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# Abstract.

The purpose of this thesis was to examine the genetic structure of the North Yorkshire coast, comparing the traditionally insular fishing settlements to the surrounding rural populace. Specifically it was thought that the fishing villages might approximate the conditions of the stepping-stone model, which could then be tried and tested, and compared to alternative predictions of kinship from isonymy, Malecot's migration matrix, and isolation by distance.

The results showed that the fishing communities were highly endemic; high values of kinship were obtained and were in the order of those given for other isolates. The much more mobile rural settlements provided a marked comparison. Values of kinship predicted from the various models agreed quite well with the exception of the stepping-stone model. The violation of the assumption that migration did not occur between non-adjacent settlements was thought to be responsible for this.

# Migration and Genetic Structure Among North Yorkshire Coastal Populations.

S.J. Sherren

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# Contents.

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# Introduction

The original purpose of this investigation was to evaluate the one-dimensional linear stepping-stone model of migration. This was achieved by comparing the prediction of population structure given by the model with empirical estimates of population structure obtained from demography, isonymy, and other migration models in a situation to which the model might be expected realistically to apply, namely the coastal populations of North Yorkshire.

Geographically, the coastal settlements of Staithes, Runswick, Whitby, Robin Hoods Bay, Scarborough, and Filey, comply with the principal constraint of the model: they are discrete settlements linearly arranged, and are but a few links in a much longer chain of coastal settlements. Migration is inhibited on one side by the sea, and on the other by the North Yorkshire moors. Admittedly these populations are of different sizes.

Historically, however, the fishing communities of these settlements have the reputation of being extremely insular – cutting themselves off not only from neighbouring fisher-folk, but also from the surrounding rural community. The fisher populations varied rather less in size than the total town populations and considering their social isolation as discrete and closely knit colonies, in addition to their physical distribution, they closely approximate the conditions of the stepping-stone model.

The rural communities, on the other hand, while physically isolated by the moors, did not share the social isolation of the fishermen. Indeed the 19th century agricultural hiring system encouraged a highly mobile rural work-force. The two occupational groups contrast fairly well and the two were used comparatively.

My original intent to apply the stepping-stone model to such data developed very much into an examination of the cultural dichotomy between the fishermen and rural workers. It was hoped to assess just how far the culture and traditions of the fisher folk did in fact segregate them from the surrounding communities. Folk-lore

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suggests high levels of inbreeding and incest amongst the villages – to what extent was this true? Vansina (1973) discusses oral testimony 'as a mirage of reality';

> "A major source of error and falsification is the influence exerted on the contents of a testimony by the functions of the testimony and the purposes of the informant" (Vansina 1973 p95).

Indeed Fox (1982) has given an example of a fishing community on Tory Island where ideally the fishing crews were recruited by chains of kinship and affinity but where, in practise, many of the boat owners picked their crews first and then rationalised the link later. In North Yorkshire was the tradition of marrying within the fishing village and the legendary hostility and competition towards other villages ( both coastal and rural) a reality or was it more of an aspiration which helped to bind the fisher work-force together? If a reality, to what extent did their traditions affect the genetic structure of the area?

## Chapter 1.

# The Theoretical Background : The Genetic Structure of Populations.

Genetics, in general, looks at the genetic constitution of the individual and the mechanisms of heredity which pass genetic information from one generation to the next. *Population genetics* is concerned with heredity in ‘ populations’ – the genetic constitution of populations and how this constitution changes over time.

It is important to define what is meant by the term ‘ *population* ’, for it does not merely refer to the inhabitants of a particular town or country, as a geographer, for example, might use the term. In population genetics it is synonymous with the ‘ *gene pool* ’. Commonly described as the Mendelian population, it is a community of inter-breeding, sexually reproducing individuals.

The most inclusive Mendelian population is the species. However, individuals of the human species do not freely interbreed. Non-random mating occurs due to a variety of social and physical factors.

*Geographical distance* is well known to deter mobility. Put more clearly, it can be said that the frequency of migration between two places decreases the further the two are apart. The exponential relationship between human movement and distance has been examined in a number of studies, mostly under the ‘ Isolation by Distance’ model (see below), but also in separate studies such as Boyce et. al.'s (1967) study on the frequency of marriage and distance in Otmoor. Geographical boundaries (such as rivers, moorlands and mountains) have also been found to affect mating patterns (Kuchemann *et al.* 1967 and Challands 1978). Coleman (1979 and 1984), however, has suggested that geographical distance alone should not be used to make inferences on genetic structure since it is so often intertwined with factors like social class and age at marriage. In a similar vein, he also found that marriage distance was related to population size.

*Human culture* and social organisation are other major determinants of population subdivision. For example, the culture and language of the Basque population help to give these people a social identity which distinguishes them from their neighbours and is, biologically speaking, manifested in the fact that they have the highest frequency of rhesus negative in the world. There are a number of papers which assess the effects of socio-economic status on marital migration (for example, Coleman 1981, Abelson 1978, Kuchemann *et al.* 1974, and Mukherjee *et al.* 1980). Other studies have taken different ' classes' or ' occupational groups' as Mendelian populations themselves. For example, Harrison and his colleagues (1970, 1974a, and 1974b) consider the genetic variation between social classes in the Otmoor region; Smith and Hudson (1984) and Sherren (1983) have considered the relationship between different occupational groups on the North Yorkshire and West Sussex coasts respectively; Imaizumi (1986) has estimated inbreeding amongst groups of different occupational, religious, and educational status. There are many religious isolates where small population size and inbreeding have resulted in high frequencies of deleterious alleles. The Old Order Amish and the Ashkenazi Jews are good examples of this. Major religions, such as the Roman Catholic Church, where there is a strong preference for marriage within the church may also inhibit random mating.

*Demographic factors* such as the age at marriage, sex ratio, family size, and position within the household, for example, may affect mate choice. Many of these factors are also inter-woven with marital distance and social class, for example. (Such relationships have been studied by Coleman 1977, Mascie-Taylor 1986, and Brennan *et al.* 1982.) Other studies have shown that past links and familiarity with a place may also play a role in attracting people to return to an area (Kramer 1981 and Choldin 1973).

Lastly, *population history* is a determinant of population structure. Tristan da Cunha with its founder effect and successive ' bottlenecks' is a prime example of this. Similarly Cavalli-Sforza (1983) has shown how the history of Taiwan offers a much more succinct explanation of genetic structure than isolation by distance.

Thus it is seen that there are a number of often inter-woven factors that inhibit random breeding. This may result in population subdivision, or in more extreme cases, it may give rise to the formation of a small population with which genetic exchange is virtually eliminated – namely, an ' isolate' . The actual definition of an isolate is fairly ' woolly' since it has been so widely applied in a variety of different contexts. This difficulty has been discussed extensively by Roberts (1975) and Benoist (1973). In my opinion, an isolate describes a small population which is cut off either geographically or socially from any surrounding peoples and, as a consequence, mate choice is usually limited. Inbreeding or the marriage of relatives (outside the immediate family) usually results, ultimately reducing the genetic variation within the population. What is important, however, is the extent of isolation, since it is this which prohibits the introduction of new genetic material into the population.

The Hardy-Weinberg law states that the process of heredity alone does not change genotypic frequencies. Evolution is dependent upon the action of natural selection, mutation, migration and genetic drift. Mutation and gene flow are the source of variation, in the first place by an actual change in the genetic material, and in the second, by the introduction of new genes from outside the population. Genetic drift reduces the genetic variation by the random fluctuation of gene frequencies from generation to generation (occurring only within the *small* population). Natural selection may reduce genetic variation by the elimination of unfit genotypes, or it may maintain genetic variation as in the case of the sickle-cell polymorphism.

The relationship between genetic drift and gene flow deserves a more thorough explanation here since it is this which is so largely analysed in the theoretical models of population structure. Gene flow into a population increases heterogeneity. At the extremes it may be predicted that if immigration is extensive, Hardy-Weinberg equilibrium may be disturbed, resulting in the establishment of a new equilibrium point. If gene flow is limited and the effective population size is small, random genetic drift will occur. The erratic fluctuations of gene frequencies under drift will result in the loss of the rarer alleles over the course of time, providing that the population size remains small. As alleles are lost, there will be fewer heterozygotes; as inbreeding increases, the proportion of homozygotes will rise. Founder effects or bottlenecks, factors often associated with the small population, occur when the numbers of a population are drastically reduced by a catastrophe or in the process of founding a new population. There are a number of isolates where drift effects have been shown to occur, for example, the high occurrence of *retinitis pigmentosa* amongst the islanders of Tristan da Cunha and dwarfism (Ellis-van Creveld syndrome) and pyruvate kinase anaemia amongst the Old Order Amish.

It is the analysis of the interaction of these four evolutionary mechanisms that lies at the heart of population genetics. For by understanding the processes of a population's evolution it is hoped to account for the observed genetic variation of the contemporary gene pool.

## Kinship and Inbreeding

These two important parameters enable one to characterize the state of a population and are widely used as such a measure in population genetics. Wright (1921, 1922) was the original pioneer of the work on inbreeding. He defined the inbreeding coefficient, F, as the correlation between uniting gametes.

Malecot (1948) defined the inbreeding coefficient, F, as the probability that two homologous genes are identical by descent. The inbreeding coefficient thus measures the consanguinity of an individual. The coefficient of kinship, f, was coined by Malecot to measure the relationship between individuals. It is the probability that a gene taken at random from individual i, at a given locus, will be identical by descent to a gene taken at random from individual j, at the same locus. (This coefficient was originally termed the ' coefficient of co-ancestry' (Malecot 1948 p8).) In the absence of mutation F is identical to the coefficient f of the parents (Cavalli-Sforza and Bodmer 1971 p502).

Reid (1975) has pointed out that there are important theoretical differences between these two approaches. Malecot's definition is limited to parental consanguinity, while Wright's coefficient refers to the correlation arising from any sort of assortative mating. It therefore has much wider implications. Although, when the contribution to F is limited to consanguineous mating, the definitions are interchangeable.

Morton has described the above definitions of kinship and inbreeding as the ‘ genealogical ’ model of inbreeding. The 1966 paper states:

> “The genealogical model, although originally derived by Wright in terms of correlation, is better represented by the probability that two allelic genes be identical by descent from a common ancestor”(Yasuda and Morton 1966 p251).

Malecot’s definition of kinship and inbreeding are the preferred definitions in this work.

Morton states that the genealogical model is just one of four methods of estimating inbreeding. These four methods have been summarised diagrammatically and are reproduced in Fig. 1.1 (Yasuda and Morton 1966; and Morton 1982b). The advantage of such a summary is that it elucidates the relationship between the different estimates of kinship and inbreeding.

I shall simply give a very brief synopsis of the models here: the detailed relationships between kinship estimates from specific migration models will be discussed in later chapters. Wright’s hierarchical model assumes that every sub-population is related to the others by a branching process.The inbreeding coefficient relative to the total population is represented by $F_{IT}$. Allen (1965) describes this as the total inbreeding coefficient, F. Wright defined $F_{IS}$ as the average over all the subdivisions of the correlation between uniting gametes relative to their own subdivision, or as Allen (1965) has stated, it is the non-random inbreeding coefficient, $F_n$. Wright’s $F_{ST}$ was originally defined as the mean coefficient of kinship within subdivisions, although Allen (1965) later refers to it as random inbreeding, $F_r$.

$$F_{IT} = F_{IS} + (1 - F_{IS})\,F_{ST}$$

Or, in Allen’s notation;

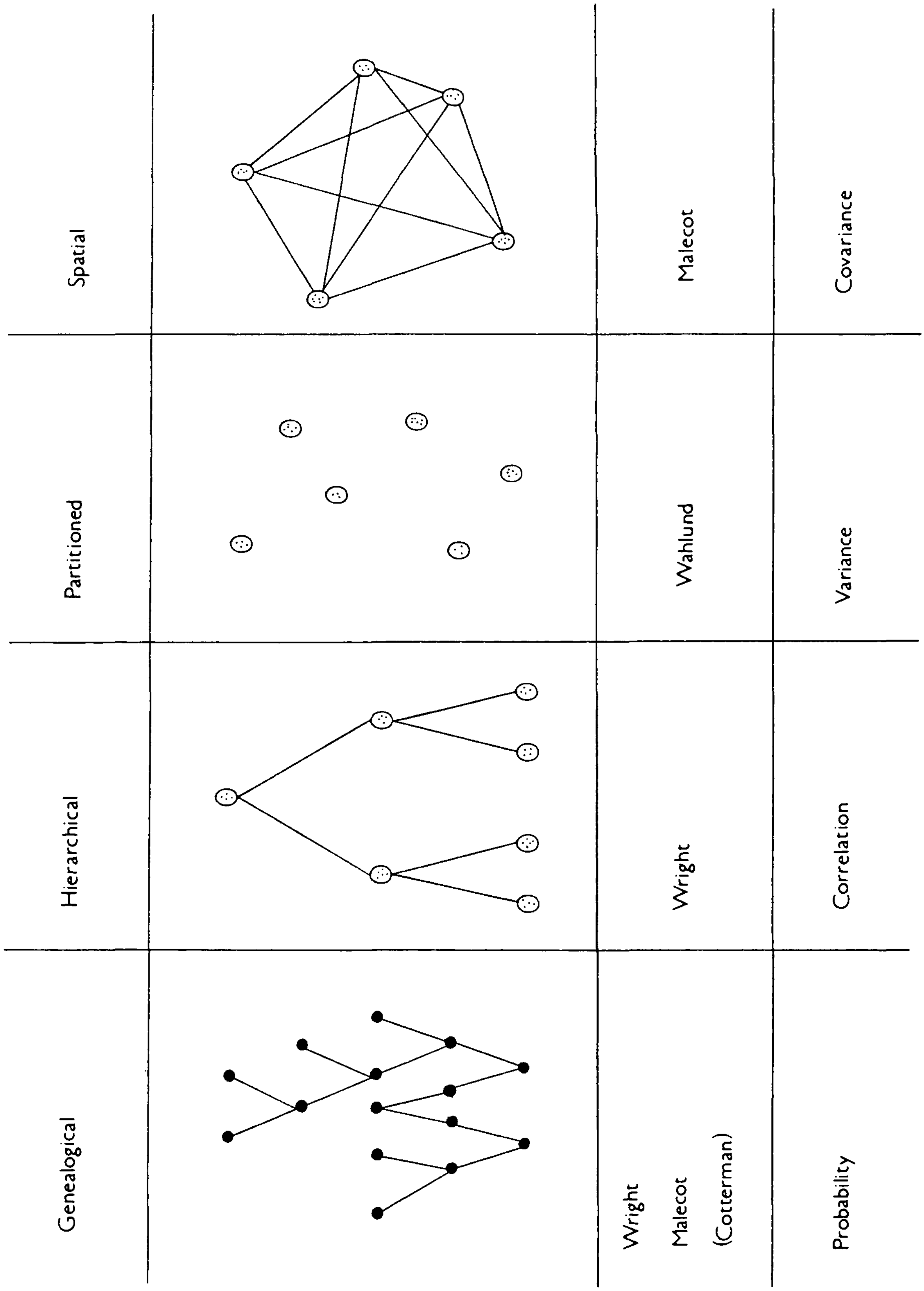


**Fig. 1.1: A Summary of the Four Methods of Estimating Inbreeding**

*(from Yasuda and Morton 1966, Morton 1982b.)*

$$F = F_n + (1 - F_n)F_r$$

(The definitions of these terms have also been reviewed by Libet (1983).)

Non-random inbreeding approximates the amount of inbreeding added in a generation (or over a certain period of time). It thus reflects current marriage practices. The value may be either negative or positive. Random inbreeding, on the other hand, measures the differentiation of sub-groups within a population and is based on the standardised variance. As such it can be interpreted as the probability that a random gene in a sub-population may be identical by descent to a gene in another sub-population. It is thus analagous to the kinship coefficient, f. It follows that it will always be a positive quantity.

The partitioned model really refers to Wahlund's variance. The proportion of homozygous genes in a population increases under genetic drift. When two drifting populations are fused, an excess of homozygous genes results (and by implication, a deficiency of heterozygotes) by a quantity that is twice the variance of the gene frequencies of the individual populations. Hence the decrease of overall heterozygosity due to drift within each of the colonies is a direct measure of the heterozygosity between them.

$$Wahlund's \quad variance = \frac{\sigma^2}{\overline{pq}}$$

Where $\sigma^2$ is the variance of gene frequencies between populations, and $\bar{p}$ and $\bar{q}$ are the mean gene frequencies. It has a close relationship to the inbreeding and kinship coefficients. It is a measure of the departure of the total, subdivided, population from random mating, which is analogous to the inbreeding coefficient, or it can be thought of as a form of the inbreeding coefficient for a group of populations, as opposed to the inbreeding coefficient of an individual. It is, however, directly analogous to the mean kinship coefficient (Cavalli-Sforza and Bodmer 1971).

$$f = \frac{\sigma^2}{\overline{pq}}$$

The spatial model is Malecot's contribution. Given a number of populations, n, it is possible to construct a matrix, $\Phi$, whose kinship, $\phi_{ij}$, between populations i and j is defined as the probability that a random gene from i is identical by descent with a random gene in j. (This particular model is discussed in detail in chapter 6.) This measure is thus equated with the kinship coefficient, and in comparison with the hierarchical model, $\phi_{ii}$, is analogous to $F_{ST}$ or the mean local kinship (Jorde 1980p145).

Thus it is seen that the various 'models' of estimating kinship and inbreeding are inter-related. Some of the models rely on differing sources of data. For example, the spatial model depends upon raw migration data while the partitioned model relies upon either genetic or pedigree data. Both the hierarchical and genealogical models may be estimated from isonymy and pedigree information; ' bioassay ' from phenotypic traits has also been used to estimate kinship in keeping with the genealogical model.

One of the difficulties arising from the use of different data sources is that the results obtained from historical material are not always directly comparable with results from genetic data. There is a distinction between kinship estimated relative to an ancestral population, as in most migration models, and kinship estimated from all genetic data and isonymy, where it is relative to the contemporary population array. Morton (1973b) has distinguished the two as *a priori* kinship and 'conditional' kinship respectively. The problems of relating *a priori* and conditional kinship, however, are resolved by the application of the hierarchical model to kinship. For if $F_{IT}$ is equivalent to *a priori* kinship and $F_{IS}$ is analagous to conditional kinship, *a priori* kinship may be defined as;

$$\phi_{ij} = r_{ij} + (1 - r_{ij})\phi R$$

where $\phi_{ij}$ is the *a priori* kinship relative to the founders; $r_{ij}$,is the conditional kinship relative to the contemporary gene pool; and $\phi R$ is the random kinship for individuals relative to regional founders which are considered sufficiently remote such that the descendents are distributed randomly throughout the contemporary region (Morton 1973b, p67 and Relethford 1980a, p68).

The ability to compare the differing techniques of estimating kinship from often differing materials is a tremendous asset in confirming the predictions of population structure. Moreover, it offers the opportunity to assess the relative merits and shortcomings of the various migration models or methods of analysing population structure. It is, thus, the estimation of kinship which lies at the very heart of this thesis.

The actual tools and methodology used in analysing population structure may be considered under two sub-sections, according to the materials upon which they are based.

### Methods of Genetic Analysis

Much work and time has been devoted to this subject. Here, however, I shall only give a brief synopsis of the type of work that has been done rather than give a more detailed account of the methods used. For while the two subjects of historical demography and genetic analysis are very importantly intertwined, a genetic survey was beyond the scope of this study.

The genetic composition of human populations, from the point of view of genetic markers, has been analysed in a number of studies (for example; Rouger *et al.* 1982; Lai and Bloom 1982; Karaphet *et al.* 1981). The difficulty with such surveys is that while they draw on history to suggest the possible causes and processes responsible for the observed gene frequencies, it is almost impossible to quantify the actual processes involved. This problem has been reviewed by Felsenstein (1982).

A number of studies have drawn on measures of genetic distance to represent the difference in gene frequencies between two populations. Genetic distance has been used, for example, to assess the biological affinities of the Cornish (Harvey *et al.* 1986); and to examine the biological relationship between towns in Western Ireland

(Relethford and Lees 1983); to measure the genetic affinities of groups of Romany gypsies (Sunderland 1982); and to analyse the relationship between South American tribes (Ward and Neel 1970). For the most recent and comprehensive review on the subject see Jorde (1985), and also Lalouel (1980).

The matrix of R statistics was developed by Harpending and Jenkins (1973) to examine the pattern of gene frequency variation among sub-populations of a total population. For example, it has been used by Roberts *et al.* (1981a) to estimate the genetic similarity between districts in Cumbria and also by Workman *et al.* (1976) to analyse the genetic variation and covariation between groups of rural Finns. Most interestingly, it has been used to predict isolation by distance: such estimates are directly comparable with results obtained from migration data. This is an enormous advantage for it may help to assess the methods used and it certainly elucidates predictions of population structure. Eriksson and his colleagues, for example, have compared results for the Åland Islands and found that the genetic estimates, which incorporated factors of founder effect and genetic drift as well as patterns of recent gene flow, showed that geographical distance was less important as a determinant of population structure than was indicated by the migration analysis. Additionally, Wahlund's variance has been used in several studies to examine population differentiation (Relethford *et al.* 1980 and Roberts *et al.* 1981b).

Bioassay of kinship refers to a number of estimation techniques that are used to derive the coefficient of kinship from observed population variation. The work of Morton and his co-workers is almost entirely responsible for the founding and popularisation of this method (Morton *et al.* 1968; Morton *et al.* 1971a; and for the most recent summary, Morton 1982b). By this method, kinship has been predicted using blood group data, isonymy, clans, and other phenotypic material including metrics. More recently, work by Relethford and his associates has utilised kinship bioassay calculated from anthropometric data (Lees and Relethford 1982; Relethford *et al.* 1981; and Relethford 1980a).

### Isonymy

Isonymy literally means identity of surname. A surname is analogous to the Y chromosome in that it is inherited patrilineally. Thus it may be used as a genetic marker. First suggested by G. Darwin in 1875, the idea was regenerated in studies like Fisher and Vaughan (1939), Ashley and Davis (1966), Hatt and Parsons (1965), who considered the relationship between blood groups, surnames, and ancestry. Later studies (Kaplan and Lasker, 1983; Tavares-Neto and Azevado 1978; Gottlieb 1983; Stevenson *et al.* 1983) have confirmed the usage of surnames as indicators of racial origin. Others have, less directly, used the turnover of surnames in different 'populations' as measures of population constancy and migration (Buckatzch 1951; Watson 1975; Dobson 1973; Dobson and Roberts 1971; Swedlund and Boyce 1983; McClure 1979).

Isonymy was first suggested as a measure of consanguinity by Kamizaki in 1954, and was later articulated by Crow and Mange in 1965, and revised by Crow in 1980. The inbreeding coefficient for a population may be estimated as the total proportion of isonymous marriages divided by 4. [As the degree of consanguinity is proportional to the frequency of isonymous marriages, the total inbreeding coefficient (F) will always equal P/4.] This has been estimated in a number of studies (Roberts and Rawling 1974; Weiss 1980; Swedlund and Boyce 1983).

Gabriel Lasker (1977) developed a method to estimate the degree of genetic relationship between two (or more) populations. This is calculated according to the frequency of shared surnames, or ' isonymic pairs' , between the two groups. The coefficient of relationship (Ri) may be given as;

$$Ri = \sum \frac{(N_{s_1} \cdot N_{s_2})}{2(N_1 \cdot N_2)} \quad 1.1$$

where; $N_{s1}$ is the frequency of surname s in the first population, $N_{s2}$ is the frequency of surname s in the second population, $N_1$ is the total number of individuals in the first population, and $N_2$ is the total number of individuals in the second population.

That is, for example; the number of occurrences of each surname in Scarborough to the number of occurrences of the same surname in Whitby, over the total number of surnames sampled for each town in 1851, will estimate the biological relationship between the two. The value of Ri will be zero if there are no surnames common to both groups. This is analogous to Crow and Mange's (1965) estimation of random inbreeding except that because the estimate is of general relationship it is twice as big as that for inbreeding.

Lasker's method ultimately rests, however, on two fundamental assumptions; firstly, that all surnames are monophyletic, and secondly that the relationship through the male line is proportional to that through the female lines. The fallibility of such assumptions has led to widespread criticisms of the method (Crow 1983, Roberts and Roberts 1983, Weiss *et al.* 1983, and Sorg 1983).

The multiple origins of many common surnames results in an over-estimation of Ri. This is clearly shown by Lasker and Mascie-Taylor (1983), with the surname 'Smith' . Comparisons with other estimates of biological relationship also demonstrate the problem of polyphyleticism (Roberts and Roberts 1983; Hurd 1983). Certainly, rare surnames are better indicators of true genealogical relationship. Accordingly, Lasker (1983), has suggested that surnames of different frequencies should be separately reported. However, other disadvantages of the method still make it impossible to interpret Ri as an absolute measure of biological relationship.

The second assumption, that relationships through the male line are proportional to those through the female line, has been considered more critically in the last decade. Smith and Sherren (1987) used marriage records to examine the assumption with regard to the relationship between occupational groups in Selsey, West Sussex; comparison of the generational change in men's occupation against the brides' nuptial move from the occupational group of their fathers to that of their husbands, revealed that there was a statistically significant difference, with the men being more conservative. Clegg (1986) has also arrived at a similar conclusion for two Outer-Hebridean populations; females had a greater propensity to migrate. The direction of this difference suggests that Ri will tend to over-estimate kinship. However, the cohesion of the North Yorkshire fishing villages (see chapter two) would suggest that this might not prevail here: indeed Smith and Hudson's (1984) partial testing of this assumption in Fylingdales tentatively suggests that this could be the case.

Another difficulty with isonymy is the nature of the data themselves. This is, however, discussed in detail in chapter three.

The within-population coefficient of relationship is sample-size dependent; this is clearly shown by Smith and Hudson (1984), and also in Clegg (1986) where he found that the use of parental surnames, yielding a four times greater amount of data, gave more reliable inbreeding (Crow 1980) coefficients. This problem, however, is frequently unacknowledged, for example, in Kuchemann *et al.* (1979) and Lasker *et al.* (1979). Sample sizes approximately below 200 are particularly vulnerable, and yet a great many sample sizes fall exactly within this range. A possible solution to this problem may be found in the substitution of the following formula;

$$R_{ss} = \sum \frac{(N_{s_1}(N_{s_1} - 1))}{2N_1(N_1 - 1)}, \qquad 1.2$$

which is in fact analogous to a formula suggested by Lasker (1968).

The one major advantage of isonymy is, however, the relative ease, speed and inexpense of analysis. Open to a wide variety of sources in both a contemporary and a historical context, it spans a longer period than pedigree studies, and a more definite period than genetic studies. As a crude and approximate measure of the genetic relatedness between populations, its value should not be under-rated. Isonymy is an ideal tool for analysing population structure and subdivision (Swedlund and Boyce 1983), ' population hierarchy' (Weiss 1980), and contrary to James (1983), ' geographical and age clusters' . To quote Lasker (1978a p239):

> " Even if coefficients of relationship by isonymy tend to overstate the kinship there is no reason to doubt the relative degrees of relationship derived in this way."

A number of studies using Lasker's coefficient have considered geographical or spatial units over time (Lasker *et al.* 1979; Raspe and Lasker 1980; Lasker 1978b; Souden and Lasker 1978; and Kuchemann *et al.* 1979). A few have applied the coefficient to see if social factors, such as different occupation, constrain gene flow (Sherren 1983; Smith and Hudson 1984; Smith, Smith and Williams 1984).

In this study Lasker's coefficient will be used to calculate the relationship within and between social and geographical units or ' populations' along the North Yorkshire coast 1851-1881. Primarily indicative of population subdivision, the results will partially test one of the major assumptions of the stepping-stone model of migration, and secondly, predictions of kinship will be compared to those obtained from other measures of genetic inter-relatedness (–matrices; isolation by distance; *etc*).

## Methods of Historical Analysis

The prediction of population genetic structure from demographic records is a subject largely based on mathematical theory. Collected demographic data, parish registers, and census data are but a few of the raw materials used. The use of such data has the advantage of a temporal dimension, but suffers inevitably from the weaknesses of the data themselves. (This is discussed in full in chapter 3.)

The subject aspires to study human evolution, but in reality most of the models concentrate on the dual effects of migration and drift, and thus at the micro-evolutionary level. It is difficult to estimate the rôle of selection, and in particular, mutation, from historical records alone. Historically, it is only possible to study selection at the level of the individual or, as most studies have done, at the aggregate level of the 'population' . By this I mean fertility and mortality rates. For example, Clegg (1977) has considered the effects of infant tetanus on the population structure of the island of St. Kilda. Crow's Index of Total Selection (Crow 1958) is based upon this premise: the index of total selection is $I = \frac{V}{\overline{W}^2}$, where V is the variance in the number of offspring and $\overline{W}$, the mean number of offspring. The index has been applied to the populations of Deerfield, the Ramah Navajo, Polish Hill (see Swedlund 1980 for a summary), and most recently to the Utah Mormons (Jorde and Durbize 1986).

Essentially, however, the method suffers from the weaknesses that much of the variance in fertility and mortality is probably the result of cultural and non-genetic environmental factors. On the other hand, it does give some indication of selection when genetic data are not at hand (Swedlund 1980). A more satisfactory interpretation of Crow's index can be given if we consider that it measures the opportunity for selection, and at least can indicate where selection could not be occurring.

Before going on to discuss the migration models individually, it is perhaps necessary to comment on a parameter which is common to them all, the effective population size $N_e$. This is distinguished from the total population size and is determined by the number of parents producing the following generation. It is crucial to the analysis of population structure, since estimates of the mean kinship coefficient and the variation of gene frequencies depend upon it.

As Fix (1979) has pointed out, $N_e$ is actually very difficult to measure accurately despite its importance to population genetics theory. This is partly because of the mathematical problems involved in combining the effects of all the various factors which influence the value of $N_e$, quite apart from the fact that such data are not always readily available (Salzano *et al.* 1973). Jorde (1980) has summarised the factors influencing the value of $N_e$: They include, differential fertility, the presence of more than one generation in a population, the fact that generations overlap, the presence of consanguineous mating, unequal sex ratios, temporal changes in population size, and migration.

Kimura and Crow (1963) have defined the population effective size either in terms of the amount of increase in homozygosity (inbreeding effective number) or the amount of gene frequency drift (the variance effective number). However, despite such formulations, $N_e$ is usually taken as a third of the total population size $\frac{N}{3}$

(Jorde 1980; Cavalli-Sforza and Bodmer 1971), an approximation which has been justified by census statistics. Deviations in the age-structure of a population may of course affect the validity of this approach and the estimation of $N_e$ should therefore be made with caution (Jorde 1980).

## The Island Model: S. Wright 1943

This is the earliest and simplest of all the models. It assumes a subdivided population, in which every colony is panmitic, and of equal size, $N_e$ . Each colony exchanges genes with each other and drift is balanced by migration. Each unit will approach the same gene frequency when $4N_eM_e \geq 1$. ($M_e$ is the effective migration rate.) As migration increases gene frequency variance decreases. At equilibrium the expectation of variance is given by;

$$f = \frac{\sigma^2}{pq} = \frac{1}{1 + 4N_eM_e}$$

The island model has been applied in a number of studies. For example, Relethford (1981) has assessed the effects of population growth on expected homozygosity in the island model. Cavalli-Sforza and Bodmer (1971) have applied the model to data from Japan. A number of other applications are reviewed in Roberts (1975) and Jorde (1980).

The model suffers from a number of unfulfilled assumptions. Exchange between populations is rarely equal. It does not, for example, allow for the effects of distance, (a problem later addressed in Wright's ' Neighbourhood Model' ), nor does it allow for variable population size. The appeal of the model really lies in the simplicity of the formula (Cavalli-Sforza and Bodmer 1971).

## The Stepping-Stone Model

This model was first studied by Malecot in 1950 and Kimura in 1953. In the model the population is subdivided into discrete colonies which only exchange migrants with their immediate neighbours. In the one-dimensional model the colonies are infinitely distributed along a straight line. This can be represented graphically, as in figure 1.2. The nearest realistic equivalent would be a settlement along a mountain valley, a river, or a coast line.

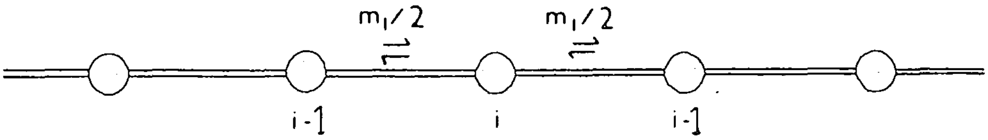


Fig. 1.2: The One-Dimensional Stepping-Stone Model

The model assumes that the Mendelian populations are all of equal size N, and that migration from one colony to the next is at the rate, m, in each generation, so that $\frac{m}{2}$ is the proportion of individuals exchanged between a pair of adjacent colonies per generation.

The mean kinship coefficient between neighbouring clusters is, approximately, at equilibrium

$$f_0 = \frac{1}{1 + 4Nb\sqrt{1 + \frac{2m}{b}}}, \qquad 1.2$$

(Malecot 1950, Cavalli-Sforza and Bodmer 1971). This reduces to

$$f_0 = \frac{1}{1 + 4N\sqrt{2mb}}, \qquad 1.3$$

when $b \leq m$. The terms of these equations should be explained precisely: f used with the subscript 0, refers to the mean kinship coefficient of one cluster; m is synonymous with Malecot's (1950) 2m and Kimura and Weiss' (1964) $m_1$ – it is the estimate of close range migration or more exactly, it is the proportion of individuals exchanged with immediate neighbours, b is systematic pressure, ‘ the coefficient of recall to equilibrium' – It is the sum of mutation, linearised stabilising selection, and long range migration. Since the effects of selection and mutation are usually outweighed by the latter, for all practical purposes b may be estimated from long range migration. Kimura and Weiss (1964) and Weiss and Kimura (1965) denote b by $m_\infty$, and Malecot uses the symbols v or k.

Kimura and Weiss (1964) have used a different formula from Malecot.

$$V_p = \frac{\overline{p}(1-\overline{p})}{1+4Nm(1-r(1))}, \qquad 1.4$$

where $\overline{p}$ is the frequency of gene A in the entire population. (p572, Kimura and Weiss 1964.) Essentially this formula (1.4) differs from Malecot's equation (1.3) in that it uses the variance of gene frequencies,

$$\frac{\sigma^2}{\overline{pq}},$$

rather than the inbreeding coefficient (f). However, it is easy to translate one from the other since,

$$\frac{\sigma^2}{\overline{pq}} = f \qquad (Wahlund's \quad variance)$$

Indeed when b≤m the two equations (1.3) and (1.4) give the same results (Cavalli-Sforza and Bodmer 1971 p427). Thus while in formula 1.2 and 1.3 $f_0$ is a measure of the mean kinship coefficient of one cluster, it is also an approximation to the standardised variance of gene frequencies of neighbouring clusters.

The correlation between clusters decreases with distance x (the number of steps between them) approximately according to

$$\rho(x) = \left(1 + \frac{b}{m} - \sqrt{(1+\frac{b}{m})^2 - 1}\right)^x$$

which for b≤m is

$$\rho(x) = e^{-x\sqrt{\frac{2b}{m}}}$$

Thus correlation falls off exponentially with distance in the one-dimensional case. This was derived by Kimura and Weiss (1964) and is interesting since Malecot (1948,1959) independently estimated the same form of isolation by distance function (see below, equation 1.7). Malecot (1950) and Cavalli-Sforza and Bodmer (1971) have given the coefficient of kinship between clusters at distance x as

$$f(x) = f_{\phi} \rho(x),$$

where f(x) refers to the mean kinship of two individuals taken from clusters separated by a distance x. Once more Kimura and Weiss (1964) give an equivalent formula to calculate the variance of gene frequencies between colonies x steps apart.

$$V_p = \frac{\bar{p}(1-\bar{p})}{1+2N_e C_0}$$

where

$$C_0 = \frac{2R_1 R_2}{(R_1 + R_2)}$$

in which

$$R_1 = \sqrt{(1+\alpha)^2 - (2\beta)^2},$$

and

$$R_2 = \sqrt{(1-\alpha)^2 - (2\beta)^2},$$

in which $\alpha = 1 - m - b$, and $2\beta = m$.

The change in gene frequencies from one generation to the next in a colony is given by the equation

$$p'i = (1 - m - b)\, pi + \frac{m}{2}\,(p_{i-1} + p_{i+1}) \; + b\bar{p} + \xi i$$

where pi is the frequency of gene A in the first generation, $\bar{p}$ is the mean gene frequency, and $\xi i$ is the change in pi due to random genetic drift (Kimura and Weiss 1964).

The one-dimensional stepping-stone model has been extended to two and three dimensions by Kimura and Weiss (1964) and Weiss and Kimura (1965). The two-dimensional model is shown in figure 1.3.

Here each colony exchanges migrants with four adjacent colonies. Migration rates along the different axes may vary, hence $m_A$ and $m_B$. The migration rate along the same axis, however, is constant, as it is in the one-dimensional case. Thus each colony exchanges genes with its neighbours at a rate of $\frac{m_A}{2}$ or $\frac{m_B}{2}$ along each axis.

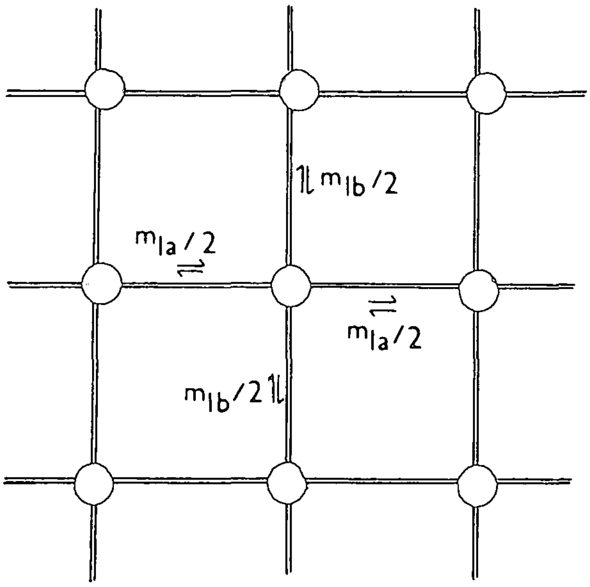


**Fig. 1.3: The Two-Dimensional Stepping-Stone Model**

It is interesting that the decrease of genetic correlation with distance depends very much on the number of dimensions used in the stepping-stone model. The rate of decrease increases proportionally with the higher dimensional models. Hence in the one-dimensional case, the correlation falls off exponentially with distance, in two dimensions it falls off more rapidly and in three dimensions it falls off still more rapidly.

The discontinuous stepping-stone model can also be converted to a continuous model (Kimura and Ohta 1971, and Cavalli-Sforza and Bodmer 1971). The coefficient of kinship between neighbours at equilibrium in the one dimensional case is given by $f_0$ where $\delta$ is the population density along the line, and $\sigma$ is the standard deviation of the distance between birthplaces of parent and offspring.

$$f_0 = \frac{1}{1 + 4\sigma\delta\sqrt{2b}}$$

Cavalli-Sforza and Bodmer (1971) have found that the continuous and discontinuous one- dimensional models give the same result if $\sigma^2 = m$ and $\delta$ (the number of individuals per unit per distance) is taken as the size of the colony N in the discontinuous model, (at least as long as $b \leq m$ or $b \leq \sigma^2$). Also Kimura and Weiss (1964) have demonstrated that the one-dimensional discontinuous stepping-stone model approximates Wright's island model when inter-colony migration is zero.

Maruyama (1969,1970b, and 1970c) has studied a finite circular stepping-stone model and a rectangular model. He devised these to overcome two of the major assumptions of the stepping-stone model. Firstly, that the number of colonies is infinite, which is obviously untrue. Secondly, that migration rates are symmetric between each colony, a condition which rarely prevails in living populations.

Using the finite models, Kimura and Maruyama (1971) have shown that the tendency towards local differentiation is much weaker in a two-dimensional rather than a one-dimensional habitat. For the two-dimensional stepping-stone model of finite size, marked local differentiation can only result when migration between colonies is sufficiently rare so that $Nm \leq 1$. On the other hand, if $Nm \geq 4$, the population appears approximately panmitic.

The stepping-stone model has been used for much theoretical analysis. For example, Maruyama (1970a, and also 1971a, 1971b,1972,1974a,and 1974b) has used the stepping-stone model to examine the rate of decay of heterozygosity in subdivided populations. One of his more interesting findings was that fixation (of a mutant) is apparently independent of population structure. Feldman and Christiansen (1975) have used the linear stepping-stone model to study the effects of population subdivision on the evolution of two linked loci.

There are very few practical applications of the stepping-stone model. Morton *et al.* (1973) simulated the population structure of Switzerland using the one-dimensional circular stepping-stone model with constant values of migration and population size. They found that the inbreeding coefficient for Alpine isolates was in good agreement with independent estimates of kinship, but that the inbreeding coefficient for all of Switzerland was much higher than in other estimates. On the other hand, he suggested that this could be accounted for by avoidance of consanguineous marriage in Switzerland and that it did not necessarily imply that the simulation was too approximate.

Relethford (1980a and 1980b) has used a very similar approach. Kinship was calculated between colonies in a circular stepping-stone model using estimates of Malecot's isolation by distance parameters a and b (Relethford *et al.* 1981), and the demographic parameters of $N_e$ (effective population size) and m (long range migration). He found that the resulting values of kinship were in good agreement to those estimated from anthropometric bioassay and that, like Morton (1973), the observed population structure could therefore be adequately represented by a simple linear model.

Jovanovic *et al.* (1984) have described a migration model to analyse long and short range migration on the island of Hvar, situated in the Adriatic. The linear chain of settlements could be modelled by a linear stepping-stone model and I believe that they have done this (personal communication), but I can find no published references to date.

One of the reasons for the limited number of practical applications of the stepping-stone model must be the theoretical criticisms of it. I have already mentioned two of the major pitfalls of the original models: populations are not infinitely distributed and symmetric migration is found only rarely. Moreover, the results are based on an equilibrium situation and most human populations are not at equilibrium (Jorde 1980). Also it is assumed that migration rates are constant in space and time, and that migration only occurs between adjacent sub-groups. Non-random migration is also not allowed for. Hence socio-economic factors and the advantages of geographical location are excluded from the analysis (Schull and Macluer 1968, Roberts personal communication). Moreover, populations that are distributed linearly are very rarely of equal size, nor are they usually equi distant (Cavalli-Sforza and Bodmer 1971). Finally, even within sub-groups one cannot necessarily assume that there is random mating.

Despite such severe criticisms, however, the stepping-stone model does present a relatively simple and straightforward method of predicting the amount of local variation and correlation under drift equilibrium, and of analysing the principle factors involved, – such as population size and mobility, for example (Cavalli-Sforza and Bodmer 1971). Furthermore, in the cases where it has actually been applied (see above), the circular stepping-stone model has given a reasonable approximation to the observed population structure. To conclude:

> "...any mathematical model is but an approximation to reality, requiring many assumptions and simplifications if it is to be amenable to analysis. Attempts may be made to investigate the robustness of the models, that is, to find out how greatly the results are affected by relaxation of certain assumptions, and to test them by simulation... but the assumptions should always be kept in mind. " (Cannings and Cavalli-Sforza 1973 p107).

## Migration Matrices

This approach considers real migration data from which a matrix is formed and, in turn, population structure is predicted. Thus it has the advantage of dealing with particular migration rates as opposed to estimated average rates as used in the discrete models, or by distance only as in the continuous models.

To be specific, the migration between the populations under consideration is presented in an array of s populations, which is symmetrical (s × s), the diagonal elements of the matrix $s_{ii}$ describe endogamy, (or where there has been no movement from i), whereas the off-diagonal elements $s_{ij}$ give the probability of moving from population i to population j. It is thus a matrix of Markov transition probabilities. Some authors (Swedlund *et al.* 1984; Jorde 1984; Morton 1973c) have chosen to make the above raw matrix symmetrical, for under conditions of perfect symmetry, population sizes stay constant through time. This is done simply by averaging the above-diagonal elements $m_{ij}$ and the below-diagonal elements $m_{ji}$. The one drawback of this is that it distorts the actual migration patterns, but the degree of inaccuracy obviously depends on how far the observed matrix deviates from the perfect symmetry.

While a number of different lines have been adopted, all the methods are essentially computer simulations which predict population structure on the basis of the input matrix and other input parameters (such as population size and systematic pressure). Thus, Jorde (1980 p162) has described the matrix approach as lacking "the elegance and generality of other models". While this is true, all the models depend on input parameters (such as population size and long range migration) to some extent, which, if accurately assessed, should be made with reference to demographic data and in pratice may be no easier to obtain than the migration matrix. The ' generality ' of other models in comparison to the matrix approach is therefore questionable.

However, one real drawback, as discussed by Jorde (1980), is the universal assumption that a matrix of observed migration events can be interpreted as migration probabilities that remain constant through time. This is quite a thing to claim at any point in our history! Disease, war, poor harvests, availability of work, *etc.* are all major variables prompting fluctuations in patterns of human movement. The last two centuries in particular have seen migrations on a scale much greater than ever before. One must therefore be careful in drawing conclusions from a model which projects momentary migration rates to a state of equilibrium.

Wood (1986) has stated that the problem with the migration matrix approach lies in their convergence properties: that the models take an unrealistically large number of generations to reach equilibrium and yet predictions can only be drawn from the models at equilibrium. He has suggested a method to overcome the problem. This situation has not, however, arisen here: in all cases convergence was attained in less than five generations (see chapter 6).

One final reservation, and one that applies to all demography, is that the matrices are of course subject to the limitations of the parish register or census material available (see chapter 3). However, other limitations, and indeed advantages, are model-specific, for the different matrix methods vary considerably and it is in this light that I will go on and discuss them individually.

## Hiorns, Harrison, Boyce, and Kuchemann (1969) Migration Matrix

This stands out from the other types of matrix model in that it assumes that the initial population subdivisions are unrelated. From this premise it considers the increasing relatedness resulting from genetic exchange between populations. Homogeneity is said to have been reached when 95% of the ancestry of the populations is shared in common.

The model has been applied to migration between geographical units (Hiorns *et al.* 1969; Hiorns *et al.* 1973; Smith,M.T. 1981), and between social classes (Harrison *et al.* 1971; Fowler 1982; Sherren (unpub.)). Coleman (1980) uses a modified version of Hiorns matrix in the Reading area.

While it is probably the most straightforward model to use, there are a number of serious drawbacks. It does not take into consideration the effects of random genetic drift. Jorde (1980) cites this as the principle reason for the rapid rate of convergence in the Oxfordshire parishes. For in the absence of drift, the populations can do nothing other than converge: the model does not make allowance for differentiation. This problem will be particularly accentuated in small populations but may not be at all acute in relatively large populations. The difficulty remains in how one can predict such a problem.

## Bodmer and Cavalli-Sforza 1968 Migration Matrix.

Using parent-offspring migration data, Bomer and Cavalli-Sforza distinguish between the forward-migration matrix and the backward-migration matrix. The former indicates the number of individuals in j whose children are born in i. In other words it depicts where people are going to, and it is therefore used to predict the composition of a population after t generations of migration.

$$n_1 = n_0(M^*)^t$$

where; $n_1$ is the distribution of individuals after one generation; $n_0$ is the initial distribution of individuals; and $(M^*)^t$ is the forward-migration matrix iterated until convergence is reached.

The latter, on the other hand, gives the number of offspring in j whose parents were born in i. More simply, it shows where people are coming from. It is used to assess the variation and covariation in gene frequencies within and between colonies. Unlike the matrix of Hiorns and his associates, drift is considered. It is assumed to be the random sampling of genes, taking place for every colony at every generation. Systematic pressure (theoretically the effects of selection, mutation and long range migration) is considered in the ' coefficient of recall to equilibrium' , $\alpha_i$, and $x_i$ is the gene frequency of such long range migrants. Of particular note is their use of the angular transformation to make the gene frequency variance independent of the frequency itself. (It is the use of this that really distinguishes their model from the migration matrix derived by C. A. B. Smith in 1969).

The expected frequency of a gene in the $n^{th}$ generation in terms of those in previous generations is thus given by:

$$pi^{(n)} = \sum_{j=i}^{k} (1-\alpha_i)\, M_{ij}\, P_j^{(n-1)} + \alpha_i x_i\,,$$

where k is the number of subdivisions. The covariance of the transformed gene frequencies between subdivisions in the $n^{th}$ generation is given by:

$$cov\left(\theta_i^{(n)}\theta_j^{(n)}\right) = \frac{1}{8}\sum_{l=1}^{k}\frac{1}{N(l)}\sum_{r=1}^{n-1}(m_{il}^{(r)}m_{jl}^{(r)}),$$

where $\theta_i^{(n)} and \theta_j^{(n)}$ are transformed gene frequencies in subdivisions i and j in the $n^{th}$ generation, N(l) is the population size of the $l^{th}$ generation, and $m_{il}^{(r)}$ is the $il^{th}$ element of the $r^{th}$ power of $(1-\alpha_i)M_{ij}$. The equation is iterated until the variance-covariance matrix converges.

