0.531	0.910	0.551	0.994	1.137	0.627	0.995	0.013	0.049	0.185	0.373	0.273	0.087	0.020	21739	289	1069	4029	8119	5944	1906	433
East Sussex		9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	903	0	0	0	3	42	373	485
Lochinver/Mallaig		8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	250	0	1	4	22	77	103	43
Lowestoft		7.734	7.552	0.535	1.027	0.558	1.121	1.252	0.690	0.972	0.006	0.019	0.073	0.221	0.357	0.241	0.084	9648	57	183	703	2130	3441	2322	807
Newlyn		8.025	7.824	0.418	0.447	0.443	0.550	0.706	0.339	0.996	0.000	0.001	0.008	0.099	0.505	0.344	0.043	5149	0	3	44	509	2602	1769	221
North Shields		8.597	8.377	0.444	0.859	0.476	0.994	1.102	0.603	0.935	0.001	0.003	0.017	0.080	0.273	0.413	0.213	6729	5	22	113	535	1840	2779	1434
Peterhead		8.110	7.917	0.390	0.569	0.414	0.671	0.789	0.435	0.992	0.000	0.001	0.011	0.097	0.443	0.379	0.069	45584	6	50	497	4420	20167	17257	3137
Scarborough		9.220	9.010	0.358	0.364	0.396	0.522	0.655	0.361	0.939	0.000	0.000	0.000	0.004	0.057	0.464	0.475	3015	0	0	1	11	172	1398	1432
Stornoway		8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	682	0	0	0	5	108	463	106
Whitby		9.163	8.932	0.412	0.331	0.443	0.462	0.640	0.353	0.947	0.000	0.000	0.000	0.004	0.058	0.480	0.459	2159	0	0	0	8	125	1036	990
Hull	(LT)	7.734	7.552	0.535	1.027	0.558	1.121	1.252	0.690	0.972	0.006	0.019	0.073	0.221	0.357	0.241	0.084	6057	36	115	444	1337	2160	1458	507
Fleetwood	(SH)	8.597	8.377	0.444	0.859	0.476	0.994	1.102	0.603	0.935	0.001	0.003	0.017	0.080	0.273	0.413	0.213	4751	4	16	80	378	1299	1962	1012
Eyemouth	(BX)	8.366	8.121	0.411	0.532	0.444	0.722	0.848	0.467	0.932	0.000	0.001	0.009	0.074	0.359	0.440	0.117	4661	1	5	44	345	1672	2050	544
Lerwick	(KB)	8.870	8.680	0.540	0.439	0.570	0.565	0.803	0.443	0.952	0.000	0.000	0.002	0.021	0.163	0.521	0.293	3563	0	1	8	74	585	1871	1050
Pittenweem	(KB)	8.870	8.680	0.540	0.439	0.570	0.565	0.803	0.443	0.952	0.000	0.000	0.002	0.021	0.163	0.521	0.293	2123	0	0	5	44	347	1109	623
Scalloway & Isles	(KB)	8.870	8.680	0.540	0.439	0.570	0.565	0.803	0.443	0.952	0.000	0.000	0.002	0.021	0.163	0.521	0.293	1848	0	0	4	38	301	963	541
Plymouth	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	1723	0	0	0	5	80	711	925
Milford Haven	(AY)	8.870	8.680	0.540	0.439	0.570	0.565	0.803	0.443	0.952	0.000	0.000	0.002	0.021	0.163	0.521	0.293	1685	0	0	4	35	275	878	493
Oban	(MD)	8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	1285	1	4	21	111	397	531	220
Seahouses	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	1281	0	0	0	4	60	529	688
Arbroath	(SY)	8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	1235	0	0	0	9	196	839	191
Macduff	(SY)	8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	1023	0	0	0	7	162	695	158
Scrabster	(LO)	8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	969	1	3	16	84	299	401	166
Whitehills	(SY)	8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	936	0	0	0	7	148	636	145
Looe	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	930	0	0	0	3	43	384	499
Flamborough	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	927	0	0	0	3	43	383	498
Filey	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	866	0	0	0	3	40	357	465
Buckie	(LO)	8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	786	0	2	13	68	243	325	135
Falmouth	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	734	0	0	0	2	34	303	394
Portpatrick	(LO)	8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	662	0	2	11	57	204	274	114
Lossiemouth	(SY)	8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	661	0	0	0	5	105	449	102
Wick	(SY)	8.700	8.496	0.368	0.255	0.399	0.384	0.554	0.305	0.993	0.000	0.000	0.000	0.007	0.158	0.679	0.155	626	0	0	0	4	99	425	97
Amble	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	591	0	0	0	2	28	244	317
Whitehaven	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	585	0	0	0	2	27	241	314
Girvan	(LO)	8.425	8.237	0.416	0.821	0.442	0.931	1.031	0.568	0.957	0.001	0.003	0.017	0.086	0.309	0.413	0.171	553	0	2	9	48	171	229	95
Portsmouth	(ES)	9.204	9.110	0.338	0.493	0.354	0.562	0.664	0.366	0.919	0.000	0.000	0.000	0.003	0.047	0.413	0.537	529	0	0	0	2	25	218	284
Rest	(ES+LI+SY)	-	-	-	-	-	-	-	-	-	0.000	0.001	0.006	0.032	0.171	0.502	0.288	9398	2	9	53	303	1609	4716	2705
TOTAL		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	192986	416	1555	6541	21477	57887	72939	32172
PERCENTAGE		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	0.2	0.8	3.4	11.1	30.0	37.8	16.7