This matrix approach has been applied to populations throughout the world. (Ward and Neel 1970; Ferák *et al.* 1980; and Harrison *et al.* 1974a). While the model has several advantages, namely that it allows for drift and takes into consideration long range migration, it has been criticised by Imaizumi *et al.* (1970). Of particular relevance here, the matrix only gives approximations to the coefficient of kinship: the results are expressed as gene frequency correlations.

### Malecot's migration matrix, 1950.

I should say at once that although I have described this method as Malecot's, Malecot was in fact only responsible for the original recurrence equation. Morton (1969) then modified this and it was Imaizumi, Morton and Harris (1970) who first demonstrated the matrix method itself. It has since been widely used (Eriksson *et al.* 1973; Mielke *et al.* 1976; Boyce *et al.* 1978).

Essentially the model predicts kinship between colonies. It uses a backward, column-stochastic transition matrix (P), and takes into consideration systematic pressure ($S_k$), effective population size ($N_k$), and random genetic drift ($D^{(r-1)}$). The matrix of kinship coefficients ($\Phi$) is predicted using the equation;

$$\Phi(t) = \sum_{r=1}^{t} S^r P'^r D^{(r-1)} P^r S^r. \qquad 1.5$$

where $P'$ is the transpose of P, S is a diagonal matrix of elements $1 - S_k$, and ($D^{(r-1)}$) is genetic drift.

The equation is iterated until $\Phi$ converges at generation t. At convergence, $\Phi$ represents the equilibrium state (in other words, kinship values remain constant from one generation to the next).

Harpending and Jenkins (1974) have shown that it is often preferable to transform the kinship matrix $\Phi$ to a conditional kinship matrix R, following the formula:

$$r_{ij} = \frac{\phi_{ij} + \overline{\phi}_{...} - \overline{\phi}_{i.} - \overline{\phi}_{.j}}{1 - \overline{\phi}_{..}}, \qquad 1.6$$

where:

$$\overline{\phi}_i = \sum_k W_k \phi_{ik}$$

($W_k$ is the population size of subdivision k divided by the total population size.

$\overline{\phi}_j = \overline{\phi}_i$ , due to symmetry.

$\overline{\phi}_{\cdots} = \sum_{i,k} W_i W_k \phi_{ik}$.)

Essentially the R matrix specifies kinship relative to a contemporary array of gene frequencies, rather than to the ancestral array. In other words it estimates conditional kinship rather than *a priori* kinship, which is estimated in the $\Phi$ matrix.

The diagonal elements of the R matrix may be averaged to estimate the equilibrium values of $F_{st}$ (the effective population size is used to weight the sum). Values of $F_{st}$ may thus be used as an index of between-subdivision genetic heterogeneity. Jorde's papers (1982,and Jorde *et al.* 1982a) exemplify some of his work using Harpending and Jenkins R matrix. It has also been used by Roberts (1982) and Swedlund *et al.* (1984).

In summary, this model has the advantage of taking into consideration random genetic drift, a factor of particular importance here since the small insular fishing villages may provide suitable conditions for drift. Fundamentally, however, the model also has the supreme advantage of actually predicting kinship which can easily be compared to values of kinship predicted by isonymy and other migration models. For my purposes, therefore, this model would seem to be the most suitable.

## Isolation by Distance

The work on isolation by distance was founded by Sewall Wright in 1943. Most populations are not random breeding units because individual migration distances are usually smaller than the total distribution of the species. This phenomenon, which he called ' isolation by distance' , leads to local differentiation in gene frequencies caused by genetic drift. There are several isolation by distance models, all of which are based on the premise that the population is infinitely and uniformly distributed.

### A. Wright's Neighbourhood Model

Wright (1943,1951) suggested the neighbourhood model in which random inbreeding was restricted by distance. The total area is divided into ' neighbourhoods' , within which there is random mating. The size of the neighbourhood depends on the geographical distance between parents and their offspring and the effective population size is the number of breeding individuals within the neighbourhood. (Alternative migration data such as matrimonial migration may be used.) Mathematically, neighbourhood size may be given by,

$$2\sigma^2\pi,$$

where $\sigma$ is the standard deviation of the parent-offspring migration distances. The effective population size is the number of breeding individuals within that neighbourhood.

Predictions of the inbreeding coefficient, F, or the coefficient of correlation between adjacent gametes, E, can be made from the model. The genetic consequences of the model depend largely upon the size of the ' neighbourhood' , but also on the ratio of the total area to the neighbourhood area and on the breeding system (Dobson 1973, Roberts 1975).

There have been relatively few applications of this model to human data. Populations that have been studied include the Dinka (summarised in Roberts 1975), Sweden (Alström and Linelius 1966), Eighteenth century Northumberland (Dobson 1973), and the Japanese (cited in Harrison and Boyce 1972, p139).

The model rests on a number of assumptions. Foremost, Wright assumed that the parent-offspring migration distribution was normal. This has been criticised as observed distributions are always leptokurtic (Jorde 1980, Roberts 1975). Jorde (1980), however, comments that Wright was aware of this and has shown that neighbourhood size is largely independent of the form of this distribution. In view of the leptokurtic curve, however, Malecot and Kimura have both chosen exponential forms for their models.

The assumption that the variance ($\sigma^2$) for grandparent-grandchild migration is twice that of parent-offspring distances (and so on for each preceding generation) has also been criticised (Jorde 1980, Roberts 1975). The uniformity of distribution within the neighbourhood is also questionable (although, this applies to all isolation by distance models). Similarly random mating, random survival of offspring, and random migration do not necessarily pertain. Jorde (1980) has summarised much of the work done on the actual distribution of parent-offspring and matrimonial migration distances. Generally there were found to be many different factors affecting the distribution: for example, population density, marital age, occupation, and social class.

### B. Malecot's Approach

Malecot (1948, 1950, 1959, 1973) has shown that the coefficient of kinship will decrease with geographic distance as a negative exponential. Morton and his colleagues (Morton *et al.* 1968, Morton *et al.* 1971b, Morton *et al.* 1973, Morton and Smith 1976) have been largely responsible for popularising the use of Malecot's model, evaluating kinship coefficients from genetic or migration data.

The model assumes a population distributed uniformly along an infinite line; the probability of migration depends solely upon distance. Other assumptions include constant migration rates and an absence of gene frequency clines. The mean kinship between individuals (d) distance apart is given as,

$$\phi(d) = ae^{-bd}, \qquad 1.7$$

where $\phi$(d) is precisely defined as the identity of genes as a function of distance; a is a measure of local kinship; and b is the exponential decline of kinship with distance.

Malecot (1959) redefined the equation to allow for the effects of dimensionality,

$$\phi(d) = ae^{-bd}d^{-c},$$

where c = 0 for a linear model and $\frac{1}{2}$ for a two-dimensional model. Subsequent studies, however, have shown that this is ineffectual for most human populations, for distances migrated are usually quite small and c is thus effectively 0 for all dimensions (Malecot 1973, Jorde,L. B. 1980).

Negative values of kinship are to be expected when they are estimated from a contemporary gene pool due to the effects of random genetic drift (Morton 1973a). The application of Malecot's distinction between *a priori* and conditional kinship helped to solve this problem (Relethford 1980a). *A priori* kinship is estimated from equation (1.7). Morton (1973b,1982b) gave the estimation of conditional kinship,

$$r(d) = (1 - L)ae^{-bd} + L,$$

where L $\leq$ 0 is the kinship at large distance within the region. This equation is used when kinship is bioassayed from phenotypes or quantitative traits. Criticisms of the procedure are discussed in Jorde (1980).

Morton (1982b) has discussed the use of isolation by distance as a first-order correction to estimates of kinship from isonymy. However, he concludes that the history of surnames is short compared to genes and that this will still bias estimates downwards.

The methods of estimating parameters ' a ' and ' b ' fall into two main categories: by formula and by non-linear regression. Morton (1969) and Jorde (1980) state that a and b are estimated by the equations:

$$a = \frac{1}{1 + 4N_e\sigma m^{\frac{1}{2}}},$$

$$b = \frac{(8m)^{\frac{1}{2}}}{\sigma},$$

where $N_e$ is the effective population size, $\sigma$ is the standard deviation of the distribution of parent-offspring distances, and m is the systematic pressure (usually estimated as the proportion of long range migrants).

Morton (1977,1982a,1982b) has restated the method of estimating a and b:

$$a = \frac{1}{4N_e m_e + 1}, \qquad 1.8$$

$$b = \frac{\sqrt{2m_e}}{\sigma'} \tag{1.9}$$

where once more $N_e$ is the effective population size, but $m_e$ is the effective systematic pressure, and $\sigma'$ is the standard deviation of parent-offspring distance excluding long range migration. $m_e$ is derived by Malecot's formula:

$$m_e = \sqrt{m(m+2k)}, \tag{1.10}$$

where m is long range migration and k is short range migration. (In Morton's 1982a paper, the equation to estimate ' b ' is incorrect. It is given as $b = \sqrt{\frac{2m_e}{\sigma'}}$ instead of $b = \frac{\sqrt{2m_e}}{\sigma'}$.)

However, Jorde (1980, p169) states that "in practice a and b are usually estimated by a non-linear regression technique" , (where kinship is estimated from bioassay or migration data). Table 1.1 summarises the methods and results of a number of studies.

Estimates of a and b have been thoroughly compared by Jorde (1980). Sorting populations into three groups, he found that generally hunter-gatherer and horticulturist populations had higher values of a than either the modern island or continental populations. Parameter b, on the other hand, was significantly higher only for the island populations.

One of the major criticisms of the isolation by distance model is that parameters a and b are poorly defined (Cannings and Cavalli-Sforza 1973, Jorde 1980). The equations upon which they rest are ultimately dependent on the the distinction between long and short range migration, which is arbitrary. For there is rarely any real discontinuity in the distribution of migrants (Morton 1982a, Cavalli-Sforza 1983). This problem is discussed in detail in chapter 7. The majority of studies appear to by-pass this problem by estimating a and b by non-linear regression (given values of kinship and the migration distances.) Many recent studies by Jorde and others, base their estimates upon results obtained from Malecot's migration matrix (see Table 1.1). The drawbacks of this, however, are that once more, population subdivision is assumed. One is not dealing with a uniformly distributed population

## TABLE 1.1
## COMPARISON OF METHODS AND RESULTS FOR ISOLATION BY DISTANCE

### 1. WESTERN POPULATIONS

| 'a' | 'b' | Population | Method | References |
|---|---|---|---|---|
| .008 | .031 | Rural Western Ireland | Kinship estimated from anthropometric bioassay. Parameters a & b estimated using non-linear regression. (Relethford 1980b) | Relethford,J.H. Lees,F.C. & Crawford,M.H. 1981. |
| .001 | .018 | | Kinship estimated from isonymy, a & b from non - linear regression. | |
| .002 | .006 | Iceland | R matrix was estimated from blood group data, a & b from non - linear regression. | Jorde,L.B. et al. 1982. |
| .005 | .0005 | | Kinship calculated from a migration matrix, a & b from non - linear regression. | |
| .004 | .038 | Cumbria | R matrix estimated from genetic data, a & b by non - linear regression. | Roberts,D.F. Jorde,L.B. & Mitchell,R.J. 1981 |
| .00007 | .009 | | Kinship estimated from Malecots migration matrix, a & b from non - linear regression. (Father - child migrat.) | |
| .00005 | .014 | | (Mother - child migrat.) | |
| .005 | .862 | Otmoor | Kinship estimated from Malecots migration matrix, & fitted to the distance equation using Distan (Morton 1968). | Imaizumi,Y. Morton,N.E. & Harris,D.E. 1970 |
| .0025 | .0185 | All Switzerland | Kinship estimated from blood group bioassay, & fitted to the distance equation using Distan. | Morton,N.E. et al. 1973 |
| .002 | .076 | | As above, except that kinship was estimated from isonymy. | |
| .002 | .014 | | As above, except that kinship was estimated from a migration matrix. | |

Table 1.1 Cont.

| 'a' | 'b' | Population | Method | References |
|---|---|---|---|---|
| .0007 | .032 | Belgium | ABO blood group bioassay was used to estimate kinship. a & b were calculated using Distan. | Imaizumi,Y. & Morton,N.E. 1969 |
| .001 | .0099 | Sweden | | |
| .0006 | .0064 | Japan | | |
| .009 | .007 | Kumamoto prefecture, Japan | Kinship was estimated from Malecots migration matrix, and fitted to the distance equation using Distan. | Imaizumi,Y. 1971 |
| .018 | .941 | Uto City, Japan | | |
| .014 | .214 | Shimomashiki Gun, Japan | | |
| .015 | 1.724 | Tomiai village, Japan | | |
| .0006 | .1775 | Connecticut Valley, U.S.A. 1790 -1809 | Kinship was estimated from Malecots migration matrix, a & b, by non-linear regression. | Swedlund,A.C. Jorde,L.B. & Mielke,J.H. 1984 |
| .0003 | .1575 | 1830 -1849 | | |
| .000007 | .0077 | Utah Mormons 1876 -1885 | | Jorde,L.B. 1982 |
| .000068 | .0236 | All periods | | |
| 2. Isolated/ Island Populations. | | | | |
| .005 | .04 | Aland Islands 1850 -1899 | | Mielke,J.H. et al. 1976 |
| .0002 | .0214 | 1940 -1949 | | |
| .015 | .199 | Pre-1900 | An R matrix was calculated from genetic data, & fitted to the distance equation by non - linear regression. | Jorde,L.B. et al 1982c. |
| .0135 | .500 | All periods | | |

Table 1.1 cont.

| 'a' | 'b' | Population | Method | References |
|---|---|---|---|---|
| .007 | .018 | Barra (Outer Hebrides) | 1977 Formulae | Morton,N.E. et al. 1977 & Morton,N.E. 1977 |
|  |  | Sanday, Orkney Islands | Program written to estimate a & b from estimates of inbreeding. | Relethford,J.H. & Brennan,E.R. 1982 |
| .0239 | .0855 | Sanday born husbands & wives 1855 - 1884 |  |  |
| .0208 | .0337 | All husbands & wives 1855- 84 |  |  |
| .0161 | .1557 | Irish isolates 1890's | Kinship calculated from isonymy, & a & b from non - linear regression (Relethford 1980a). | Relethford,J.H. 1980a |
| .0069 | .0643 | Alpine isolates | Kinship estimated from blood group bioassay & fitted to the distance equation by distan. | Morton,N.E. et al. 1973 |
| .0044 | .1262 |  | As above, except that kinship was estimated from isonymy. |  |
| .0071 | .0570 |  | As above, except that kinship was estimated from a migration matrix. |  |
| 3. Hunter - Gatherer Populations |  |  |  |  |
| .072 | .003 | Pingelap & Mokil Atolls | 1977 Formulae | Morton,N.E. et al. and Morton,N.E. 1977 |
| .043 | .0005* | Namu Atoll | Kinship obtained from a migration matrix & estimates were fitted to the distance equation by distan. | Pollock,N. et al. 1972 |
| .044 | .013 | Bedik, Senegal. |  | Langaney,A. & Gomila,J. 1973 |
| .010 | .069 | Niokholonko, Senegal. |  |  |

Table 1.1 cont.

| 'a' | 'b' | Population | Method | References |
|---|---|---|---|---|
| .030 | .052 | New Guinea | As above, except that kinship was estimated from pooled blood group data. | Imaizumi,Y. & Morton,N.E. 1970 |
| .033 | .001 | Micronesia | As above, except that kinship was estimated from pooled blood group data. | Imaizumi,Y. & Morton,N.E. 1970 |
| .0538 | .1978 | Bougainville, Solomon Islands | Kinship was estimated from an R matrix, & a & b by a non - linear regression technique. | Relethford,J.H. 1985 |

* Misquoted in Jorde 1980 as .005

as ideally set out in the original model. Long range migration is simply migration from outside the immediate study area. This is an important criticism since it implies knowledge of population subdivision and population size. Yet an inappropriate description of the underlying population structure will not only bias all derived statistics, but will also render any comparative studies incomprehensible (Mielke 1980). Thus the traditional distinction between ' discrete' and ' continuous' models does not, in reality, obtain. Wright's neighbourhood model is perhaps the one exception, providing a real basis for a continuous model of migration. The second disadvantage of results based on matrices is that the results are obviously dependent on the assumptions and limitations, not only of the isolation by distance approach, but also on the matrix method that precedes it. Neither is there an independent estimate of kinship.

Mathematically, Malecot's theory was criticised by Felsenstein (1975), but was defended by Lalouel (1977) who showed that much of the criticism was in fact based on a misinterpretation. Swedlund (1980) has stated that the pooling of within-community matings (or births) as marriages (or births) that occur at essentially zero distance apart may exaggerate the leptokurtic nature of mating (or parent-offspring) distributions. As with all migration models, equilibrium is once more dubiously assumed (Cannings and Cavalli-Sforza 1973, and Jorde 1980). Cavalli-Sforza (1983) criticises the number of studies which fail to report the homogeneity of the isolation by distance slopes when obtained from more than one genetic marker.

One of the greatest criticisms of the isolation by distance model, however, is that the model over-simplifies the genetic structure, so that many of the underlying trends and peculiarities are lost (Fix 1979, Cavalli-Sforza 1983). Fix, and also Jorde (1980), have stated that the subdivision of the data into smaller groups (by time or spatial subdivision, as Mielke *et al.* (1976) have done, for example) renders a clearer picture of the situation. Cavalli-Sforza (1983) has given an interesting illustration of this problem. Applying isolation by distance to Taiwan surname data he found absolutely no correlation between kinship and distance. Referring to historical records he found that the pattern of settlement was almost entirely accountable for this. Tree analysis could illuminate the problem where isolation by distance had failed. He does conclude on a rather more optimistic note, saying that while isolation by distance "cannot generate a clear or complete understanding of population structure" , it can say something about the "relative importance of migration between close neighbours" , and it can perhaps detect "the strength of other factors of importance (other than geography) in determining the similarities and differences between populations" (Cavalli-Sforza 1983 p246).

Moreover, there are two considerable practical advantages of the isolation by distance model. It can be applied to very large populations and areas, such as Iceland or Switzerland (Table 1.1). Secondly, because it has been so widely applied, it is possible to compare estimates of a and b which aids in their evaluation.

On the theoretical side, while isolation by distance does not give a precise account of population structure, it does give a very valuable general overview. It estimates the relative importance of geographical distance and by so doing may indirectly indicate other evolutionary factors involved. Indeed there are cases where the uniform distribution assumed by isolation by distance is better suited to the pattern of settlement than the discrete settlement pattern assumed by discontinuous models. An example in the present study is given by the nineteenth century agricultural labourers of North Yorkshire. While there are drawbacks of this model, there are limitations attached to every model of population structure: to quote Workman and Jorde (1980 p487-488):

> " Since process cannot be inferred directly from structure, it is necessary to construct causal models, based on observations or theory, in order to obtain inference on macro or micro evolutionary processes. "

## Conclusions

I have thus reviewed, albeit briefly, the various methods by which kinship or some measure of biological relationship may be predicted from migration models, isonymy, and by bioassay from phenotypic traits. By such analysis it is hoped to gain an understanding of the evolutionary processes responsible for the observed genetic structure.

However, one of the most widely discussed criticisms of the last decade is that the theory of population genetics fails to do just that. Harpending (1974) was one of the first to level such a criticism. Mielke (1980) has commented that where historical records permit detailed genetic analysis, the theory and models are not used. He cites Robert's analysis of the islanders of Tristan da Cunha as an example. The problem is perhaps best summarised in the following quotation from Cannings and Cavalli-Sforza (1973 p105):

> " The study of population genetics has set itself an ambitious goal. The existence of a mathematical theory of evolution (the most elaborate theory in biology...".

The problem partly stems from the difficulties encompassed in trying to measure evolutionary mechanisms. To be more precise, natural selection, the primary driving force of evolution, is very difficult to measure in human populations. Drift and gene flow are much easier to study, but are thought to have played a major role only at the micro-evolutionary level and not in the more global and long-term sense.

While the importance of natural selection in long-term evolution is assured and the mechanism is well documented for other species, it remains a fact that examples of natural selection maintaining balanced polymorphism or causing progressive change in gene frequencies in human populations are extremely rare.

Hope may rest on prospective analyses of the human genome (discussed recently by C. Joyce in *New Scientist*, March 5 1987). In the meantime, however, there is a need to develop methods to detect evolutionary change using data that have already been accumulated (Jorde 1980).

On the other hand, Jorde (1985) has argued that drift and gene flow have played more important roles in human evolution than is usually attributed to them.

Cavalli-Sforza (1973) has discussed the relative importance of drift and selection. In a very interesting summary of his work on the South American Indians, Neel (1983) has suggested a theory of evolution that is distinct from but analogous to the Punctuated Equilibrium theory of Gould and Eldredge. He purports that very rapid evolution took place due to the random action of drift in small, isolated and yet expanding groups. (I refer to the fissioning of new groups from the established tribal villages.) While natural selection did operate, genetic drift was attributed greater importance than it is traditionally in Neo-Darwinian theory. He concludes that rapid human evolution broke down with the agglomeration of population units. This concept of evolution is rather similar to Wright's shifting balance theory which perhaps provides a better analogy to the observed processes than Punctuated Equilibrium does (Kimura 1983 p12-14).

Despite the debates surrounding natural selection, part of the problem in studying evolution in population genetics, must lie in the difficulty of attempting to predict human behaviour. Inevitably, the rigidity of the models leaves a number of unfulfilled assumptions. Many of these have been discussed above.

In order to evaluate the models it is imperative to test their assumptions, as so many authors have stated (for example, Swedlund 1984; Workman and Jorde 1980). One way of assessing how closely such assumptions are met is through testing the degree of concordance between different data sources. As we have seen above, this has been achieved with the isolation by distance model. However, in a more general sense it remains true that the clearest understanding of the evolution of contemporary population structure is achieved through wide-scale studies encompassing both historical perspective and genetic analysis. For the two data sources not only test the assumptions of the models, but they confirm and complement each other's predictions of population structure. Genetic analysis, for example, takes into account evolutionary factors from an ancestral population, whereas migration data give a detailed account of more recent gene flow and the potential for genetic drift. There are two major examples where populations have been studied thoroughly with both genetic and demographic data : in the Ȧland Islands (Workman and Jorde 1980, and Jorde *et al.* 1982b) and amongst the South American Indians (Salzano *et al.* 1967, Neel and Salzano 1967, Neel 1967, Neel and Ward 1969, Ward and Neel 1970, Neel and Weiss 1975, Ward and Neel 1976, and for the most recent summary, Neel 1983).

However, while time and money often prevent the scope of such far reaching studies, it is just as advantageous to test the assumptions of a model by comparing its results with predictions made from alternative models, all based on the same data. Indeed this is the objective of this work: to compare and contrast estimates of kinship from isonymy, Malecot's migration matrix, isolation by distance, and the stepping-stone model, and by so doing executing the practical evaluation of the stepping-stone model.

There is also evidence to suggest that work of a similar vein is in progress. For example, Relethford (1985a) has stressed the importance of testing theory and has presented a method for examining the theoretical relationship between population size and inbreeding in human populations. He has also drawn attention to two other areas where similar attempts have been made. Residual analysis of the isolation by distance model (as used by Relethford and also Jorde and his colleagues) elucidates factors which effect among-group variation, or, to quote Relethford (1985b p318):

> " instead of focussing on how well the data fit the model, it focusses on the determination of what factors (if any) influence the lack of fit".

Relethford also cites Harpending and Ward's examination of the theoretical relationship between two different measures of genetic variation, genetic distance, and heterogeneity.

Swedlund *et al.* (1985) has compared multi-dimensional scaling representations of results obtained through isonymy and marital migration with geographical maps. Marital migration corresponded well with geography, and while the correspondence with isonymy was not as good, they found that isonymy *was* informative of the relationships between the communities. Indeed they argued that the degree of differentiation between the two maps might be due to the fact that isonymy was informative of processes not revealed in the migration matrices. Relethford (1986c) has also recently compared the results of migration matrix and isonymy analysis and found them very similar with exceptions only for known historical events.

Jorde (1980) has suggested a method to test the equilibrium results of the Malecot migration matrix. This method was subsequently used in Swedlund *et al.* (1984) analysis of the Connecticut valley population, although the results were not entirely satisfactory, it was thought this was due to the inappropriateness of the chi-squared test in this particular instance.

Thus it is seen that since Harpending's original criticism in 1974, much work has been done, and is still in progress, to evaluate and advance the theory of population genetics. Indeed recent papers by Relethford have presented a new 'gravity model' of human population structure (Relethford 1986a and 1986b).

Beyond the glimpses of such optimism, there are still some major advantages of the demographic approach to be considered. Demographic data, for example, facilitate a temporal and historical dimension to population studies. Detailed demographic data allow detailed analysis at the family and community level – important for studying differential fertility and mortality and more specifically, for tracing genetically inherited diseases. Moreover, one of their most outstanding advantages must be that they provide a basis for exploring the relationship between culture and biology, a major area of overlap in social and biological anthropology and an area which is so obviously of critical importance in the study of human evolution.

# Chapter 2

## The Historical Background: The North Yorkshire Coast.

The study area consists of the North Yorkshire coastal settlements of Staithes, Hinderwell, Runswick, Whitby, Fylingdales, Robin Hood's Bay, Scarborough and Filey. Situated on the edge of the North York moors, the area is one of outstanding natural beauty. Many of the villages, nestled on the cliff tops, have enormous character and charm – the back-drop to a rich history and a tapestry of local mystique, legend and adventure.

**Figure 2.1: Boats in Whitby Upper Harbour**

*Taken by Frank Meadow Sutcliffe circa 1875*

The famous smuggling histories of villages like Staithes and Robin Hood's Bay evoke scenes reminiscent of such novels as ' Moonfleet' by J. Meade-Faulkner (1898-

1932). The fisherman's life-style is depicted well in books like 'Foreigners' by Leo Walmsley (1935), and 'A Poor Man's House' by Peter Reynolds (1908). While the aura of the place is epitomised by some of the local personalities such as the whaler William Scoresby, (famed to have caught over 533 whales) or the familiar face of Henry Freeman (photographed by Frank Meadow Sutcliffe, see Figure 2.2); he was coxwain of the Whitby life-boat and was estimated to have saved over three hundred lives. Captain Cook spent his early days in the vicinity and even Robin Hood is reputed to have sought refuge there.

Throughout their long histories, however, these communities have frequently been besieged by grief and severe hardship. Shipping disasters are numerous. It was not uncommon for a woman to lose both her husband and son in one night. One of the most tragic disasters was the 1861 lifeboat disaster at Whitby, in which 12 men, many of them related, were drowned. The ravages of the sea have also denuded much of the coast-line and, with it, many of the precariously balanced houses which cling to its top. An example of this was in the 17th century, when the entire village of Runswick was washed away and the inhabitants saved only by attending the funeral of a friend at the Parish church of Hinderwell.

The area is steeped in superstition and legend, from Dracula in Whitby, to the curing powers of ' Hob Hole' , and a myriad of fishermen's taboos. Even as late as the Second World War a stone mason, whilst making alterations at a farmstead between Oalham and Glaisdale, was asked to provide a new witch post (Barker 1977). Apart from the superstition which pervades the region, the various strains of Christianity are also firmly established. Home of the abbeys of Whitby, Fountains, Riveaulx, Ampleforth, Mount Grace, the area retained its Roman Catholic heritage, even subsequent to the Reformation. Priest-holes, secret prayer meetings under the patronage of some county families are familiar hallmarks of the 16th and 17th centuries, while the 19th century ports were found fertile ground for the renewed religious fervour of the Non-Conformists.

By contrast, the middle-classes of the 19th century sought pleasure in the spa town of Scarborough, which developed a healthy tourist industry characterised in

**Figure 2.2: Henry Freeman**

*Taken by Frank Meadow Sutcliffe*

its extensive deck-chair clad beach, candy-floss, and glittering amusement-arcades rather than for its medicinal qualities.

## Situation

Figure 2.3 shows the position of the settlements used in the study and their relative parochial boundaries. (Figure 2.4 explains the geographic relief of the area).

Almost all the land adjacent to the coast climbs steeply to 200 feet above sea level and over, up to the surrounding moorland at over 800 feet. Low-lying land is found only in the Esk river valley and in the Vale of Pickering, in which Scarborough and Filey are situated. The topography of the Moorland was mostly shaped during the Ice Age. The moors lie on oolite limestone, overlaid by sandstone which makes a poor, barren soil, sustaining little but heather and rough pasture for sheep.

This steep and rugged moorland surrounds the coastal villages to the west and south, engulfed on the other sides by the North Sea. Such conditions enforced severe physical isolation on both the inland and the coastal communities, isolation which remained until the laying of the first railways in the 19th century. The coming of the railways did much to connect these communities to larger towns. Barker(1977) makes the point that it was only as recently as 1949 that Barnsdale acquired its first road and it was only in 1961 that it was supplied with electricity. Even today there are a limited number of roads. The main roads either hug the coastline or use the rather higher ground on either side of the vale of Pickering. The only main roads to actually cross the moors are the A171 from Middlesbrough to Whitby and the A169 from Whitby to Pickering. There are a few minor roads that cross the moors but they rarely survive the winter months without being closed. Flooding and drifting snow make progress slow or impossible on the bleak approaches to Whitby during winter.

'Till the year 1750, all the roads about Whitby lay in a state of nature, rough, rugged and uneven; it was dangerous for a man on horseback to come into town in the winter season of the year, but more so for any loaded carriage then to approach

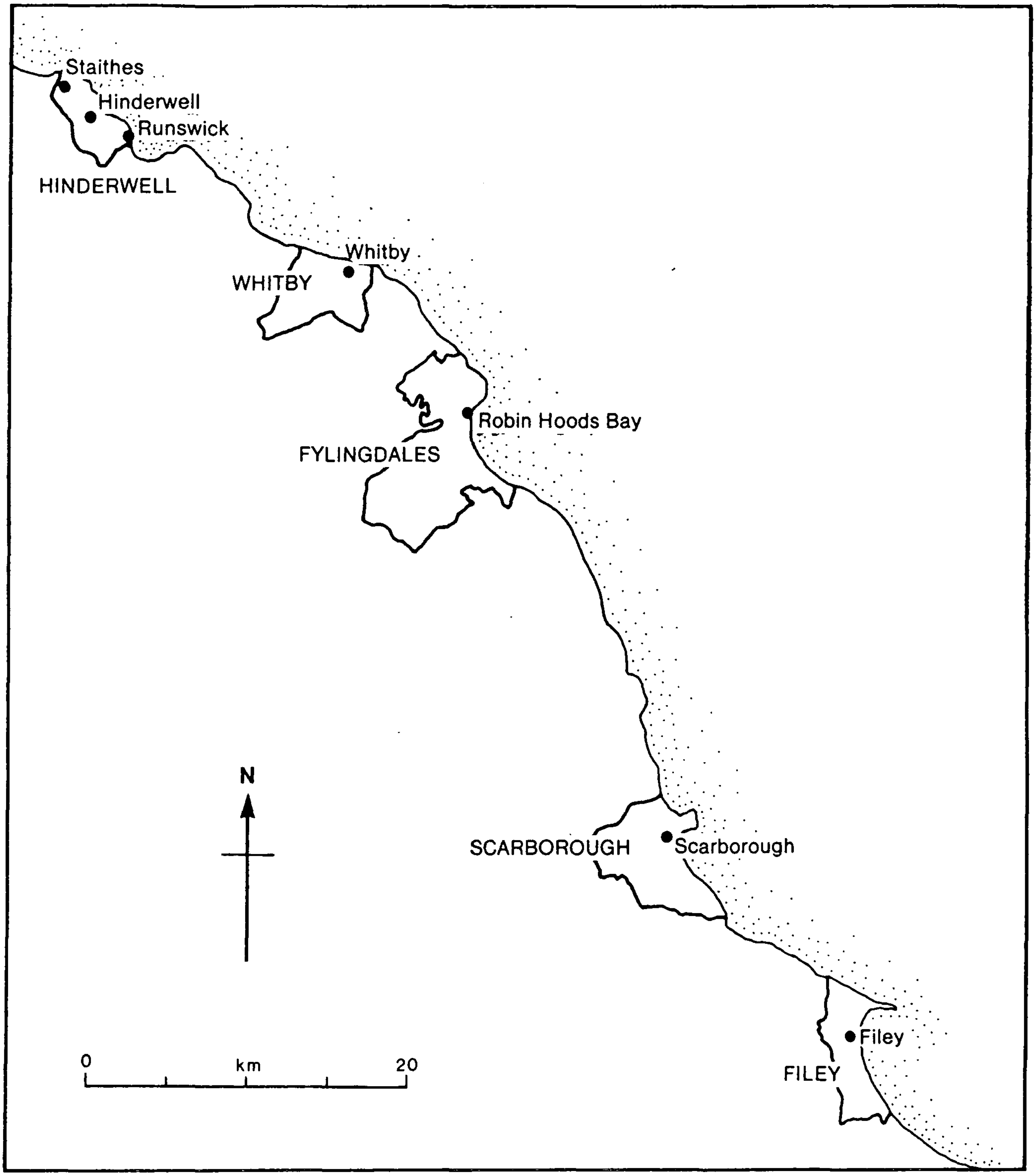


Figure 2.3: The study area

the place' (Shaw Jeffrey 1923 p10). The first turnpiked road was completed in 1759, while the first coach service to York (which ran twice weekly) did not open until 1788. The coming of the railway, joining Whitby to Pickering in 1836, did much to relieve the town from its isolation, although it was not until 1885 that the railway link connecting Whitby to Scarborough (and thus completing the line built earlier in 1845 between Scarborough and York) was opened.

Scarborough and Filey, both lying within the Vale of Pickering, did not suffer the isolation that Whitby had endured. The more temperate terrain enabled establishment of good road and rail connections to occur earlier. The smaller fishing villages of Runswick, Staithes and Robin Hood's Bay, however, did suffer severe isolation. Macquoid writing in 1883 (p341) stated that the carriers cart only went twice weekly from Whitby to Fylingdales and yet the nearest railway station was approximately six miles away. He similarly remarked that it was ' not easy to get in and out of Staithes except by the seaway, for the road leading to it is singularly steep' . Runswick to this day lies at the bottom of a gradient of 1 in 3. Before 1860 there was no road between Whitby and Sandsend (situated between Whitby and Hinderwell) ' It was necessary to take into account the state of the tide in planning a journey' (Barker 1977 p178). The eventual construction of this road was due to the kind patronage of the Maharajah Dhuleep and his elephants!

This physical isolation is a key factor in the social, economic, and historical development of this area.

## History

The prehistory of North East Yorkshire is marked by a pattern of repeated invasion and subsequent settlement, resulting in a highly diverse people and heterogeneous gene pool. The earliest evidence of human settlement is the paleolithic (early stone age) camp on Eston Nab. Otherwise archaeological material of this period is scanty, and it is only by the middle stone-age that more substantial evidence of

Figure 2.4: Exerpt from Bartholomews ' half-inch' map of the North Yorkshire Coast

man is found. The most notable site is Starr Carr, just south of Scarborough, it was a lakeside settlement consisting of some twenty people, comprised of both fishermen and hunters. It is dated at about 7500 B.C., and is one of the major early archaeological sites in Britain (Darvill 1987; Higham 1986; and Hawkes 1986.) Recent excavation has revealed a Neolithic site near Loftus, close to Staithes (Cleveland County Archive section 1983).

The later Neolithic peoples were spread widely over the area and have left some evidence of their occupation. Long barrows, usually identified with the Mediterranean region, have been located in the environment, but megalithic galleries or passage graves are scarce, indicative of a uniform culture. One characteristic peculiar to Yorkshire is the tendancy to cremate the bodies actually within the grave. The largest example of such a long barrow is at Scambridge. There is also a barrow at Scarborough, noted because it is particularly well endowed with flint axes, knives and arrowheads. Tools of this nature are found throughout the area at Whitby, Robin Hood's Bay and Scarborough. The area is also particularly rich in stone circles (King 1965; Hawkes 1986; and Elgee 1930).

Some later round barrows, associated with the Beaker peoples of Denmark, Germany and Holland, have been found in Whitby and may indicate a landing at Esk-Mouth. Food vessels of the same era at Peak and Scarborough are thought to have originated in Ireland. The varied physique associated with the culture may reflect a mingling of cultures. Elgee (1930) states that such a mingling of cultures subsided in the mid Bronze Age, and out of it there emerged a fairly uniform culture, which remained for approximately 1000 years – one which was characterised by ' urns' rather than ' beakers' . Settlement sites and the round barrows of this period occur profusely throughout the moors. Two sites of this era are particularly notable, High Bride Stones stone circle at Grosmont, just south of Whitby, and Loose House Road barrow, north of Rosedale Abbey.

The most significant late Bronze Age or early Iron Age settlement in the area is found at Castle Hill in Scarborough, dated between 700 to 400 B.C. The pottery and the bronze t-type and Hallstadt swords are of a style that betrays its origins in

Central Europe, and it is thus likely that the late Bronze Age culture was introduced by invaders from the Continent.

Castle Hill was also the site of a Roman signal station at Scarborough. It is thought that similar beacons existed at Filey and Ravenscar. Ptolemy's geographical account of Britain mentions both Scarborough and Filey, and although they are excluded from his general tables of the whole Roman Empire, it is likely that these two bays may have been occasionally used by them. Land communication to this area was reached by Wade's Causeway, which stretches from the Pickering area towards Whitby. Other evidence of Roman occupation lies further away at Cawthorn Camps, just north of Pickering (King 1965; Hawkes 1986).

Only the major trends of the early prehistory of the North Yorkshire coast are outlined here, for while the origins of the coastal settlements obviously date from these very early times, it is somewhat less likely that the gene pools of these ancient peoples are strongly represented in the later 19th century settlements which are of interest in this study. The major subsequent invasion and plunderings of the Angles, Vikings and finally the Normans makes this almost a surety, quite apart from the ' evolutionary' changes that may have occurred in the gene pool, through the action of natural selection and genetic drift.

The Roman occupation was troubled in later decades by the raids of the Picts, Scots, Saxons and the Franks. The pressure from the North led to their final departure from the ' extremities' of Britain in the early 5th century (Campbell 1982). After the withdrawal of the Romans there was an influx of teutonic invaders. From the written sources of the time it would appear that the years 449-456 were the most notable for the introduction of Saxons into Britain. Two of the most notable leaders, Hengest and Horsa established a settlement in Kent. Little account is given of the Northern Kingdom of Deira at this time, although a date is given for the succession of Ida to the Kingdom in 547 (Campbell 1982 and Young 1817).

The history of these times was recorded in the Anglo-Saxon Cronicles and in the scholarly writings of Bede, the venerated monk of Jarrow, and scholars like Eddius Stephanus. Bede writes extensively on the monastery, founded in 655 by King

Oswy, at a place called Streanaeshalsh (Bede's spelling), now known as Whitby. Hilda, the first abbess, was greatly respected and loved, and is still commemorated in Whitby today. Bede wrote of Hilda:

> "Christ's servant Abbess Hilda, whom all her acquaintances called Mother because of her wonderful devotion and grace, was not only an example of holy life to members of her own community; for she also brought about the amendment and salvation of many living at a distance, who heard the inspiring story of her industry and goodness" (Bede's History of the English speaking Peoples p.248).

The Abbey was undoubtedly a major religious centre within Anglo-Saxon Britain. It was the setting for the great conference known in Church history as the Synod of Streanaeshalch, at which the annual fixing of the date of Easter was established. The commanding Abbey at Whitby was witness to the passing of many of the Celtic saints: Hilda, Caedmon the first English poet, guided by ' divine inspiration' ; Princess Aelffled (Bede's spelling), ' Lady' Hilda's successor, and devoted friend of St. Cuthbert. Under Princess Aelffled's influence the monastery further increased in power and wealth, becoming in the later 7th century the most important religious community in Northumbria.

Rather less is known of the villages surrounding Whitby at this time. Farnill (1966) mentions that ' the first regular settlers (at Robin Hood's Bay) were probably Saxon peasants' . It is known that both the name ' Hinderwell' and the original church there were of Saxon origin. There is, however, little evidence of Saxon settlements in either of these parishes. Archaeological finds suggest that there were Angles living in the vicinity of Scarborough in the 6th century. The principal site in the area lies at ' Crossgates' rather than Scarborough itself, and the archaeological evidence indicates that these settlers were farmers and not fishermen (Binns 1966a). There is little evidence of any settlement at Filey during this period (Andrews 1946).

The principal settlement in the area at this time was Whitby or Streanaeshalch. Here for 200 years after its establishment the abbey and its environs prospered, but with the beginning of the Viking raids its fortunes abruptly changed. The Vikings came across the sea to conquer, plunder and destroy. The Anglo-Saxon Cronicle relates the pillaging of Lindisfarne, one of England's most sacred places of pilgrimage, and archaeologists have found a stone carving depicting the event (Bronsted 1960). Whitby Abbey was similarly obliterated and the name of Streanaeshalch forgotten (Macquoid 1883). The Viking invasion was not confined to Whitby; rather they ravaged the whole of the northern coast, leaving whole areas desolate before they finally settled. By 867 AD all Northumbria and Deira was a Danish colony and remained so until the Norman conquest.

Little is known of the Danish presence in the towns and hamlets of the area; the best indication of their settlement is left in traces of their dialect, place names such as ' Ugglebarnaby' ' Stoup Brow' and some of the fishermens terms and mythology (Logan 1983; Barker 1977; Gee 1928; Andrews 1946). Binns (1966a) does state that there is ' some justification for the legend of the foundation of Scarborough by a Viking, for it seems to have been of more significance in the 10th century than previously, for many of our references to Scarborough are in Old Norse' . He suggests that the foundation of Scarborough was probably as late as 966, and was first settled by a Viking of the name Thorgils Skaroti as a key port in the east-west route between Dublin and Scandinavia, due to which, Scarborough soon grew in importance and wealth.

The history of Whitby during the Danish colonisation is unclear. Both Young (1817) and Macquoid (1883) state that after the destruction of the abbey, the whole town ' lay desolate' for approximately 200 years. Atkinson (1874 p78) suggests that this was true only with respect to the abbey. The town of Whitby, he states, ' was one of the busiest scenes of Danish colonisation' . Possibly built on a different site to Streanshealch, the town at first received the name Prestebi, soon superseded by the name Whitebi, indicative of the harbours white cliffs (Atkinson 1874 and Gaskin 1909). Well before the Norman conquest, according to Atkinson, Whitby became prosperous and with it many of the neighbouring towns, such as ' Thingwal' ; the lands and possessions later found by the Normans, bear testament to the thriving life of the Whitby area.

The end of the Viking era was marked by considerable tension between King Harald of England and his brother Tostig, interested in the conquest of his brother's country. In 1065 Tostig raided the country, aided by Flemish mercenaries. Scarborough was the site of one of these sieges. The town was devastated and according to Binns (1966b) was enough to account for the absence of Scarborough from the Domesday book without allowing for subsequent wasting of the region by the Normans.

Tostig's harassment no doubt aided the Conquerer's success at the Battle of Hastings in 1066. At first, the Northern Danish lords swore allegiance to William; it was an uneasy peace and by 1068 they had rebelled. Their defeat was followed by the Norman ' ravaging of North' by which large parts of Northumberland were once more plundered, destroyed, and laid to waste. Still eighteen years after in the great Domesday survey, entries of ' Waste' appear on page after page of the Yorkshire Lordships.

Whitby and much of its environs did not escape the pillage; the Domesday book speaks of the desolation there caused by a leader of the Normans. Hinderwell is mentioned in the survey, and much of it appears to have remained intact. Two manors are recorded within the village, as well as a manor at Sneaton (which is the first record of any settlement within the environs of Staithes). Also mentioned is a small manor at Roxby. Fylingdales is included in the Manor of Whitby and Sneaton, thus superficially it appears to have suffered with Whitby for the entry declares ' nearly all waste' . More thorough examination reveales the existence of two manors in the vicinity with as much as 900 acres of cleared land. All this area from Hinderwell to Flyingdales was bequeathed to the Earl of Chester, William's nephew, who in turn bestowed them upon William de Percy, a friend and companion in arms.

Filey, together with the other villages in the parish, had consisted of 84 caracutes of land before the Norman conquest. Afterwards only 7 caracutes and a half were left, the rest of the land was ' waste' . Under William, Filey was given to

Gilbert de Gaunt and has since been in the hands of the Lords of Hunmanby.

Gradually events in North East Yorkshire, after the Norman conquest, seem to have calmed down and peace was slowly established. The cyclical pattern of invasion, desolation and resettlement had finally been broken. In Whitby a Norman soldier, named Reinfrid, re-built the Abbey, naming it after St. Hilda, and revived the monastic religion under the rule of St. Benedict. William de Perci's grant of the port of Whitby to the monastery (including the earliest recording of fishing tithes) greatly increased the Abbey's stature within the town. However, small disturbances seem to have still afflicted the town and abbey in the earlier years, so that it was not until the beginning of the 12th century that peace was fully restored (Macquoid 1883).

The monks of Whitby held lands at both Hinderwell and Fylingdales. (Those at Hinderwell were later relinquished, to pass through the hands of the local noblemen). Farnill (1966) discusses the movement of the chapel at St. Ives to the 12th century site of Fylingdales parish church at Raw; he suggests that this is indicative of the shift in the population centre towards the sheltered bay, perhaps accomodating the growth of the fishing industry. The first written evidence of the village at Robin Hood's Bay does not come until much later in the 15th century. Similarly while Hinderwell was peacefully settled and much documented soon after the Conquest, there is little record of any permanent settlement at Staithes or Runswick much before the 14th century and Young (1812) suggests an even later origin for Runswick. The fishing industry may well have preceded the settlement there, given the proximity of Sneaton to the later site of Staithes.

The town of Scarborough was not re-established until the 12th century when the castle was built by William le Gros. Later in 1155 King Henry II recovered the crown lands and developed the castle further, finally granting the town the first Charter of Liberties in 1163. By this time the community had come into existence and was prospering (Rushton 1966).

Under Norman settlement a market was established in Filey, to which Flemish merchants came to buy wool and hides. There is also evidence of the early establishment of the fishing industry (Andrews 1946).

Thus by the 13th century the lives of these peoples were relatively undisturbed. Essentially this state existed right up to the 19th century. The major events in its modern history were the dissolution of the monasteries, plague in the 13th and 14th centuries and the civil war in the 17th century. The ancestral ' gene pool' , however, was established. Many locals believe firmly that they are descended from the Vikings, and this is suggested by Atkinson (1874) and Gee (1928 p28), who wrote:

> "any of the residents of the coast villages are, no doubt, directly descended from the Vikings. Norse mythology has tinctured all our local folk-lore; and the Danish manners and customs survive even in these later days. Even our speech is witness to the conquests that they made ".

Both Young (1817) and Clark (1982) suggest that the population is more likely descended from a mixture of Angle, Viking and Norman finally settling in the late medieval period. This is in fact supported by the dialect, which has its roots in the language of all three ' groups' and much of its form and vocabulary taken from old and middle English (Barker 1977).

The modern history of the area is interesting in that it helps to understand the nature of the 19th century settlements. Undoubtedly the major contributing factors are not so much the politics of the passing decades but the sociology and industry.

By the end of the 12th century the development of both Whitby and Scarborough was considerable. The market at Filey was suppressed to give way to the growing importance of Scarborough (Andrews 1946). In 1189 Richard II granted a charter for erecting the town of Whitby into a borough (Young 1817). This charter was, however, revoked only 10 years later under the persuasion of the monks. There is no question that the Abbey exerted a considerable influence over the town of Whitby and that the Abbot was extremely powerful. Gaskin (1909) likens his position to that of a great baron.

The plague in the 14th Century did not devastate the population on quite such a scale as was witnessed in other counties in Britain. It was, however, responsible for the death of 223 priests out of a total of 535 in the Diocese of York (Ziegler 1969). Andrews (1946) states that the plague carried off two thirds of the East Yorkshire population. The wars of York and Lancaster were felt in the region but had no major repercussions (Young 1817).

Whitby was profoundly affected by the dissolution of the monasteries in 1539, for the monastery had looked after the sick and destitute, provided work and encouraged trade. After its dissolution, not only was the building destroyed and its riches plundered, but many were left unemployed and trade was severely interrupted. Shaw Jeffrey (1923) states that they were left with nothing other than fishing to depend on. Farnill (1966) goes further stating that in the latter 16th century Robin Hood's Bay was a more important place than Whitby. This is according to an early mariner's chart on which links between Rotterdam and Bay town are clearly marked, while Whitby is omitted altogether. The development of the alum industry in the 17th and 18th centuries did much to pull Whitby out of a depression. Not only did it offer employment, but it stimulated the growth of new industries such as shipbuilding (for transport of coal) and related and subsidiary manufacturing trades. By the 19th century the shipbuilding trades had grown so extensively that there were few fishermen, and by this date it had once more become the most prosperous and the busiest port on the coast.

The effects of the English Civil War were severely felt in parts of the district, chiefly in Scarborough (Young 1817). Scarborough Castle was the scene of a three month siege between the Royalists and Roundheads. The town's economy suffered badly through the fundings of the armies and physically through damage inflicted upon the town (Barker 1882). Oliver's Mount in Scarborough serves as a reminder of the siege.

The most important economic development of the 18th and 19th centuries was the tourist industry. This affected Scarborough, Filey and Whitby, stimulating a dramatic increase in the populations of the first two towns. Whitby, which received rail communication later than the other two resorts, was a town basking in the success of its whaling and shipbuilding industries and it did little to seriously advance the prosperity of this new trade. Scarborough flourished during the 19th century not only as a ' spa town' but also as a major fishing and commercial port (Martin 1966).

## Economy

The industry of the coast was typically reflected in its geography. It was dominated by fishing, agriculture and in the north, mining. In the towns there were a variety of professionals and tradesmen, and both Scarborough and Whitby enjoyed a booming shipbuilding industry which inspired the growth of many subsidiary trades. Victorian Whitby was renowned for its jet.

For over 270 years alum was mined within a thirty mile radius of Whitby; the industry declined in the mid-Victorian period and thus just preceds the immediate study period. There were large works at Sandsend, Boulby and Loftus, all of which closed in the 1860's. The villagers of Staithes played an important part in the manufacture of alum throughout the 17th and 18th centuries by the production of large quantities of burnt kelp or seaweed. By the 1800's this had ceased with the introduction of ' black ashes' to replace the traditional use of kelp. The works at Low Peake and Stoupe Brow directly employed many of the inhabitants of Robin Hood's Bay right up until the mine's closure in 1858, which forced a dramatic decrease in the population size as the workforce then had to find new work.

The Cleveland alum industry was soon superceded by ironstone mining. The moors have a history of ironstone mining and smelting from the ancient smelter dated at approximately 550 BC, found on Levisham moor, to the discovery in the 1820's of ironstone in the vicinity of Staithes (Mead 1978). In 1838 the Wylam Iron Company began the exploitation of the ore just one mile west of Staithes, but this was out-classed by a superior source of ironstone located at Grosmont just nine years later. Work was not continued at Staithes until the 1850's when Thomas Seymour and Cox resumed the work. This was taken over in 1854 by Palmers of Jarrow who constructed the harbour one and a half miles south west of Staithes at ' Port Mulgave' to handle the traffic in iron ore to the Tyne. The production of ore was considerable enough to stimulate the Tyne iron smelting and shipbuilding industries. By 1875 another mine was also opened up at Grinkle (two miles from Staithes). Production continued well into the first half of the 20th century when rail connections rendered Port Mulgrave obsolete, and then in 1934 the Grinkle mine was flooded (Clark 1982).

The development of the ironstone industry had a number of important consequences for the social life in Staithes and the surrounding villages. Primarily it attracted the immigration of new workers, increasing the resident populations and giving rise to the growth of new communities such as Port Mulgrave. These changes are significantly reflected in the 19th century census returns. Port Mulgrave, for instance, is only first recorded in the 1861 census and the number of immigrants recorded as ' miners' from all over the British Isles increased dramatically in the parish of Hinderwell during the 1860's. In particular miners came from the West Country due to the collapse of the tin mines there, and also from Ireland where famine had taken its toll.

Agriculture was and is a staple economy throughout North Yorkshire. Some 23% of all employees in the county of North Yorkshire were engaged in agriculture in 1851 (Hastings 1981). Most of the farms in the vicinity of Hinderwell were small, ' only few of them averaging fully one hundred acres each' (Atkinson 1874). In Fylingdales, it is likely that the farms were even smaller given the large number of farmers recorded in the census returns for that parish. It is not unlikely that the farmers here tended little more than small land-holdings. There were some big land-owners in the district, although their land was frequently divided into smaller plots. Filey is perhaps the exception in that it is situated on low lying marshy ground; by the 19th century there were fewer than six farms in the parish.

Much of the agriculture concentrated on husbandry, with herds of cows, and as many pigs and a herd of moorland sheep. Horses were bred on a small scale, but the breeding of cattle met with greater success and as witness to this, there were several local shows, the larger ones taking place at Whitby, Scarborough and Helmesley. Little wheat was grown on moorland areas for the soil is of a poor quality. In much of the area crops were only grown for home consumption. In the Dales and more fertile regions, the soil provided growth for oats, corn and seeds. Cheese making was a speciality of the Dales.

A farm of 500 acres required a work force of about twelve men; a foreman and six hired workers who worked the land and tended to the horses, also two shepherds, two labourers and a stockman (Day 1981). In 19th century Yorkshire they followed a system of ‘ hiring’ men for a year at a time, from the first week in December until Martinmas Day on the 23rd of November of the following year. Thus the agricultural workforce was highly mobile and it was unlikely that a man would remain in his ‘ home village’ all his life. It was not unusual, however, for a man to be given the opportunity to return to the same farm for another year, but his decision depended on the terms offered. The annual ‘ hirings’ were held in every country town on the first Market Day after November 23rd. It was one of the town's busiest days of the year. It was full of farmers, foremen and their wives, and workers and their families all looking for work. It was the place of family reunion, and new friendships.

Life on the farm was strongly centred around the foreman's wife, for on many farms, particularly in the Wolds, it was her role to feed and house all the labourers (Day 1981). She had an agreement with the farmer concerned regarding the sum of money he paid her each month. It was usual for a foreman's wife to receive a free supply of milk and potatoes and permission to keep a few hens. In Day's (1981 p17) opinion ‘ she experienced a very hard life indeed’ . It was not unusual for a middle-aged foreman to have accumulated sufficient capital to enable him to rent a small farm; this may well have been the case in Fylingdales. Farmers were normally either land-owners of a sizeable acreage or ten~~n~~ants of a reasonably sized farm under Church or the Squire's ownership. Farmers as a group were therefore much more sedentary than the labourers whose profession encouraged mobility.

## Fishing

> "Until about the 1920's fisherfolk were almost a race apart... a man was first a fisherman, second a seaman and third a Yorkshireman.." (p16 Dyson 1977)

The fishing industry does not represent a mere economy, but a completely different culture and a singular way of life, quite distinct from the surrounding communities.

This is in part owing to the physical situation of many of these villages; for Robin Hood's Bay, Staithes and Runswick were all built at the bottom of a particularly inaccessible cliff face which physically distinguished them from their environs (see figures 2.5, 2.6, 2.7, 2.8). To quote Frank (1982 p38);

**Figure 2.6: Looking down on the village of Staithes**

Figure 2.5: Staithes Harbour

> "Runswick, Staithes and Flamborough were predominantly fishing villages, but elsewhere, as at Whitby, the fisherfolk were only part of the larger population. Even so, clustered about the waterfront, they consistituted a distinctive group. At Scarborough many fishing families dwelt in Quay Street; while Filey's Queen Street, as one former resident put it, was ' the quarter where the fishermen lived!' Indeed, ' quarter' is precisely the correct word to describe what amounted almost to a cultural, as well as a physical segregation" .

An article by Charles Dickens (jun) (1870 p229) describes Whitby:

> "Whitby... has a distinctive pecularity as a fishing town, with a large population dependent entirely on fishing. They live, for the most part, in a place called the ' Craig' , at the back of the harbour, in wretched, old,

Figure 2.7: Runswick Bay

> tumble-down tenements, built years ago in the cliff side, for which they paid three or four pounds a year" .

Figure 2.9 depicts this scene of Whitby. Socially these communities were very close built, made up of a number of inter-related families. For example, Johnson (1973 p106) writes of Runswick;

> "Our village... was no different to any other along the coast, if anything ours was one of the worst, because we were the smallest and therefore the most intermarried, more like one family" .

As a consequence there were many people of the same surname within any one village, and the tradition of naming children after their parents or grandparents meant that nick-names were often used to identify one person from another. In North Yorkshire the names that were amongst the most frequent were Verrill and Theaker in Staithes; Calvert in Runswick; Winspear, Storr and Freeman in Whitby; Storm in Robin Hood's Bay; and Cammish and Cappleman in Scarborough and

Figure 2.8: Robin Hood's Bay

Filey.

The prevalence of one or two surnames due to the very close relationship shared by such a community is a feature which has been observed in other fishing settlements. In Scotland, the harbours in the vicinity of Carrick are inhabited largely by the Sloans and McCrindles (Czerkawska 1975). While the names Pegg, Bishop and Scotter are usually associated with the fishing village of Sheringham in Norfolk, and Harrison and Nockels with the neighbouring fisherfolk of Cromer (Pers. comm.). In Cornwall the 1851 census for the port of Mevagissey shows an abundance of fishermen with the surname Mills, while the census for Port Loe contains a large number by the name of Dunston. Faris (1967) describes a similar situation in Cat Harbour, Canada, but he suggests that this is due to the severe geographical isolation caused by the icing over of the harbour in winter and to the people's historic battle against the government to settle there. Contrarily, Mewett (1982 p104) asserted that kinship is important because it is the family which provides 'a principle of association' that defines the social set to which people belong.

**Figure 2.9: Crag and Whitby Lower Harbour**

*Taken by Frank Meadow Sutcliffe*

It was thus in North Yorkshire that kinship was an important definitive factor in distinguishing members of the community. Johnson (1973) comments that people had to be born in the village of Runswick to be accepted by the natives who were called ' Nagars' . When his parents moved to Runswick in 1904 from the adjacent village of Hinderwell, his family and two other old ladies were the only persons not to be born there; ' all the other villagers were related... so in a sense (the) three households were the outcasts of the village' .

There was a very strong preference for marrying within the community. Farnhill (1966 p32) refers to a clip from a magazine article written about Robin Hood's Bay in 1858:

> "A clannish feeling prevails. Any lad who should choose to wed with

**Figure 2.10: Isaac Verrill of Staithes**

*Taken by Frank Meadow Sutcliffe*

an outsider would be disgraced" .

Seymour (1974 p126) writes similarly of Staithes;

> "The people were, and still are, very clannish. Verrills and Theakers formed many of the families, and they inter-married closely.."

Until recently it was a common belief in this village that it was impossible for a man born outside the village to marry a Staithes girl and that ' foreigners' who had attempted courtship were ' summarily run out of the village' (Clark 1982 p33).

The tremendous insularity of the fisherfolk extended so far that even fellow townsmen or parishioners of differing occupations were considered as ' outsiders' . Erichsen (1886 p463) wrote of the inhabitants of Staithes:

> "fisherfolk all, except a little settlement of miners on the cliff top" .

Agricultural labourers, miners and tradesmen were not a part of these fisher communities.

The social ' gap' between occupational groups was reinforced by opposing religious beliefs (Clark 1982). For example most of the fishing populace were strongly Methodist by the 19th Century.

> "In 1824 the fishermen were a neglected and lawless class, earning much money and spending, after great takes of fish, large sums in riotous living; ... But all this is now changed ... owing to the good example and labour of religious bodies of the borough, but more especially to that of the Primitive Wesleyan Methodist" (Baker 1882 p49).

Clark (1982) directly compares the methodist settlements of Staithes and Runswick to the village of Hinderwell, the focus of Anglicanism in the parish. Since the Church owned 45 acres of glebeland and was traditionally the keeper of a bull, it was in the farmers' interest to overtly display allegiance to the Church. Newby (1977) discusses the crucial relationship between landlord and labourer in the mid 19th century. Farm workers were recipients of education, charity and village leadership. In return they gave their labour and a general willingness to receive. Thus the allegiance and consolidation of the farming folk to the Anglican religion, perhaps enhanced the rift between them and the non-conformist fisherfolk.

The relationship between occupation and religion was reflected in the fishing villages themselves. In Staithes there was a tendency for the Primitive Methodist chapel to be attended by fishermen, the Wesleyan by the small business people, and the Congregational chapel by ironstone miners (Clark 1982). Besides the established religions, the fisherfolk were also extremely superstitious. There was a considerable number of occupational beliefs which were thought to predict, control or influence the forces of fate and chance. For example, it was considered to be ' bad luck' to launch a boat on Fridays; to utter the word ' pig' in a situation connected with fishing; for women to wind wool after dark, for it winds fishermen to their graves; to go to sea after meeting a woman on the way to work; to whistle at sea; or to put anything white on board a boat. The pig taboo was quite widespread and has been found in other fisher communities in Cullercoats, Holy Island, and even as far off as Newfoundland! Some of these taboos persist to this day although they are rarely openly admitted (Clark 1982). These superstitions may well have served the consolidate the social isolation and peculariarities of these communities from the wider world.

The fishermen's ganseys had very distinctive patterns of which certain patterns or types of stitch were often associated with their home town or village. For example one of the Bay patterns was knitted in moss stitch and small cables. Miss Verril of Staithes knits a pattern of garter and moss stitch in a pannel repeated vertically (Pearson 1984). Figure 2.11 below shows a number of gansey patterns, of which all but two are typical of Sherringham in Norfolk.

Staithes was also famed for its bonnet, worn by the fisher-women, as by this lady in figure 2.12 below.

Most of these factors, like the non-conformist religion, superstition, and gansey patterns, were a part of the fisherman's identity right along the coast of Britain. The rift between fishermen and agricultural labourer is, however, a peculiarity of Yorkshire, for it did not occur in either Norfolk or Scotland. In Norfolk the local gentry and farmers gave the fishermen support in times of difficulty.

> "Things might have been desperate had not land- owning families helped through bad patches. Perhaps most remembered were the Upchers of Sheringham Hall who did more than run second-hand clothing stalls, give the town its first lifeboat, lend money to the fishermen to buy boats and start Bible classes and Sunday Schools, they concerned themselves with the fishermans' daily trials"(p20 Festing 1977).

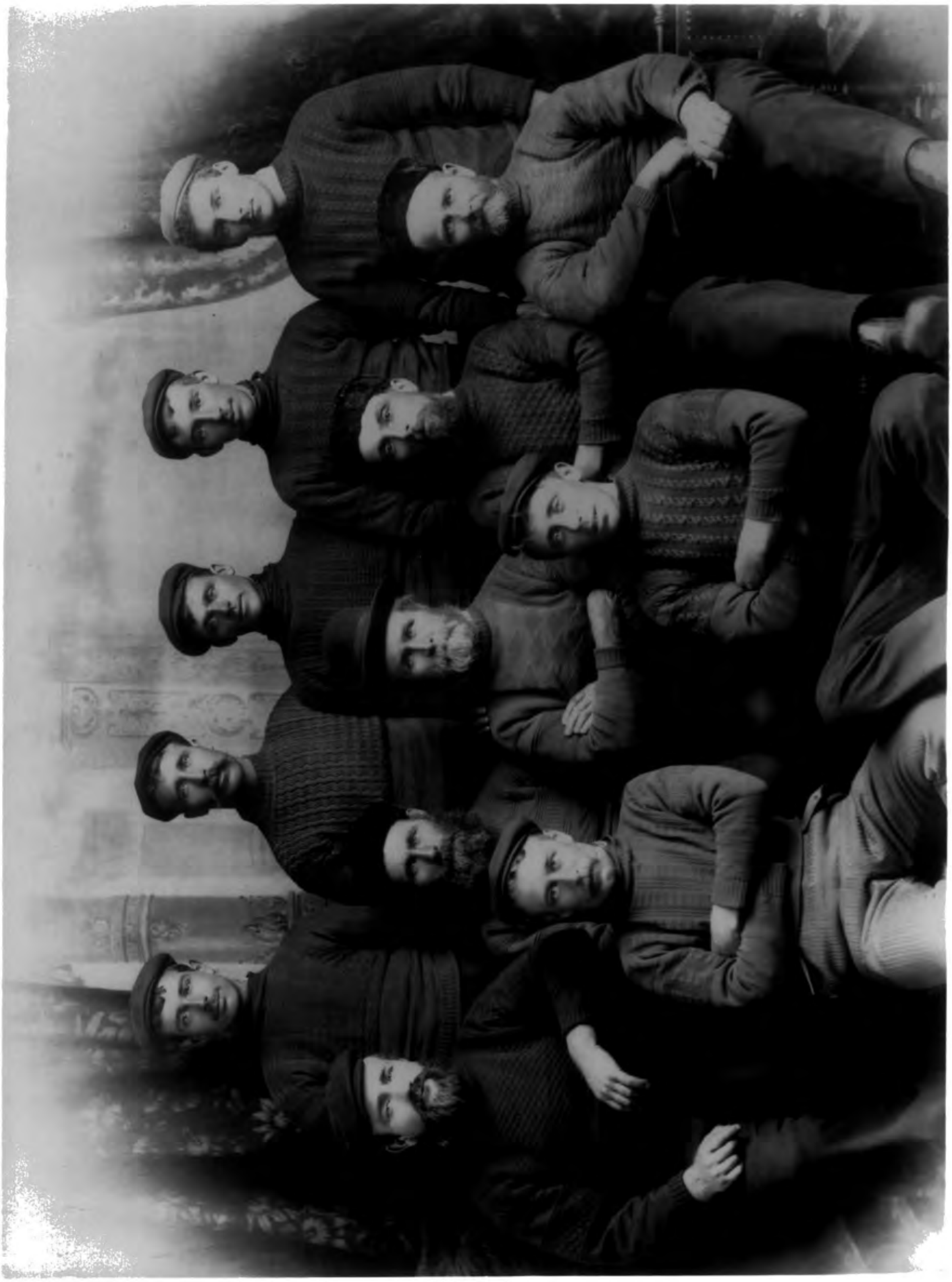


**Figure 2.11: Norfolk Fishermen**

*By courtesy of the Norfolk Museums Service*

**Figure 2.12: Peace**

*Taken by Frank Meadow Sutcliffe*

There was a dual exchange between the agricultural labourers and fishermen in Carrick: carts were lent to carry fish from the beach, and at harvest time the fisherfolk helped out at the farms (Czarkawska 1975). In Scotland many boats were actually owned by crofters who divided their time between the sea and the land (Dyson 1977). It is difficult to know why there was such a rift between the Yorkshire fishermen and the agricultural labourers and farmers of the area. The unique physical situation of the villages must have contributed, as perhaps the different religious allegiance did. One factor emphasised by the fishermen themselves is the radically different nature of the fishermen's work compared to that of farming (see below), although again this was true of places where the two occupations closely interacted.

The fishing villages were not only independent from the outside world, but between themselves they maintained a fierce rivalry and competition. Writing in respect to the 19th century Filey fisherman, Dyson (1977) states that they were a unique community, keeping themselves apart not only from other inhabitants who opened lodging houses, but also from the fishermen. Johnson similarly comments on the rivalry between Staithes and Runswick;

> "For two neighbouring villages I have never known so much real competition nearly bordering on hatred. It was the same with the fishing: if one village had better catches than the other there were provocative remarks passed" (Johnson p37 1973).

This sort of competition was typical of many fishing villages, as between the ' Crabs' and ' Shannocks' of Cromer and Sheringham in Norfolk, for example (Stibbons *et al.* 1983).

The tremendous insularity of these maritime villages, is in turn reflected in the attitudes of the neighbouring villagers. Even today people from Hinderwell and Runswick refer to ' the funny lot' in Staithes and references are made to the prevalence of madness and incest in the village. David Clark (1982 p33) quotes a reference made to an incestuous union:

> "They say that a young couple moved into the cottage and there was a strange smell in it. They eventually found a baby's body wrapped up in a blanket in the attic" .

Macquoid (1883 p341) describes the people of Robin Hood's Bay as ' very primitive' ;

> "We heard that the ' Evil eye' is still believed in through the district and that till quite lately one of the inhabitants, then fatally gifted, always

walked out with his eyes fixed on the ground... his glance was cursed".

Thus it is true to say that the North Yorkshire fishermen did have a distinctive culture which singled them out from the encircling habitations. According to Strathern (1981) it is kinship and prior association with a village that helps to give a community a sense of belonging. This belief is epitomised in Gee's comment on the North Yorkshire fisherfolk (1928 p50):

> "He is not only the son of fisher-parents, but usually the heir to the accumulated knowledge and ability of generations, for the fisher-people are strangely tribal" .

On the other hand the nature of the actual occupation of fishing has played a very large part in shaping the social structure and beliefs of these people. For ' the employment itself involves a way of life which is conducive to separation from the rest of a predominantly agricultural society' (Czerkawska 1975 p75).

Prior (1982) has examined the relationship between occupation and social structure in three different river communities (fishermen, canalmen and bargemen) in Oxford from 1500-1900. She found that their occupation strongly dominated their way of life. Bargemen and fishermen both married within their own communities of boat people, within Fisher Row and along the river, rather than marrying the ordinary citizens of the towns and villages from which they came.

Family life and the fishing industry were inextricably intertwined in North Yorkshire: ' Houses were work-places as well as dwellings' (Frank 1976 p65), and the women and children played a crucial ancilliary role in the ' business' .

> "Fishing marriages have a long history of partnership, with the wife not only keeping house for her husband but actively participating in the work" (Czerkawska 1975 p35).

The actual catch was the man's domain, but the collection of mussels or limpets, the *mucking* (cleaning the line and hook of old bait and other debris), *skeining* (removing the mussels and limpets from their shells), and baiting the *long lines* was womens' work. See figures 2.13 and 2.14. It was usual for any unmarried women, widows and children to participate in these tasks also.

> "By this time tea is over, and while we talk, the boys and girls get to work at the lines... and the whole family is soon seriously busy" (p469 Erichsen 1886).

**Figure 2.13: Girls skaning Mussels**
*Taken by Frank Meadow Sutcliffe*

Up until about 1914 it was usual for each line to have 26 to 28 score hooks. Each coble (fishing boat) carried a crew of three, two men and a lad, and each man fished two lines, while the lad fished one line. Thus for a single nights fishing the number of hooks to be baited for the crew of a three man coble ranged from a minimum of 2,600 (with two men and a lad) to a maximum of 3,360 (with three men) (Frank 1976).

Womens' work was extremely hard and unremitting.

**Figure 2.14: Fetching in the Lines**

*Taken by Frank Meadow Sutcliffe*

> "as soon as (the men) went off, we used to bring the mussels in and we used to start – my auntie used to help me a lot – and sometimes they were all froze, you know: you got bad fingers with them" (Frank 1976 - from an interview with Alice Hind: p60).

Shortages of mussels in the 19th century led to a growing reliance on limpets or *flithers*. *Flither-picking* thus became a permanent feature in the lives of the fisherwomen and girls along the Yorkshire coast. For most of the year, the long lines dominated the daily routine. Once the men had gone off, wives, sisters and daughters set out, regardless of the weather and in spite of their rather ineffectual dress against the rain and the wind.

The demand for *flithers* became so great during the 19th century that stocks became exhausted at Staithes and then Runswick also, so that it was not uncommon for these women to go to Robin Hood's Bay to gather bait.

> "They would walk to Whitby and spend the night with friends in the fishing community, early the next day walk to Bay, pick the flithers, carry them on their heads back to Whitby, put the flithers on the carrier's cart for Staithes, and then walk home. It was a round journey of 35 miles" (Frank 1976 p64).

Once the bait had been collected the mussels were *skaned* and the lines baited. This work was done in the home. When the cobles returned from the fishing grounds the women went down to the harbour to meet them, get the lines, and carry them back home coiled in wicker baskets or *skeps* upon their heads. Once home the *mucking* or *caving* began and then the baiting. In the meantime, the men moored the cobles and saw to the selling of the catch. Then they would go home, eat, and then work alongside the women.

In the herring season the women had an easier time just mending the nets. Throughout the year, however, women were also responsible for drying and salting the fish. Some women had stalls on the quayside, while others tramped long distances with baskets of fish on their heads up to thr rural towns and villages.

The arduous physical and mental strains of this way of life resulted in the ill-health and the premature death of some fishwives (Frank 1974).

> "It was a style of life accepted sometimes conciously and by choice, but often fatalistically and with a sense of inevitability" (Frank 1976 p70).

Given the peculiar harshness of their way of life, it is hardly surprising that these communities were insular; the nature of their work really demanded it. This view is reflected in the two following quotes:

> "It was of no use a fisherman marrying a girl ' off the land' – for she would never stand up to the gruelling hard work of being a fisherman's wife" (Seymour 1974 p126).

> "Their brides were both quiet, hard- working girls, Hilda being brought up in a fishing village and knew exactly what was expected of a fisherman's wife, but Mary coming from the country must have had an awful time at first coming right into a fishing family and having to learn (apart from being a housewife) how to skane mussels and flithers, clean and bait long lines, and doing numerous other jobs strange to her which a fisherman's wife did" (Johnson 1973 p83).

The fishermen were not only dependent on their families but also on each other for launching the boats, and the operation of the lifeboats and so forth. Without co-operation it would have been impossible to work effectively. Friendships were reinforced by bonds of kinship.

The great importance attached to kinship by the fishermen is a phenomenon which has been found in a number of similar contexts. For example, it is often a major criterion in the recruitment of fishing crews (Cohen 1982, Stiles 1979). The 19th century gentry used it as a basis for determining the successor to a family business (Crozier 1965). In North Yorkshire kinship played a similar but even broader role: it partly determined just who the community was and it served to reinforce the very important balance of co-operation between colleagues.

The ownership and maintenance of fishing boats and their tackle and, at the other end, the profits raised by each expedition, were shared. Each large boat carried about seven people, five men usually had shares and of those men, one of them actually owned the boat while the other four and the owner were joint proprietors of the fishing gear. Of the two remaining men, one had a half share and the other was a boy and was allowed a small sum. The proceeds of each fishing expedition were divided into six parts or six and a half parts: One share was for the boat, one share went to each of the five men, and the half share to the sixth man – so that the owner had two shares, one for the boat and one for himself as a fisherman (Young 1817).

The fishing year in North Yorkshire followed a distinctive pattern. From October through to May, they were engaged in the *long-line* fishing for cod, haddock, ling or turbot. This was carried out in boats known as cobles - hence the name ' The coble coast' (Dyson 1977). See figure 2.15.

**Figure 2.15: Cobles at Staithes circa 1875**
*Taken by Frank Meadow Sutcliffe*

The forward part of the coble was rather like that of a Viking longboat, with a deep bow and high shoulders so that the boat could be launched from an open beach at any time. The stern was low and sloping, with a long spear-like rudder, ideal for beaching stern first (Walker 1973). These winter cobles carried three men, with two lines each.

Towards the end of February, the fishermen started potting for crabs and lobster simultaneously with the winter *line-fishing.* Then in May, the ‘ spring fishing’ started. This was carried out with herring nets and *long lines* for *metting* and *overing* to catch the small spring herrings to use as bait on the big hooks. This lasted about four to six weeks.

By June the larger boats were launched and used for the herring season. During the first half of the 19th century the traditional five man cobles were used, but these were superseded after 1833 by the *yawl* which was cheaper and easier to run. The Filey *yawls* were kept at Scarborough and the fishermen used to go by train to join the boats for a weeks fishing – hence, these two towns were closely connected (Shaw 1867).

The herring were caught by the drift netting method. The fish habitually lie on the bottom of the sea during the day, but rise to feed on plankton at the surface at dusk; it is then when the drift nets were used. The method was simple but efficient: a line of nets was suspended vertically in the water and the rising fish allowed to swim into them. The nets themselves were complex gear, and needed great skill to make up and handle. They were dressed with creosote and regularly immersed in a solution of boiling water and cutch to preserve them from the salt water. This was, of course, womens work: such women were referred to as *beatsters* (Butcher 1979).

Up until the 18th century the Dutch had dominated the herring fishery, and only a small number of English boats had been involved. It was the decline of Dutch dominance that gave rise to the herring boom of the 19th century. The herring shoals were thought to have migrated from Scotland down into Britain during the summer and the herring boats accordingly followed. The Cornish, East Anglians, Yorkshiremen, and the Scots all followed the fish around the coast. 19th century Staithes *yawls* ventured as far north as Aberdeen, and by late September vessels from Staithes, Scarborough and Filey were found in Norfolk waters.

Off the Yorkshire coast the main herring season was in August and September, described as ‘ the harvest of fishing’ by the Rev. Shaw (1867 p126). By the 1870’s

Yorkshire harbours were packed with ' Zulus' and ' Fifes' from the Moray of Firth, Cornishmen from Mount's Bay, and men from Norfolk and even as far away as the Isle of Man (Frank 1982). Dyson (1977) writes that Scarborough's small harbour was crowded during the season, with fifty Penzance boats, two hundred East Anglian boats and three or four hundred from Scotland. In 1885 there were reputedly over eighty boats from Cornwall alone, mostly from Penzance, Mousehole, Fowey, St Ives and Newlyn. (See figure 2.16).

> "Cornishmen are remembered in Whitby for their religious faith, good seamanship, and their fondness of cabbage" (Frank 1982 p105).

**Figure 2.16: Cornish boats at Whitby**
*Taken by Frank Meadow Sutcliffe*

The Scottish boats were noted for the fine quality of their cotton nets, their boats and their new method of fishing and computation. Rather than counting the herring individually, they measured them in bulk. These Scotsmen were followed by a fleet of ‘ fisher-lassies’ (known in the south as Scotties) who did all the gutting and packing. They were mostly composed of the fishermens’ wives, sisters, daughters, mothers and so forth.

Despite the influx of fishermen into Yorkshire at this time, their migration was merely temporary and very few appeared to marry in or out of their own fisher communities (see chapter 4). However, there was a tremendous migration of fishermen on a permanent basis into Scarborough (and to a much lesser extent, Filey and Whitby) from the Norfolk coast during the latter half of the 19th century. These were men that may have been enticed by the opportunities indicated to them during the herring season, but whose migration was actually provoked by the crisis in the Norfolk inshore crabbing industry.

In the 1850’s the Yorkshire ‘ crab pot’ was introduced in Norfolk and the market there was expanded dramatically by the building of the first railways. Such developments led to a crisis of over-fishing and resulted in a serious depletion of crab and lobster stocks, so much so that by 1876 a Royal Commission was set up with the prospect of imposing various restrictions on fishing for shellfish. Frank Buckland’s report stimulated the 1877 bill which finally reversed the situation (Stibbons *et al.* 1983). In the meantime, however, many families had been forced to leave their homes;

> “so the fishermen decided to pack their bags and try their luck up and down the coast. Crab boats were loaded up with household goods and went off under oar and sail anywhere between the Thames estuary and the North Yorkshire coast” (p22 Festing 1977).

Conversation with an elderly Norfolk fisherman, Mr. Leonard ‘ Teapot’ West revealed that the situation was dire and that they would not have gone if they had not been forced by the extenuating circumstances. He could remember his grandfather, also known as ‘ Teapot’ , and his great grandfather, ‘ Claxton’ , migrating to Grimsby. A list of fisherfolk who migrated from the Norfolk villages of Cromer and Sheringham down to Yorkshire is given in table 2.1. (The expression 'down to Yorkshire' is deliberate since it expresses the the fishermens' perception of the route.) Many of the names are the traditional surnames of the fisher families in these villages (Pers. Comm.).

During the 19th century the traditional character of fishing was revolutionised with the introduction of the trawler. The trawler had been developed simultaneously in Barking and Brixham and was found to be a successful means of meeting the increased market during the war with France. Peace time Britain was less demanding and the trawlers required new markets, and hence moved to ports like Dover and Ramsgate, gradually moving up the coast. The first fleet in Northern England was established at Scarborough where the tourist industry provided a ready market. By the early 1830's trawling was poised on the brink of creating a North Sea boom. This was fired in 1837 by the discovery of the Silver Pits and the subsequent mapping out and exploitation of the rich Dogger Bank. The increased use of ice and rail gave rise to an ever increasing market, and by mid century the industry was booming. The ports of Grimsby, Hull, Yarmouth and Lowestoft were established as major trawling centres; Scarborough maintained a small fleet but the rest of the Yorkshire coast was untarnished.

> "With the coming of the trawling fleets in the North Sea, in the middle of the last century, the story of fisherfolk in Britain becomes divided: trawlermen led a very different life to the fishermen with his own boat in a small coastal community" (Dyson 1977 p21).

> "But the trawl men are not the regular fisher class. They are recruited from the ordinary ranks of urban general labour, whereas the true fisher class are a people by themselves, living in the coastwise villages, born to the calling, and having largely a language, dress, outlook and habits of their own" (Leatham 1932 p1-2).

Part of the reason for this distinction between the ' true fisherfolk' and the trawlermen lies in their different life-styles, instigated mainly by the ' fleeting system' under which the trawlermen worked. According to this system, the *smacks* (or trawlers) went to sea in fleets numbering perhaps 100 or more, sailing under the overall direction of an ' admiral' . Fleets remained at sea for eight weeks at a time, transferring their catches to carrier vessels who plied between the fleets and the ports. For the crew this meant eight weeks at sea and only a week on land between trips. It was very different from the family-based economy of the long-line fishermen.

The recruitment of the labour force also starkly contrasted to the traditional kin-based succession. According to a Grimsby smack owner apprentices were hired from ' whatever place they can obtain them' (Rule 1976). Thompson (1976 p19) who has studied this carefully, concludes that ' the choice of fishing as an occupation may have some connection with the influence of the father; although the high level of wages before 1914 also brought lads into the industry from farming backgrounds' . In the main the workforce were ' working class' and not of the exclusive breed of ' fisherfolk' .

Quite apart from the introduction of a new way of life, the trawlers had a profound economic effect upon the inshore communities. With the *long-lines* and *drift nets* the fish had previously had a chance: they caught themselves by biting a baited hook or swimming unwittingly into the net. The trawlers, on the other hand, were undiscriminating and manipulative; the net was simply dragged along the sea bed collecting everything and anything within its path. It gave man a vastly superior advantage over his quarry. This method of fishing also destroyed the spawn and fry in its wake, which ultimately led to the depletion of fish stocks, while in the meantime, the markets were flooded and fish prices subsequently depressed. The *long-line* fishermen also found that the trawlers interfer~~r~~ed with their gear.

By 1863 a Royal Commission was set up on the grounds that the trawlers were threatening the livelihoods of the traditional inshore fishing communities. The worst affected stretch of coastline was that between Berwick and the Humber. The Commissioners actually visited Staithes and Filey in 1863. However, the government was unsympathetic to their complaints, and the Sea Fisheries Act of 1868 only served to bolster the trawlers.

By the 1870's the first steam power was used off the coast, worsening the fate of the inshore fishermen. In 1878 another Royal Commission looked into their complaints. This time, however, the Commissioners gleaned that the populations of the inshore communities had risen, that the number of boats had increased, and that the gross value of the catches had also gone up. They did not seek explanations for these increases in terms of changes within the local economy and nor did they assess the individual households income and living standards (Frank 1982). The report once more favoured the trawlermen. From the late 1870's onwards the inshore communities were left to cope with the trawlers and market conditions as best they could. The inshore industry dramatically declined and by the outbreak of the first World War the last of the Staithes *yawls* had stopped fishing. Today there is no fishing at all from Runswick and Robin Hood's Bay. At Staithes and Filey there are a few cobles that partake in some part-time fishing, but really only Whitby and Scarborough are left as fishing ports.

Table 2.1: Migrants from Cromer & Sheringham to Yorkshire.

| | | | | | | |
|---|---|---|---|---|---|---|
| CROMER | 1851.. | to Scarborough; | Thomas Buck | Fisherman | 32 yrs | Married |
| | | . | Matthew Nockles | . | 37 yrs | . |
| | | . | James Harrison | . | 30 yrs | . |
| | 1861.. | . | James Harrison | . | 44 yrs | . |
| | | . | Matthew Nockles | . | 47 yrs | . |
| | | . | Mary Nockles | . | 49 yrs | . |
| | | . | William Nockles | . | 35 yrs | . |
| | 1871.. | . | James Harrison | . | 5 yrs | |
| | 1881.. | . | John Margarson | . | 19 yrs | Single |
| | | . | Ben Margarson | . | 50 yrs | Married |
| | | . | James Harrison | . | 64 yrs | . |
| | | . | Isaac Allan | . | 35 yrs | . |
| | | . | William Nockels | . | 56 yrs | . |
| | | . | Sophia Nockels | Fisherman's wife | 52 yrs | . |
| | | . | John Jarvis | Fisherman | 42 yrs | . |
| | | . | Lucy Jarvis | Fisherman's wife | 39 yrs | |
| | | . | George Jarvis | Fisherman | 18 yrs | Single |
| SHERINGHAM | 1861.. | . | William Bishop | . | 37 yrs | Married |
| | 1871.. | . | Robert Pegg | . | 37 yrs | . |
| | | . | Mary Pegg | Fisherman's wife | 31 yrs | . |
| | | . | Richard Pegg | Fisherman | 25 yrs | . |
| | | . | John Pegg | Scholar | 11 yrs | Single |
| | | . | Henry Woodhouse | Fisherman | 24 yrs | Married |
| | | . | Harry Pipe | . | 24 yrs | . |
| | | . | William Bullamon | . | 36 yrs | . |
| | | . | Henry Burton | . | 23 yrs | . |
| | | . | William Pardon | . | 28 yrs | . |
| | | . | George Harman | . | 28 yrs | . |
| | 1881.. | . | Richard Pegg | . | 34 yrs | . |
| | | . | William Long | . | 55 yrs | . |
| | | . | Henry Burton | . | 33 yrs | . |
| | | . | Daniel Luke | . | 40 yrs | . |
| | | to Filey; | James Scotter | . | 30 yrs | . |

# Chapter 3.

## Materials and Methods.

There are multifarious sources of data available to the demographer. Accounts of mobility are provided by settlement papers, freeman rolls, apprenticeship records, and church court depositions (Clark 1979), but all these sources are limited to the period covered, and several are biased towards townspeople, who may be likely to have migrated further than country dwellers. There are two further primary sources of data which are not so limited, however, these are the English 19th century population census, limited in its time span but unrivalled for its comprehensiveness, and the English parish registers, which, unlike all other sources, span several centuries.

The first civil registration of births, marriages and deaths was in 1837. Prior to that date, registers of baptisms, marriages and burials were only kept by the Church of England. The first registers were kept in the reign of Henry VIII in 1538, but not all of these very early ones have survived the ravages of time; they mostly date from the latter part of the 16th century. At first registration was left to the vagaries of the incumbant and little effort was made to ensure completeness and accuracy. Some attempt was made at standardisation at least in marriage records, by the passing of the Hardwicke Act in 1753, which introduced pre-printed registers with spaces for the origin of marriage partners as well as details of names and the date of the ceremony. The 1812 Rose Act brought the registration of baptisms and burials to the same standard and improved that of marriages slightly by numbering the pages of the books so that omissions could be checked. The passing of the Civil Registration Act in 1837 involved another change in the type of details recorded: the new printed books for marriages, for example, required details of occupation, age at marriage and residence at the time of marriage (Finlay 1981 and McLaughlin 1986).

Eversley (1966) discusses the problems of completeness and accuracy in the parish registers. Under-registration before 1837 might be caused by political upheaval (for instance, there are long gaps in registration during the Commonwealth period); by a lack of conscientiousness on the part of the incumbent, by laxity of religious observance or by the presence of non-conformity. Inaccuracy of contents can also cause problems for the investigator. A serious defect in the marriage entries mentioned by Eversley (1966) concerns the possible unreliability of the information on origin in the early 19th century in connection with the Poor and Settlement Laws. Between 1753 and 1837 ' parish of origin' was specified, from 1837 onwards this was changed to ' residence at the time of marriage' . It seems that bridegrooms, in particular and often with the full knowledge of the incumbent, pretended to a settlement at the place of marriage because of the risks of declaring his true origin. Eversley (1966) has commented on the much higher endogamy rates of the later 18th and early 19th centuries as compared to the 17th century and early 18th century which an increase in population alone cannot account for. After the 1837 act, non-conformity was the most serious problem, for people were no longer required, for instance, to marry within the Church of England.

Such difficulties of religious bias and standardised procedure of recording information are not encountered in the census records. These 19th century censuses are the most comprehensive material available to the demographer, for they aspire to provide a complete survey not only of every household but of the entire parish and aggregatively the country. It gives information on address, age, relationship to the household head, marital status, sex, occupation, birthplace, christian and surnames. The first official census was taken in 1801, although it was not until 1841 that data was recorded nominatively by the use of the household schedules under the organisation of T.J. Lister. These first records were written in pencil but are still easily legible today. In 1851 there were a number of significant changes. The country and town of birth were recorded, whereas in 1841 there had just been a column to be marked ' Y' for yes, if the individual was born in the county of residence, or ' N' if he was born outside, with a separate column if he was from Scotland, Ireland or ' foreign parts' . The second important change was that the relationship of each person to the household head was given for the first time. Both these amendments are crucial to the study of migration: Specifically, migration between the birthplace of a parent and the birthplace of a child. The final minor distinction between the books of 1841 and 1851 is that the latter were written in ink. The format of the census remained unchanged from 1851 to 1911. Owing to the Registrar General's one hundred year rule censuses later than 1881 are not yet available to the public. Exceptionally, the 1861 returns are not wholly complete, nor are they in such good condition (Wrigley 1966), although they still provide good information for the bio-demographer.

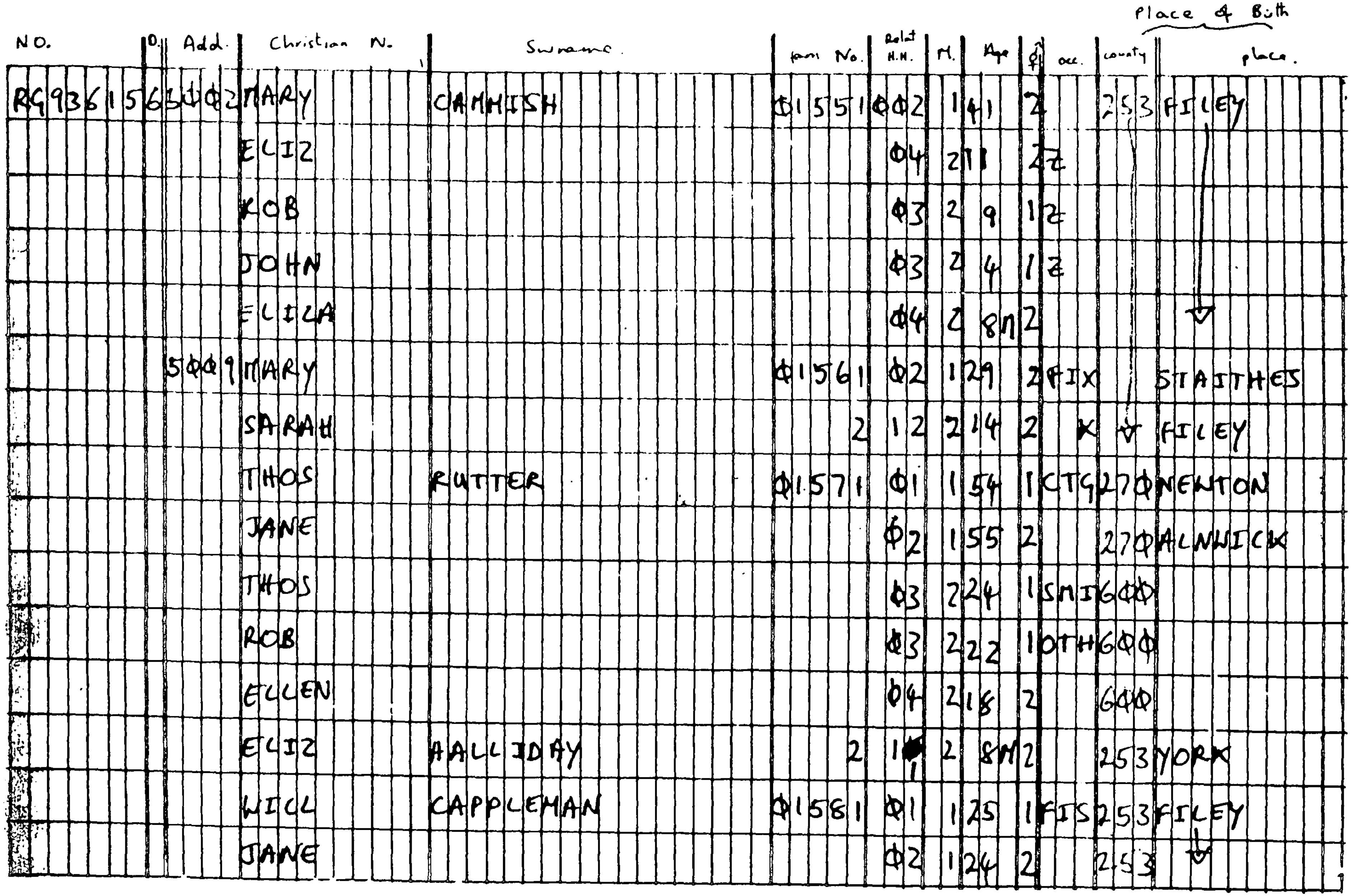
For this study the data were taken from the enumerators' returns for 1851, 1861, 1871, and 1881 censuses of the coastal towns of North Yorkshire. The 1841 census was not used since a major portion of this work deals with migration. The area chosen includes the villages of Staithes, Runswick and Hinderwell (all within Hinderwell parish), Fylingdales and Robin Hood's Bay (within Fylingdales parish), the town of Filey and only selected samples of Whitby's and Scarborough's populations. Due to the limited amount of time available, it was not possible to collect all the material for these two latter towns. For they are both large with total population sizes of 30,504 and 8,820 in 1881 Scarborough and Whitby respectively. Since one of the principal aims of this study is to compare the fishing and rural populations, I selected the families of individuals working as agricultural labourers, fishermen, or farmers only. Over all this yielded a total sample size of 31,351 individuals.

The data were collected from the Public Records Office in London and were coded onto data sheets, an example of which is given in fig.3.1. Columns 1-7 give the census reference number, and column 8, the date, coded as 6 for 1861, 7 for 1871 and so on. The addresses were coded according to the parish in column 9 and then the town within the parish in column 10, and finally by street name in columns 11 and 12. (In fact in the actual analysis, the street names were not utilised). Hinderwell parish, for example, was represented by the figure '1' and Filey, as the fifth parish, by the figure '5'. Staithes and Runswick, villages within the same parish, were indicated by the configuration 12 and 13 respectively. Christian and surnames were written out in full in columns 13 to 40.

In the following columns I recorded something called the ' family number' and the relationship to the household head. This provides the basis for classifying each family in each town, and within the family unit, deciphering the relative relationships of the individuals. This is important for estimating parent-offspring migration. It could also be invaluable, of course, for pedigree analysis.

Marital status (column 50) was simply recorded as 1, 2, or 3 for married, single and widowed. Age (columns 51-53) was noted as it had been in the censuses. This caused difficulties since the computer inevitably does not understand ' months' and ' days' . I therefore wrote into my SPSSX program (see below) a command to convert days and months to decimals. Sex (column 54) was simply coded as 1 for male and 2 for female. All these parameters are invaluable for double-checking the data. For example age, marital status and the relationship to the household head and occasionally occupation, all correspond to each other. Similarly sex corresponds with name and often (in 19th century Britain) with occupation.

Occupation was coded in columns 55 to 57. Many occupations were coded under the miscellaneous category of ' other' , — for example; vicars; cordwainers; annuitants; gentlemen; tradesmen and so forth. Otherwise fishermen were classified as FIS and distinguished from coast-guards (CTG), seamen (SN), boat makers (BTM), ship owners (SPO), mariners and sailors (MAR) and (SAL), and even from associated occupations such as fishmongers, fish servant, fish hawkers, fish net makers and hook makers, which were all termed FB for fish-business. For while many of these occupations are closely related, there are distinguishing factors which should be respected. Coast guards, for example, were a part of the Royal Navy and therefore a migratory group, quite distinct from the fishermen. Ship owners were generally the proprietors of commercial trading boats, and not the fishing cobles, although this was not always the case, for in Robin Hood's Bay the fishing boat owners were sometimes described as ' ship owners' rather than fishermen. ' Fish business' is probably the category most closely inter-woven with the fishermen, possibly including a small number of fishermen's widows working as net makers



|  |  |  |  |  |  |  |  |  |  |  | Place of Birth |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. | O. | Add. | Christian N. | Surname | fam No. | Relat H.H. | M. | Age | ♀♂ | occ. | county | place. |
| RG93615 | 6 | 3402 | MARY | CAMMISH | 01551 | 002 | 1 | 41 | 2 |  | 253 | FILEY |
|  |  |  | ELIZ |  |  | 04 | 2 | 11 | 2 | Z |  |  |
|  |  |  | ROB |  |  | 03 | 2 | 9 | 1 | Z |  |  |
|  |  |  | JOHN |  |  | 03 | 2 | 4 | 1 | Z |  |  |
|  |  |  | ELIZA |  |  | 04 | 2 | 8M | 2 |  |  |  |
|  |  | 5009 | MARY |  | 01561 | 02 | 1 | 29 | 2 | FIX |  | STAITHES |
|  |  |  | SARAH |  | 2 | 12 | 2 | 14 | 2 | X |  | FILEY |
|  |  |  | THOS | RUTTER | 01571 | 01 | 1 | 54 | 1 | CTG | 2700 | NEWTON |
|  |  |  | JANE |  |  | 02 | 1 | 55 | 2 |  | 2700 | ALNWICK |
|  |  |  | THOS |  |  | 03 | 2 | 24 | 1 | SMI | 600 |  |
|  |  |  | ROB |  |  | 03 | 2 | 22 | 1 | OTH | 600 |  |
|  |  |  | ELLEN |  |  | 04 | 2 | 18 | 2 |  | 600 |  |
|  |  |  | ELIZ | HALLIDAY | 2 | 1 1 | 2 | 8M | 2 |  | 253 | YORK |
|  |  |  | WILL | CAPPLEMAN | 01581 | 01 | 1 | 25 | 1 | FIS | 253 | FILEY |
|  |  |  | JANE |  |  | 02 | 1 | 24 | 2 |  | 253 |  |

Fig. 3.1: One of the Data Sheets used.

but also encompassing the fishmongers and hawkers who may have had close ties also with the tradesmen. I included them all in this category since their specific relationship to the fishing industry is unknown while simultaneously it is clear that they are all closely related occupations.