TABLE 15

APPENDIX 1

The Sea Fish Industry Authority

The Sea Fish Industry Authority was established by the 1981 Fisheries Act and took over many of the functions and personnel of its predecessors, the White Fish Authority and the Herring Industry Board. It is the duty of the Authority to promote the efficiency of the sea fish industry as a whole by carrying out research and development, giving advice, providing training, promoting marketing and consumption, and making grants and loans for fishing vessels, processing plant and co-operative activities.

Funding is by a levy on all sea fish landed, or trans-shipped, within British waters plus money from the Ministry of Agriculture, Fisheries and Food to cover the research and development programme and for funding of the fishing vessel grants and loans scheme.

The administrative headquarters are in Edinburgh, but there are representatives throughout the UK. Under the direction of a Chief Executive, the Authority is split into a Finance Division, a Secretariat and Administration Division, a Technical Division and a Marketing Division. Matters of policy are decided by a board of twelve members nominated by Ministers.

In recent years the Authority has been re-structured to increase the marketing effort as a result of recommendations made in a report "The Marketing of Fish" by Wight, Cross and Stevenson. Their major conclusion was that the fish industry was in a much poorer state than it need be. To overcome the problems it was necessary to advertise and promote fish, to match supply with demand, to ensure a supply of a varied range of products, and to supply products of high quality by control of spoilage.

A £14 million project, the "Seafish Industry Development Programme" has been set up as a multi-disciplinary programme designed to tackle the problems. The programme provides for advertising and promotion, for training of people already in the industry and for new recruits, for assistance with re-structuring the industry and for the methods of raising quality standards.

Two Divisions within the Authority committed to promoting fish quality, amongst their other duties, are the Technical Division and the Marketing Division.

The Technical Division is responsible for carrying out research and development, organising training, producing Kingfisher Charts for fishermen and for studying the cultivation of marine fish. Within the Division the Fish Technology Unit specialises in the handling of fish from capture through to consumption.

Extensive studies by staff of the Unit have given an insight into many of the problems of the industry and enabled advice and recommendations to be given aimed at raising quality standards. Projects have ranged from the development of an integrated system for boxing fish at sea to improved packaging for chilled fish and better retail practices. The present approach is to present the advice and recommendations in guidelines produced in collaboration with the trade. These guidelines provide sets of realistically based standards which will result in a high quality product so ensuring increased consumer satisfaction and a healthier industry. Guidelines have already been produced for fish packed in a controlled atmosphere and the next guidelines in the series will cover retailing of chilled fish followed by handling on vessels and at ports and during distribution.

It is intended that the information derived from the current project is to form one of the bases of the guidelines for handling white fish on board vessels and through the port system, as it is basically a statement of the current situation and defines the effects of various handling practices observed at UK ports on fish quality.

APPENDIX 2

The Torry Research Station Quality Scale.

The Torry Research Stations work on the sensory assessment of the eating quality of fish began in 1947. The aim of this work was to establish a reasonably simple and reliable technique of quality assessment, whose validity would be accepted on a basis of factual knowledge and not just as an act of faith. There were four main sensory assessors established namely; appearance, raw odour, cooked odour and cooked flavour.

The system was developed over a period of several months by a small group of four to six people examining several hundred fish of all qualities from freshness to putridity and arrived at descriptive terms which could be mutually agreed upon for the various successive stages of spoilage. Scores running from ten or five to zero were then attached to the various descriptive terms, using the principle that adjacent unit steps should be equally easy to perceive, as this could lead to scoring scales which were convenient to use. Interpolated half marks on the scoring scales were also used. The score sheets were improved during subsequent usage, and scales for the general appearance of raw fish are illustrated on page 83.

It is important to note the descriptive terms which have been used. Expressions involving value judgements such as 'excellent' or 'bad' are avoided, and imprecise comparitive terms such as "strong' and 'slight' are used as little as possible. The aim was to choose terms which are reasonably unambiguous to the scorer and it most probable that this together with the fact that the members of the T.R.S. Testing Panel are very highly trained individuals, led Ehrenburg and Shewan ("The Development And Use Of A Taste Panel Technique" 1960) to claim :

"The conclusion in the last section that the assessment technique was reliable in the long run was based on inconsistencies in findings which themselves were only of the order of 3% of the total range of variation. The sensitvity of this kind of assessment technique can therefore be high."