Agricultural labourers (AGL) and farmers (FMR) were also distinguished since in socio-economic terms they represent two quite different groups: the former is usually associated with hired labour and the latter with land-ownership. Other occupations that were identified were the various mining industries (MR), (IMR), (JMR) and (ALM), and labourers (LAB), smiths (SMI), servants (SER) and scholars (Z). Farm servants were coded as agricultural labourers since the difference between the two rests solely on residence and not the type of work.

For every occupation, the retired, the wives, the widows, and sons and daughters were classified. For example, a fisherman (FIS) was distinguished from a fisherman's widow (FIY) and a fisherman's son (FIK) and so forth.

Finally, the place of birth was coded under the county (columns 58-60) and the place of origin (columns 61-71). The county of birth was coded numerically, and the place, written in full.

It took three months to collect the data from the Public Record Office, and at least twice that time to go through and check and prepare the data before I could go on to the analysis. This perhaps bares some testimony to the inaccuracies and difficulties of such material.

To begin with, there are undoubted difficulties of coverage. For the census is taken on one night of a particular year. While it is nationally comprehensive, locally it will never be so, for there are always likely to be individuals who were absent on that particular night. While this problem has been minimised by picking a suitable day of the year not coincidental with seasonal work and public holidays, it is inevitable that some will be missed. (The census is usually taken in March or April, missing, of course, the Easter Bank Holiday). Men of seafaring professions are particularly vulnerable absentees. Indeed the 1881 census recorded far higher numbers of fishermen than in the previous decade, numbers that could not be attributed to the natural growth of the industry alone. The significant factor here was that they had recorded the crews of all boats in port for the subsequent fourteen days and not the usual twenty-four hours (Bellamy 1978). However, this problem is likely to be less severe amongst inshore fishermen who return daily to their homes. It could affect the herring fisheries but then again the herring season extends from summer (Scotland) to December (Norfolk) and is not operating during the early spring. Thus there is little reason for any exceptional difficulties of coverage and indeed there is little evidence of it. Moreover, by sampling censuses of different dates, a dynamic picture of the population was obtained.

Undoubtedly the greatest source or difficulty and frustration with the census is the errors that exist within the material itself. To quote P.M. Tillott (1968 p5):

> "Error, or more normally inconsistency, stemming from human failings is of fairly frequent occurrence in the returns" .

Given the mechanics of the initial collection of the census returns and then the process of transferring that information to a computer, it is not all that surprising.

The process of census taking begins at the level of the household: household schedules were delivered by the enumerators and were left to be filled in according to the number of inhabitees. Problems of illiteracy are likely to have arisen and, if they could read and write, did they fully understand the given instructions? In Wales there was the additional problem of language: In such cases enumerators often had to fill the schedule in themselves. In a similar vein, colloquial terms were often used to describe occupation, forename, and birth place. Moreover, there was the question of honesty. Many feared that the census was associated with the assessment of taxation, for example, and were therefore reluctant to impart the correct information. Although to some extent this may have been quelled by the existence of the legal penalty for false returns.

The enumerators were responsible for overseeing the process of census collection. Negligence and ignorance on their part is a major source of error. Eddie (conference) has suggested that they were poorly paid and it is probable that their work may have been quickly and carelessly done without reference to all the relevant details. Indeed it is true that they were often accompanied by police escorts. Taylor (1951) remarks on the case of the Irish enumerators who swelled the census numbers since they believed that they were to be paid by the results! Such an incident is, however, unparalleled in English census taking.

There is also much evidence that enumerators differed widely in their ability to read and interpret the lengthy instructions given to them by the registrars. Although these instructions were not without ambiguity (Tillott 1968).

However, the greatest source of enumerator error is likely to have arisen from their task of copying the collected household schedules to the books known as the enumerators returns. (It is these books that are retained in the Public Record Office today: the household schedules have been destroyed). For quite apart from expected copier error, the enumerators frequently amended householders' answers. While this was only to right obvious errors or incomplete definitions, it is questionable as to whether such amendments actually portrayed the life of the household or whether in fact it reflected the enumerators perception of how they lived. For example, after 1871 all children had to legally attend school until the age of 13. Officially therefore children below that age were registered as scholars, while in reality it was highly probable that children in the country helped on the farms. Similarly, householders were instructed to put down a son who worked on the farm as farmer's son rather than agricultural or farm servant. In such ways the enumerators often shaped the way that the census was filled in.

Futhermore, when the enumerators' books reached the central census office in London, they were counted and checked there by clerks who repeatedly varied widely in their interpretation and treatment of the material before them. Many were willing to amend the material to obtain their results (Tillott 1968 and Eddie pers. com.). However, fortunately such changes are usually recognisable since they are overwritten on the original enumerators books.

Beyond the initial collection of the censuses there were undoubtedly errors incurred in my transcription of the data. While I obviously did my best to ensure a high degree of accuracy, reading 19th century hand-writing off micro-fiche in a darkened room certainly frustrated my chances of complete success. Secondarily, the data then had to be copied from the data sheets on to the computer. This was done by a highly professional team of ladies in the Durham University Computer Centre and it is highly unlikely that anything other than a very occassional slip was made.

While I have now stated the reasons for the time-consuming process of checking the data, I have said little about the kinds of difficulty I encountered. There were three major areas which were extremely problematic and with which I shall deal with in turn: Problems in recording occupation; inaccuracies in spelling, closely linked with the worst difficulty of all, checking each place of birth. Otherwise errors within the data were haphazard but relatively straightforward to correct. I achieved this through the use of the SPSSX package on the computer. By checking the frequencies of each variable, it was possible to pull out the alien frequencies, such as a three or four in the sex variable (coded one or two only). Then by using logical statements, it was possible to ensure that the correlated variables, like marital status and age or sex and relationship within the household, were in agreement.

This computer analysis did not, however, provide an assessment of either the surnames or forenames, birthplace data, and it offered only a limited check on occupational data. Occupation is difficult to check. Sex and age are to some extent correlated with occupation; for example, women did not go out to fish in the 19th century and although they were usually strongly associated with the industry they would not have been termed ' fishermen' but rather ' fishwives' , ' fish net makers' *etc.* This can be checked by the use of a logical statement. However, there are many more codes where there is no check. Moreover, there are extensive problems encompassed in the recording of occupation which simply cannot be certified or amended without additional information not given in the census.

It is, for example, extremely common to find occupation recorded in very general terms, such as ' labourer' or ' cotton-hand' . The type of work is not specified and the position of responsibility is also omitted. Alternatively, reference is solely

Table 3.1: The Frequency of Ambiguous Birth Places Changed to a Central Location within Each County.

| COUNTY | CENTRAL LOCATION | FREQUENCY |
|---|---|---|
| Bedfordshire | Bedford | 6 |
| Cambridgeshire | Cambridge | 9 |
| Cheshire | Chester | 5 |
| Cornwall | Penzance | 6 |
| Cumbria | Carlisle | 4 |
| Derbyshire | Derby | 1 |
| Devon | Exeter | 3 |
| Dorset | Weymouth | 1 |
| Durham | Darlington | 32 |
| Essex | Colchester | 1 |
| Gloucestershire | Gloucester | 5 |
| Hampshire | Winchester | 1 |
| Hertfordshire | Hertford | 1 |
| Kent | Dover | 5 |
| Lancashire | Preston | 2 |
| Leicestshire | Leicester | 1 |
| Lincolnshire | Lincoln | 22 |
| Norfolk | Norwich | 44 |
| Northamptonshire | Northampton | 8 |
| Northumbria | Newcastle | 4 |
| Nottinghamshire | Nottingham | 4 |
| Rutland | Uppingham | 2 |
| Staffordshire | Stafford | 5 |
| Suffolk | Lowestoft | 5 |
| Sussex | Brighton | 1 |
| Westmorland | Kendal | 1 |
| Wiltshire | Salisbury | 1 |
| Worcestershire | Worcester | 1 |
| | | |
| Wales | Cardiff | 6 |
| Scotland | Edinburgh | 71 |

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gives the numbers changed for each county. This at least provided some measure of migration from 'other' counties. The Yorkshire missing data remained 'missing' since the allocation of a central point would have led to bias since the places of residence were so far dispersed. In all the total number of birthplaces identified was 1,222.

Once all the data had been checked and corrected (as far as possible), it was all copied to one large data file which was then fit for analysis. Throughout the study the statistical package SPSSX was used to manipulate and handle the data. For each part of the analysis required specific data variables. For example, isonymy required only the surnames, withdrawn according to occupation, date and address. While the application of the migration models depended on parent-offspring migration data.

The detailed description of the materials and methods used for the specific parts of the analysis are given in the relevant chapters. For there were many problems specific to the individual models which are better discussed in the appropriate context. Hence all I shall do here is give a very brief outline of the methods I have used in each chapter.

*Chapter 4:*

This discusses all the methods and materials used to estimate and illustrate 'migration' into and within North Yorkshire. Place of birth, Place of residence migration and Parent-offspring migration is considered. SPSSX was used to obtain frequency listings of the number of migrants from each distance category. The Gimms plotting program (Waugh 1986) was used to represent the frequency of migrants against distance (in kilometers). A program, written by Bob Williams (of the Computer Centre, University of Durham), was used to plot the distribution of migrants on maps of Great Britain.

### *Chapter 5*

This chapter discusses the results of the isonymy analysis. Since there were some missing surname data, the sample included a total of 31,291 individuals, variously grouped by occupation, date and address. Isonymy was estimated according to Lasker's 1977 formula (equation 1.1), using a computer program written by Bob Williams. The results were represented diagrammatically using the computer packages Clustan (Wishart 1978) and MDS-X (Coxon *et al.* 1986).

### *Chapter 6*

This chapter presents the results of the migration matrix approach. Parent-offspring data were used and considered in terms of occupation, date and town. Malecot's recurrance equation (1.5) and Harpendening and Jenkins's formula (1.6), were used to calculate the results using a computer program written by L.B. Jorde, University of Utah and modified by myself.

### *Chapter 7*

In this chapter Malecot's isolation by di~~s~~stance model was studied. Parent-offspring data were used in relation to occupation, date and town. This analysis met with considerable difficulty (specified in chapter 7) and a number of computer programs were used. These include:

1. A program to estimate the normal curve distribution written by myself.
2. Durham University's ' Curvefit' program.
3. A program to calculate the parameters ' a' and ' b' according to Morton's 1977 equations (1.8 and 1.9), written by William McVicker, Univeristy of Durham.
4. A program to estimate the isolation by distance equation (1.7), written by myself (Appendix 1).
5. Bob Williams's program to plot graphs.

## *Chapter 8*

The results of the stepping-stone model are presented in this chapter. The model was only considered from the point of view of the fishermen and their offspring in each census year. The stepping-stone model was calculated according to the formula given in Cavalli-Sforza and Bodmer (1.2), using a computer program written by myself (Appendix 2).

# Chapter 4

# The Raw Migration Data

In studies of human genetics there are two principal ways in which gene flow is measured, from marital migration data and parent-offspring migration data. The latter is theoretically the most reliable and accurate method of estimating gene flow between subdivisions, since marital migration data may include couples who will not reproduce, and the place of birth or place of residence of either of the couple at the time of marriage is quite likely to differ from the birthplace of the future offspring, and may not therefore be indicative of gene flow. On the other hand, it is often difficult to obtain parent-offspring information without the time-consuming process of record linkage, whereas marital migration, is much more accessible (from marriage records). Despite such fears over the reliability of marital migration, a recent paper by Jorde (1984) has shown that there is in fact little to choose between the two, and that marital migration data is a reliable estimate of gene flow.

In this study the most expedient way of compiling migration data from the census records, was to consider the movement between the place of birth and place of residence for each individual. This was not entirely satisfactory since the present place of residence was not necessarily a permanent situation, and the movement may not therefore have been representative of gene flow. Parent-offspring data, which measures the distance between the birthplace of the parent and the birthplace of the child, does give a direct and reliable estimate of gene flow. It was much more difficult to obtain this information from the census records as the data had to be processed ' hierarchically' by SPSSX. In other words SPSSX had to consider each family rather than the individual as a unit. However, with this new version of the SPSS package, it was possible.

Both sets of raw migration data were considered, rendering a total sample of father-offspring distances of 11,272 and 13,164 mother-offspring distances, compared to a total sample of 30,787 birthplace-residence distances. Individuals for whom the birthplace was not given or whose birthplace could not be deciphered from the census records were omitted. SPSSX was used to calculate the migration distances using Pythagoras' theorem. This formed the raw material for all the subsequent migration analyses – migration matrix; isolation by distance; and the stepping-stone model. The data were considered by subdivision according to the census date, occupation and town of residence. Figure 4.1 below summarises the categories used.

Graphs plotting the migration distances against the cumulative frequency of migrants gave a preliminary indication of the major trends. The cumulative percentage frequencies were used instead of the actual frequencies since they drew a much clearer and more easily interpreted line on the graphs. Only the first 90% of all migrants were used to plot the graphs since it was not practicable to draw the Y axis from a range of 0 kilometers to beyond 400 kilometers. By excluding the extreme 10% of distance categories this problem was overcome, and a more manageable scale was achieved.

Figures 4.2, 4.3 and 4.4 show the change in the number of migrants over time, for the birthplace-residence migration, father-offspring and mother-offspring migration. The first two figures are very similar; they both show that the number of migrants and the distance migrated, increases over time. Overall the mother-offspring material shows that there is slightly less gene flow between populations and that there is no specific increase in migration over time.

Figures 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12 plot the migration distance against the cumulative frequency for the three major categories of occupation for each census year using birthplace-residence and parent-offspring data. Comparing the two sets of data for each census year, it is seen that they both indicate the same trends. In every case at least 70% of the fishermen are endemic (in other words, they either lived and were born in the same place or the children were born in the same town as their parents). The agricultural labourers and farmers were much more mobile: the majority of these individuals moved away, or had their children in a different town from their place of birth. On the other hand, the remaining 20-30% of the mobile fisherfolk were found to migrate much further distances than the agricultural

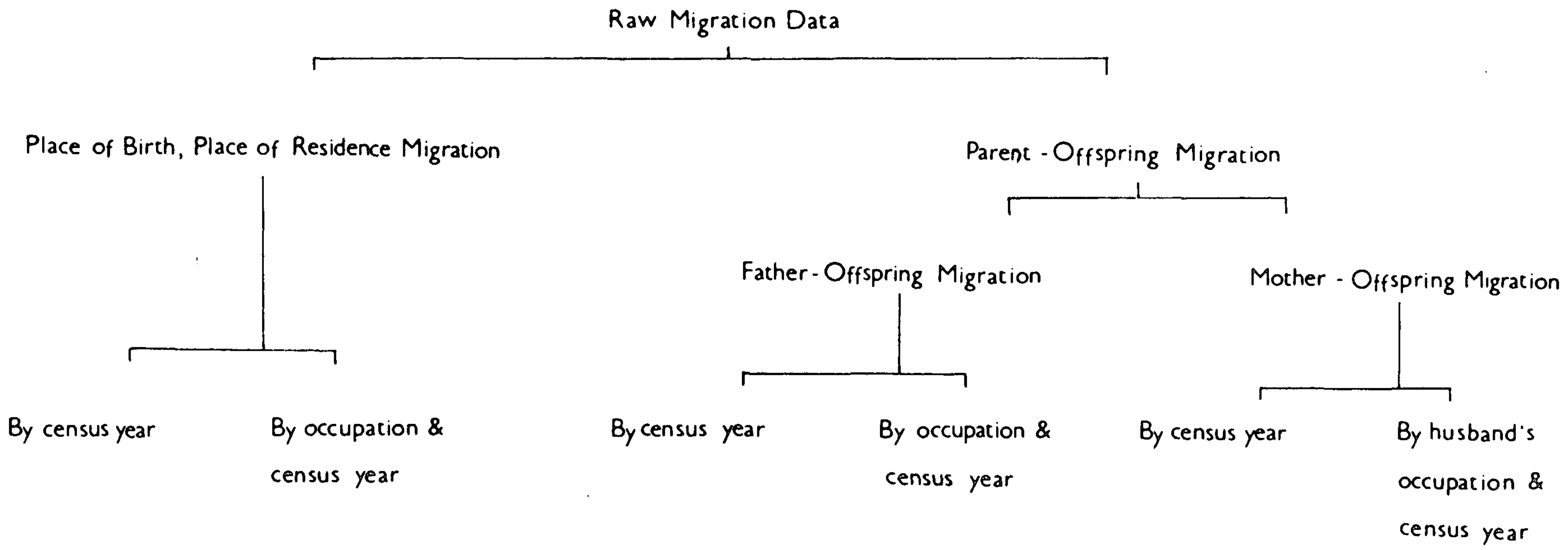


Fig. 4.1: Summary of The Migration Analysis

labourers, see, for example, the 1871 graphs (figures 4.9 and 4.10). Thus overall the rural folk tended to move about but within a localised radius, whereas few of the fishermen moved, but those who did, did so over extensive distances of often well over 100 kilometres.

In some cases the graphs show a noticeable change of slope at a particular distance, for instance, the number of migrant fishermen increases sharply at 15 kilometres. In this case, it is caused by migration from Filey to Scarborough, initiated by the strong fishing connections between these two towns (see chapter 2). At other points, as where the 'steps' occur beyond the 100 kilometre mark for the fishermen, the cause is the migration of large families (including all the children). Very occasionally there are towns which are equi-distant from the town of origin which also appear as little sharp inclinations in the frequency of migrants.

There are some discrepancies between the parent-offspring and the birthplace-residence data. For example, the two data sets present slightly different results for the 1881 farmers and agricultural labourers. The parent-offspring data indicates that both groups are more endemic than the results from birthplace-residence data indicate. Such small differences between the two data sets may partly be due to the fact that the parent-offspring data only considers one of the adult sexes at a time, and then it excludes all those individuals who are not married, whereas the other data source includes everyone in the census for whom the birthplace was known. Secondly, as mentioned above, it is likely that the birthplace-residence data include temporary migrations (for example, of servant girls before they marry), and it may not reflect gene flow at all.

On the other hand the two sets of data do show remarkably similar trends, and the discrepancies between the two were only very minor.It seemed that little was to be gained from using both sets, and in the interests of time, it made more sense to choose only one data set to work with. Thus for all subsequent genetic analyses the parent-offspring material alone was used since it is likely that this is the most reliable marker of gene flow. The birthplace-residence material, however, was used to plot the overall orientation of migration on maps of Britain for this gave a fairly clear over-view of the general direction of all migration into the area (see below).

Figures 4.13, 4.14, 4.15 plot distance against the cumulative frequencies for the three major occupations over time. Figures 4.16, 4.17 and 4.18 plot the analagous results for the wives of those three occupational groups. The graphs for the fishermen and women are distinct from the men and women of the other occupational groups: a much higher proportion of the fisher children were born in the same place as their parents, it is over 70% in most years. The difference between the fishermen and women is that the men who do migrate, do so over great distances (100 kilometres or more) whereas the women migrate over much shorter distances (90% of them within a 60 kilometre radius). Also the endemicity of the male fisher population clearly declines over time, whereas their wives do not show such a clear cut tendency. In 1851 the women are clearly less endemic that their husbands, but by 1861 the two are more or less the same.

The majority of the children of the agricultural labourers and their wives seem to be born within a 60 kilometre radius of their homes, but relatively few of them actually at the same birthplace of either of their parents, although a higher proportion of the wives seem to be born in the same town as their children (about 30-40% as compared to 20-30% of their husbands). There is no clear upwards or downwards trend over time and the extent of gene flow seems to vary only a little between census years. The farming folk seem to follow a remarkably similar pattern: the majority of children are born within only a 30 kilometre radius of their parents, while only an approximate figure of 40% are born in the same village as either of their parents. These results thus confirm some of the historical assertions – that the fishing communities are close knit and that the agricultural labourers are a highly mobile group of workers. The most interesting finding at this point was to discover that some fishermen migrated such extensive distances. Where were they coming from? Were they migrating to all the North Yorkshire ports or just, for example, to Scarborough and Whitby?

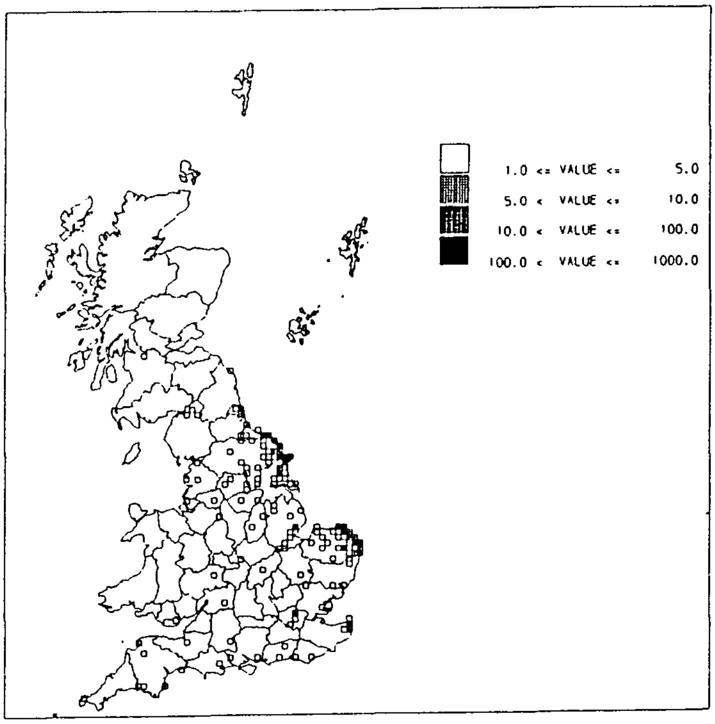
In order to assess the 'orientation' of these moves, the place of birth of each individual was plotted on a map of Britain (figure 4.19). The fishermen were then compared to the rural occupations, figures 4.20 and 4.21, (farmers and agricultural labourers were considered together here). The two maps starkly contrast, with the majority of rural migrants originating more locally from within Yorkshire while most of the fishermen have migrated from the coastal ports, with a considerable number from Norfolk. Figure 4.22 is a map of Britain marking the names of all the fishing ports that are on figure 4.20 – or in other words it gives the names of the origins of the sea-faring migrants to North Yorkshire. Migrants from Norfolk were most likely moving to escape the hardship inflicted by the decline of the crab industry there (see chapter 2).

The remaining question is whether these sea-faring migrants journeyed to all the Yorkshire ports. In order to answer this, the fishermen were divided into six groups according to their home-towns, and their birthplaces plotted accordingly on the six separate maps (figures 4.23, 4.24, 4.25, 4.26, 4.27, 4.28). It is clear that Scarborough was the chief recipient, while Robin Hood's Bay, Staithes and Runswick remained very insular. The Norfolk crab men thus migrated to Scarborough rather than the smaller inshore fishing villages. A few went to Filey, although given Filey's close links with Scarborough this not surprising. Table 4.1 lists all those who migrated from the fisher towns of Norfolk giving the town they settled in and their marital status. (Cromer and Sheringham are included here as well as in table 2.1, to cover those migrants who were not fisherfolk). It is interesting that many of the migrants were already married although only relatively few appear to have brought their families with them. This is confirmed by figure 4.29, which plots the birthplaces of all the fishwives: not as many appear to have originated from Norfolk, rather more seem to have come from inland Yorkshire.

It is known that many Norfolk fishermen did return to their homes. Personal conversation with a Sheringham fisherman 'Teapot' West revealed that much of the migration was seasonal, many fishermen moved between Yorkshire and Sheringham according to the state of the fishing at Sheringham. The Salvation Army was established in Sheringham by some fishermen who returned from Yorkshire. While cultural diffusion was inspired by such migrations, large scale gene flow did not necessarily occur although it is very likely that some Norfolk men did marry and settle in Yorkshire. However, it is important to remember that this was more or less confined to Scarborough and Filey, and to a much lesser extent, Whitby, not the smaller inshore villages.

Returning to the rural folk, figure 4.30, shows all the birthplaces of the agricultural labourers and farmers wives. Unlike the fishermen, there is a much greater similarity between the two sexes here.

This chapter has given a preliminary overview on the pattern of migration into the North Yorkshire coastal region. The 'movers' and the orientation of migration have been examined, and the fisherfolk have been identified as a distinctive group apart from their rural neighbours. The exchange between the study population has not been considered here for it is covered in chapter 6 'The Migration Matrix Analysis' . All the subsequent migration analyses use parent-offspring data. The following chapter, however, looks at the pattern of relationships indicated by identity of surname – namely isonymy.



Figures 4.20: The birthplace of each fisherman.

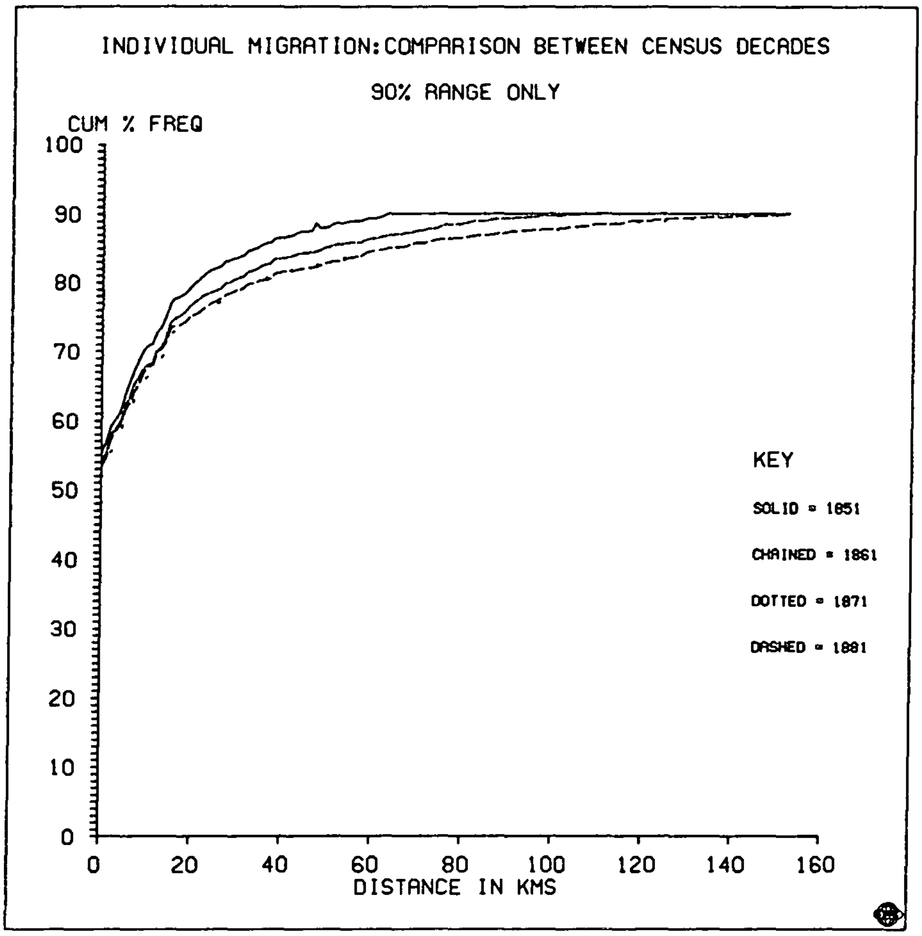
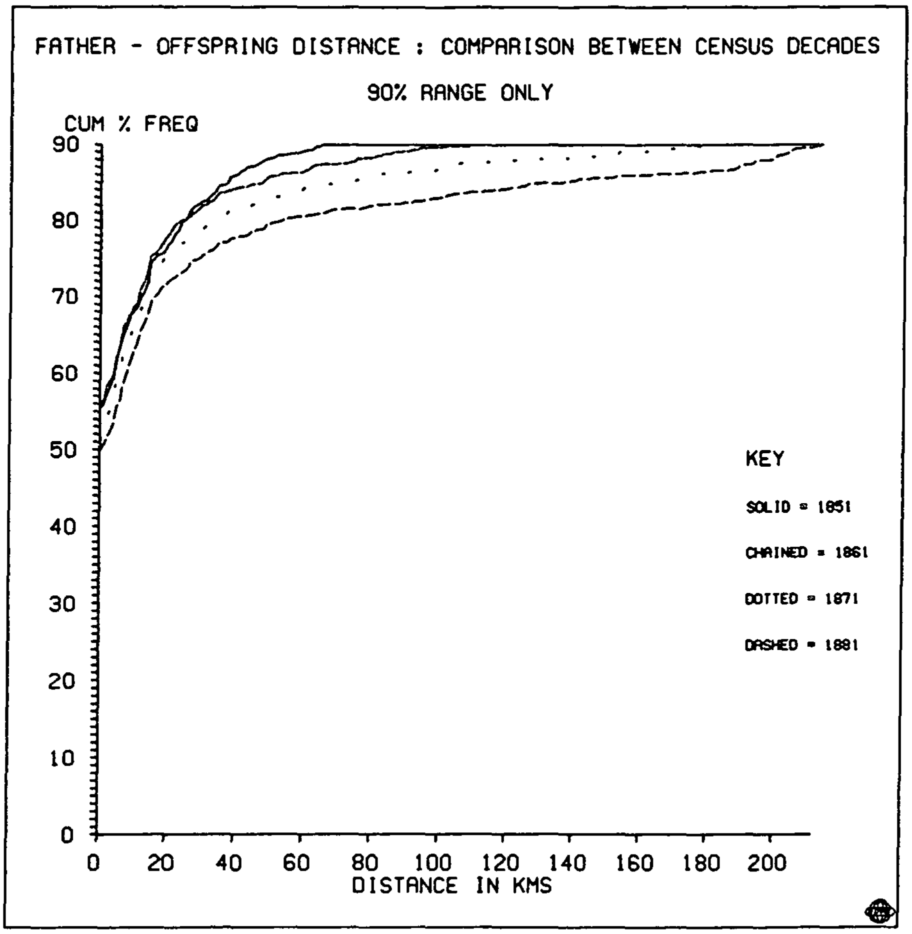

INDIVIDUAL MIGRATION:COMPARISON BETWEEN CENSUS DECADES
90% RANGE ONLY
CUM % FREQ
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
DISTANCE IN KMS
KEY
SOLID = 1851
CHAINED = 1861
DOTTED = 1871
DASHED = 1881

Figure 4.2



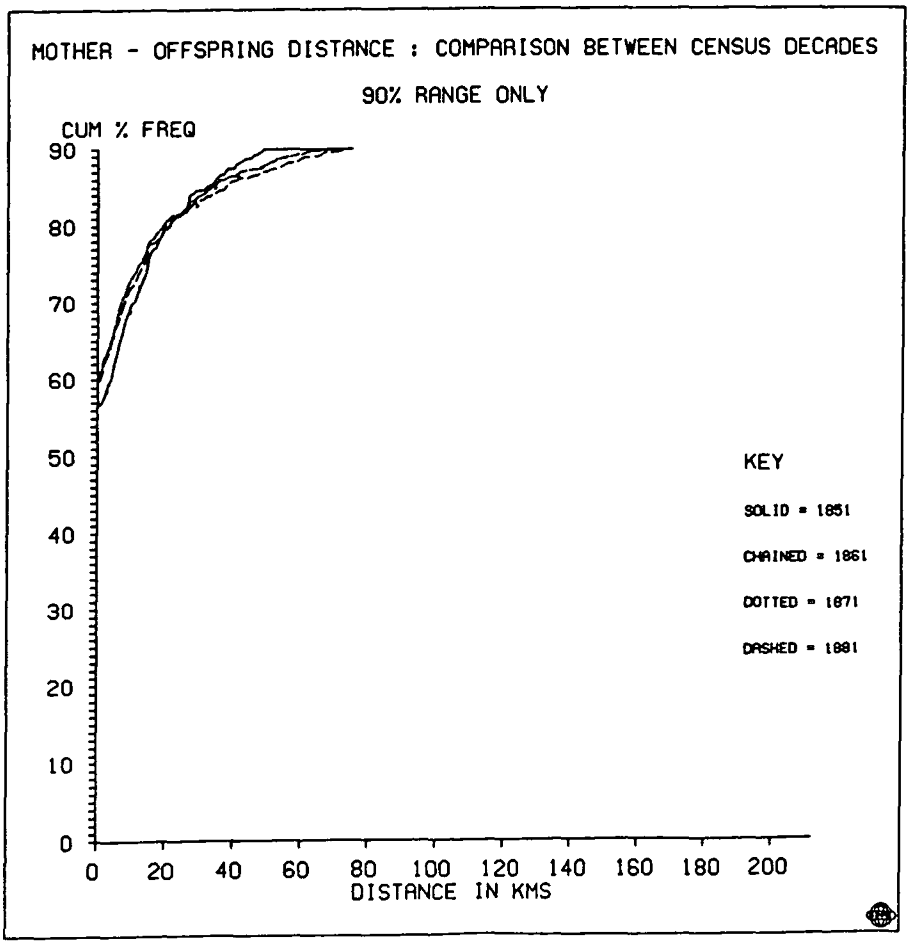
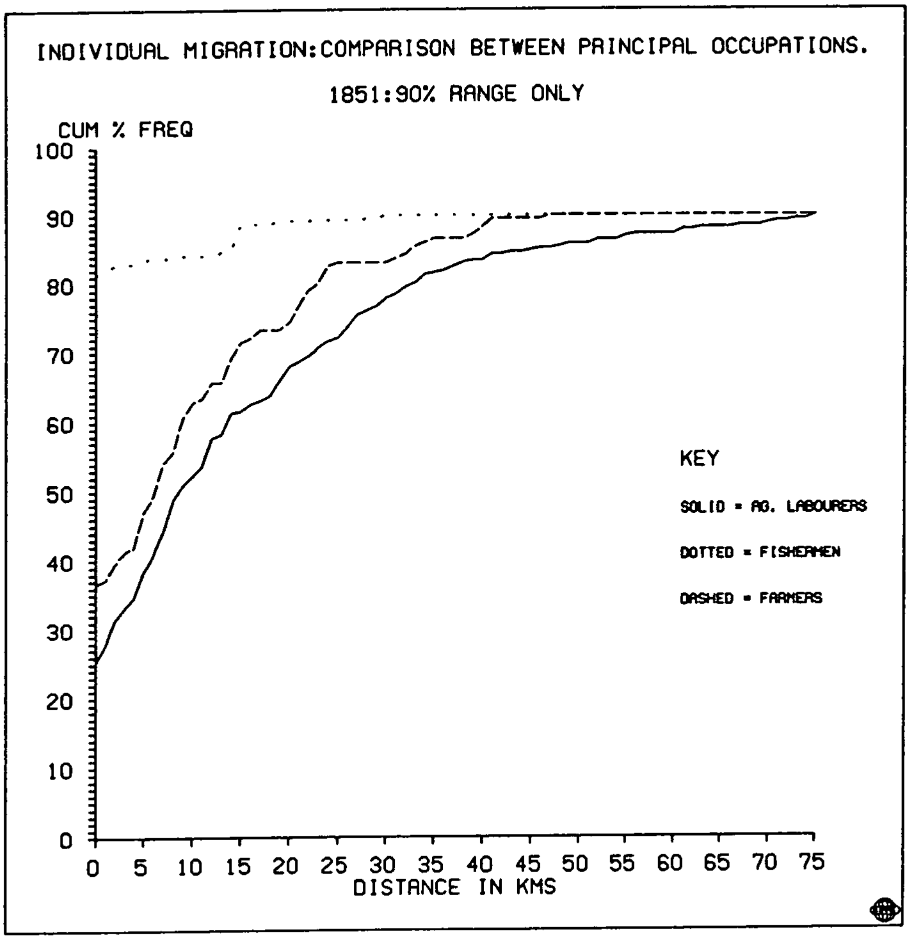


Figure 4.3 (top) and 4.4 (bottom)



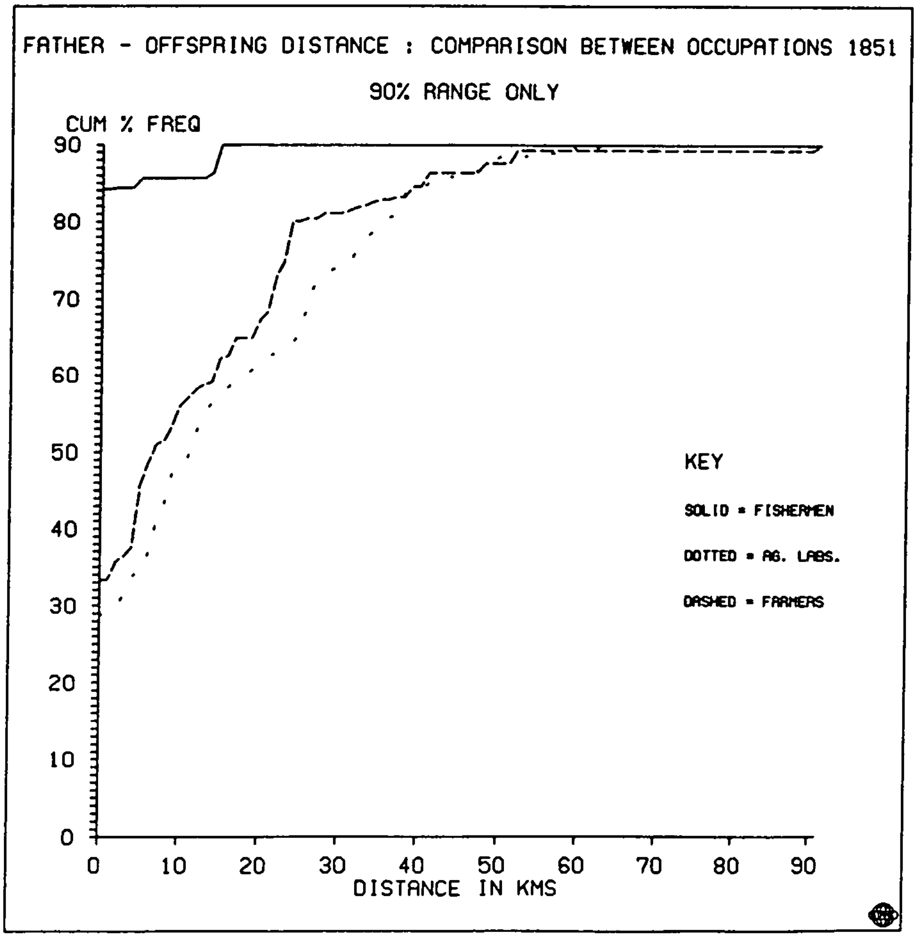
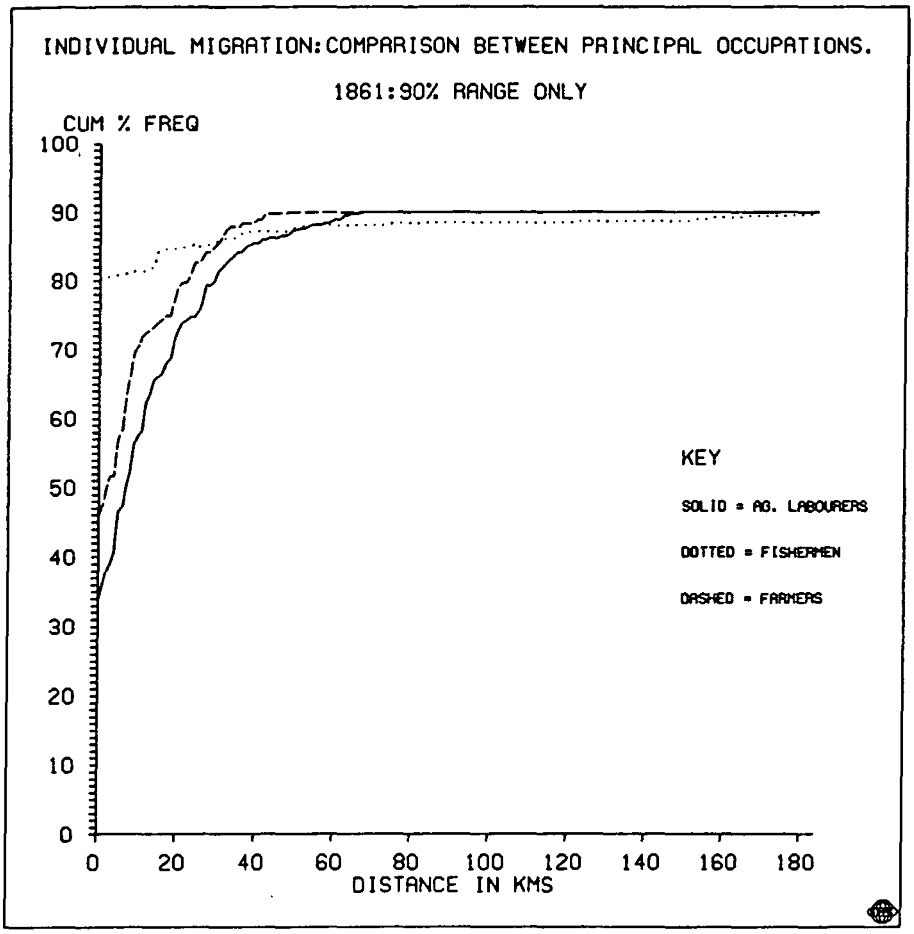


Figure 4.5 (top) and 4.6 (bottom)



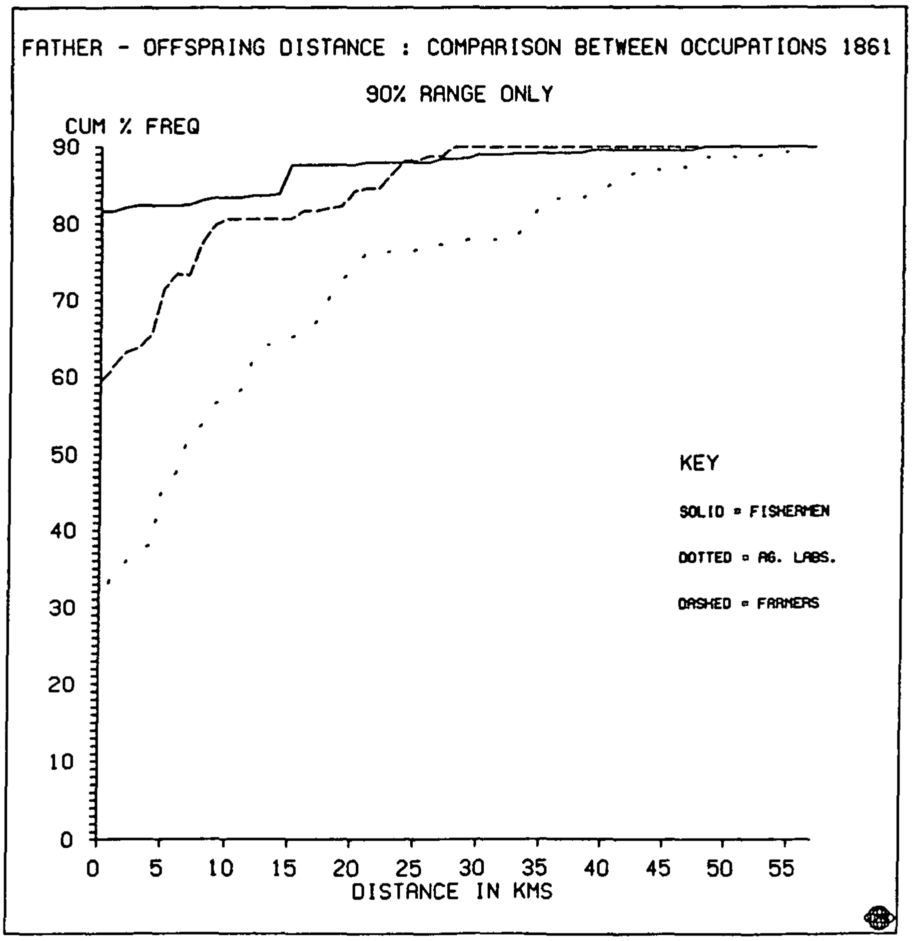
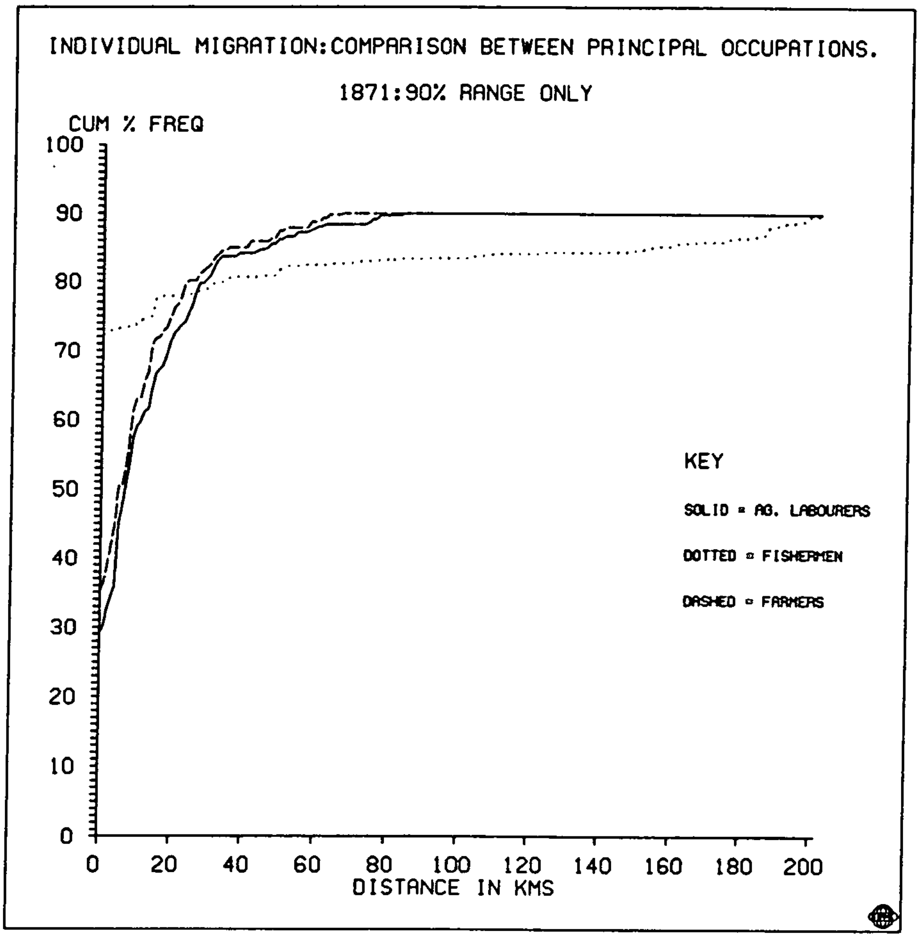


Figure 4.7 (top) and 4.8 (bottom)



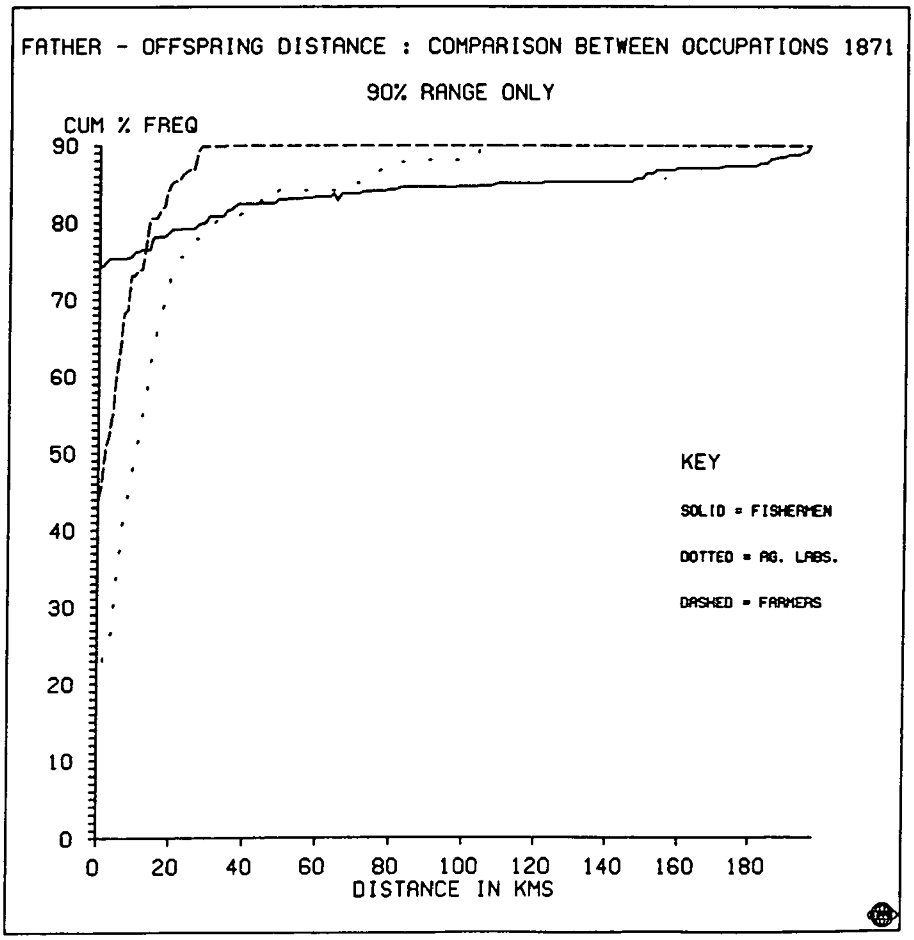
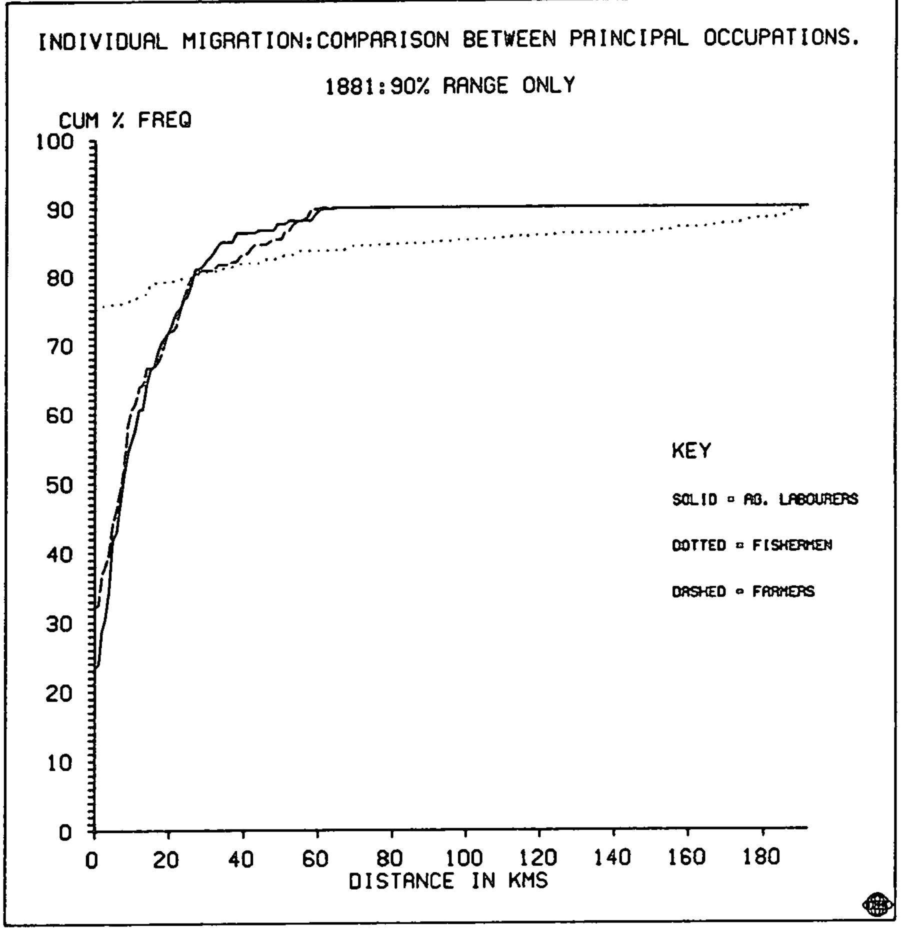


Figure 4.9 (top) and 4.10 (bottom)



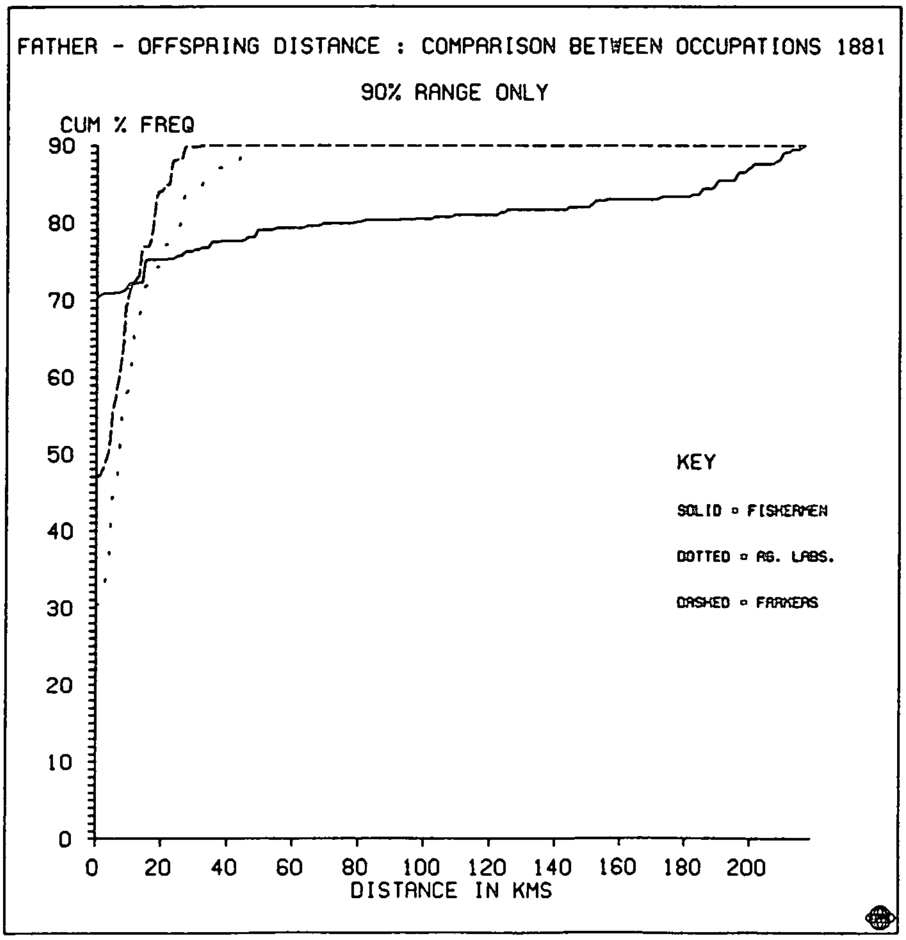
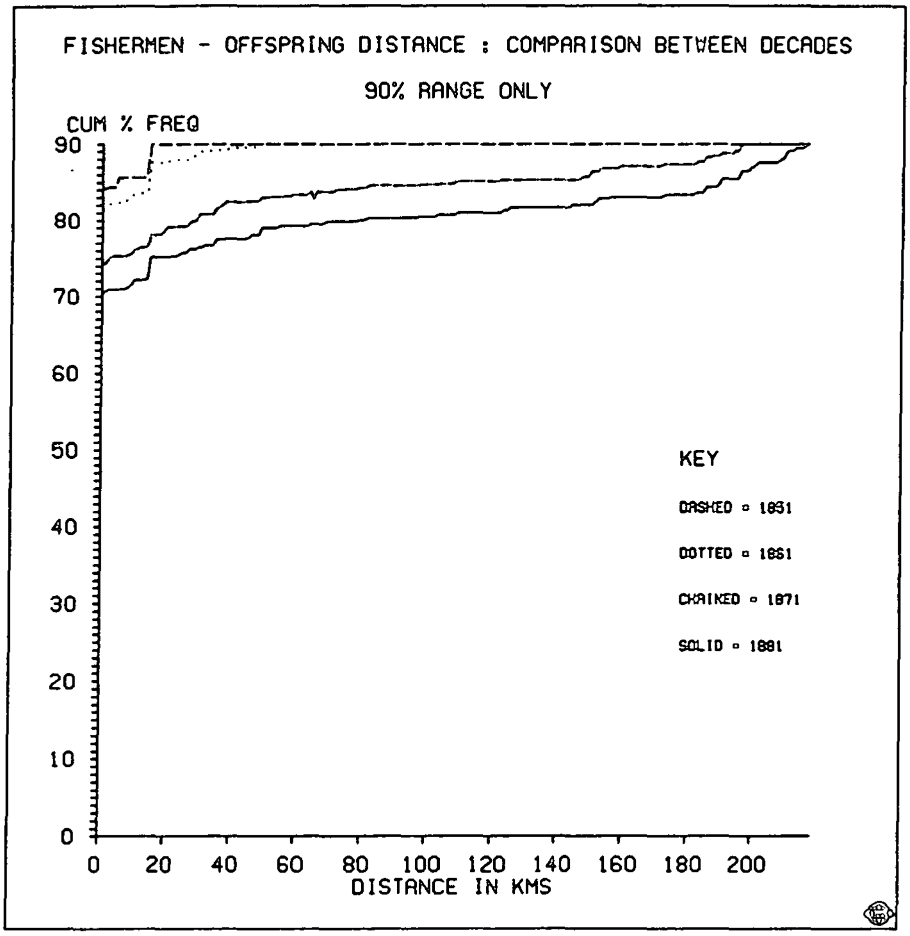


Figure 4.11 (top) and 4.12 (bottom)



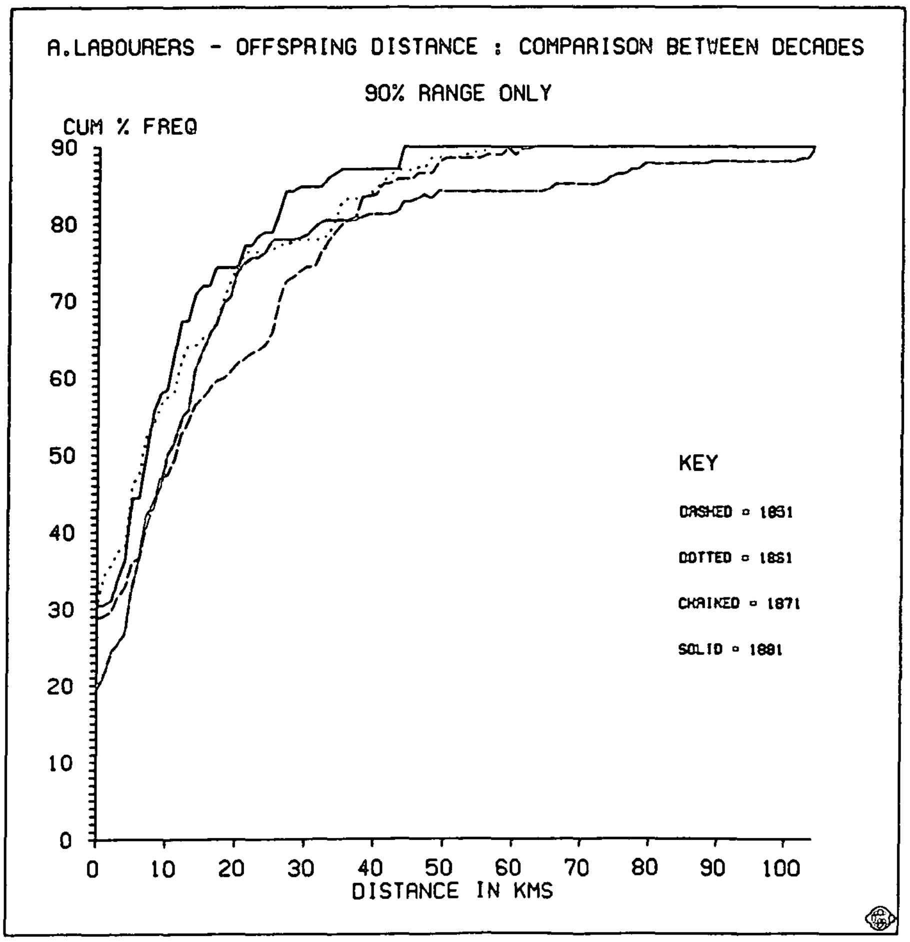
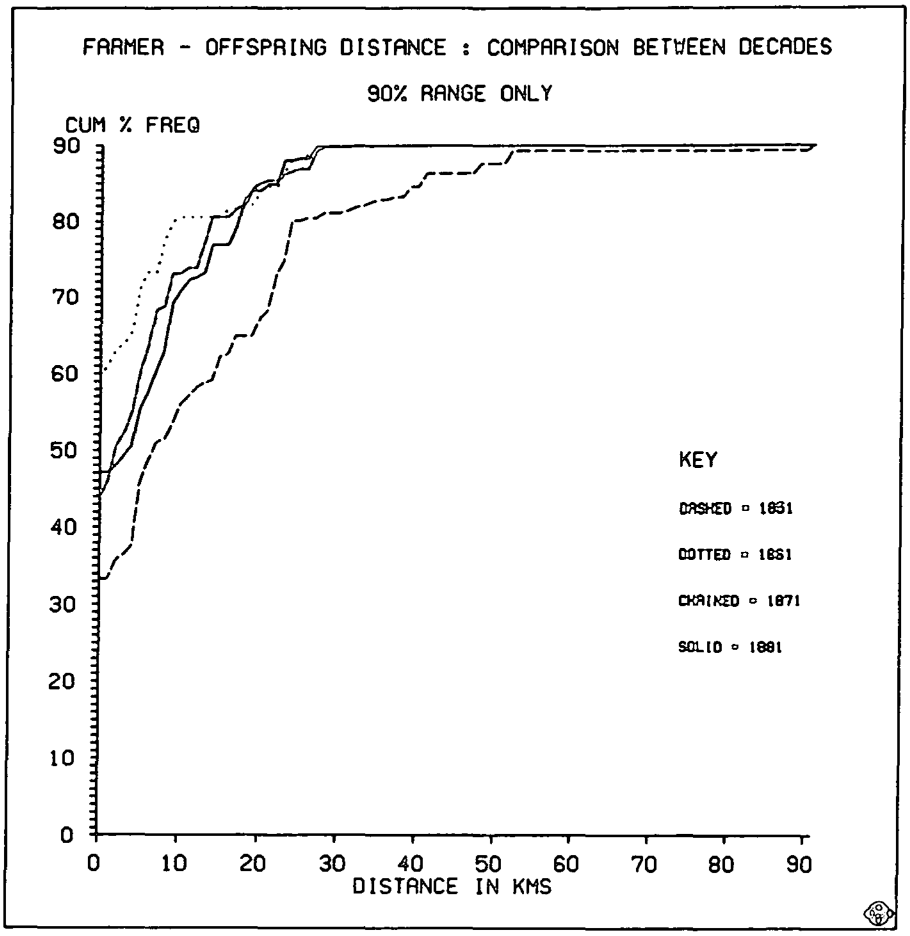


Figure 4.13 (top) and 4.14 (bottom)



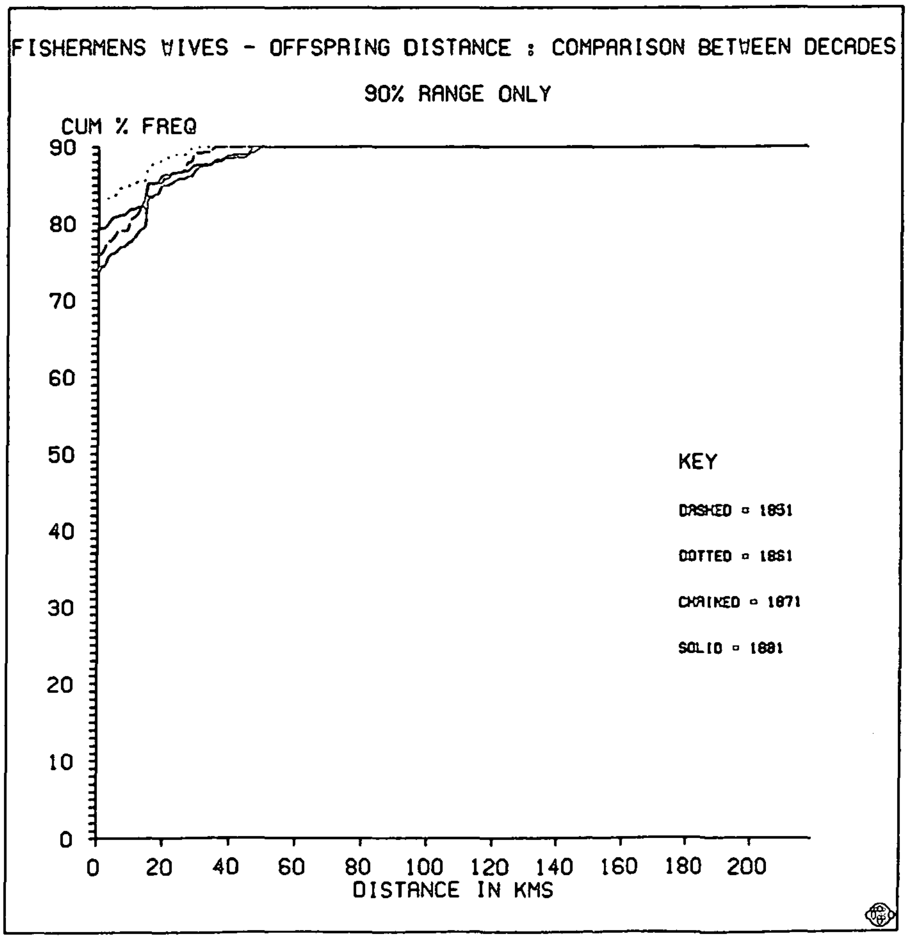
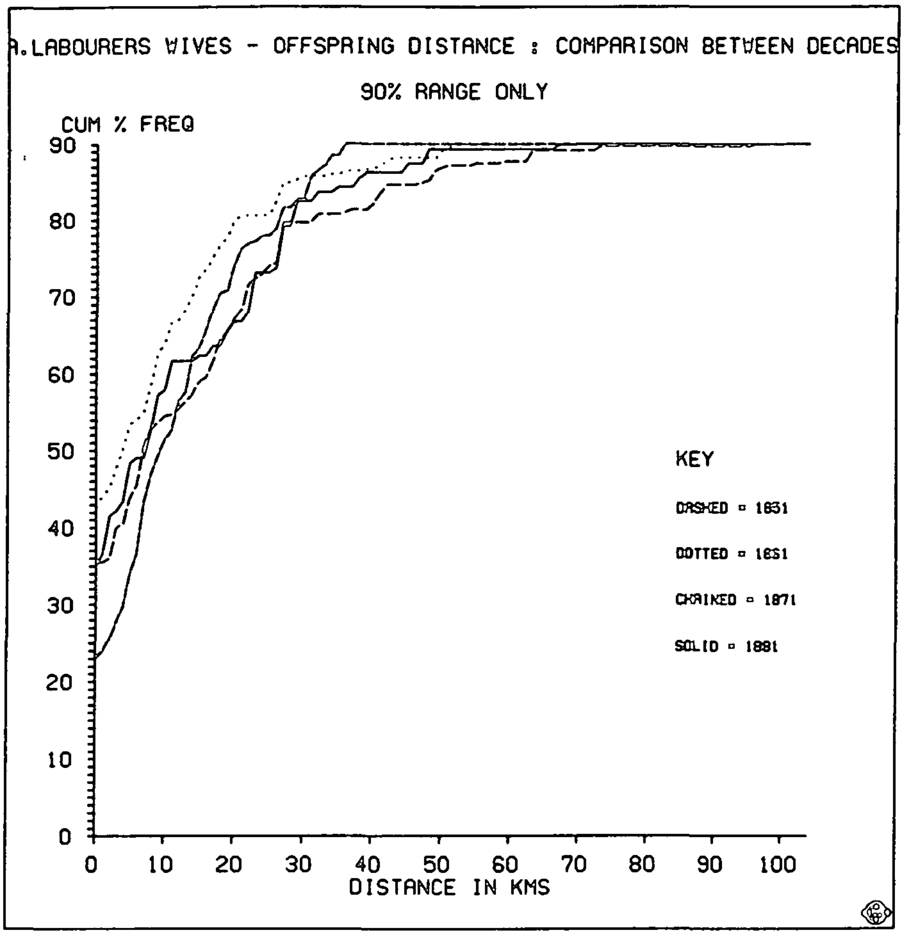


Figure 4.15 (top) and 4.16 (bottom)



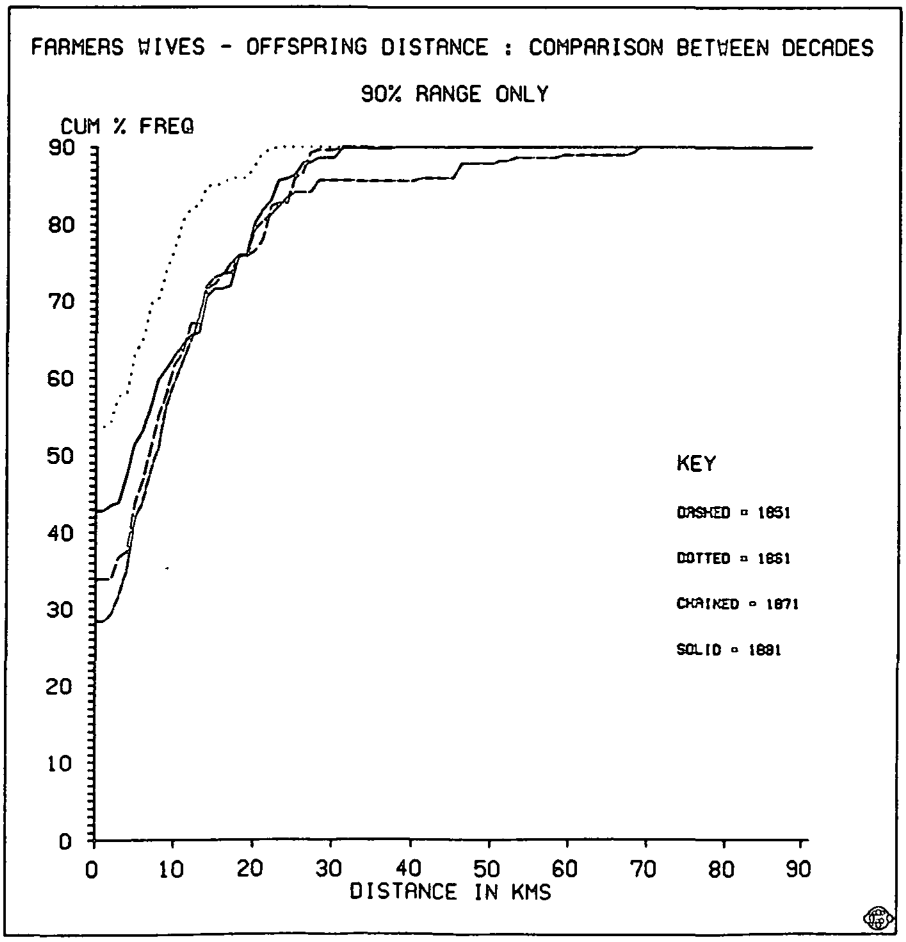


Figure 4.17 (top) and 4.18 (bottom)

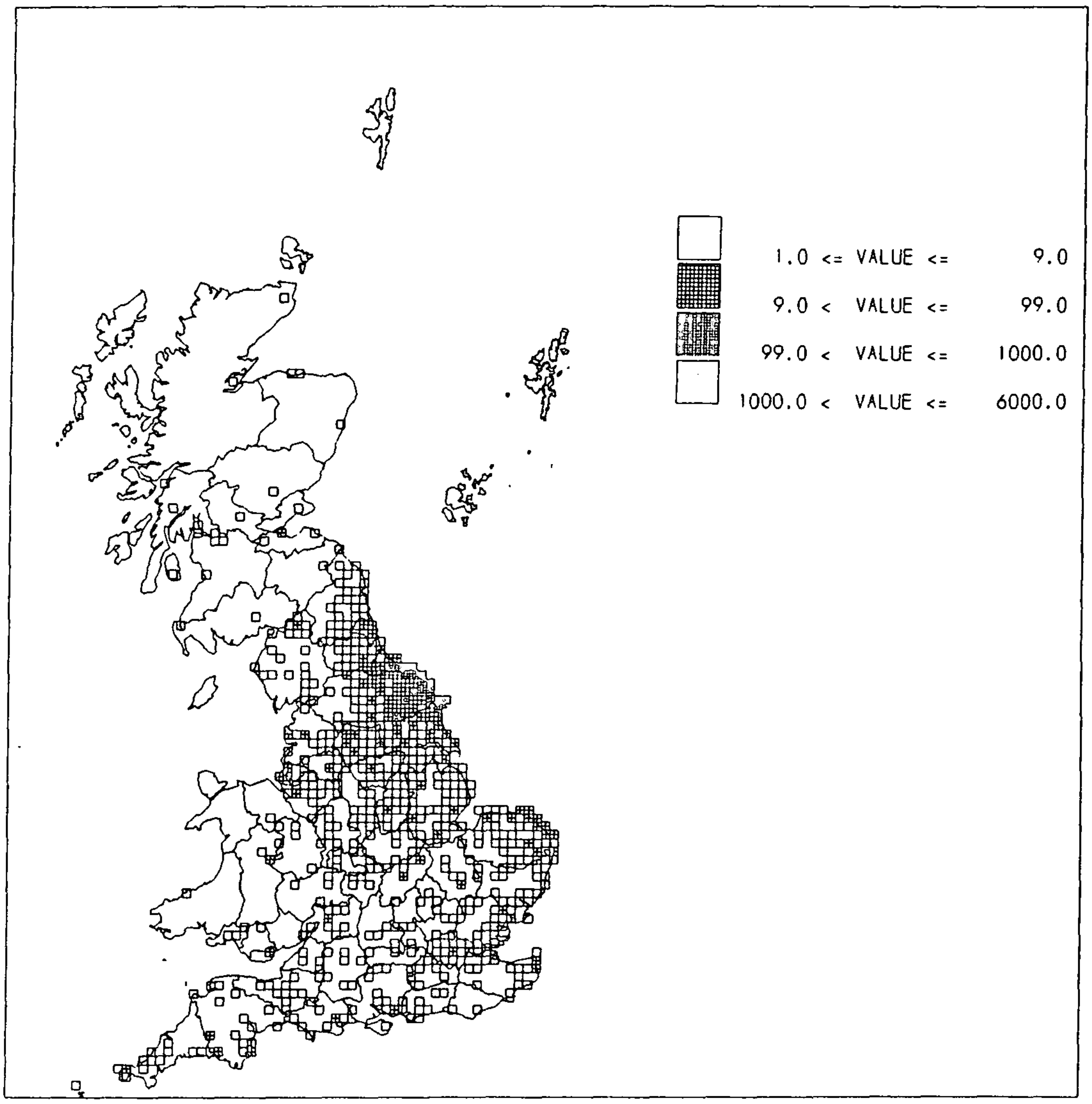


Figure 4.19: The birthplace of each resident in the study area.

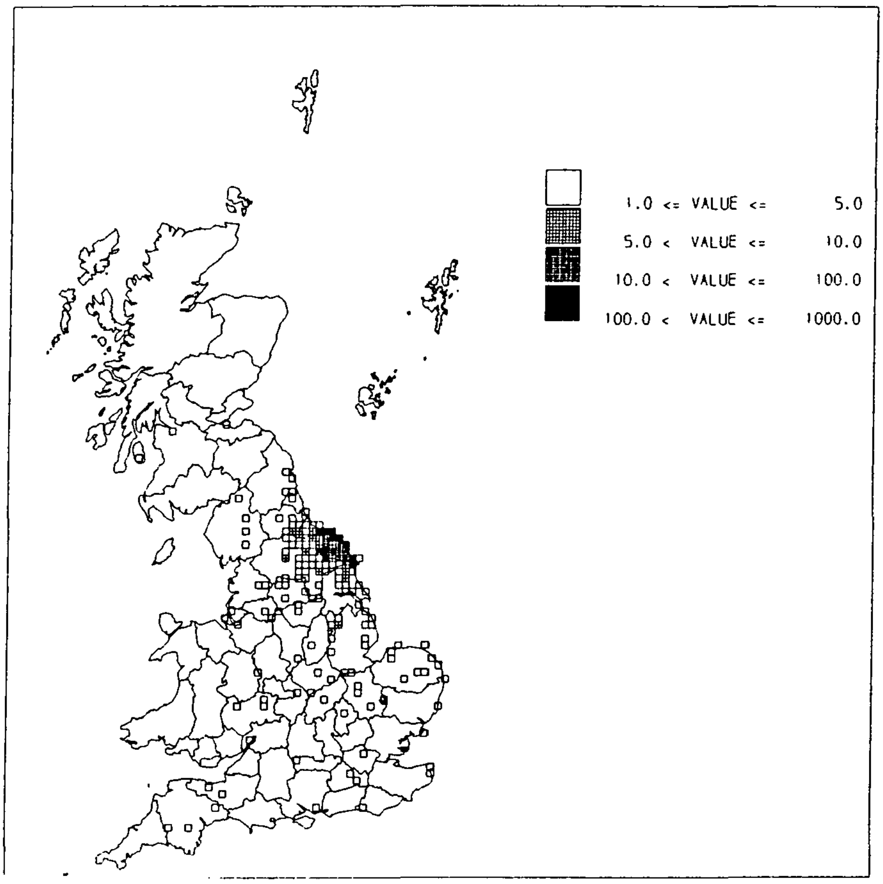


Figure 4.21: Birthplace of each individual employed in farming.

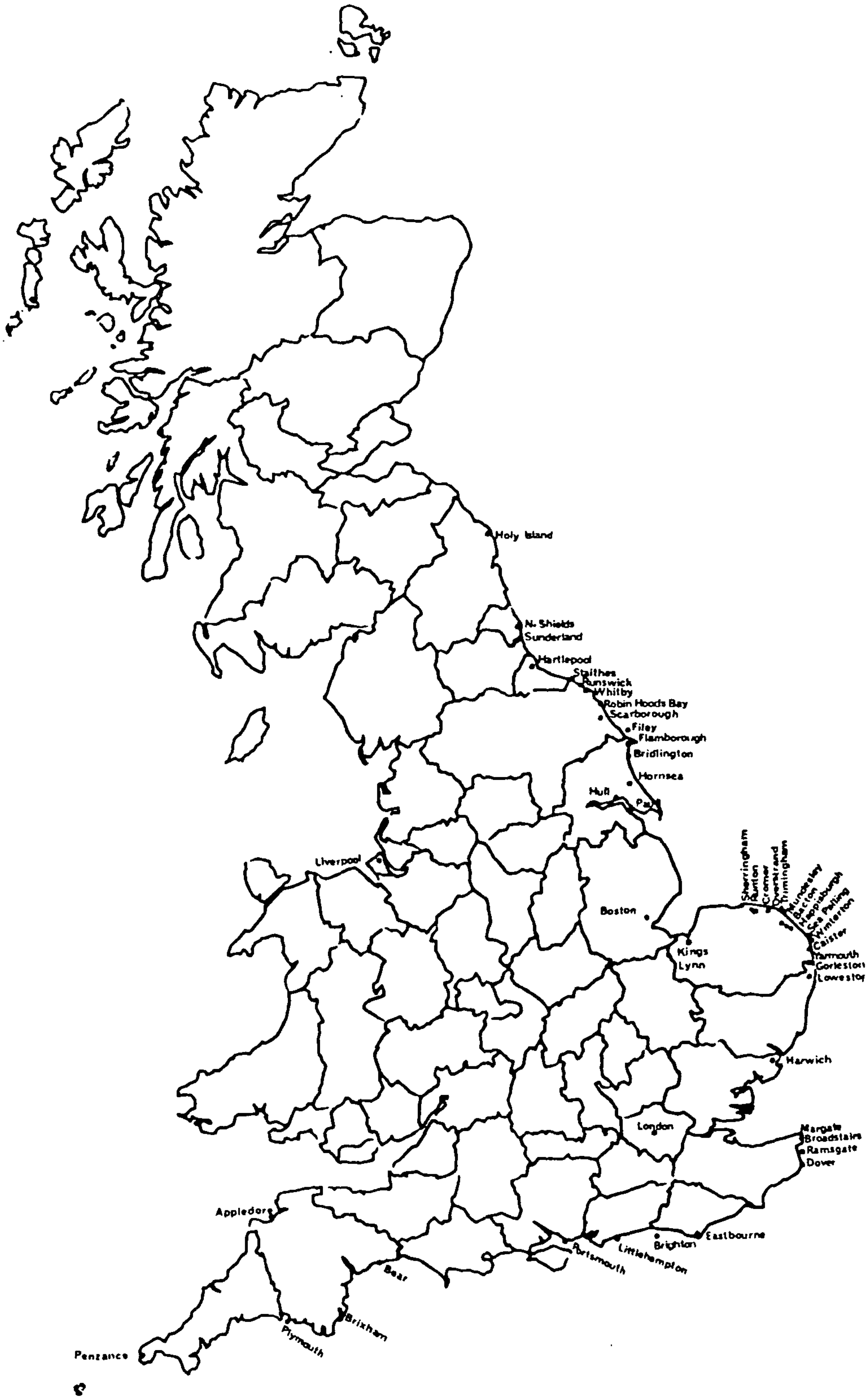


Figure 4.22: The principal fishing ports of England.

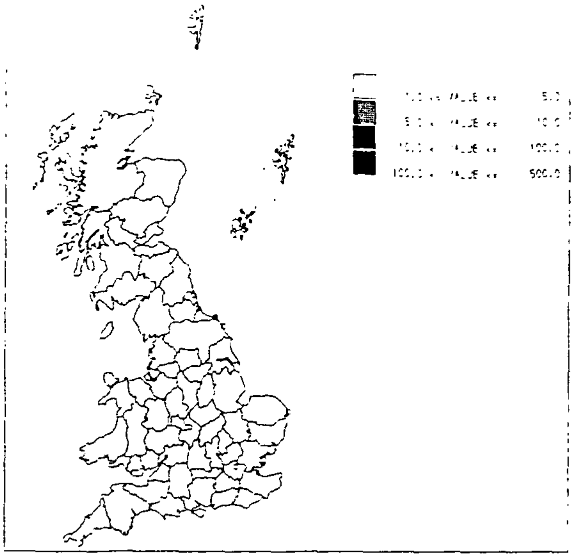


Figure 4.23: Birthplaces of the Staithes fishermen.

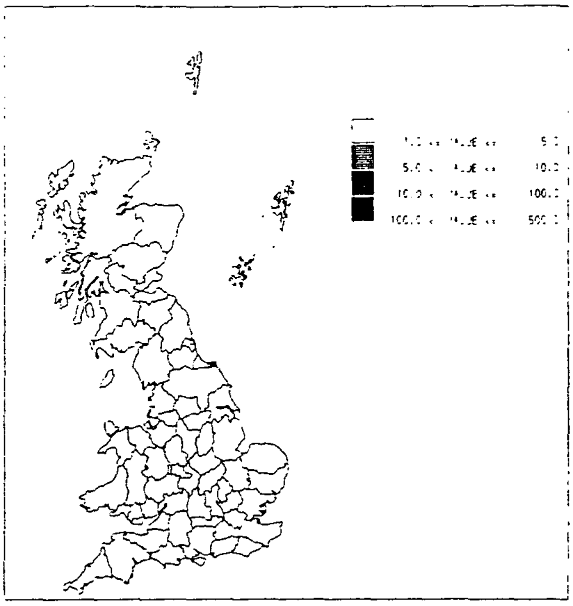


Figure 4.24: Birthplaces of the Runswick fishermen.

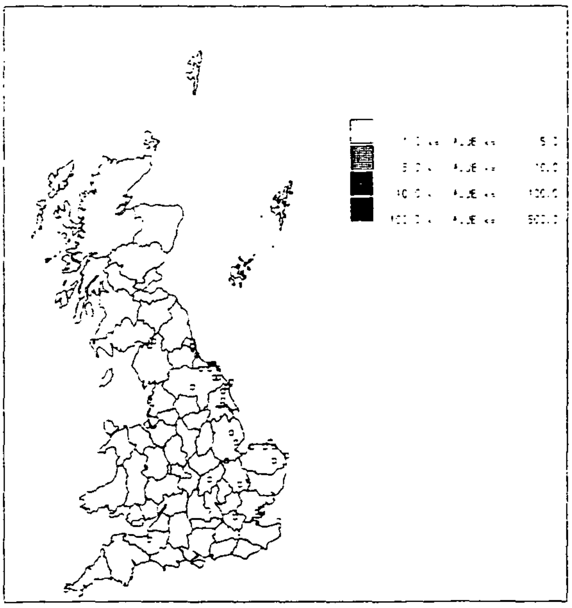


Figure 4.25: Birthplaces of the Whitby fishermen.

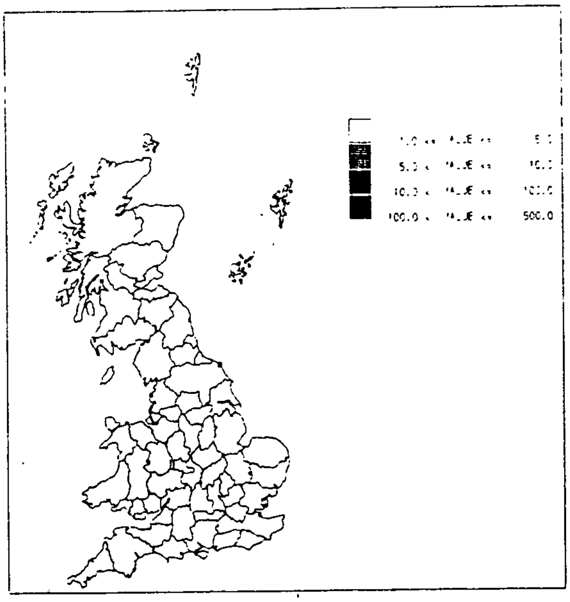


Figure 4.26: Birthplaces of the R.H.B. fishermen.

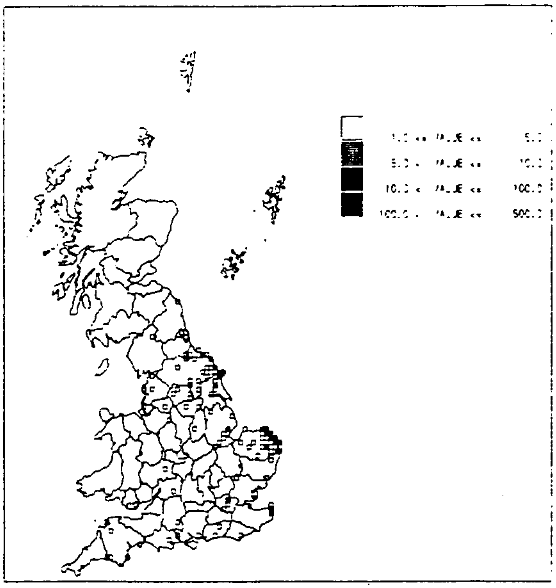


Figure 4.27: Birthplaces of the Scarborough fishermen.

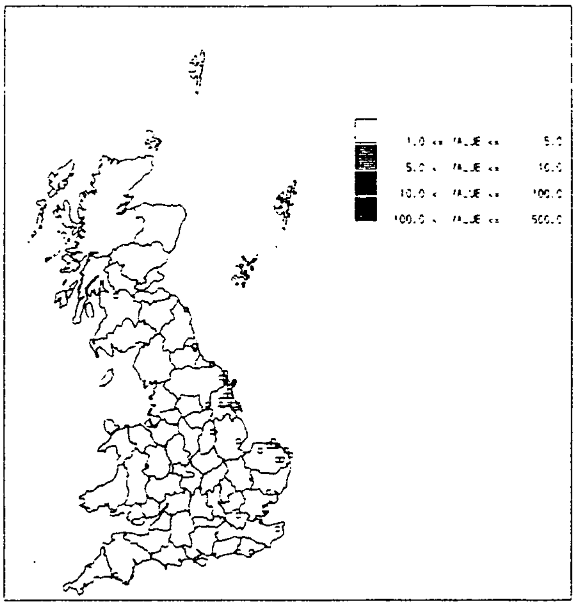


Figure 4.28: Birthplaces of the Filey fishermen.

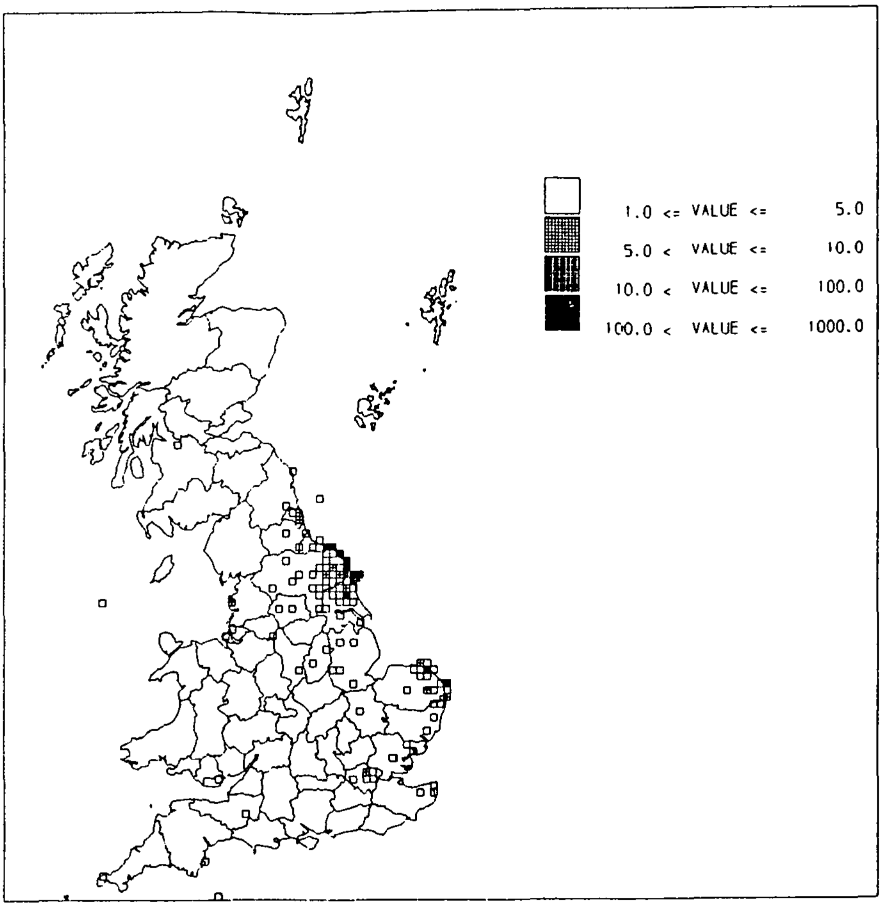


Figure 4.29: Birthplaces of the fishermen's wives.

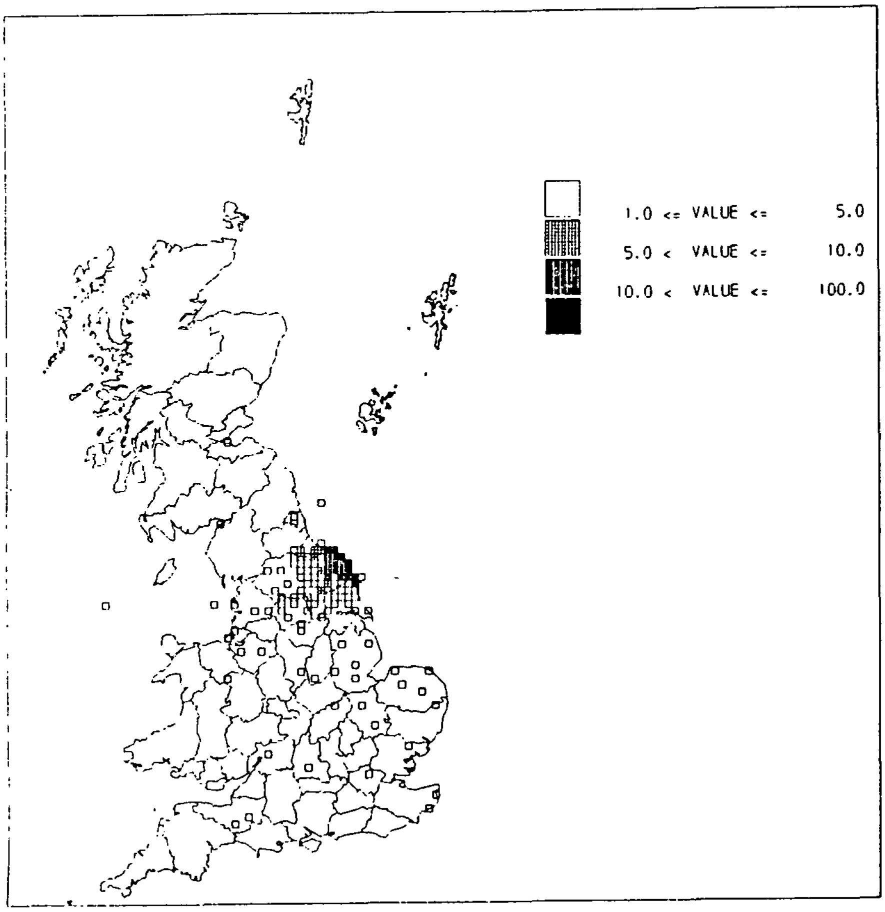


Figure 4.30: Birthplaces of the country wives.

## TABLE 4.1: MIGRANTS TO THE N. YORKSHIRE COAST FROM NORFOLK FISHING VILLAGES

### FROM THE NORFOLK COAST

| | | | | | | |
|---|---|---|---|---|---|---|
| BACTON | 1851.. | to Scarborough; | Thomas Coles | fisherman | 22yrs | Married |
| | 1861.. | to Scarborough; | Charles Coles | fisherman | 32yrs | Married |
| | | to Filey; | Sarah Scotter | other | 36yrs | Single |
| | | to Filey; | John Scotter | - | 16yrs | Single |
| | 1871.. | to Filey; | John Read | fisherman | 26yrs | Married |
| | | to Filey; | Emily Martin | - | 29yrs | Single |
| CAISTOR | 1881.. | to Scarborough; | George Martin | fisherman | 30yrs | Married |
| CROMER | 1851.. | to Scarborough; | Thomas Buck | fisherman | 32yrs | Married |
| | | to Scarborough; | Caroline Buck | - | 5yrs | Single |
| | | to Scarborough; | Matthew Nockels | fisherman | 37yrs | Married |
| | | to Scarborough; | James Harrison | fisherman | 30yrs | Married |
| | 1861.. | to Scarborough; | James Harrison | fisherman | 44yrs | Married |
| | | to Scarborough; | Mathew Nockels | fisherman | 47yrs | Married |
| | | to Scarborough; | Mary Nockles | - | 49yrs | Married |
| | | to Scarborough; | William Nockles | fisherman | 35yrs | Married |
| | 1871.. | to Scarborough; | James Harrison | fisherman | 55yrs | Married |
| | | to Scarborough; | Isaac Ewen | agl. lab. | 29yrs | Married |
| | | to Scarborough; | F. Margarson | scholar | 12yrs | Single |
| | | to Filey; | George Sharp | other | 21yrs | Single |
| | | to Filey; | Eliza Sharp | other | 16yrs | Single |
| | 1881.. | to Scarborough | John Margarson | fisherman | 19yrs | Single |
| | | to Scarborough | F. Margarson | servant | 22yrs | Single |
| | | to Scarborough | Ben Margarson | fisherman | 50yrs | Married |
| | | to Scarborough | James Harrison | fisherman | 64yrs | Married |
| | | to Scarborough | Isaac Allan | fisherman | 35yrs | Married |
| | | to Scarborough | William Nockels | fisherman | 56yrs | Married |
| | | to Scarborough | Sophia Nockels | fisherman's wife | 57yrs | Married |
| | | to Scarborough | John Jarvis | fisherman | 42yrs | Married |
| | | to Scarborough | Lucy Jarvis | fisherman's wife | 39yrs | Married |
| | | to Scarborough | George Jarvis | fisherman | 18yrs | Single |
| | | to Scarborough | James Warner | scholar | 14yrs | Single |
| | | to Scarborough | William Warner | scholar | 14yrs | Single |
| | | to Filey | George Sharp | other | 30yrs | Married |
| GIMINGHAM | 1861.. | to Filey | Mathew Bullimer | fisherman | 33yrs | Married |
| | | to Filey | John Scotter | labourer | 34yrs | Married |
| | | to Filey | Mary Scotter | other | 30yrs | Single |
| | | to Filey | William Scotter | fisherman | 32yrs | Single |
| | | to Filey | James Scotter | - | 12yrs | Single |
| | | to Filey | William Scotter | - | 9yrs | Single |
| | | to Filey | James Scotter | fisherman | 32yrs | Married |
| | 1871.. | to Filey | James Bullemere | fisherman | 44yrs | Married |
| | | to Filey | Louisa Bullemere | fisherman's wife | 44yrs | Married |
| | | to Filey | George Bullemere | fisherman | 15yrs | Single |
| | | to Filey | Jessie Bullemere | scholar | 12yrs | Single |
| | | to Filey | Sarah Scotter | fisherman's wife | 49yrs | Married |
| | | to Filey | James Scotter | fisherman | 21yrs | Single |
| | | to Scarborough | Mathew Bullamore | fisherman | 40yrs | Married |
| | 1881.. | to Whitby | Mathew Bullaman | fisherman | 52yrs | Married |

TABLE 4.1 CONTINUED:

| | | | | | | |
|---|---|---|---|---|---|---|
| GIMINGHAM | 1881.. | to Filey | James Bullemore | fisherman | 54yrs | Married |
| | | to Filey | Louisa Bullemore | fisherman's wife | 54yrs | Married |
| | | to Filey | Charles Bright | labourer | 40yrs | Married |
| | | to Filey | Fanny Wiseman | fisherman's widow | 32yrs | Widow |
| GORLESTON | 1861.. | to Scarborough | Rich Cockerill | fisherman | 22yrs | Married |
| | 1881.. | to Scarborough | Sam Mop | fisherman | 46yrs | Married |
| | | to Staithes | Charles Horne | fisherman | 26yrs | Married |
| HAISBRO' | 1861.. | to Scarborough | Hannah Joes | - | 13yrs | Single |
| | | to Scarborough | George Joes | scholar | 9yrs | Single |
| | | to Scarborough | James Joes | scholar | 5yrs | Single |
| | | to Scarborough | Ellenor Joes | - | 3yrs | Single |
| | 1871.. | to Scarborough | James Ives | scholar | 15yrs | Single |
| | | to Scarborough | Ellen Ives | scholar | 13yrs | Single |
| | | to Filey | Sarah Sharp | scholar | 10yrs | Single |
| | | to Filey | Ed Sharp | scholar | 7yrs | Single |
| | 1881.. | to Filey | Ed Sharpe | other | 18yrs | Single |
| | | to Scarborough | Ellen Reeve | - | 23yrs | Single |
| | | to Scarborough | Han. Stamforth | fisherman's wife | 32yrs | Married |
| | | to Scarborough | James Ives | fisherman | 25yrs | Single |
| | | to Scarborough | George Naves | fisherman | 46yrs | Married |
| | | to Scarborough | Robert Allen | fisherman | 54yrs | Married |
| HEMSBY | 1851.. | to Staithes | Jane Forward | - | 33yrs | Married |
| | 1871.. | to Filey | Theresa Fowley | scholar | 13yrs | Single |
| HUNSTANTON | 1881.. | to Filey | Harry Records | scholar | 8yrs | Single |
| MUNDESLEY | 1861.. | to Scarborough | John Scotter | fisherman | 29yrs | Married |
| | 1881.. | to Scarborough | John Scotter | fisherman | 39yrs | Married |
| NORTHREPPS | 1871.. | to Scarborough | Will Nockles | fisherman | 45yrs | Married |
| ORMESBY | 1871.. | to Scarborough | Frances Knights | - | 35yrs | Married |
| | 1881.. | to Scarborough | Margaret Pye | fisherman's wife | 36yrs | Married |
| | | to Scarborough | William Pye | scholar | 14yrs | Single |
| | | to Scarborough | Joseph Pye | scholar | 7yrs | Single |
| | | to Scarborough | Richard Watson | fisherman | 26yrs | Married |
| | | to Scarborough | Sam Crisp | fisherman | 41yrs | Married |
| | | to Scarborough | Ben Knight | fisherman | 42yrs | Married |
| | | to Scarborough | Eliz. Garbell | fisherman's wife | 65yrs | Married |
| | | to Scarborough | James Stodhard | fisherman | 49yrs | Married |
| | | to Scarborough | George Cassey | scholar | 12yrs | Single |
| | | to Scarborough | Anna Cassey | scholar | 10yrs | Single |
| RINGSTEAD | 1861.. | to Scarborough | Mathew Langley | fisherman | 33yrs | Married |
| ROLLESBY | 1871.. | to Scarborough | George Hunt | fisherman | 30yrs | Married |
| RUNTON | 1861.. | to Scarborough | John Pull | fisherman | 32yrs | Married |
| | | to Scarborough | Mary Pull | - | 23yrs | Married |

TABLE 4.1 CONTINUED:

| | | | | | | |
|---|---|---|---|---|---|---|
| RUNTON | 1871.. | to Filey | George Scotter | fisherman | 26yrs | Married |
| | 1881.. | to Filey | William Henry | fisherman | 32yrs | Married |
| | | to Filey | Martin Scotter | fisherman | 26yrs | Married |
| | | to Whitby | James Able | fisherman | 57yrs | Widow |
| | | to Scarborough | Rachel Baines | fisherman's wife | 33yrs | Married |
| SCRATBY | 1871.. | to Filey | Ed Powley | scholar | 9yrs | Single |
| | 1881.. | to Filey | Ed Powley | fisherman | 19yrs | Single |
| | | to Filey | Alfred Powley | fisherman | 33yrs | Married |
| SEA PALLING | 1851.. | to Filey | Jacob Martin | fisherman | 28yrs | Married |
| | | to Filey | Robert Wiseman | fisherman | 20yrs | Married |
| | | to Fylingdales | Cath Newton | - | 18yrs | Married |
| | 1861.. | to Scarborough | William Feather | fisherman | 29yrs | Married |
| | | to Scarborough | Henry Georges | fisherman | 33yrs | Married |
| | 1871.. | to Scarborough | William Baker | fisherman | 31yrs | Married |
| | | to Scarborough | William Feather | fisherman | 39yrs | Married |
| | | to Scarborough | James Brown | fisherman | 44yrs | Married |
| | | to Filey | Robert Wiseman | other | 48yrs | Married |
| | | to Filey | Henry Martin | fisherman | 37yrs | Married |
| | | to Filey | Walter Martin | scholar | 11yrs | Single |
| | | to Filey | Sarah Martin | scholar | 9yrs | Single |
| | 1881.. | to Scarborough | William Feather | fisherman | 49yrs | Married |
| SHERINGHAM | 1851.. | to Whitby | Eliz. Anthony | - | 49yrs | Married |
| | 1861.. | to Scarborough | William Bishop | fisherman | 37yrs | Married |
| | | to Scarborough | Jessie Bishop | scholar | 11yrs | Single |
| | 1871.. | to Scarborough | Robert Pegg | fisherman | 37yrs | Married |
| | | to Scarborough | Mary Pegg | - | 31yrs | Married |
| | | to Scarborough | John Pegg | scholar | 11yrs | Single |
| | | to Scarborough | Richard Pegg | fisherman | 25yrs | Married |
| | | to Scarborough | Henry Woodhouse | fisherman | 24yrs | Married |
| | | to Scarborough | Harry Pipe | fisherman | 24yrs | Married |
| | | to Scarborough | William Bullamon | fisherman | 36yrs | Married |
| | | to Scarborough | Henry Burton | fisherman | 23yrs | Married |
| | | to Scarborough | William Pardon | fisherman | 28yrs | Married |
| | | to Scarborough | George Harman | fisherman | 28yrs | Married |
| | | to Scarborough | Charlotte Croston | - | 24yrs | Married |
| | 1881.. | to Scarborough | Richard Pegg | fisherman | 34yrs | Married |
| | | to Scarborough | William Long | fisherman | 55yrs | Married |
| | | to Scarborough | Henry Burton | fisherman | 33yrs | Married |
| | | to Scarborough | Daniel Luke | fisherman | 40yrs | Married |
| | | to Filey | James Scotter | fisherman | 30yrs | Married |
| SIDESTRAND | 1871.. | to Scarborough | George Clark | fisherman | 33yrs | Married |
| SOMERTON | 1871.. | to Scarborough | Richard Plane | fisherman | 39yrs | Married |
| SOUTHREPPS | 1881.. | to Scarborough | Steven Howitt | fisherman | 31yrs | Married |
| | | to Scarborough | George Blogg | fisherman | 42yrs | Married |
| | | to Scarborough | Robert Gray | fisherman | 36yrs | Married |

TABLE 4.1 CONTINUED:

| | | | | | | |
|---|---|---|---|---|---|---|
| TRIMINGHAM | 1861.. | to Scarborough | John Bullimer | fisherman | 22yrs | Married |
| | 1871.. | to Scarborough | Caroline Reynolds | - | 22yrs | Married |
| | | to Scarborough | John Bullamore | fisherman | 32yrs | Married |
| | | to Scarborough | William Jarvis | fisherman | 26yrs | Married |
| | | to Scarborough | Mathew Bullamon | fisherman | 42yrs | Married |
| | | to Scarborough | Jos Pardon | fisherman | 25yrs | Married |
| | | to Scarborough | Harriet Pardon | - | 22yrs | Married |
| | | to Scarborough | Phoebe Sellars | - | 24yrs | Married |
| | 1881.. | to Scarborough | John Bullamore | fisherman | 42yrs | Married |
| | | to Scarborough | William Cabitt | fisherman | 33yrs | Married |
| | | to Scarborough | Mary Cabitt | fisherman's wife | 26yrs | Married |
| | | to Scarborough | Francis Alard | fisherman | 23yrs | Single |
| | | to Scarborough | George Pardon | fisherman | 36yrs | Married |
| | | to Scarborough | Phoebe Sellars | wife | 33yrs | Married |
| | | to Scarborough | Caroline Reynolds | - | 32yrs | Married |
| | | to Scarborough | Charlotte Owston | - | 34yrs | Married |
| TRUNCH | 1871.. | to Filey | Eliz. England | other | 32yrs | Married |
| | | to Filey | Jacob Winship | fisherman | 36yrs | Married |
| | 1881.. | to Filey | Sarah Winship | fisherman's wife | 48yrs | Married |
| WALCOTT | 1861.. | to Scarborough | Mary Brown | fisherman's wife | 25yrs | Married |
| | 1871.. | to Scarborough | Mary Brown | fisherman's wife | 34yrs | Married |
| WELLS | 1881.. | to Filey | William Records | scholar | 11yrs | Single |
| | | to Filey | Elen Records | scholar | 10yrs | Single |
| WINTERTON | 1861.. | to Scarborough | James Brown | fisherman | 35yrs | Married |
| | 1871.. | to Filey | Martha Gedge | other | 39yrs | Married |
| YARMOUTH | 1851.. | to Filey | Susan Hebden | - | 41yrs | Married |
| | | to Filey | Charles Borrett | scholar | 8yrs | Single |
| | | to Filey | George Borrett | scholar | 12yrs | Single |
| | | to Filey | Steven Borrett | scholar | 10yrs | Single |
| | | to Filey | Charlotte Crawford | - | 36yrs | Married |
| | | to Filey | Steven Todd | other | 46yrs | Married |
| | | to Whitby | George Palmer | sailor | 21yrs | Single |
| | | to Scarborough | Sarah Appleby | - | 27yrs | Married |
| | 1861.. | to Scarborough | William Larm | fisherman | 18yrs | Single |
| | | to Scarborough | Sarah Larm | scholar | 14yrs | Single |
| | | to Scarborough | James Palmer | fisherman | 22yrs | Single |
| | | to Scarborough | John Zules? | fisherman | 27yrs | Married |
| | | to Scarborough | Charles Jenkinson | fisherman | 36yrs | Married |
| | | to Scarborough | George Thirkettle | fisherman | 33yrs | Married |
| | | to Scarborough | Eliz. Miller | fisherman's wife | 40yrs | Married |
| | | to Scarborough | Susan Warford | wife | 34yrs | Married |
| | | to Scarborough | Matilda Race | - | 20yrs | Married |
| | | to Scarborough | Eliz. Banks | - | 29yrs | Married |
| | | to Scarborough | Sarah Appleby | - | 37yrs | Married |
| | | to Filey | John Winns | - | 5yrs | Single |
| | | to Filey | Maryann Winns | - | 13yrs | Single |
| | | to Filey | Sam Gaye | fisherman | 67yrs | Married |
| | | to Filey | George Bonnett | labourer | 22yrs | Married |
| | 1871.. | to Filey | John Newby | fisherman | 21yrs | Married |
| | | to Filey | Sam Gedge | labourer | 44yrs | Married |

TABLE 4.1 CONTINUED:

| | | | | | | |
|---|---|---|---|---|---|---|
| YARMOUTH | 1871.. | to Filey | George Gedge | other | 40yrs | Married |
| | | to Whitby | Samuel Lacey | fisherman | 47yrs | Married |
| | | to Scarborough | Ann Jenkinson | - | 45yrs | Married |
| | | to Scarborough | Eliz. Banks | - | 38yrs | Married |
| | | to Scarborough | Ed Liffen | fisherman | 43yrs | Married |
| | | to Scarborough | Sophia Liffen | - | 30yrs | Married |
| | | to Scarborough | Esther Liffen | scholar | 6yrs | Single |
| | | to Scarborough | Rosaline Liffen | scholar | 8yrs | Single |
| | | to Scarborough | Edwin Liffen | - | 15yrs | Single |
| | | to Scarborough | Georgiana Gorble | - | 13yrs | Single |
| | | to Scarborough | Ed Westgate | fisherman | 43yrs | Single |
| | | to Scarborough | William Larm | fisherman | 27yrs | Married |
| | | to Scarborough | Sarah Appleby | - | 47yrs | Married |
| | | to Scarborough | Joseph Green | fisherman | 24yrs | Married |
| | | to Scarborough | Thomas Cole | fisherman | 47yrs | Married |
| | | to Scarborough | John King | fisherman | 54yrs | Married |
| | | to Scarborough | Eliz. King | - | 50yrs | Married |
| | | to Scarborough | Maria King | - | 24yrs | Single |
| | | to Scarborough | William Cooper | fisherman | 49yrs | Married |
| | | to Scarborough | Sarah Cooper | - | 52yrs | Married |
| | | to Scarborough | Mathew Howbett | fisherman | 27yrs | Married |
| | | to Scarborough | Walter Lurrell | fisherman | 38yrs | Married |
| | | to Scarborough | Richard Cockerill | fisherman | 30yrs | Married |
| | | to Scarborough | Eliz. Adams | - | 52yrs | Married |
| | 1881.. | to Hinderwell | William Gowan | miner | 22yrs | Single |
| | | to Hinderwell | William Gowan | miner | 49yrs | Married |
| | | to Whitby | Jos Wormald | fisherman | 40yrs | Married |
| | | to Filey | George Gedge | fish buis. | 50yrs | Married |
| | | to Filey | Martha Gedge | fish buis. | 44yrs | Married |
| | | to Filey | James Newby | fisherman | 28yrs | Married |
| | | to Filey | George Day | labourer | 32yrs | Married |
| | | to Scarborough | Eliz. Banks | - | 49yrs | Married |
| | | to Scarborough | Joseph Watson | fisherman | 24yrs | Married |
| | | to Scarborough | William Cooper | fisherman | 59yrs | Married |
| | | to Scarborough | Sarah Cooper | - | 62yrs | Married |
| | | to Scarborough | Alfred Brightiner | fisherman | 36yrs | Married |
| | | to Scarborough | Fred Laws | fisherman | 40yrs | Married |
| | | to Scarborough | Anthony Godfrey | fisherman | 28yrs | Married |
| | | to Scarborough | John Pointer | fisherman | 29yrs | Married |
| | | to Scarborough | John Crisp | fisherman | 41yrs | Married |
| | | to Scarborough | Sarah Crisp | - | 35yrs | Married |
| | | to Scarborough | Sam Crisp | fisherman | 17yrs | Single |
| | | to Scarborough | Sarah Appleby | fisherman's wife | 57yrs | Married |
| | | to Scarborough | Georgiana Gown | fisherman's wife | 23yrs | Married |
| | | to Scarborough | Henry Thomas | fisherman | 32yrs | Married |
| | | to Scarborough | Richard Cockerill | fisherman | 42yrs | Married |
| | | to Scarborough | Henry Burgess | fisherman | 50yrs | Married |
| | | to Scarborough | Ed Rowland | fisherman | 36yrs | Married |
| | | to Scarborough | Eliz. Adams | fisherman's wife | 62yrs | Married |

EXTRACTED FROM THE 1851-1881 CENSUSES OF NORTH YORKSHIRE.

# Chapter 5

# The Isonymy Analysis

The methods used in this analysis were relatively straightforward and are given in chapter 3. The year 1851 was taken as a starting point for the analysis and this yielded a sample of 6,371 individuals. Throughout this analysis I have fastidiously examined each pair-wise relationship between each sub-group. While this undoubtedly helps to seek out any trends within the data which are not immediately obvious to the observer, it must also be bo~~u~~rne in mind that the method of isonymy itself suffers from a number of serious assumptions, like ~~mono~~phyleticism (see chapter 1), and as such it should not be used as an absolute measure of kinship but as a more general indicator of the overall pattern of relationships. Values of isonymy calculated within sub-groups have been assessed with caution since Smith and Hudson (1984) have shown that small sample sizes (below 200 individuals) can severely distort the values of Ri obtained (see chapter 1).

## A. Ri within and between 'subdivisions ' for the year 1851

### 1. Parish.

Administratively, the area divides into five parishes. Sample sizes are given in table 5.1.

TABLE 5.1 SAMPLE SIZES FOR EACH PARISH BY CENSUS YEAR

| | H | W | FYL | SC | FIL |
|---|---|---|---|---|---|
| 5 | 1736 | 506 | 1751 | 878 | 1500 |
| 6 | 2564 | 468 | 1722 | 1256 | 1863 |
| 7 | 2601 | 472 | 1558 | 1562 | 2235 |
| 8 | 2472 | 549 | 1442 | 1840 | 2316 |

All are well over two hundred and the within parish coefficients should therefore be uninfluenced by sample size (see Smith and Hudson 1984). Table 5.2 gives the values of Ri.

Without exception the within parish values of isonymy are at least three times

TABLE 5.2

COEFFICIENTS OF RELATIONSHIP (Ri) WITHIN & BETWEEN PARISHES FOR 1851

| | H | W | FYL | SC | FIL |
|---|---|---|---|---|---|
| H | .0058 | | | | |
| W | .0012 | .0058 | | | |
| FYL | .0013 | .0011 | .0062 | | |
| SC | .0009 | .0005 | .0007 | .0039 | |
| FIL | .0008 | .0005 | .0009 | .0013 | .0062 |

greater than those between parishes. The mean within parish coefficient of relationship is .0056 (S.D. .0009). Scarborough is notably less inter-related than the other towns (Ri = .0039). Between parish coefficients suggest that the five parishes fall into two more closely related groups. On the one hand, Hinderwell, Whitby and Fylingdales, (mean Ri between these three parishes is .0012), and on the other, Filey and Scarborough (between which Ri = .0013), as compared to the mean value of Ri of .0007 (S.D. = .0002) between the first group (composed of Hinderwell, Whitby and Fylingdales) and the second group (comprised of Scarborough and Filey). Two of the parishes, Hinderwell and Fylingdales, are comprised of several villages and hamlets which were historically self-contained. Isonymy was therefore re-calculated between each village and town within the parish boundaries of the study area.

## 2. Town

Sample sizes for each town in 1851 are given in table 5.3; all are above two hundred people.

TABLE 5.3 SAMPLE SIZES FOR EACH TOWN IN EACH CENSUS YEAR

| | H | ST | RUN | PM | W | RHB | FYL | SC | FIL |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 275 | 1126 | 335 | | 506 | 867 | 884 | 878 | 1500 |
| 6 | 593 | 1325 | 430 | 216 | 468 | 900 | 822 | 1256 | 1863 |
| 7 | 645 | 1307 | 369 | 280 | 472 | 732 | 826 | 1562 | 2235 |
| 8 | 497 | 1330 | 285 | 360 | 549 | 707 | 735 | 1840 | 2316 |

Fylingdales was divided into two large groups, Robin Hood's Bay and Fylingdales, since many of the lesser hamlets were closely inter-related and yielded small sample sizes (Smith and Hudson 1984). Table 5.4 gives the coefficients of relationship within and between the towns.

TABLE 5.4 COEFFICIENTS OF RELATIONSHIP

(Ri) WITHIN & BETWEEN VILLAGES FOR 1851

| | H | ST | RUN | W | RHB | FYL | SC | FIL |
|---|---|---|---|---|---|---|---|---|
| H | .0128 | | | | | | | |
| ST | .0016 | .0092 | | | | | | |
| RUN | .0010 | .0008 | .0263 | | | | | |
| W | .0015 | .0012 | .0007 | .0058 | | | | |
| RHB | .0013 | .0014 | .0008 | .0010 | .0125 | | | |
| FYL | .0017 | .0014 | .0009 | .0013 | .0026 | .0073 | | |
| SC | .0012 | .0008 | .0010 | .0005 | .0007 | .0007 | .0039 | |
| FIL | .0007 | .0009 | .0004 | .0005 | .0009 | .0009 | .0013 | .0062 |

For those cases where the town and parish were coextensive (Scarborough, Whitby and Filey) the values of Ri were obviously identical to those given in table 5.2 above. For the remaining villages (Staithes, Runswick, Hinderwell, Fylingdales and Robin Hood's Bay) the coefficients of relationship are appreciably higher than the within parish values, confirming the fact that these villages are indeed separate individual entities within their parish boundaries. Runswick is particularly interrelated (Ri = .0263), and surprisingly, shows remarkable independence from both the neighbouring villages, exhibiting closest ties with Scarborough (Ri = .0010). Staithes and Hinderwell are similarly independent of each other, sharing no closer ties than they do to Whitby, Robin Hood's Bay and Fylingdales.

This is understandable in view of the historical insularity of the fishing villages from each other and from the rural population (see chapter 2). Robin Hood's Bay as a fishing village, is also very close-knit, but it is more closely related to rural Fylingdales than the villages within Hinderwell parish are. It would appear that the social history of the area has indeed influenced the pattern of biological relationship between these settlements.

## 3. Occupation

The entire geographical area was divided into eight occupational categories:

TABLE 5.5 SAMPLE SIZES OF OCCUPATIONAL GROUPS IN 1851

| | |
|---|---|
| AGL | 357 |
| CTG | 22 |
| FB | 42 |
| FIS | 603 |
| FMR | 173 |
| MR | 52 |
| OTH | 581 |
| SN | 241 |

sample size varied from 22 to 603 (table 5.5).

Values of Ri are given in table 5.6.

TABLE 5.6 ISONYMY WITHIN & BETWEEN OCCUPATIONS IN 1851.

| | 5AGL | 5CTG | 5FB | 5FIS | 5FMR | 5MR | 5OTH | 5SN |
|---|---|---|---|---|---|---|---|---|
| 5 AGL | .0028 | | | | | | | |
| 5 CTG | .0007 | .0248 | | | | | | |
| 5 FB | .0020 | .0016 | .0192 | | | | | |
| 5 FIS | .0008 | .0006 | .0033 | .0066 | | | | |
| 5 FMR | .0015 | .0016 | .0015 | .0010 | .0062 | | | |
| 5 MR | .0017 | .0017 | .0018 | .0014 | .0018 | .0244 | | |
| 5 OTH | .0012 | .0011 | .0019 | .0014 | .0016 | .0017 | .0027 | |
| 5 SN | .0007 | .0005 | .0019 | .0026 | .0011 | .0011 | .0018 | .0078 |

The three highest within-group coefficients correspond to those sample sizes well below two hundred and cannot therefore be taken as true estimates of relationship. Otherwise values of Ri amongst the 'fishermen', 'farmers' and 'seamen' respectively, are high compared to the 'others' and 'agricultural labourers'. Within-group coefficients are also higher than between-group coefficients. Overall this suggests some hierarchical subdivision, the sea faring categories being particularly insular.

The relationship between the fishermen and 'fish business' is particularly close (Ri = .0033), in fact greater than the relationship within the argicultural labourers and within the 'others'. Since many of the fish net makers, hook makers, and fish servants, all included in the 'fish business' category, were frequently fishermen's wives and offspring, this is understandable. The fishermen are also 'close' to the seamen (Ri = .0026). Coefficients of relationship between the fishermen and other occupations are lower, particularly with the agricultural labourers (Ri = .0008) and also with the coast guards. The seamen are more distantly related to all the remaining occupations than they are to the 'fish business' and 'others' categories; they are particularly distant from the agricultural labourers and coast guards. This suggests a partial clustering and detachment of the two principle maritime sectors, fishermen and seamen, from the wider community – particularly the rural population. The high within-group coefficients for both reaffirms their insularity and independence.

The 'fish business' group, despite their strong affiliation to the fishermen (and to a much lesser extent, the seamen), are in fact also reasonably close to all sectors (notably the agricultural labourers). This is attributable to the fact that it is a miscellaneous category, comprised of a number of different occupations, especially the more urban retailing job of fishmonger.

The coast guards, as a part of the Royal Navy, are a more transient, unsettled group, originating from all over England. They are, however, inter-related to the Yorkshire population (mean Ri=.0011), particularly to the miners, farmers, and 'fishbusiness'.

The agricultural labourers are related to all the land based occupations, although they are not very close to the farmers despite the occupational overlap. Differences in economic status and/or mobility may account for this. The coefficients of relationship between the remaining occupational categories do not show any specific trends: The miners, 'others' and farmers are all related to the rest of the population.

Thus there is an apparent socio-economic subdivision of the population – particularly between the land and sea based professions. Since this and geographical factors have an effect on the population structure, Ri was estimated between each occupation for each town.

## 4. Occupation by Town

Sample sizes for each town's occupational groups in 1851 are given in table 5.7. Since subdivision rendered notably small samples, many below twenty, only the major occupational categories of agricultural labourers, farmers, fishermen, and

TABLE 5.7 SAMPLE SIZES OF
THE MAJOR OCCUPATIONAL GROUPS IN EACH TOWN IN 1851

| | H | ST | RUN | W | RHB | FYL | SC | FIL |
|---|---|---|---|---|---|---|---|---|
| AGL | 33 | 17 | - | 101 | - | 67 | 102 | 32 |
| FMR | 18 | - | - | 22 | - | 80 | 32 | 8 |
| OTH | 39 | 121 | 16 | - | 82 | 81 | - | 204 |
| FIS | - | 142 | 52 | 29 | 44 | - | 165 | 170 |

'others' were considered. Even the coastal towns have no agricultural employees and the rural towns no fishermen. The category 'others' is excluded for Scarborough and Whitby since theirs was a selected sample consisting only of fishermens' and agriculturalists' (including farmers') offspring. Values of Ri are given in table 5.8.

Of the samples used, the majority were well below two hundred and the within-group coefficients are therefore greatly distorted. The mean between-group coefficient of relationship is .0014 with a large standard deviation of .0018. The pattern of relationships is depicted in figures 5.1 and 5.2.

The former is a three-dimensional representation of the relationships between groups, computed from a multi-dimensional scaling package (Coxon *et al.* 1986). Essentially the spatial distances between the points correspond to the relative genetic distance between them (and *vice versa*). The degree of stress (.1827), which is quite high here compared to the stress based on random data (.2385), indicates the degree to which the data has had to be distorted in order to represent it graphically. Due to the high stress value a two-dimensional solution was thought to be too inaccurate to use in comparison to the three-dimensional solution. The cluster analysis (Wishart 1978) in figure 5.2, on the other hand, groups categories most closely related to each other. The two figures used in conjunction, help to clarify the general pattern of relationship indicated in the original isonymy matrix (table 5.8).

There are no apparent trends; only the close relationship between Runswick fishermen and 'others' is obvious. Careful examination of the results does, however, reveal some underlying tendencies.

Agricultural groups are relatively inter-related right down the coast. For exam-

TABLE 58 ISONYMY WITHIN AND BETWEEN OCCUPATIONAL GROUPS FOR EACH TOWN IN 1851

| | H AGL | H FMR | H OTH | ST AGL | ST FIS | ST OTH | RUN FIS | RUN OTH | W AGL | W FIS | W FMR | RHB FIS | RHB OTH | FYL AGL | FYL FMR | FYL OTH | SC AGL | SC FIS | SC FMR | FIL AGL | FIL FIS | FIL FMR | FIL OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H AGL | .0234 | | | | | | | | | | | | | | | | | | | | | | |
| H FMR | .0076 | .0432 | | | | | | | | | | | | | | | | | | | | | |
| H OTH | .0039 | .0042 | .0240 | | | | | | | | | | | | | | | | | | | | |
| ST AGL | .0062 | .0065 | .0030 | .0398 | | | | | | | | | | | | | | | | | | | |
| ST FIS | – | .0013 | .0028 | .0031 | .0299 | | | | | | | | | | | | | | | | | | |
| ST OTH | .0019 | .0025 | .0012 | .0012 | .0019 | .0105 | | | | | | | | | | | | | | | | | |
| RUN FIS | – | – | – | .0005 | .0007 | .0019 | .0440 | | | | | | | | | | | | | | | | |
| RUN OTH | .0019 | – | .0056 | – | .0011 | .0033 | .0192 | .0469 | | | | | | | | | | | | | | | |
| W AGL | .0016 | .0003 | .0007 | .0020 | .0014 | .0007 | .0001 | .0006 | .0059 | | | | | | | | | | | | | | |
| W FIS | .0010 | .0019 | .0009 | .0020 | .0016 | .0005 | .0020 | .0011 | .0013 | .0351 | | | | | | | | | | | | | |
| W FMR | – | – | .0017 | .0013 | .0025 | .0013 | .0004 | – | .0018 | .0008 | .0268 | | | | | | | | | | | | |
| RHB FIS | – | – | .0014 | – | .0025 | .0004 | – | .0007 | .0009 | .0004 | .0041 | .0821 | | | | | | | | | | | |
| RHB OTH | .0003 | .0013 | .0022 | .0018 | .0005 | .0005 | .0008 | .0034 | .0011 | .0017 | .0005 | .0068 | .0111 | | | | | | | | | | |
| FYL AGL | .0018 | .0020 | .0009 | .0044 | .0017 | .0008 | .0007 | – | .0012 | .0028 | .0020 | .0020 | .0019 | .0137 | | | | | | | | | |
| FYL FMR | .0004 | .0024 | .0005 | .0007 | .0009 | .0009 | .0017 | .0004 | .0006 | .0011 | .0005 | .0007 | .0019 | .0059 | .0133 | | | | | | | | |
| FYL OTH | .0026 | .0031 | .0023 | .0007 | .0034 | .0021 | .0016 | .0011 | .0010 | .0013 | .0033 | .0031 | .0014 | .0049 | .0046 | .0116 | | | | | | | |
| SC AGL | .0006 | .0002 | .0012 | .0003 | .0013 | .0013 | .0011 | .0018 | .0006 | .0007 | .0006 | .0001 | .0009 | .0004 | .0006 | .0009 | .0055 | | | | | | |
| SC FIS | .0015 | .0018 | .0009 | .0016 | .0008 | .0005 | .0005 | .0007 | – | .0003 | .0007 | .0003 | .0005 | .0005 | .0004 | .0006 | .0003 | .0072 | | | | | |
| SC FMR | .0004 | .0008 | .0008 | – | .0009 | .0013 | .0054 | .0010 | .0007 | .0016 | – | – | .0007 | .0011 | .0035 | .0021 | .0017 | .0004 | .0215 | | | | |
| FIL AGL | .0004 | – | .0004 | .0037 | .0003 | .0011 | – | .0010 | .0011 | .0016 | – | .0003 | .0011 | .0030 | .0033 | .0009 | .0004 | .0004 | .0005 | .0234 | | | |
| FIL FIS | .0008 | .0010 | .0004 | – | .0003 | .0007 | – | .0002 | .0006 | .0004 | .0005 | – | .0006 | .0002 | .0002 | .0003 | .0006 | .0043 | .0005 | .0012 | .0318 | | |
| FIL FMR | .0019 | .0069 | .0016 | – | .0009 | .0041 | – | .0078 | – | .0021 | – | – | .0007 | .0009 | .0015 | .0007 | .0006 | .0007 | .0019 | – | .0011 | .0781 | |
| FIL OTH | .0006 | .0017 | .0014 | .0004 | .0017 | .0009 | .0008 | .0017 | .0006 | .0008 | .0004 | .0009 | .0013 | .0009 | .0012 | .0013 | .0007 | .0007 | .0010 | .0009 | .0027 | .0015 | .0045 |

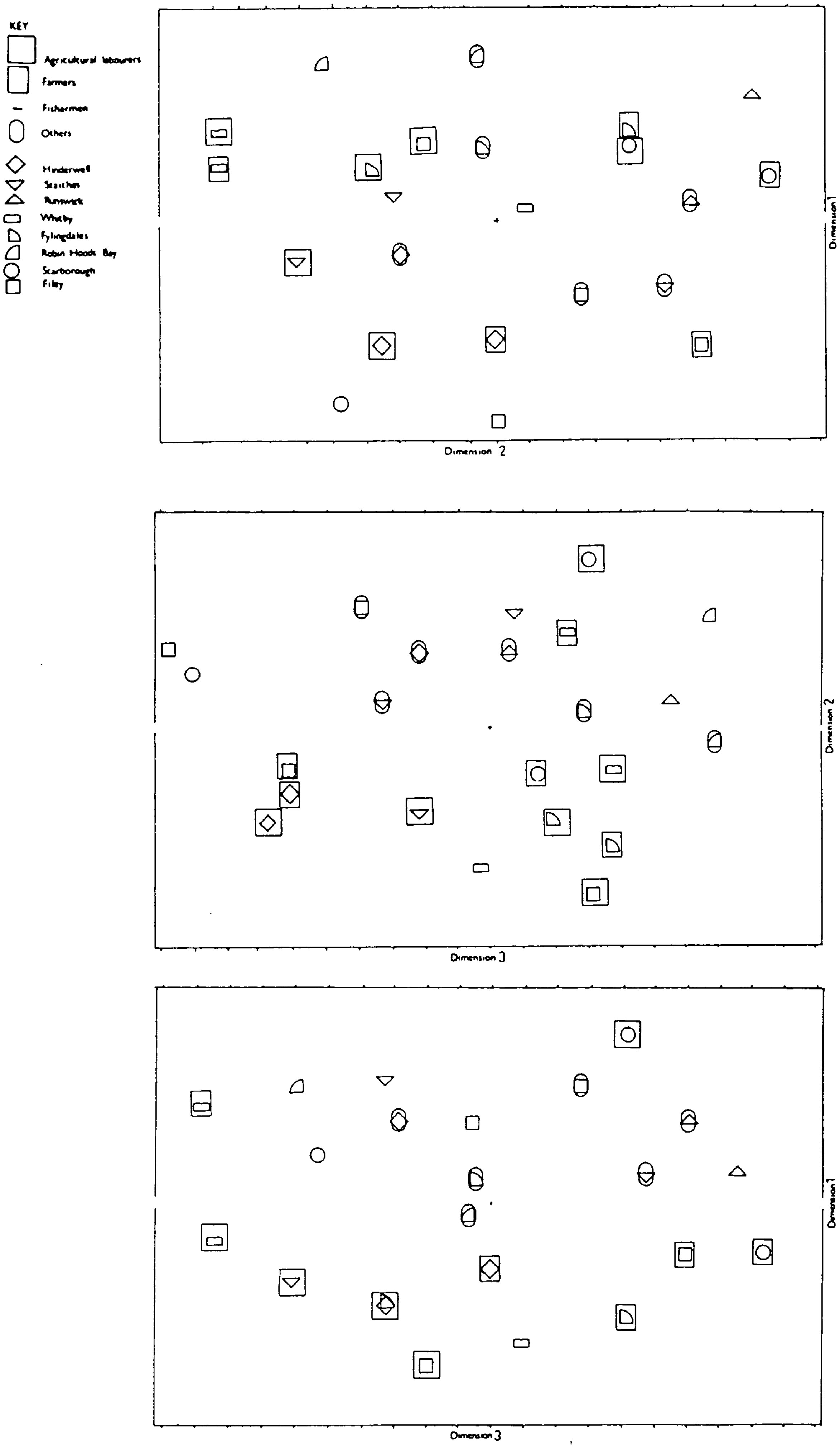


Figure 5.1. A three-dimensional representation of table 5.8

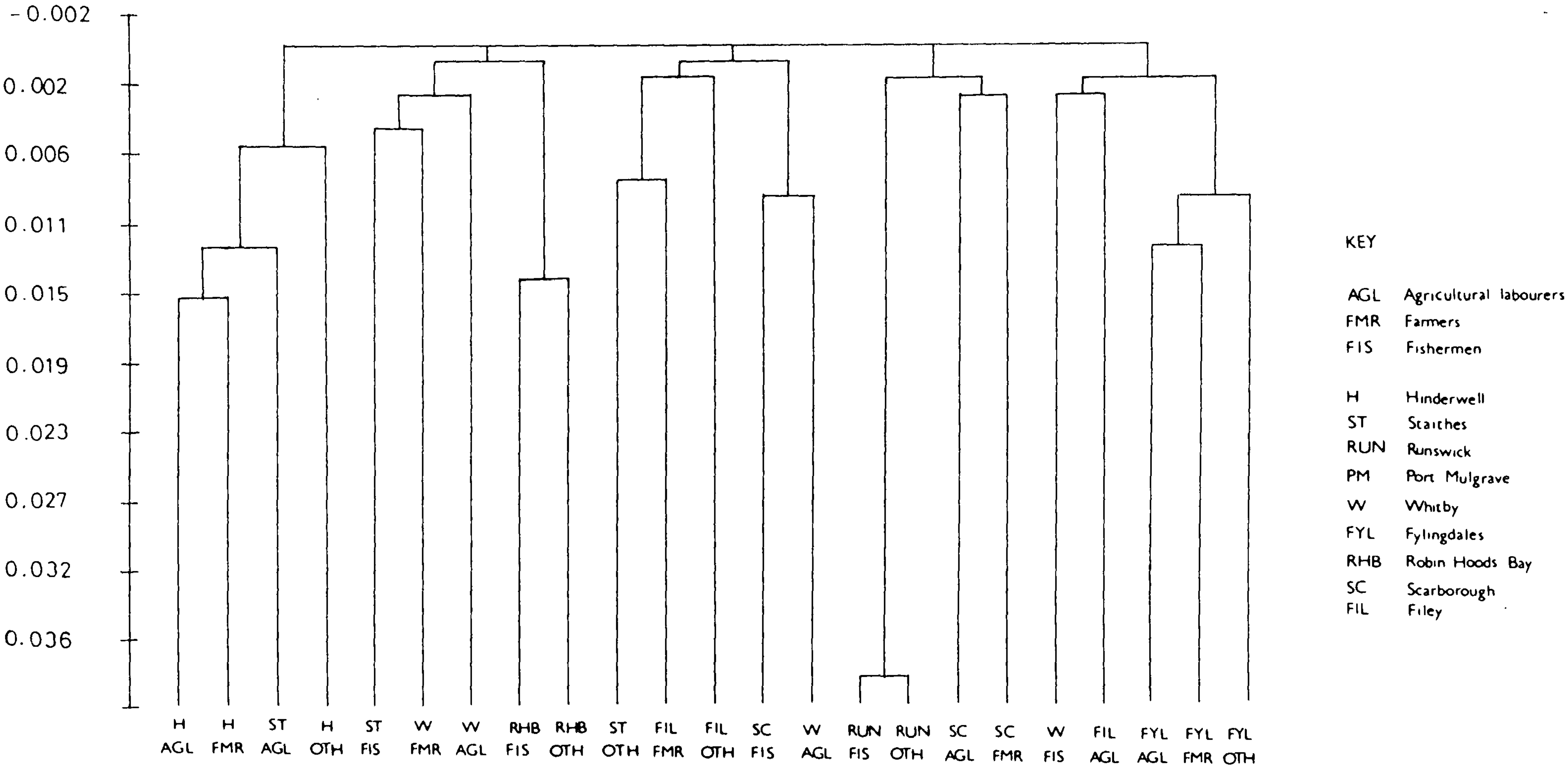
ple, Ri between Fylingdales agricultural labourers and Staithes agricultural labourers = .0044; between Staithes agricultural labourers and Filey agricultural labourers Ri = .0037; between Fylingdales agricultural labourers and Filey agricultural labourers Ri = .0030; between Fylingdales farmers and Scarborough farmers Ri = .0035; and lastly between Fylingdales farmers and Filey agricultural labourers Ri = .0033.

There are, however, farming communities which are not so closely related. Values of Ri between Hinderwell labourers and both Filey and Fylingdales farmers and labourers are relatively lower. Both Scarborough and Whitby appear to be proportionately less related to the wider farming community (with the exception of the Fylingdales and Scarborough farmers). Indeed, this is true even within the two parishes themselves, between the agricultural labourers and farmers. The relationship between the Filey farmers and the rest of the rural population is bizarre; while being completely unrelated to the agricultural labourers of Filey itself, they are closely related, relatively speaking, to the Hinderwell farmers (Ri = .0069).

This pattern of inter-relationships appears to be independent of geographical distance. It is difficult, for example, to explain why the Filey and Staithes agricultural labourers should exhibit proportionally higher values of Ri, while the Hinderwell agricultural labourers remain relatively unrelated to those in Fylingdales who are nearer. Lower values of relationship obtained for the rural communities of Scarborough and Whitby are more understandable since they are larger, more cosmopolitan and fluid societies. The notably small number of Filey farmers (8) may (partly) account for their rather ambiguous inter-relationships: possibly a difference in socio-economic status between the agricultural labourers and themselves maintained the insularity of the two groups. This was indicated above although it is not apparent here in the other parishes.

However, where these factors do not apply and geographical distances are small as in the subdivided parishes of Hinderwell and Fylingdales, spacial proximity is reflected in the pattern of relationship. For example; between Hinderwell agricultural labourers and farmers Ri = .0076; between Hinderwell agricultural labourers and

Figure 5.2. Cluster analysis based on information from table 5.8



Staithes agricultural labourers Ri = .0062; between Hinderwell farmers and Staithes agricultural labourers Ri = .0065; and between Fylingdales agricultural labourers and farmers, Ri = .0059.

The relationship between Hinderwell agricultural labourers, farmers and 'others' is also, relatively speaking, close (Ri = .0039 and .0042 respectively). This pattern is also echoed in Fylingdales parish while, despite their geographical proximity, Runswick 'others' were completely unrelated to either Hinderwell farmers or Staithes agricultural labourers. Fylingdales 'others' show proportionately high values of relationship with Hinderwell and Whitby farmers (Ri = .0031 and .0033 correspondingly). In defiance of geographical distance, Filey farmers show strong ties with Runswick 'others' (Ri = .0078) and also with Staithes 'others' (Ri = .0041).

As above, the fishing communities appear to be rather insular. Scarborough and Filey fishermen are the most closely related (Ri = .0043) but remain apart from the other coastal villages. Robin Hood's Bay is as independent, showing nearest ties with Staithes (Ri = .0025), while being completely unrelated to the Runswick fishermen. Whitby's closest fishing connections are with Staithes and Runswick (Ri = .0016 and .0020 respectively) in agreement with their geographical situation. Most notable is the low value of Ri between the neighbouring communities of Staithes and Runswick fishermen (Ri = .0007).

The zero values of isonymic relationship between Runswick fishermen and Hinderwell agricultural labourers, farmers, and 'others' confirms the isolation of the Runswick fisherfolk, even from villages within the same parish. On the other hand, the especially close relationship between the Runswick fishermen and 'others' (Ri = .0192), affirms the interwoven, but insular nature of that community. This is in accordance with the results of section 2 (Town), where a particularly high coefficient of relationship was estimated for the village of Runswick as a whole.

Staithes is less independent, although the unrelatedness of Hinderwell agricultural labourers and Staithes fishermen, and the relatively close relationship between Staithes agricultural labourers and fishermen (Ri = .0031) suggests a similar phenomenon. Robin Hood's Bay is also reasonably inter-related, with a value of Ri between the fishermen and 'others' of .0068, but the village as a whole is also more akin to their neighbouring village (Fylingdales) than is the case in Hinderwell parish. Filey fishermen are only closely related to Scarborough fishermen and, to a lesser extent, Filey 'others'; they are very independent of all other groups, baring no relationship at all to the Filey agricultural labourers (Ri = 0). Values of Ri between the Scarborough fishermen and agricultural labourers and farmers are also very low (Ri = .0003 and .0004 respectively). In Whitby the pattern is similar, but less pronounced.

Despite the apparent conformity, there are some anomalies. For example, Scarborough farmers and Runswick fishermen are comparatively closely related (Ri = .0054); between Staithes fishermen and Fylingdales 'others' Ri = .0034; between Robin Hood's Bay fishermen and Whitby farmers Ri = .0041: and lastly between Whitby fishermen and Fylingdales agricultural labourers Ri = .0028. There appears to be no apparent explanation for such tendencies, beyond the chance sampling from the Yorkshire coastal gene pool as a whole.

To recapitulate, the results indicate several broad trends. Scarborough and Whitby are both less inter-related either as communities, or with other villages, which reflects their standing as the larger commercial towns. Filey, particularly its fishermen, seem to be closest to Scarborough, while the other three parishes are more inter-related.

Overall, the fishing villages do appear to be insular, independent from each other and moreover, from the agricultural communities. (Only the Staithes agricultural labourers and fishermen gave a relatively high value of Ri and even then the labourers are more closely related to those of neighbouring Hinderwell.) The isonymy results suggest that Runswick was a singularly secluded spot. The fishermen's closest connections otherwise are with 'others' from the same areas.

Generally the rural community is inter-related right down the coast irrespective of geographical distance – Fylingdales and Hinderwell parishes agricultural communities are especially close knit. The bizarre relationship between Filey farmers and Hinderwell parish remains inexplicable. Only Filey maintains the sharp distinction between farmers and agricultural labourers indicated in the occupational analysis.

Predictably, the 'others' categories are affiliated to both the fishing and agricultural groups, and do not really constitute a community in themselves. Only the 'others' of Hinderwell parish are reasonably closely related, while the tie between Runswick and Robin Hood's Bay 'others' is disproportionately and rather inexplicably strong.

In summary it can be said that the 1851 coastal population of North Yorkshire was not panmitic, but was subdivided culturally and geographically. By estimating isonymy for succeeding years (1861, 1871, and 1881) temporal changes in the population structure may be observed.

### B.Ri within and between years over the period 1851-1881

### 1. Town

It is clear from the analysis above that the population of North Yorkshire is subdivided by settlement and not by parish. Thus isonymy was only calculated within and between the former for subsequent decades. By 1861 Port Mulgrave was newly established and is therefore included as a separate village.

Sample sizes for every town in each decade are given in table 5.3, and the coefficients of relationship by isonymy within and between these categories are presented in table 5.9.

Figure 5.3 is a three-dimensional graphical representation of the results. The degree of stress (.1383, compared with raw data stress of .2756) is acceptable: Unfortunately the two-dimensional solution gave too high a stress value for it to be used with confidence. The cluster analysis, used concomitantly with the spatial MDS-X interpretation, is shown in figure 5.4.

All sample sizes are over two hundred and the within-group coefficients should therefore be independent of sample size. In 1851 Scarborough was the least interrelated town; this follows for subsequent years. Indeed the coefficient of relationship

TABLE 59 ISONYMY WITHIN & BETWEEN TOWNS FOR EACH CENSUS YEAR

| | 5 H | 5 ST | 5 RUN | 5 W | 5 RHB | 5 FYL | 5 SC | 5 FIL | 6 H | 6 ST | 6 RUN | 6 PM | 6 W | 6 RHB | 6 FYL | 6 SC | 6 FIL | 7 H | 7 ST | 7 RUN | 7 PM | 7 W | 7 RHB | 7 FYL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 H | .0128 | | | | | | | | | | | | | | | | | | | | | | | |
| 5 ST | .0016 | .0092 | | | | | | | | | | | | | | | | | | | | | | |
| 5 RUN | .0010 | .0008 | .0263 | | | | | | | | | | | | | | | | | | | | | |
| 5 W | .0015 | .0012 | .0007 | .0058 | | | | | | | | | | | | | | | | | | | | |
| 5 RHB | .0013 | .0014 | .0008 | .0010 | .0125 | | | | | | | | | | | | | | | | | | | |
| 5 FYL | .0017 | .0014 | .0009 | .0013 | .0026 | .0073 | | | | | | | | | | | | | | | | | | |
| 5 SC | .0012 | .0008 | .0010 | .0005 | .0007 | .0007 | .0039 | | | | | | | | | | | | | | | | | |
| 5 FIL | .0007 | .0009 | .0004 | .0005 | .0009 | .0009 | .0013 | .0062 | | | | | | | | | | | | | | | | |
| 6 H | .0055 | .0017 | .0008 | .0008 | .0011 | .0017 | .0010 | .0007 | .0077 | | | | | | | | | | | | | | | |
| 6 ST | .0017 | .0083 | .0006 | .0010 | .0010 | .0011 | .0007 | .0007 | .0016 | .0103 | | | | | | | | | | | | | | |
| 6 RUN | .0012 | .0012 | .0133 | .0012 | .0010 | .0012 | .0011 | .0008 | .0011 | .0011 | .0193 | | | | | | | | | | | | | |
| 6 PM | .0028 | .0024 | .0001 | .0008 | .0013 | .0011 | .0007 | .0011 | .0028 | .0018 | .0006 | .0171 | | | | | | | | | | | | |
| 6 W | .0014 | .0019 | .0011 | .0029 | .0011 | .0017 | .0006 | .0010 | .0019 | .0014 | .0013 | .0020 | .0071 | | | | | | | | | | | |
| 6 RHB | .0016 | .0015 | .0005 | .0011 | .0105 | .0027 | .0007 | .0009 | .0012 | .0010 | .0009 | .0018 | .0012 | .0112 | | | | | | | | | | |
| 6 FYL | .0021 | .0009 | .0010 | .0012 | .0026 | .0058 | .0008 | .0008 | .0018 | .0008 | .0010 | .0009 | .0019 | .0026 | .0071 | | | | | | | | | |
| 6 Sc | .0011 | .0009 | .0010 | .0006 | .0008 | .0007 | .0024 | .0021 | .0009 | .0009 | .0011 | .0005 | .0006 | .0008 | .0007 | .0040 | | | | | | | | |
| 6 FIL | .0005 | .0006 | .0006 | .0004 | .0006 | .0006 | .0012 | .0047 | .0005 | .0005 | .0007 | .0008 | .0008 | .0007 | .0006 | .0017 | .0048 | | | | | | | |
| 7 H | .0046 | .0020 | .0008 | .0011 | .0009 | .0014 | .0011 | .0008 | .0046 | .0017 | .0016 | .0034 | .0019 | .0011 | .0015 | .0009 | .0007 | .0063 | | | | | | |
| 7 ST | .0015 | .0090 | .0009 | .0010 | .0009 | .0010 | .0007 | .0007 | .0014 | .0106 | .0012 | .0016 | .0012 | .0010 | .0007 | .0008 | .0008 | .0016 | .0134 | | | | | |
| 7 RUN | .0013 | .0014 | .0109 | .0010 | .0006 | .0011 | .0011 | .0006 | .0014 | .0013 | .0149 | .0017 | .0014 | .0005 | .0010 | .0009 | .0007 | .0018 | .0014 | .0161 | | | | |
| 7 PM | .0030 | .0015 | .0011 | .0009 | .0006 | .0013 | .0008 | .0006 | .0033 | .0011 | .0015 | .0043 | .0027 | .0006 | .0019 | .0008 | .0005 | .0026 | .0009 | .0018 | .0107 | | | |
| 7 W | .0013 | .0013 | .0011 | .0027 | .0011 | .0020 | .0008 | .0009 | .0011 | .0013 | .0018 | .0007 | .0037 | .0010 | .0023 | .0009 | .0006 | .0011 | .0009 | .0017 | .0017 | .0077 | | |
| 7 RHB | .0015 | .0013 | .0012 | .0012 | .0099 | .0023 | .0007 | .0010 | .0009 | .0009 | .0009 | .0019 | .0013 | .0105 | .0024 | .0008 | .0008 | .0011 | .0008 | .0006 | .0005 | .0012 | .0115 | |
| 7 FYL | .0018 | .0011 | .0016 | .0011 | .0024 | .0049 | .0008 | .0007 | .0016 | .0009 | .0018 | .0009 | .0016 | .0024 | .0054 | .0006 | .0005 | .0012 | .0007 | .0015 | .0016 | .0021 | .0021 | .0069 |
| 7 SC | .0006 | .0010 | .0010 | .0005 | .0008 | .0008 | .0023 | .0018 | .0014 | .0008 | .0011 | .0007 | .0007 | .0007 | .0006 | .0028 | .0015 | .0007 | .0007 | .0009 | .0008 | .0006 | .0007 | .0007 |
| 7 FIL | .0004 | .0006 | .0003 | .0005 | .0006 | .0006 | .0010 | .0044 | .0003 | .0004 | .0004 | .0009 | .0008 | .0007 | .0005 | .0015 | .0040 | .0006 | .0004 | .0004 | .0003 | .0006 | .0008 | .0004 |
| 8 H | .0055 | .0018 | .0008 | .0012 | .0009 | .0011 | .0008 | .0009 | .0046 | .0016 | .0015 | .0038 | .0020 | .0013 | .0013 | .0007 | .0006 | .0052 | .0017 | .0021 | .0024 | .0007 | .0013 | .0011 |
| 8 ST | .0017 | .0087 | .0024 | .0012 | .0008 | .0009 | .0007 | .0006 | .0014 | .0107 | .0015 | .0014 | .0012 | .0008 | .0007 | .0008 | .0004 | .0018 | .0125 | .0017 | .0012 | .0012 | .0008 | .0007 |
| 8 RUN | .0004 | .0015 | .0093 | .0010 | .0006 | .0009 | .0011 | .0007 | .0010 | .0011 | .0148 | .0026 | .0015 | .0003 | .0007 | .0009 | .0007 | .0016 | .0011 | .0143 | .0022 | .0022 | .0004 | .0014 |
| 8 PM | .0018 | .0016 | .0011 | .0006 | .0011 | .0013 | .0007 | .0009 | .0025 | .0015 | .0014 | .0027 | .0015 | .0011 | .0017 | .0007 | .0006 | .0026 | .0014 | .0013 | .0035 | .0008 | .0009 | .0014 |
| 8 W | .0011 | .0014 | .0011 | .0023 | .0009 | .0013 | .0005 | .0010 | .0012 | .0012 | .0017 | .0011 | .0032 | .0010 | .0014 | .0007 | .0007 | .0014 | .0010 | .0009 | .0012 | .0037 | .0011 | .0012 |
| 8 RHB | .0013 | .0012 | .0013 | .0011 | .0092 | .0029 | .0007 | .0007 | .0008 | .0008 | .0016 | .0008 | .0010 | .0096 | .0032 | .0008 | .0007 | .0009 | .0007 | .0010 | .0005 | .0014 | .0100 | .0033 |
| 8 FYL | .0016 | .0007 | .0010 | .0011 | .0022 | .0047 | .0007 | .0007 | .0017 | .0006 | .0010 | .0007 | .0032 | .0024 | .0054 | .0005 | .0005 | .0011 | .0005 | .0007 | .0017 | .0020 | .0023 | .0059 |
| 8 SC | .0006 | .0009 | .0008 | .0004 | .0007 | .0006 | .0018 | .0020 | .0004 | .0006 | .0009 | .0008 | .0006 | .0008 | .0005 | .0023 | .0016 | .0007 | .0005 | .0008 | .0005 | .0008 | .0008 | .0005 |
| 8 FIL | .0005 | .0008 | .0004 | .0006 | .0007 | .0006 | .0010 | .0040 | .0004 | .0005 | .0006 | .0010 | .0009 | .0009 | .0006 | .0015 | .0036 | .0007 | .0004 | .0012 | .0003 | .0007 | .0010 | .0005 |

| | 7 SC | 7 FIL | 8 H | 8 ST | 8 RUN | 8 PM | 8 W | 8 RHB | 8 FYL | 8 SC | 8 FIL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 SC | .0038 | | | | | | | | | | |
| 7 FIL | .0014 | .0043 | | | | | | | | | |
| 8 H | .0006 | .0006 | .0084 | | | | | | | | |
| 8 ST | .0007 | .0003 | .0018 | .0138 | | | | | | | |
| 8 RUN | .0009 | .0004 | .0013 | .0016 | .0236 | | | | | | |
| 8 PM | .0006 | .0006 | .0017 | .0013 | .0012 | .0101 | | | | | |
| 8 W | .0005 | .0007 | .0013 | .0011 | .0007 | .0010 | .0067 | | | | |
| 8 RHB | .0007 | .0007 | .0008 | .0006 | .0010 | .0009 | .0009 | .0115 | | | |
| 8 FYL | .0006 | .0005 | .0011 | .0006 | .0006 | .0016 | .0013 | .0030 | .0078 | | |
| 8 SC | .0024 | .0015 | .0006 | .0005 | .0008 | .0006 | .0006 | .0007 | .0004 | .0032 | |
| 8 FIL | .0014 | .0036 | .0008 | .0004 | .0007 | .0006 | .0008 | .0008 | .0005 | .0015 | .0040 |

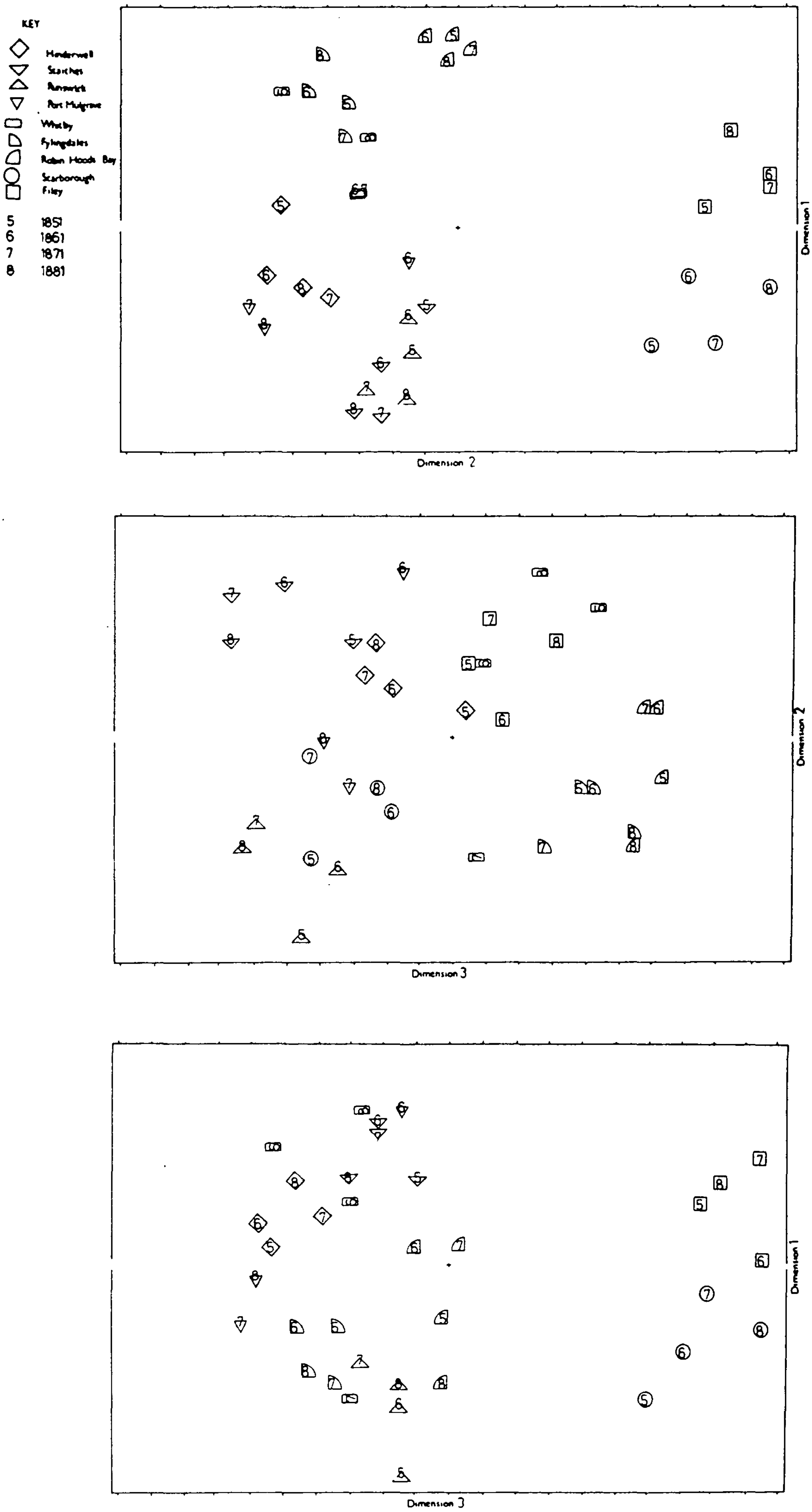


Figure 5.3. A three-dimensional representation of table 5.9

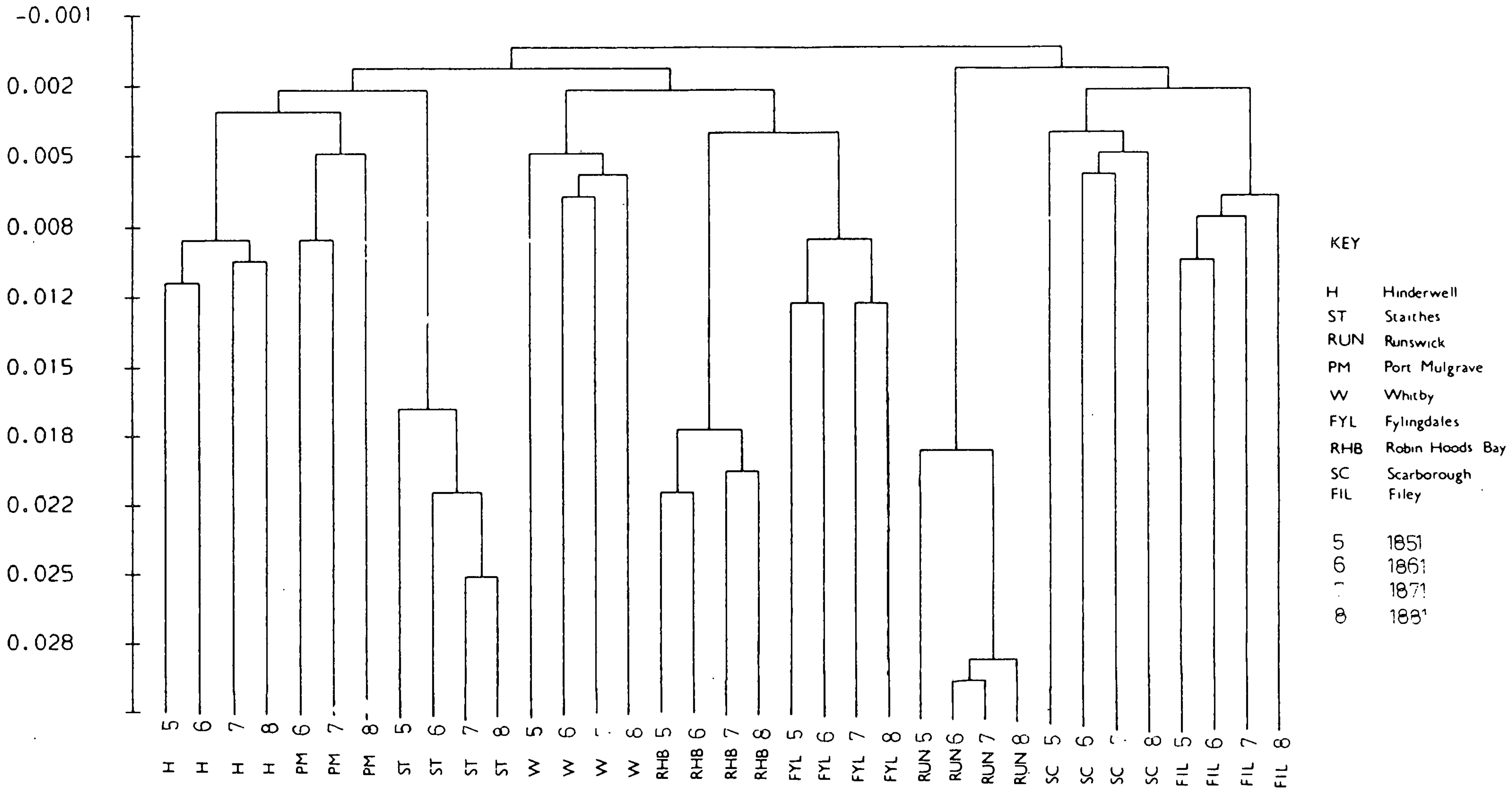
calculated within Scarborough remains remarkably constant over time despite the marked increase in the (selected) population size. Moreover the relationship between census years is relatively stable, with the populations of 1851 and 1881 predictably being the least related to each other.

The value of Ri estimated within Filey decreases quite notably between 1851 and 1861, and then more gradually towards the latter part of the century – reflecting, perhaps, the considerable population growth associated with the development of the town as a holiday resort. Again the relationship between years declined proportionally over time. By 1881 the value of Ri within both Scarborough and Filey is the same, which may not only signify the growth of Filey but also, perhaps, reflects the influence of expanding Scarborough.

Whitby fishing and farming communities become more inter-related over the years and once more those populations furthest apart in time are also those which are the least related. The relationship within both Fylingdales and Robin Hood's Bay fluctuates with an overall increase and decrease respectively. The latter is also true of Hinderwell and Runswick, although throughout the period Runswick remains the most inbred community (mean Ri = .213). While the relationship within Fylingdales and Robin Hood's Bay declined proportionally between census years, in Runswick the three latter decades appear to be more closely 'clustered' than the more insular population of 1851 (confirmed in figure 5.4). This is undoubtedly associated with the considerable population increase between 1851 and 1861. In Hinderwell the middle years are less inter-related than 1851 and 1881 and this is similarly explained by the influx of migrant ironstone miners to the area during this period.

Port Mulgrave, founded only in 1854, drawing the majority of its population locally but also with migrants from as far as Cornwall and Ireland, sees a steady growth in population size matched by a reduction in the value of Ri both within and between decades. Staithes becomes consistently more and more inter-related over time while its population size increases. This is indicated in figure 5.4 and may be attributed to the ironstone industry. However, overall there appears to be a general

Figure 5.4. Cluster analysis based on table 5.9



trend towards a gradual breakdown of relationship within the towns towards the end of the century, although the relative relationships within the different villages remains constant. For example, Runswick, followed by Staithes and Robin Hood's Bay is, throughout the entire period, the most closely-knit community. This is clearly demonstrated in figure 5.4.

The pattern of relationships between the different towns has already been discussed for 1851. By analysing the coefficients of relationship estimated for subsequent decades it is possible to assess the temporal changes, if any, in the population structure.

As figures 5.3 and 5.4 demonstrate, the relationship within the villages, right across the period, is higher than the relationship estimated between the different locations. This may suggest some spatial subdivision of the total population, although the weaknesses of the isonymy method should be kept in mind and the results might be best considered as a general rather than an absolute guide to the pattern of relationships amongst the North Yorkshire coast.

The pattern of relationship between the villages alters remarkably little between decades. The clustering of Scarborough and Filey, independently of the other villages, is extremely clear from figure 5.3. Values of Ri between these two towns fluctuates very slightly, with a small increase between 1851 and 1861, but overall maintaining a mean value of .0014. The relationship between these two towns to the other villages generally remains constant, although Hinderwell and Scarborough, Staithes and Filey, and Fylingdales with both Scarborough and Filey become very gradually more distantly related.

Whitby's relationships oscillate over time, though again it must be emphasised that the changes are very small. For example, Ri estimated between Runswick and Whitby in 1871 was .0017, compared to a value of .0007 in 1851 and 1881. Similarly Fylingdales appears to be 'closer' to Whitby in 1871 (Ri = .0021) than in other years. Indeed Runswick and Fylingdales themselves are more inter-related in 1871 than either before or after (Ri = .0015). It is difficult to pin-point an explanation for this, beyond chance!

Thus, while Runswick remains the least integrated village, it was more open by 1871, although in 1881 the trend seems to have been slightly reversed. (The higher value of Ri with Whitby and Fylingdales coincides with the date at which the village itself was least inbred.) Notably, Staithes and Runswick become more inter-related, the value of Ri was estimated as .0008 in 1851, compared to .0016 in 1881. Considering their geographical proximity this is understandable.

By contrast, Staithes becomes increasingly more insular. By 1881 the town itself is more closely-knit, but moreover, it is more distantly related to both Fylingdales and Robin Hood's Bay (In 1851, Ri = .0014, compared to .0006 in 1881 for both towns).

Hinderwell follows this in that it too becomes less related to these two villages over the decades. Meanwhile, the relationship between Fylingdales and Robin Hood's Bay fluctuates, with a net increase. The value of Ri between them in 1881 was calculated at .0030, the highest estimated between any two villages.

Generally speaking, however, the changes observed are very small and essentially the pattern of relationship amongst the Yorkshire villages remains reasonably static. The only major break with the past was initiated by the founding of Port Mulgrave. As a part of Hinderwell parish, it follows the general tendency in being least closely related to Scarborough and Filey. In agreement with its geographical proximity, it is most closely related to Hinderwell in all decades, although this relationship declines over time. Whitby similarly becomes more distantly related over the years. Ties between the Port and Staithes, Runswick and Fylingdales fluctuates, while Robin Hood's Bay gradually became more related to it. The coefficients of relationship between Port Mulgrave and these six towns are higher, relatively speaking, than those estimated between other towns (Fylingdales and Robin Hood's Bay for 1881 excepted). Since the work force of the Port was quite largely drawn from the surrounding local populations this is understandable. Fluctuations in the values of Ri may reflect employment opportunities in the established towns. For example, it is possible that the increase of Ri between Robin Hood's Bay and the Port is associated with the gradual decline of the fishing industry there and the conse-

-quent need for new employment. However, the new town also attracted migrants from further afield, which accounts for the reduction not only in the value of Ri in Port Mulgrave itself, but also between it and Hinderwell and Whitby. There is little doubt that the ironstone industry had a big impact on the neighbouring population.

The coefficients of relationship estimated between towns in sequential decades gives an indication of the migration between them, although, given the problem of polyphyleticism, it is also possible that values of Ri may be misleading. Given that this is not the case, however, it might appear that both Runswick's 1851 and 1861 populations are more inter-related to Fylingdales in 1871, possibly implying immigration from the former into the latter during this period: consequently the relationship between the two is the closest in 1871. Meanwhile the drop in Ri between Runswick's 1871 population and Fylingdales in 1881 may imply emigration from the latter and corresponds to the lower value of Ri between them in 1881. A similar pattern is observed between Runswick and Whitby, and Whitby and Fylingdales, fitting in very well with the oscillations in the values of Ri between these towns in 1871, observed above.

Robin Hood's Bay in 1871 and 1881 is more closely related to Runswick's earlier populations, explaining the slight increase in the coefficient of relationship between them in 1881. Filey's 1881 population is similarly more inter-related with Runswick in 1871, reflected in a higher value of Ri between the two in 1881. Meanwhile, migration from Runswick to Port Mulgrave is indicated by the closer relationship between Runswick's 1861 populace and Port Mulgrave in 1871. This trend was reversed, however, in the sequential decade. Again this echoes the observed pattern of relationship between the towns for each year. Furthermore, it becomes apparent that there was considerable out-migration from Runswick during the 1860's explaining the partial breakdown of its insularity. Once more this may principally be attributed to the founding of Port Mulgrave, attracting (unsettled migrant) workers into the area, so that Runswick's population grew by 95 between 1851 and 1861, but some of these moved again in following years, indicated by the reduction in Runswick's population. (Since the decline of the fishing industry did not really take effect until the end of the century this is unlikely to have been a causative factor.)

The fluctuating values of Ri observed between Staithes and Port Mulgrave are similarly reflected in the coefficients of relationship estimated between the two and other populations in adjacent years. The 1851 population of Staithes is more closely related to Whitby in 1861 than in the same year (Ri = .0012 *cf* .0019), suggestive of immigration to Whitby, corresponding perhaps with a fractional increase in the coefficient of relationship between the two towns in 1861. Generally, however, although the Staithes population grows throughout the study period (due once again to the mining industry), there appears to be little population movement away from the village.

Port Mulgrave's 1871 population is also more closely related to Hinderwell in 1861, once more indicative of the 'pull' it exerted over neighbouring villages. Immigration from Hinderwell to Scarborough is also indicated between 1861 and 1871, although this is not manifested in the coefficient of relationship calculated between them in 1871.

Thus against a rather stable population structure, the impact of Port Mulgrave and the ironstone industry on Hinderwell parish and its environs must be emphasised. Indeed, increases in the rate of genetic exchange between any two communities only really occurred along the Northern stretch of coast, frequently stimulated by this historical event. Did it also affect the relationship between the occupational groups?

## 2. Occupation

The coefficients of relationship by isonymy estimated within and between occupational groupings for each census year are presented in table 5.10. Sample sizes are given in table 5.11.

These results are represented graphically by a cluster analysis, shown in figure

Table 5·10: ISONYMY WITHIN AND BETWEEN OCCUPATIONS FOR EACH CENSUS YEAR

| | 5 AGL | 5 CTG | 5 FB | 5 FIS | 5 FMR | 5 MR | 5 OTH | 5 SN |
|---|---|---|---|---|---|---|---|---|
| 5 AGL | .0028 | | | | | | | |
| 5 CTG | .0007 | .0245 | | | | | | |
| 5 FB | .0020 | .0016 | .0192 | | | | | |
| 5 FIS | .0008 | .0006 | .0033 | .0066 | | | | |
| 5 FMR | .0015 | .0016 | .0015 | .0010 | .0062 | | | |
| 5 MR | .0017 | .0017 | .0018 | .0014 | .0018 | .0244 | | |
| 5 OTH | .0012 | .0011 | .0019 | .0014 | .0016 | .0017 | .0027 | |
| 5 SN | .0007 | .0005 | .0019 | .0026 | .0011 | .0011 | .0018 | .0078 |
| 6 AGL | .0016 | .0013 | .0020 | .0009 | .0021 | .0030 | .0014 | .0010 |
| 6 CTG | .0008 | .0072 | .0009 | .0007 | .0019 | .0011 | .0011 | .0008 |
| 6 FB | .0015 | .0006 | .0071 | .0038 | .0008 | .0013 | .0013 | .0008 |
| 6 FIS | .0007 | .0008 | .0030 | .0058 | .0008 | .0013 | .0012 | .0020 |
| 6 FMR | .0012 | .0018 | .0020 | .0008 | .0035 | .0020 | .0014 | .0008 |
| 6 MR | .0011 | .0007 | .0022 | .0011 | .0011 | .0020 | .0012 | .0010 |
| 6 OTH | .0011 | .0009 | .0018 | .0012 | .0013 | .0013 | .0017 | .0014 |
| 6 SN | .0010 | .0009 | .0021 | .0027 | .0015 | .0012 | .0018 | .0055 |
| 7 AGL | .0017 | .0014 | .0019 | .0010 | .0022 | .0033 | .0016 | .0011 |
| 7 CTG | .0010 | .0011 | .0022 | .0014 | .0023 | .0018 | .0017 | .0015 |
| 7 FB | .0024 | – | .0070 | .0025 | .0011 | .0005 | .0014 | .0011 |
| 7 FIS | .0007 | .0007 | .0026 | .0049 | .0007 | .0009 | .0010 | .0015 |
| 7 FMR | .0012 | .0013 | .0016 | .0010 | .0032 | .0010 | .0013 | .0009 |
| 7 MR | .0011 | .0005 | .0007 | .0009 | .0011 | .0019 | .0011 | .0008 |
| 7 OTH | .0009 | .0011 | .0015 | .0014 | .0011 | .0007 | .0014 | .0014 |
| 7 SN | .0009 | .0016 | .0028 | .0026 | .0019 | .0013 | .0018 | .0066 |
| 8 AGL | .0015 | .0012 | .0019 | .0011 | .0018 | .0022 | .0017 | .0012 |
| 8 CTG | .0003 | .0012 | – | .0008 | – | .0006 | .0005 | .0004 |
| 8 FB | .0008 | – | .0038 | .0038 | .0006 | .0008 | .0010 | .0016 |
| 8 FIS | .0006 | .0008 | .0023 | .0042 | .0006 | .0008 | .0009 | .0013 |
| 8 FMR | .0012 | .0014 | .0019 | .0008 | .0023 | .0019 | .0013 | .0008 |
| 8 MR | .0012 | .0004 | .0015 | .0008 | .0013 | .0023 | .0012 | .0006 |
| 8 OTH | .0010 | .0008 | .0017 | .0015 | .0013 | .0010 | .0015 | .0014 |
| 8 SN | .0014 | .0008 | .0029 | .0032 | .0019 | .0014 | .0018 | .0048 |

| | 6 AGL | 6 CTG | 6 FB | 6 FIS | 6 FMR | 6 MR | 6 OTH | 6 SN |
|---|---|---|---|---|---|---|---|---|
| 6 AGL | .0033 | | | | | | | |
| 6 CTG | .0013 | .0248 | | | | | | |
| 6 FB | .0011 | – | .0274 | | | | | |
| 6 FIS | .0009 | .0007 | .0035 | .0065 | | | | |
| 6 FMR | .0018 | .0018 | .0012 | .0006 | .0053 | | | |
| 6 MR | .0012 | .0004 | .0017 | .0010 | .0008 | .0052 | | |
| 6 OTH | .0011 | .0007 | .0014 | .0011 | .0012 | .0010 | .0021 | |
| 6 SN | .0013 | .0013 | .0011 | .0022 | .0010 | .0014 | .0014 | .0075 |
| 7 AGL | .0021 | .0007 | .0013 | .0010 | .0017 | .0013 | .0014 | .0014 |
| 7 CTG | .0023 | .0067 | .0013 | .0014 | .0021 | .0005 | .0008 | .0022 |
| 7 FB | .0013 | – | .0167 | .0019 | .0019 | .0021 | .0014 | .0026 |
| 7 FIS | .0008 | .0005 | .0032 | .0050 | .0005 | .0009 | .0009 | .0017 |
| 7 FMR | .0017 | .0019 | .0006 | .0009 | .0032 | .0007 | .0012 | .0009 |
| 7 MR | .0013 | .0004 | .0005 | .0011 | .0009 | .0020 | .0010 | .0010 |
| 7 OTH | .0010 | .0009 | .0014 | .0013 | .0010 | .0008 | .0013 | .0015 |
| 7 SN | .0014 | .0018 | .0013 | .0019 | .0013 | .0013 | .0015 | .0069 |
| 8 AGL | .0018 | .0013 | .0013 | .0010 | .0019 | .0013 | .0014 | .0014 |
| 8 CTG | .0003 | – | .0015 | .0007 | – | .0004 | .0004 | .0004 |
| 8 FB | .0005 | .0006 | .0131 | .0038 | .0011 | .0017 | .0011 | .0016 |
| 8 FIS | .0007 | .0004 | .0027 | .0044 | .0005 | .0008 | .0008 | .0015 |
| 8 FMR | .0017 | .0013 | .0012 | .0007 | .0024 | .0010 | .0013 | .0009 |
| 8 MR | .0015 | .0003 | .0012 | .0009 | .0014 | .0022 | .0010 | .0009 |
| 8 OTH | .0012 | .0009 | .0017 | .0014 | .0011 | .0010 | .0013 | .0016 |
| 8 SN | .0015 | .0020 | .0021 | .0026 | .0013 | .0011 | .0014 | .0062 |

| | 7 AGL | 7 CTG | 7 FB | 7 FIS | 7 FMR | 7 MR | 7 OTH | 7 SN |
|---|---|---|---|---|---|---|---|---|
| 7 AGL | .0037 | | | | | | | |
| 7 CTG | .0019 | .0261 | | | | | | |
| 7 FB | .0014 | – | .0328 | | | | | |
| 7 FIS | .0009 | .0009 | .0016 | .0048 | | | | |
| 7 FMR | .0017 | .0019 | .0007 | .0007 | .0055 | | | |
| 7 MR | .0013 | .0004 | .0009 | .0009 | .0007 | .0040 | | |
| 7 OTH | .0012 | .0011 | .0016 | .0011 | .0010 | .0009 | .0018 | |
| 7 SN | .0015 | .0030 | .0013 | .0015 | .0011 | .0007 | .0015 | .0043 |
| 8 AGL | .0021 | .0023 | .0011 | .0009 | .0018 | .0014 | .0012 | .0018 |
| 8 CTG | .0005 | .0039 | – | .0006 | .0001 | – | .0004 | .0007 |
| 8 FB | .0006 | – | .0177 | .0031 | .0003 | .0008 | .0015 | .0007 |
| 8 FIS | .0009 | .0009 | .0010 | .0039 | .0006 | .0008 | .0010 | .0015 |
| 8 FMR | .0021 | .0012 | .0007 | .0007 | .0034 | .0006 | .0010 | .0014 |
| 8 MR | .0014 | .0003 | .0026 | .0007 | .0008 | .0029 | .0009 | .0007 |
| 8 OTH | .0013 | .0015 | .0015 | .0012 | .0011 | .0010 | .0014 | .0017 |
| 8 SN | .0017 | .0035 | .0025 | .0022 | .0013 | .0011 | .0016 | .0070 |

| | 8 AGL | 8 CTG | 8 FB | 8 FIS | 8 FMR | 8 MR | 8 OTH | 8 SN |
|---|---|---|---|---|---|---|---|---|
| 8 AGL | .0048 | | | | | | | |
| 8 CTG | .0008 | .0308 | | | | | | |
| 8 FB | .0005 | – | .0346 | | | | | |
| 8 FIS | .0010 | .0004 | .0026 | .0039 | | | | |
| 8 FMR | .0021 | .0003 | .0005 | .0007 | .0056 | | | |
| 8 MR | .0015 | – | .0012 | .0007 | .0008 | .0058 | | |
| 8 OTH | .0013 | .0007 | .0016 | .0010 | .0011 | .0010 | .0021 | |
| 8 SN | .0020 | .0014 | .0018 | .0020 | .0013 | .0009 | .0018 | .0088 |

TABLE 5.11 SAMPLE SIZES FOR EACH OCCUPATIONAL CATEGORY 1861-1881

| | AGL | CTG | FB | FIS | FMR | MR | OTH | SN |
|---|---|---|---|---|---|---|---|---|
| 6 | 396 | 25 | 37 | 752 | 214 | 179 | 715 | 259 |
| 7 | 341 | 21 | 34 | 910 | 207 | 280 | 729 | 182 |
| 8 | 235 | 18 | 34 | 1025 | 251 | 243 | 787 | 160 |

5.6, and by the circular markings on the spatial multi-dimensional plot in figure 5.5.

Since only a five-dimensional solution produced a moderate stress value, too cumbersome to include here, a two-dimensional solution was used in figure 5.5 (stress achieved = .2047 compared to stress based on an approximation to random data, = .3016). The plot should therefore be interpreted with caution. For example the 1871 'others' contribute most to the stress value and accordingly their positioning is distorted and does not truly reflect their actual inter-relationship with other categories.

As before, the 'fish business' and coast guard categories are too small for the within-group values of Ri to be accepted as true estimates of biological relationship. The number of miners increases substantially after 1851 and thus Ri calculated within the group for 1861 and subsequent decades is acceptable.

Overall the within-group coefficients of isonymy are not stable over time. While this may reflect real trends, these fluctuations might as equally well be due to chance. In particular the fishermen are much less closely related in 1881 than in 1851, associated possibly with the immigration of a few new families into the area, as is suggested by the notably large increase in population size. The opposite trend is observed in the agricultural labourers, although the change in population size is not so severe. Meanwhile there is a moderate decrease in the value of Ri estimated within the farmers and the 'others', concurrent with an increase in population size – especially in the 'others'. The biological relationship within the miners fluctuates as does the population size: there is a simultaneous drop in Ri between 1861 and 1871 with a hundred-fold increase in the number of individuals, followed by a dramatic rise in the value of Ri and a small drop in population size between 1871 and 1881.

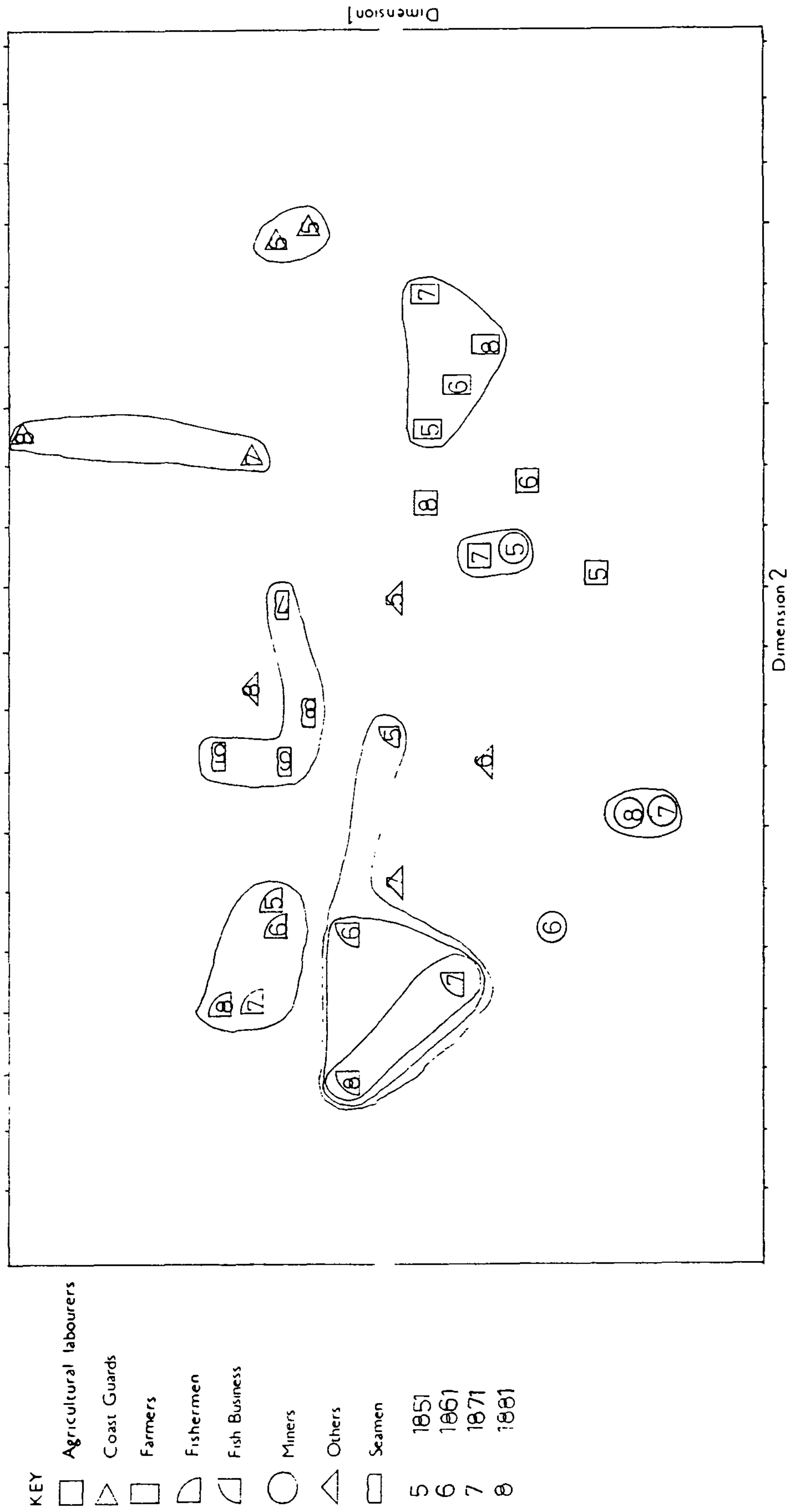


Figure 5.5. A two-dimensional representation of table 5.10

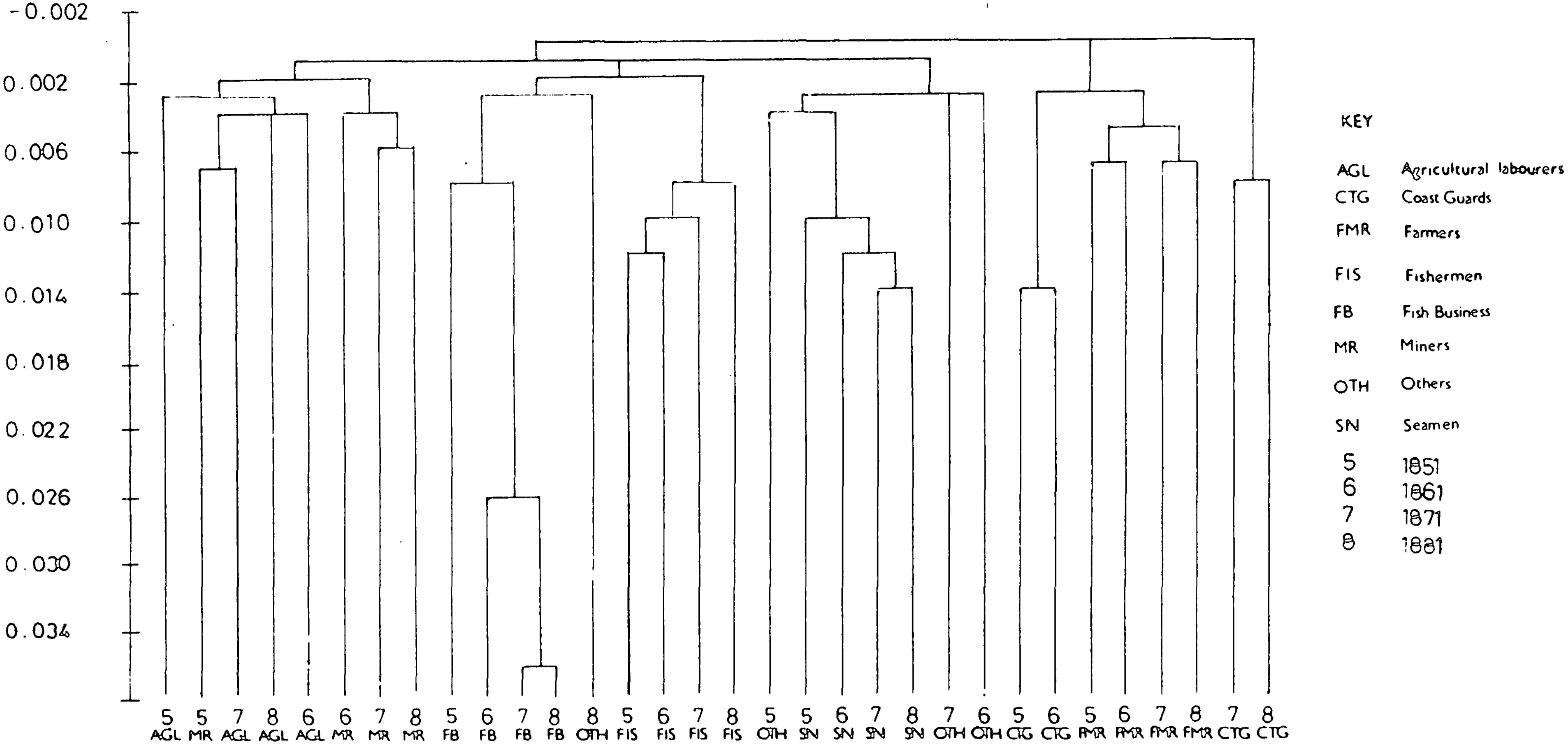
The biological relationship amongst the seamen also fluctuates, notably so between 1861 and 1871 when it substantially increases, set against a reduction in the size of the group.

The coefficient of relationship within occupational groups for different census years may be expected to decline proportionally to distances in time, so that, for example, the 1851 agricultural labourers were least closely related to the 1881 agricultural labourers. This holds true in most cases. There is, however, a surprisingly large drop in the value of Ri between, for example, the farmers in 1851 and 1861 and the miners in 1861 and 1871, so that the 1881 miners are fractionally 'closer' to the 1861 miners. This may reflect emigration from the communities; there is no evidence to support the argument that these people may simply have been away on the census-taking night. Rather more ambiguous is the disproportionately high relationship between the 1851 and 1871 seamen– offspring following in their fathers' footsteps perhaps? or census-night chance?

As in 1851 the within-group coefficients are greater than the coefficients estimated between the communities for each year, although the pattern of relationship alters over time. The very close ties estimated between the fishermen and 'fish business' in 1851 drops significantly between 1861 and 1871, only to increase a little in 1881. The relationship between the fishermen and seamen follows a similar pattern, again with an overall drop in the value of Ri. Despite this the fishermen remain more closely related to the seamen than any other occupational group. Generally the relationship decreases between the fishermen and the rest of the communities (particularly with the miners – presumably as more immigrant miners arrived), although the coast guards and agricultural labourers are less detached from the fishermen by 1881, – possibly as fishing declined, fishermen's sons sought work on land?

The relationship between the seamen and other occupational groups remains more or less stable over time with two exceptions: both the agricultural labourers and coast guards are much more nearly related to the seamen by 1881. Marked by a steady increase between the seamen and agricultural labourers (Ri = .0007 in

Figure 5.6. Cluster analysis based on table 5.10



1851 as compared to Ri = .0020 in 1881), the coast guards and seamen show an ambiguous 'high' of .0030 in 1871. Thus in comparison to 1851, the seamen are not particularly more inter-related to the other maritime occupations, but are more integrated with the entire population. A similar trend is noted in the fishermen, marked also by the drop in the value of Ri within this group itself – closing the suggested rift between the rural and coastal occupational groups.

By contrast, the 'fish business' (who were moderately inter-related with the whole community in 1851) are considerably more remote in 1881. In particular, the value of Ri drops between the 'fish business' and agricultural labourers from .0020 to .0005 in 1851 and 1881 respectively. A similar trend is observed with the coast guards, so that by the end of the period they are completely unrelated to both the miners and the 'fish business'. Indeed the affinity between all other land-based occupations tends to drop a little over time, the only exception being the farmers and agricultural labourers, between whom Ri increases from .0015 to .0021 over the decades.

Coefficients of relationship estimated between towns in sequential decades were examined above – in order to indicate gene flow between the settlements. Considering the occupational groups in the same light, the coast guards and 'fish business' appeared to be the most mobile groups.

The 1871 coast guards are much more closely related to other occupational groups in preceding and subsequent decades than the coast guards of any other decade. For example, the 'fish business', farmers, 'others', fishermen, and seamen of 1851 are all more closely related to the coast guards in 1871 than in either 1861 and 1881. Similarly the relationship is greater between the 1861 fishermen, agricultural labourers, farmers, and seamen and the 1871 coast guards, than in any other census year. The 1881 coast guards appear to be particularly independent of the earlier population – even within the coast guards themselves there is no relationship at all between the 1861 and 1881 groups. these trends are quite well indicated in figure 5.5. In all they may suggest that there must have been a very high turn-over of coast guards and that the 1871 coast guards were partially drawn from the local population (– sons of 1851/1861 fishermen, farmers, and so forth), but that by 1881 many had been replaced by officers from farther afield.

In contrast to the coast guards, there is an indication that the 'fish business' in 1871 was rather less closely related to other occupational groups than in previous or later years, and yet in 1881 they are frequently closer to other occupational groups of twenty years or more earlier. For example, the value of Ri is lower between the 1871 'fish business' and 1861 fishermen than between the latter and the 'fish business' in either 1861 or 1881. The 1871 miners are more distant from the 'fish business' in any year than the miners of 1861 or 1881. Again the 1871 farmers and seamen are more independent from the 'fish business' in 1861 and 1871 respectively than they are otherwise. This may suggest that while the 1871 'fish business' was relatively insular, the 1881 population was not, either because it attracted employees from other fields, or rather more likely (since population size drops over the period), because their offspring were entering new occupations. This is corroborated by the fact that there is a sharp decrease in the value of Ri between 1881 'fish business' and 1861 farmers and seamen, when compared to Ri estimated between the latter and the 1871 'fish business'. Moreover, since within years the 'fish business' becomes gradually more independent from the rest of the community, it does seem to suggest that it is the change in occupation of the offspring of individuals involved in the 'fish business' during 1851 and perhaps 1861 that accounts for the trends observed here.

### 3. Occupation by Town and by Census year.

Subdivision of the population on this scale gives very small samples and thus, as above, only the major occupational categories are considered. This includes the agricultural labourers, farmers, and fishermen. Here the 'others' are omitted primarily because when they are included the total number of groups (88) exceeds that allowed in the MDS-X analysis (– which handles a maximum of 80 stimuli).

Moreover, from the preceding analysis it is clear that the 'others' are quite interrelated with all occupational categories, particularly with those within the same parish, this pattern does not change over time. Despite some of the particularly small samples, the farmers are still included since they are an integral part of the agricultural community and yet constitute an independent body of people.

Despite selecting the major occupations, sample sizes are still small, the majority well below two hundred and some less than twenty (Table 5.12).

TABLE 5·12 SAMPLE SIZES FOR THE MAJOR OCCUPATIONAL GROUPS OVER TIME

| | H AGL | H FMR | ST FIS | RUN FIS | W AGL | W FIS | W FMR | RHB FIS | FYL AGL | FYL FMR | SC AGL | SC FIS | SC FMR | FIL AGL | FIL FIS | FIL FMR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 33 | 18 | 142 | 52 | 101 | 29 | 22 | 44 | 67 | 80 | 102 | 165 | 32 | 32 | 170 | 8 |
| 6 | 33 | 19 | 188 | 58 | 88 | 45 | 24 | 28 | 112 | 88 | 129 | 269 | 63 | 10 | 164 | 10 |
| 7 | 38 | 14 | 173 | 35 | 58 | 60 | 24 | 17 | 97 | 93 | 94 | 382 | 64 | 49 | 243 | 8 |
| 8 | 21 | 19 | 183 | 37 | 52 | 88 | 51 | 17 | 57 | 96 | 79 | 515 | 54 | 15 | 234 | 16 |

The coefficients of isonymy estimated within groups are therefore unreliable. Values of Ri calculated between each town's fishing and rural communities for each census year are given in table 5.13.

Such a large matrix is particularly cumbersome and difficult to interpret and the major trends are clearly illustrated in the spatial representation (Figure 5.7). Here therefore I shall concentrate on discussing the points risen by figure 5.7 rather than giving a detailed analysis of the table.

Figure 5.7 is a two-dimensional plot, derived using MDS-X. The stress is quite high (.2613), but nevertheless gives a fairly clear representation. A cluster analysis was also used (Figure 5.8) and is also indicated by the groupings in Figure 5.7).

The pattern of relationships displayed in 1851 seems to alter very little over time. The only agricultural labourers and farmers to cluster together are firstly those from Hinderwell, and secondly those from Fylingdales. In both cases they are grouped by parish, and then within that there is a partial divergence between the two occupations (Figure 5.7).

Otherwise all the rural populations are scattered, most appearing relatively inter-related with other communities, while others are isolated – indeed this is

TABLE 5.13 COEFFICIENTS OF ISONYMY WITHIN & BETWEEN EACH TOWN'S FISHING AND RURAL COMMUNITIES FOR EVERY CENSUS YEAR PT 1

| | 5 AGL H | 6 AGL H | 7 AGL H | 8 AGL H | 5 FMR H | 6 FMR H | 7 FMR H | 8 FMR H | 5 FIS ST | 6 FIS ST | 7 FIS ST | 8 FIS ST | 5 FIS RUN | 6 FIS RUN | 7 FIS RUN | 8 FIS RUN | 5 AGL W | 6 AGL W | 7 AGL W | 8 AGL W | 5 FIS W | 6 FIS W | 7 FIS W | 8 FIS W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H AGL 5 | .0234 | | | | | | | | | | | | | | | | | | | | | | | |
| H AGL 6 | .0110 | .0243 | | | | | | | | | | | | | | | | | | | | | | |
| H AGL 7 | .0056 | .0099 | .0194 | | | | | | | | | | | | | | | | | | | | | |
| H AGL 8 | .0079 | .0118 | .0094 | .0374 | | | | | | | | | | | | | | | | | | | | |
| H FMR 5 | .0076 | .0076 | .0066 | .0053 | .0432 | | | | | | | | | | | | | | | | | | | |
| H FMR 6 | .0119 | .0127 | .0090 | .0037 | .0146 | .0429 | | | | | | | | | | | | | | | | | | |
| H FMR 7 | .0097 | .0076 | .0113 | .0017 | .0158 | .0188 | .0459 | | | | | | | | | | | | | | | | | |
| H FMR 8 | .0040 | .0040 | .0048 | .0012 | .0044 | .0055 | .0263 | .0429 | | | | | | | | | | | | | | | | |
| ST FIS 5 | - | .0018 | .0015 | .0023 | .0013 | .0005 | .0010 | .0015 | .0299 | | | | | | | | | | | | | | | |
| ST FIS 6 | - | .0015 | .0021 | .0023 | .0009 | .0010 | .0005 | .0008 | .0285 | .0351 | | | | | | | | | | | | | | |
| ST FIS 7 | - | .0018 | .0022 | .0023 | .0006 | .0010 | .0010 | .0015 | .0308 | .0343 | .0390 | | | | | | | | | | | | | |
| ST FIS 8 | - | .0017 | .0021 | .0023 | .0006 | .0008 | .0006 | .0008 | .0297 | .0341 | .0363 | .0381 | | | | | | | | | | | | |
| RUN FIS 5 | - | .0008 | .0005 | .0013 | - | - | - | - | .0007 | .0002 | .0012 | .0013 | .0440 | | | | | | | | | | | |
| RUN FIS 6 | - | .0010 | .0002 | .0008 | - | - | - | - | .0005 | .0002 | .0019 | .0020 | .0321 | .0523 | | | | | | | | | | |
| RUN FIS 7 | - | .0008 | - | - | - | - | - | - | .0008 | .0003 | .0021 | .0023 | .0299 | .0495 | .0534 | | | | | | | | | |
| RUN FIS 8 | - | - | - | - | - | - | - | - | .0011 | - | .0012 | .0012 | .0205 | .0389 | .0417 | .0588 | | | | | | | | |
| W AGL 5 | .0016 | .0009 | .0014 | .0012 | .0003 | .0005 | .0003 | .0002 | .0014 | .0014 | .0015 | .0015 | .0001 | .0009 | .0008 | .0009 | .0059 | | | | | | | |
| W AGL 6 | .0014 | .0019 | .0018 | .0016 | .0016 | .0009 | .0004 | .0009 | .0027 | .0022 | .0023 | .0017 | .0001 | .0011 | .0011 | .0010 | .0025 | .0085 | | | | | | |
| W AGL 7 | .0031 | .0018 | .0016 | .0008 | .0014 | .0032 | .0031 | .0009 | .0021 | .0022 | .0017 | .0022 | .0008 | .0006 | .0010 | .0014 | .0025 | .0034 | .0122 | | | | | |
| W AGL 8 | .0032 | .0029 | .0010 | .0013 | .0021 | .0035 | .0027 | - | .0031 | .0025 | .0030 | .0028 | - | - | - | - | .0022 | .0028 | .0049 | .0162 | | | | |
| W FIS 5 | .0010 | .0010 | .0013 | .0033 | .0019 | - | - | - | .0016 | .0016 | .0015 | .0017 | .0020 | .0015 | .0019 | .0028 | .0013 | .0010 | .0015 | .0020 | .0351 | | | |
| W FIS 6 | .0023 | .0037 | .0044 | .0016 | .0031 | .0017 | .0024 | .0006 | .0007 | .0005 | .0004 | .0002 | .0015 | .0011 | .0016 | .0018 | .0009 | .0017 | .0009 | .0010 | .0111 | .0175 | | |
| W FIS 7 | .0028 | .0028 | .0026 | .0020 | .0018 | .0026 | .0018 | .0009 | .0004 | .0003 | .0002 | - | .0016 | .0017 | .0014 | .0052 | .0013 | .0017 | .0017 | .0011 | .0095 | .0081 | .0122 | |
| W FIS 8 | .0017 | .0024 | .0025 | - | .0017 | .0021 | .0016 | .0003 | .0007 | .0006 | .0006 | .0006 | .0021 | .0017 | .0021 | .0017 | .0008 | .0013 | .0016 | .0012 | .0064 | .0065 | .0058 | .0099 |
| W FMR 5 | - | .0007 | .0006 | .0021 | - | - | - | .0024 | .0025 | .0024 | .0016 | .0010 | .0004 | .0004 | - | - | .0018 | .0036 | .0051 | .0026 | .0008 | .0010 | .0015 | .0007 |
| W FMR 6 | .0006 | .0006 | .0016 | .0010 | .0023 | - | .0015 | .0022 | .0004 | .0005 | .0002 | .0003 | - | - | - | - | .0020 | .0012 | .0011 | .0016 | .0007 | .0009 | .0003 | .0002 |
| W FMR 7 | .0006 | .0006 | .0006 | - | - | - | - | - | .0032 | .0027 | .0027 | .0019 | .0004 | .0003 | .0006 | - | .0016 | .0031 | .0032 | .0040 | - | .0014 | .0003 | .0009 |
| W FMR 8 | .0015 | .0032 | .0036 | .0018 | .0027 | .0020 | .0021 | .0010 | .0025 | .0021 | .0026 | .0024 | .0002 | .0001 | - | - | .0020 | .0028 | .0017 | .0039 | .0010 | .0028 | .0018 | .0013 |
| RHB FIS 5 | - | - | - | - | - | - | - | - | .0025 | .0024 | .0016 | .0010 | - | - | - | - | .0009 | .0010 | .0017 | .0013 | .0004 | .0002 | .0015 | .0006 |
| RHB FIS 6 | - | - | - | - | - | - | - | - | .0020 | .0028 | .0018 | .0011 | - | - | - | - | .0010 | .0012 | .0021 | .0017 | .0006 | .0004 | .0018 | .0008 |
| RHB FIS 7 | - | - | - | - | - | - | - | - | .0016 | .0015 | .0010 | .0006 | - | - | - | - | .0011 | .0006 | .0010 | .0005 | - | - | .0019 | .0003 |
| RHB FIS 8 | - | - | - | - | - | - | - | - | .0016 | .0015 | .0010 | .0006 | - | - | - | - | .0008 | .0006 | .0010 | .0005 | - | - | .0014 | .0003 |
| FYL AGL 5 | .0018 | .0016 | .0013 | .0003 | .0020 | .0008 | .0016 | .0008 | .0017 | .0014 | .0010 | .0007 | .0007 | .0005 | .0008 | .0012 | .0012 | .0019 | .0029 | .0028 | .0028 | .0028 | .0022 | .0016 |
| FYL AGL 6 | .0030 | .0025 | .0024 | .0006 | .0015 | .0023 | .0025 | .0009 | .0017 | .0014 | .0012 | .0007 | .0016 | .0011 | .0019 | .0021 | .0006 | .0020 | .0031 | .0032 | .0014 | .0020 | .0015 | .0014 |
| FYL AGL 7 | .0025 | .0029 | .0017 | .0002 | .0020 | .0005 | .0011 | - | .0019 | .0017 | .0016 | .0016 | .0013 | .0010 | .0010 | .0016 | .0012 | .0022 | .0044 | .0044 | .0019 | .0023 | .0020 | .0011 |
| FYL AGL 8 | .0028 | .0016 | .0014 | .0004 | .0024 | .0018 | .0019 | .0009 | .0005 | .0006 | .0006 | .0006 | .0003 | .0003 | - | - | .0008 | .0011 | .0013 | .0020 | .0018 | .0019 | .0011 | .0009 |
| FYL FMR 5 | .0004 | .0019 | .0019 | .0006 | .0024 | .0006 | .0018 | .0006 | .0009 | .0006 | .0006 | .0002 | .0017 | .0013 | .0019 | .0027 | .0006 | .0010 | .0022 | .0014 | .0011 | .0015 | .0010 | .0010 |
| FYL FMR 6 | .0007 | .0010 | .0015 | .0002 | .0012 | .0006 | .0012 | .0006 | .0010 | .0007 | .0005 | .0004 | .0021 | .0015 | .0024 | .0034 | .0007 | .0012 | .0026 | .0012 | .0012 | .0012 | .0009 | .0009 |
| FYL FMR 7 | .0006 | .0012 | .0008 | - | .0006 | .0011 | .0004 | - | .0007 | .0005 | .0004 | .0003 | .0037 | .0029 | .0043 | .0058 | .0008 | .0013 | .0025 | .0015 | .0018 | .0016 | .0012 | .0010 |
| FYL FMR 8 | .0023 | .0022 | .0009 | - | .0008 | .0011 | .0003 | .0002 | .0005 | .0006 | .0006 | .0005 | .0022 | .0018 | .0025 | .0034 | .0013 | .0022 | .0030 | .0020 | .0030 | .0026 | .0024 | .0012 |
| SC AGL 5 | .0006 | .0009 | .0010 | .0004 | .0002 | .0013 | .0007 | .0002 | .0013 | .0010 | .0013 | .0011 | .0011 | .0008 | .0014 | .0008 | .0006 | .0008 | .0010 | .0017 | .0007 | .0013 | .0009 | .0010 |
| SC AGL 6 | .0006 | .0008 | .0025 | .0009 | .0006 | .0010 | .0025 | .0012 | .0012 | .0010 | .0012 | .0007 | .0004 | .0003 | .0004 | .0006 | .0007 | .0010 | .0015 | .0012 | .0008 | .0012 | .0008 | .0008 |
| SC AGL 7 | .0003 | .0009 | .0024 | .0007 | .0017 | .0008 | .0015 | .0008 | .0012 | .0009 | .0013 | .0007 | .0012 | .0009 | .0015 | .0008 | .0009 | .0012 | .0012 | .0019 | .0014 | .0020 | .0012 | .0011 |
| SC AGL 8 | .0013 | .0004 | - | .0003 | .0010 | .0036 | .0022 | - | .0015 | .0010 | .0009 | .0006 | .0034 | .0026 | .0034 | .0044 | .0005 | .0007 | .0020 | .0039 | .0019 | .0014 | .0013 | .0009 |
| SC FIS 5 | .0015 | .0020 | .0014 | .0007 | .0018 | .0024 | .0017 | .0011 | .0008 | .0008 | .0008 | .0008 | .0005 | .0006 | .0005 | .0001 | - | .0001 | .0005 | .0003 | .0003 | .0007 | .0007 | .0005 |
| SC FIS 6 | .0007 | .0012 | .0009 | .0008 | .0005 | .0014 | .0008 | .0005 | .0013 | .0012 | .0013 | .0011 | .0007 | .0007 | .0007 | .0003 | .0003 | .0004 | .0006 | .0009 | .0005 | .0006 | .0006 | .0003 |
| SC FIS 7 | .0001 | .0004 | .0004 | .0004 | .0011 | .0001 | .0003 | .0002 | .0009 | .0007 | .0007 | .0005 | .0003 | .0003 | .0002 | - | .0002 | .0004 | .0003 | .0006 | .0004 | .0007 | .0005 | .0003 |
| SC FIS 8 | .0002 | .0005 | .0007 | .0005 | .0008 | .0006 | .0007 | .0004 | .0007 | .0006 | .0005 | .0004 | .0003 | .0003 | .0003 | .0002 | .0003 | .0005 | .0006 | .0010 | .0006 | .0007 | .0006 | .0004 |
| SC FMR 5 | .0004 | .0023 | .0041 | .0007 | .0008 | .0008 | .0033 | - | .0009 | - | - | - | .0054 | .0040 | .0067 | .0076 | .0007 | .0005 | .0019 | .0003 | .0016 | .0021 | .0013 | .0016 |
| SC FMR 6 | .0009 | .0005 | .0008 | .0007 | .0022 | .0004 | .0005 | - | .0007 | .0001 | - | - | .0024 | .0016 | .0027 | .0038 | .0005 | .0009 | .0016 | .0012 | .0011 | .0012 | .0013 | .0013 |
| SC FMR 7 | .0002 | .0007 | .0006 | .0011 | .0013 | - | - | .0004 | .0020 | .0020 | .0018 | .0016 | .0030 | .0027 | .0033 | .0036 | .0005 | .0006 | .0009 | .0007 | .0016 | .0008 | .0005 | .0002 |
| SC FMR 8 | .0008 | - | .0002 | .0017 | .0041 | .0009 | .0006 | .0009 | .0005 | .0006 | .0002 | .0004 | .0002 | .0001 | .0002 | - | .0004 | .0009 | .0013 | .0026 | .0016 | .0014 | .0001 | .0006 |
| FIL AGL 5 | .0004 | - | - | - | - | - | - | - | .0003 | .0001 | - | - | - | - | - | - | .0011 | .0007 | .0019 | .0018 | .0016 | .0003 | .0010 | .0002 |
| FIL AGL 6 | - | - | - | - | - | - | - | - | .0028 | .0026 | .0017 | .0011 | - | - | - | - | .0005 | .0022 | .0034 | .0019 | - | .0011 | - | .0005 |
| FIL AGL 7 | .0015 | .0003 | .0002 | .0005 | .0011 | .0032 | .0022 | .0005 | .0010 | .0007 | .0010 | .0010 | - | - | - | - | .0005 | .0007 | .0014 | .0035 | .0007 | .0016 | .0003 | .0003 |
| FIL AGL 8 | - | - | .0009 | - | - | - | - | .0017 | - | - | - | - | - | - | - | - | .0003 | .0011 | .0011 | - | - | .0007 | .0005 | .0004 |
| FIL FIS 5 | .0008 | .0004 | .0005 | .0003 | .0010 | .0003 | .0002 | .0014 | .0003 | .0007 | .0004 | .0003 | - | - | - | - | .0006 | .0009 | .0015 | .0017 | .0004 | .0006 | .0004 | .0009 |
| FIL FIS 6 | .0006 | .0003 | .0006 | .0001 | .0007 | .0003 | .0002 | .0016 | - | .0007 | .0004 | .0003 | - | - | - | - | .0005 | .0009 | .0011 | .0011 | .0002 | .0006 | .0005 | .0008 |
| FIL FIS 7 | .0004 | .0002 | .0008 | .0003 | .0009 | .0002 | .0003 | .0017 | .0002 | .0001 | .0001 | .0001 | - | - | - | - | .0006 | .0010 | .0012 | .0010 | .0005 | .0006 | .0005 | .0007 |
| FIL FIS 8 | .0006 | - | .0005 | .0004 | .0015 | .0003 | - | .0018 | .0001 | .0001 | - | .0001 | - | - | - | - | .0006 | .0011 | .0014 | .0014 | .0005 | .0008 | .0007 | .0009 |
| FIL FMR 5 | .0019 | - | - | .0030 | .0069 | .0066 | .0044 | - | .0009 | .0010 | .0003 | .0007 | - | - | - | - | - | .0021 | .0011 | .0038 | .0021 | .0014 | - | - |
| FIL FMR 6 | .0045 | - | - | - | - | .0184 | .0107 | - | - | - | - | - | - | - | - | - | .0005 | .0011 | .0026 | .0086 | - | - | - | .0005 |
| FIL FMR 7 | .0038 | - | - | - | - | .0066 | .0044 | - | - | - | - | - | - | - | - | - | .0013 | .0014 | .0043 | .0072 | - | - | - | .0014 |
| FIL FMR 8 | .0019 | 0009 | .0033 | .0030 | .0034 | .0033 | .0044 | - | .0004 | .0005 | .0002 | .0003 | .0006 | - | - | - | .0021 | .0025 | .0043 | .0078 | .0032 | .0021 | .0015 | .0018 |

TABLE 5-13 PT 2.

| | 5 FMR W | 6 FMR W | 7 FMR W | 8 FMR W | 5 FIS RHB | 6 FIS RHB | 7 FIS RHB | 8 FIS RHB | 5 AGL FYL | 6 AGL FYL | 7 AGL FYL | 8 AGL FYL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W FMR 5 | .0268 | | | | | | | | | | | |
| W FMR 6 | .0038 | 0243 | | | | | | | | | | |
| W FMR 7 | .0038 | .0087 | 0260 | | | | | | | | | |
| W FMR 8 | .0035 | .0077 | .0086 | .0167 | | | | | | | | |
| RHB FIS 5 | .0041 | - | .0019 | - | .0821 | | | | | | | |
| RHB FIS 6 | .0038 | | .0022 | - | .0856 | .0931 | | | | | | |
| RHB FIS 7 | .0026 | - | .0012 | - | .0962 | .1061 | .1505 | | | | | |
| RHB FIS 8 | .0026 | - | .0012 | - | .1103 | .1197 | .1678 | .1989 | | | | |
| FYL AGL 5 | .0020 | .0006 | .0022 | .0014 | .0020 | .0024 | .0013 | .0013 | .0137 | | | |
| FYL AGL 6 | .0016 | .0015 | .0016 | .0017 | .0017 | .0019 | .0010 | .0010 | .0060 | .0104 | | |
| FYL AGL 7 | .0016 | .0013 | .0013 | .0024 | .0010 | .0011 | .0006 | .0006 | .0061 | .0067 | .0124 | |
| FYL AGL 8 | .0004 | .0007 | .0003 | .0014 | .0052 | .0056 | .0093 | .0103 | .0025 | .0040 | .0047 | .0155 |
| FYL FMR 5 | .0005 | .0005 | .0021 | .0013 | .0007 | .0009 | .0003 | .0003 | .0059 | .0049 | .0055 | .0037 |
| FYL FMR 6 | .0010 | .0004 | .0014 | .0006 | .0010 | .0012 | .0010 | .0006 | .0038 | .0050 | .0047 | .0043 |
| FYL FMR 7 | .0007 | .0004 | .0013 | .0009 | .0005 | .0006 | .0003 | .0003 | .0038 | .0053 | .0047 | .0047 |
| FYL FMR 8 | - | .0004 | .0013 | .0016 | .0001 | - | - | - | .0043 | .0056 | .0063 | .0055 |
| SC AGL 5 | .0006 | - | .0008 | .0010 | .0001 | .0002 | - | - | .0004 | .0010 | .0008 | .0014 |
| SC AGL 6 | .0016 | .0003 | .0008 | .0007 | .0009 | .0011 | .0004 | .0004 | .0008 | .0013 | .0011 | .0011 |
| SC AGL 7 | .0009 | .0006 | .0013 | .0012 | .0007 | .0009 | - | - | .0009 | .0009 | .0011 | .0006 |
| SC AGL 8 | .0011 | .0002 | .0010 | .0007 | .0020 | .0025 | .0018 | .0015 | .0011 | .0022 | .0013 | .0013 |
| SC FIS 5 | .0007 | .0002 | .0001 | .0006 | .0003 | .0004 | .0002 | .0002 | .0005 | .0004 | .0006 | .0003 |
| SC FIS 6 | .0006 | - | .0007 | .0005 | .0005 | .0006 | .0002 | .0002 | .0003 | .0004 | .0006 | .0001 |
| SC FIS 7 | .0006 | .0002 | .0006 | .0004 | .0008 | .0010 | .0006 | .0005 | .0005 | .0006 | .0008 | .0005 |
| SC FIS 8 | .0004 | .0003 | .0004 | .0002 | .0007 | .0009 | .0004 | .0004 | .0005 | .0006 | .0006 | .0003 |
| SC FMR 5 | - | - | - | .0009 | - | - | - | - | .0011 | .0030 | .0021 | .0011 |
| SC FMR 6 | .0003 | .0003 | .0010 | .0006 | .0002 | .0003 | - | - | .0010 | .0015 | .0014 | .0018 |
| SC FMR 7 | .0014 | .0010 | .0013 | .0015 | .0007 | .0008 | .0004 | .0004 | .0013 | .0010 | .0012 | .0015 |
| SC FMR 8 | - | .0015 | .0015 | .0014 | .0002 | .0003 | - | - | .0011 | .0006 | .0004 | .0018 |
| FIL AGL 5 | - | - | .0006 | - | .0003 | .0005 | - | - | .0030 | .0008 | .0019 | .0005 |
| FIL AGL 6 | .0068 | - | .0021 | - | .0045 | .0053 | .0029 | .0029 | .0037 | .0040 | .0036 | - |
| FIL AGL 7 | .0004 | .0008 | .0004 | .0012 | .0002 | .0003 | - | - | .0003 | .0008 | .0005 | .0010 |
| FIL AGL 8 | - | - | - | - | - | - | - | - | .0005 | .0006 | - | - |
| FIL FIS 5 | .0005 | .0007 | .0010 | .0003 | - | .0001 | - | - | .0002 | .0005 | .0003 | .0008 |
| FIL FIS 6 | .0004 | .0009 | .0007 | .0002 | - | - | - | - | .0001 | .0005 | .0003 | .0006 |
| FIL FIS 7 | .0007 | .0008 | .0005 | .0004 | - | - | - | - | .0003 | .0004 | .0004 | .0005 |
| FIL FIS 8 | .0008 | .0007 | .0007 | .0004 | - | - | - | - | .0004 | .0005 | .0004 | .0007 |
| FIL FMR 5 | - | .0026 | - | .0024 | - | - | - | - | .0009 | .0028 | .0006 | .0044 |
| FIL FMR 6 | | - | - | - | - | - | - | - | - | .0044 | - | .0026 |
| FIL FMR 7 | | - | .0026 | - | - | - | - | - | - | .0022 | - | .0022 |
| FIL FMR 8 | .0014 | .0013 | .0013 | .0006 | .0014 | .0022 | - | - | .0004 | .0014 | .0013 | .0022 |

| | 5 FMR FYL | 6 FMR FYL | 7 FMR FYL | 8 FMR FYL | 5 AGL SC | 6 AGL SC | 7 AGL SC | 8 AGL SC | 5 FIS SC | 6 FIS SC | 7 FIS SC | 8 FIS SC | 5 FMR SC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FYL FMR 5 | .0133 | | | | | | | | | | | | |
| FYL FMR 6 | .0081 | .0110 | | | | | | | | | | | |
| FYL FMR 7 | .0074 | .0083 | .0140 | | | | | | | | | | |
| FYL FMR 8 | .0066 | .0077 | .0112 | .0178 | | | | | | | | | |
| SC AGL 5 | .0006 | .0006 | .0009 | .0003 | .0055 | | | | | | | | |
| SC AGL 6 | .0012 | .0012 | .0008 | .0005 | .0011 | .0052 | | | | | | | |
| SC AGL 7 | .0012 | .0005 | .0007 | .0011 | .0014 | .0017 | .0070 | | | | | | |
| SC AGL 8 | .0016 | .0013 | .0017 | .0013 | .0013 | .0012 | .0017 | .0100 | | | | | |
| SC FIS 5 | .0004 | .0003 | .0002 | .0004 | .0003 | .0005 | .0010 | .0007 | .0072 | | | | |
| SC FIS 6 | .0004 | .0002 | .0002 | .0005 | .0005 | .0006 | .0013 | .0009 | .0042 | .0062 | | | |
| SC FIS 7 | .0005 | .0003 | .0002 | .0006 | .0004 | .0005 | .0012 | .0007 | .0035 | .0038 | .0045 | | |
| SC FIS 8 | .0005 | .0003 | .0002 | .0005 | .0005 | .0006 | .0012 | .0011 | .0029 | .0035 | .0030 | .0036 | |
| SC FMR 5 | .0035 | .0035 | .0032 | .0019 | .0017 | .0017 | .0016 | .0023 | .0004 | .0004 | .0003 | .0003 | .0215 |
| SC FMR 6 | .0031 | .0024 | .0018 | .0010 | .0008 | .0011 | .0011 | .0021 | .0003 | .0005 | .0004 | .0005 | .0069 |
| SC FMR 7 | .0021 | .0018 | .0018 | .0010 | .0006 | .0006 | .0008 | .0014 | .0012 | .0015 | .0010 | .0006 | .0039 |
| SC FMR 8 | .0006 | .0004 | .0003 | .0002 | .0007 | .0003 | .0008 | .0017 | .0003 | .0003 | .0005 | .0005 | .0006 |
| FIL AGL 5 | .0033 | .0014 | .0017 | .0005 | .0004 | .0008 | .0008 | .0016 | .0004 | .0004 | .0005 | .0007 | .0005 |
| FIL AGL 6 | .0012 | .0011 | .0011 | .0015 | - | .0008 | - | .0006 | .0003 | .0005 | .0006 | .0005 | - |
| FIL AGL 7 | .0006 | .0004 | .0004 | .0004 | .0008 | .0004 | .0008 | .0028 | .0003 | .0007 | .0006 | .0008 | - |
| FIL AGL 8 | .0016 | .0007 | .0014 | - | .0006 | .0005 | .0007 | .0004 | .0002 | .0006 | .0003 | .0006 | - |
| FIL FIS 5 | .0002 | .0004 | .0003 | .0002 | .0006 | .0004 | .0005 | .0005 | .0043 | .0057 | .0042 | .0046 | .0005 |
| FIL FIS 6 | .0002 | .0003 | .0002 | .0002 | .0004 | .0003 | .0004 | .0004 | .0042 | .0053 | .0041 | .0045 | .0001 |
| FIL FIS 7 | .0002 | .0003 | .0001 | .0001 | .0005 | .0004 | .0007 | .0003 | .0031 | .0038 | .0032 | .0035 | .0004 |
| FIL FIS 8 | .0002 | .0003 | .0002 | .0002 | .0005 | .0004 | .0006 | .0005 | .0029 | .0035 | .0029 | .0033 | - |
| FIL FMR 5 | .0015 | .0014 | .0006 | - | .0006 | .0005 | .0006 | .0047 | .0007 | .0002 | .0006 | .0007 | .0019 |
| FIL FMR 6 | - | .0005 | .0011 | - | .0014 | .0011 | - | .0095 | - | - | - | .0008 | - |
| FIL FMR 7 | - | .0007 | .0006 | .0006 | .0018 | .0014 | - | .0047 | - | .0002 | - | .0003 | - |
| FIL FMR 8 | .0011 | .0007 | .0003 | .0003 | .0021 | .0031 | .0036 | .0055 | .0009 | .0016 | .0013 | .0022 | .0019 |

| | 6 FMR SC | 7 FMR SC | 8 FMR SC | 5 AGL FIL | 6 AGL FIL | 7 AGL FIL | 8 AGL FIL | 5 FIS FIL | 6 FIS FIL | 7 FIS FIL | 8 FIS FIL | 5 FMR FIL | 6 FMR FIL | 7 FMR FIL | 8 FMR FIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SC FMR 6 | .0142 | | | | | | | | | | | | | | |
| SC FMR 7 | .0038 | .0117 | | | | | | | | | | | | | |
| SC FMR 8 | .0013 | .0026 | .0158 | | | | | | | | | | | | |
| FIL AGL 5 | .0017 | .0007 | .0003 | .0234 | | | | | | | | | | | |
| FIL AGL 6 | - | .0008 | - | - | .0700 | | | | | | | | | | |
| FIL AGL 7 | .0005 | .0005 | .0030 | .0041 | .0030 | .0164 | | | | | | | | | |
| FIL AGL 8 | - | .0005 | - | .0031 | - | .0027 | .0333 | | | | | | | | |
| FIL FIS 5 | .0015 | .0002 | .0015 | .0012 | - | .0008 | .0013 | .0318 | | | | | | | |
| FIL FIS 6 | .0006 | .0002 | .0012 | .0003 | - | .0007 | .0014 | .0318 | .0347 | | | | | | |
| FIL FIS 7 | .0006 | .0002 | .0011 | .0004 | .0002 | .0009 | .0020 | .0236 | .0254 | .0210 | | | | | |
| FIL FIS 8 | .0006 | .0002 | .0013 | .0011 | .0002 | .0011 | .0023 | .0213 | .0229 | .0185 | .0193 | | | | |
| FIL FMR 5 | .0010 | .0058 | .0069 | - | - | .0051 | - | .0011 | .0007 | .0010 | .0010 | .0781 | | | |
| FIL FMR 6 | - | - | .0037 | - | - | .0092 | - | .0003 | .0003 | .0006 | .0004 | .0375 | .0900 | | |
| FIL FMR 7 | .0020 | - | .0034 | - | - | .0038 | .0041 | .0037 | .0026 | .0018 | .0024 | .0156 | .0250 | .0781 | |
| FIL FMR 8 | .0025 | .0005 | .0052 | .0019 | - | .0038 | .0021 | .0024 | .0017 | .0016 | .0020 | .0117 | .0093 | .0117 | .0351 |

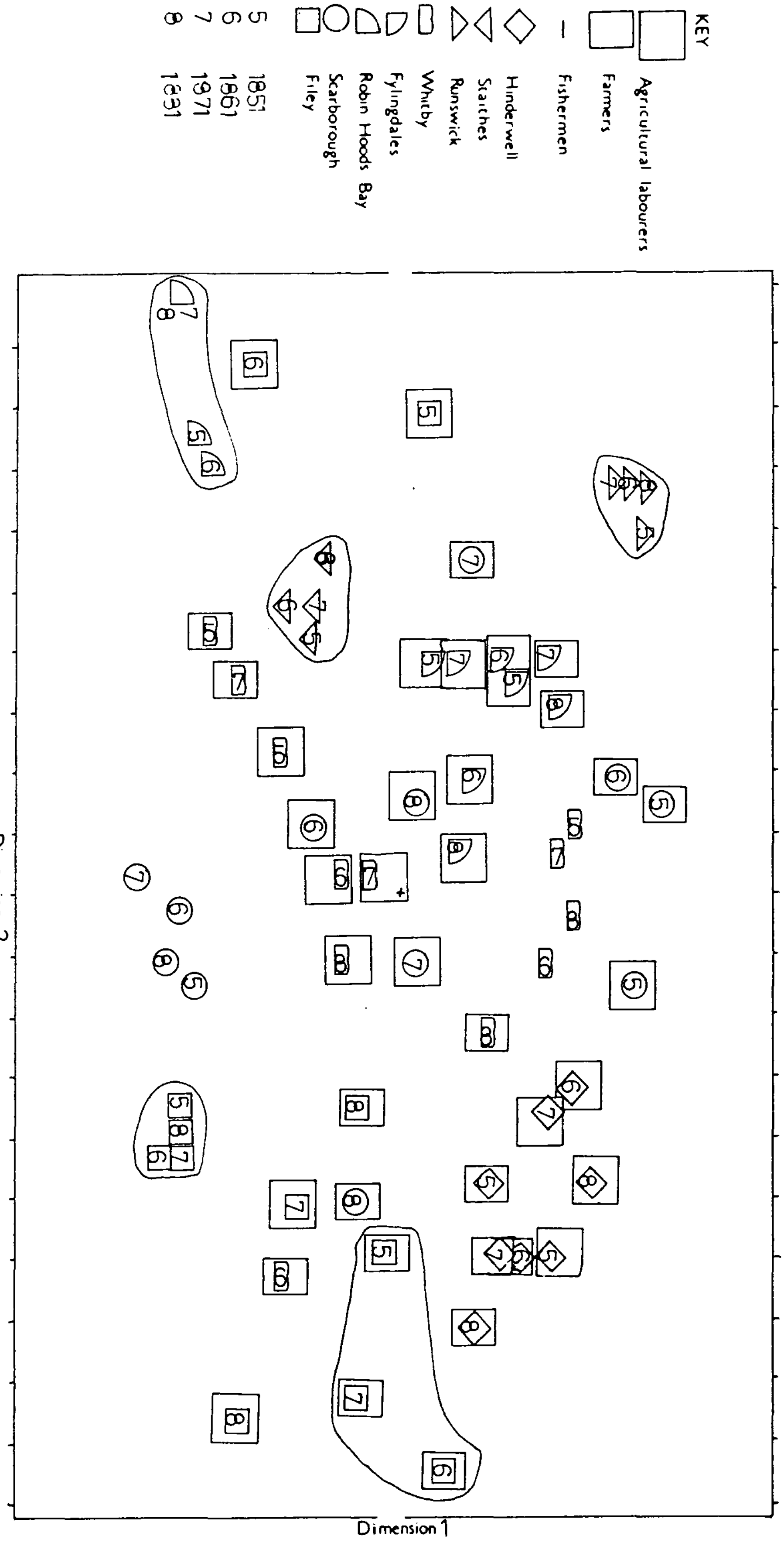


Figure 5.7. A two-dimensional representation of table 5.13

particularly true of the Filey agricultural labourers. It may be concluded therefore that the ties amongst these groups are uninfluenced by geography, socio-economic factors, or time, – which suggests that the rural population were fairly mobile.

The Filey farmers, while being a comparitively cohesive group, are incongruously related to the wider population. They are closest to Hinderwell which is geographically the most distant from Filey. The particularly small Filey sample is notable.

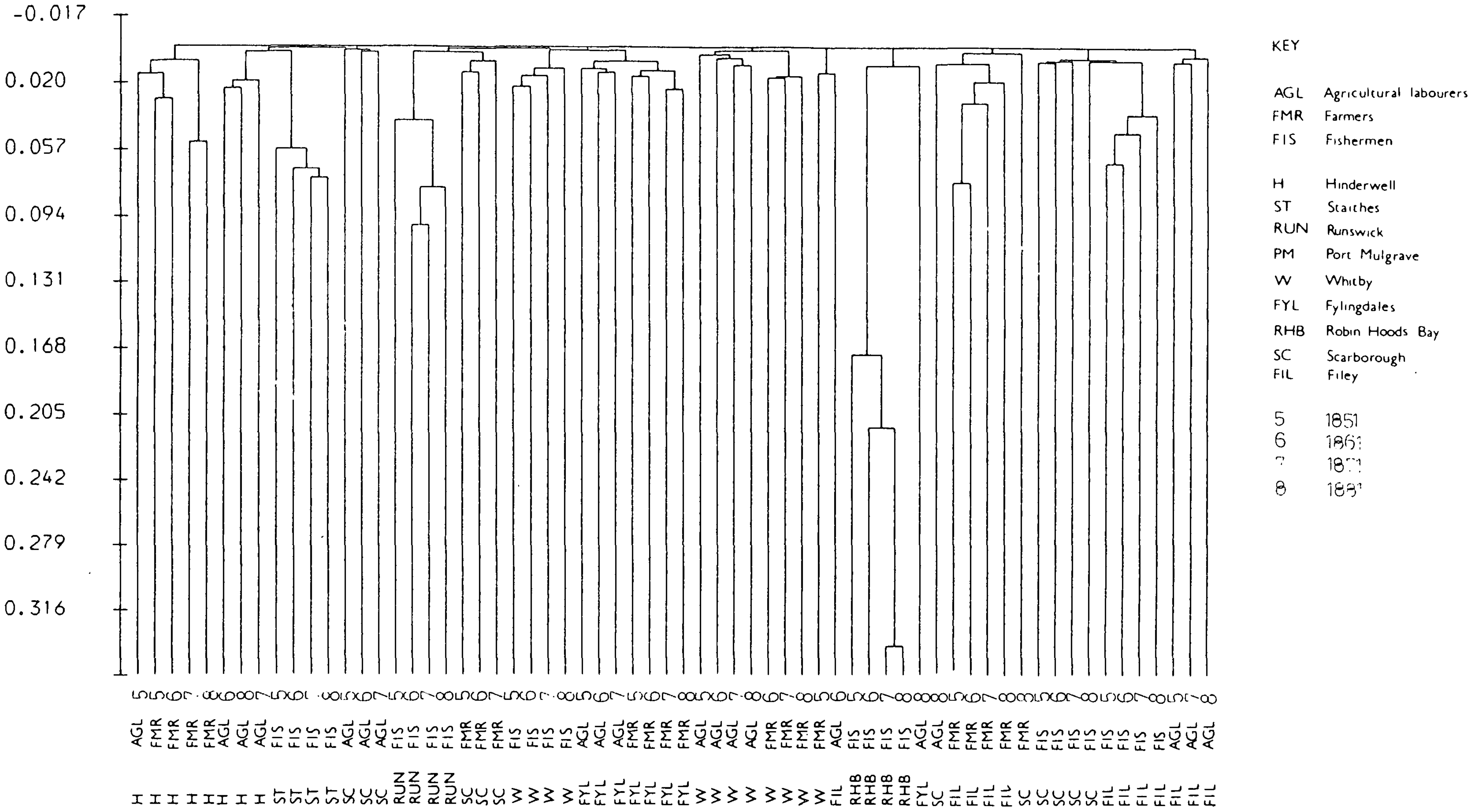
It is clear from figure 5.7 that the fisher towns are all very independent from the rural population and furthermore from each other as well, – falling into six tight clusters. Whitby's fishermen, however, are relatively closely related to the rural population of Hinderwell, Fylingdales, and, in 1851, Scarborough, this may be due to Whitby's only recent growth as a fishing port. Scarborough's and Filey's fishermen tend to cluster together away from the other coastal villages (and also from their own rural populations). It is interesting that this tendency is not as marked in the rural population.

Staithes and Runswick fishermen are remarkably independent of each other and Hinderwell rural population, in view of the fact that they are all part of the same parish and lie within only a couple of miles of each other. Indeed from table 5.13 it appears that Hinderwell farmers and Runswick fishermen are completely unrelated.

Robin Hood's Bay fishermen are perhaps the most cut off from surrounding inhabitants and are distanced from the rural population within the parish; Hinderwell agricultural labourers and farmers; all the Filey populations (particularly the fishermen); and finally Runswick fishermen, to whom they are completely unrelated. Staithes fishermen, on the other hand, are relatively 'close' to Robin Hood's Bay fishermen.

Despite the apparent insularity of the Robin Hood's Bay fishermen in figure 5.7, it is worth remembering that the above analysis ('by town and over time') showed that in fact the whole village, fishermen and shopkeepers alike, was the most closely knit of all the villages studied. Why, however, were the fishermen

Figure 5.8. Cluster analysis based on table 5.13



of this village so independent? One possible solution may be in the fact that the inshore fishing industry was on the decline in the latter part of the 19th century, and that the fishing populace of this village in particular was decreasing (table 5.12) and was likely to be comprised of the traditional fisher families rather than new-comers from ‘outside’.

As a whole, the fishing populace grew (see table 5.10) and by 1881 it was much less tightly knit than it had been in 1851 (see above, ‘by occupation’). However, from the subdivision in this section of the analysis, it is clear that the increase in numbers mainly occurred in Scarborough, and then, secondarily, in Filey, Whitby and Staithes.

In Robin Hood’s Bay and Runswick the numbers actually dropped. The concomitant boom of the herring fishery and decline of the traditional inshore industry accounts for this: the larger boats used were impracticable in the smaller harbours.

Despite such large population increases, the fishing communities generally remain strongly independent of each other and the rural population. By contrast the land based occupations are much more diffuse, only Fylingdales’ and Hinderwells’ populations forming cohesive groups. Overall therefore from this analysis it seems likely that, in comparison to the agriculturalists, the individual villages may well conform to a stepping-stone situation as insular ‘island-like’ settlements distributed linearly along the coast. The subsequent migration analyses should indicate whether or not these ‘populations’ exchanged migrants with their neighbours, or whether migration originated from alternative sources.

# Chapter 6

# The Migration Matrix Analysis

## Methods

Malecot's migration matrix method was used. While I have outlined the method above, it is necessary to show how the various elements of the equation (equation 1.5) are derived.

Initially, one starts with the raw migration matrix M (table 6.1). Here I took fishermen offspring migration data for 1881 as an example. Essentially, the elements of M, $m_{ij}$, are the number of children born in the $i^{th}$ population (rows) whose fishermen-fathers are born in the $j^{th}$ population (columns). Here there are six populations: the fishing communities of Staithes, Runswick, Whitby, Robin Hood's Bay, Scarborough and Filey. (In table 6.1, I have named the villages, however, hereafter I shall refer to them as populations 1,2,3,4,5,6,and L.D. for the long distance category respectively).

I have chosen to make matrix M symmetric, $M^s$ (table 6.2), since this conforms more closely to the model's assumption of constant population size through time. $M^s$ was then made column stochastic (in other words, a backward transition matrix) P (table 6.3). This was done simply by dividing each column element by the column total. Matrix P gives the probability that an allele originating in $S_i$ will now be in $S_j$. $P'$ is the transpose of P which is equal to P if M is symmetric. From equation 1.5, 'S' is a diagonal matrix of elements $1 - S_k$. $S_k$, the systematic pressure value, theoretically covers the effects of linear selection, mutation, and long range migration. However, since linear selection and mutation cannot be measured and their effects are usually negligible (Jorde 1980), I have followed other authors (for example, Morton 1973b, Mielke *et al.* 1976) in measuring systematic pressure as the proportion of long range migration into the population. More precisely, it is given by the proportion of genes that originate from outside the study area for each subdivision. This is obtained by referring back to the raw migration matrix M and

## FISHERMEN-OFFSPRING MIGRATION DATA (1881), USED TO ILLUSTRATE MALECOTS MIGRATION MATRIX METHOD.

| | STAITHES | RUNSWICK | WHITBY | R.H.B. | SCARBRO. | FILEY |
|---|---|---|---|---|---|---|
| STAITHES | 239 | 0 | 0 | 0 | 8 | 0 |
| RUNSWICK | 0 | 55 | 6 | 0 | 0 | 0 |
| WHITBY | 0 | 0 | 104 | 0 | 0 | 1 |
| R.H.B. | 0 | 0 | 0 | 14 | 0 | 0 |
| SCARBRO. | 1 | 0 | 0 | 0 | 324 | 3 |
| FILEY | 0 | 0 | 0 | 0 | 30 | 172 |
| (L.D. | 0 | 0 | 38 | 0 | 231 | 36) |
| (COL.TOT. | 240 | 55 | 148 | 14 | 593 | 206) |

TABLE 6.1 THE RAW MIGRATION MATRIX M.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 239 | 0 | 0 | 0 | 4.5 | 0 |
| 2 | 0 | 55 | 3 | 0 | 0 | 0 |
| 3 | 0 | 3 | 104 | 0 | 0 | .5 |
| 4 | 0 | 0 | 0 | 14 | 0 | 0 |
| 5 | 4.5 | 0 | 0 | 0 | 324 | 16.5 |
| 6 | 0 | 0 | .5 | 0 | 16.5 | 172 |

TABLE 6.2 THE SYMMETRIC MIGRATION MATRIX Ms.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | .9815 | 0 | 0 | 0 | .0131 | 0 |
| 2 | 0 | .9483 | .0279 | 0 | 0 | 0 |
| 3 | 0 | .0517 | .9674 | 0 | 0 | .0027 |
| 4 | 0 | 0 | 0 | 1.0000 | 0 | 0 |
| 5 | .0185 | 0 | 0 | 0 | .9391 | .0873 |
| 6 | 0 | 0 | .0047 | 0 | .0478 | .9101 |

TABLE 6.3 THE COLUMN STOCHASTIC MATRIX P.

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 0 |  |  |  |  |  |
| 2 |  | 0 |  |  |  |  |
| 3 |  |  | .2568 |  |  |  |
| 4 |  |  |  | 0 |  |  |
| 5 |  |  |  |  | .3895 |  |
| 6 |  |  |  |  |  | .1456 |

TABLE 6.4 THE DIAGONAL MATRIX OF Sk (SYSTEMATIC PRESSURE VALUE FOR EACH POPULATION.)

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 |  |  |  |  |  |
| 2 |  | 1 |  |  |  |  |
| 3 |  |  | .7432 |  |  |  |
| 4 |  |  |  | 0 |  |  |
| 5 |  |  |  |  | .6105 |  |
| 6 |  |  |  |  |  | .8444 |

TABLE 6.5 THE VALUES OF S.(1-Sk)

| TOTAL | POPULATION SIZES. | -3 | EFFECTIVE POPULATION SIZES |
|---|---|---|---|
| 1 | 539 |  | 179.6 |
| 2 | 93 |  | 30.6 |
| 3 | 288 |  | 96 |
| 4 | 37 |  | 12.3 |
| 5 | 1448 |  | 482.6 |
| 6 | 620 |  | 206.6 |

TABLE 6.6 POPULATION SIZE.

dividing each long distance element by the column total (table 6.1). In this case it gives the number of fathers born outside, who have children in each village (table 6.4). The element 'S' of the equation (1.5) is obtained by the sum $1 - S_k$ (table 6.5).

Genetic Drift is considered by the factor $D^{(r-1)}$, which is a diagonal matrix with elements

$$\frac{1 - {\Phi_{kk}}^{(r-1)}}{2N_k} \qquad 6.1$$

(where $N_k$ is the effective population size of the $k^{th}$ subdivision). I have assumed that the effective population size is a third of the total population size (table 6.6). $\Phi_{kk}$ is the kinship within each colony. As Morton 1973b first suggested, and as used by Mielke 1976 and Eriksson *et al.* (1973), endogamy may be estimated by $(2p_{ii} - 1)$. This may easily be calculated from matrix P (table 6.3). For example, for Staithes fishing community in 1881 $(2p_{ii} - 1)$ is

$$(2 \times .9795) - 1 = .959$$

The matrix of kinship coefficients ($\Phi$) may then be predicted using equation 1.5. The $\Phi$ matrix can then be transformed to Harpending and Jenkins's R matrix, from which the value of $F_{ST}$ may be predicted (see above).

To obtain my results I used a computer program written by L.B. Jorde. I have, however, modified his calculation of the element $D^{(r-1)}$ which allows for genetic drift. He assumed that $\Phi_{kk}$ (the kinship within each colony) used in equation 6.1, always had a value of one. This seemed to me to be an an over-simplification. Since the potential for genetic drift depends upon population size and the degree of inbreeding within a population, it seemed a plausible alternative to estimate the drift element ($D^{(r-1)}$) by using the population size (of each colony) and endogamy $(2p_{ii} - 1)$ (which can be calculated from the data) rather than the population size and kinship within each colony ($\Phi_{kk}$) (which cannot be estimated with any accuracy from the data.) While endogamy is quite clearly distinct from kinship within a population and the two are not inter-changeable, it does seem that the use of endogamy and population size could quite reasonably provide an approximate, but more realistic guide to the potential for genetic drift. I have therefore changed the program to read in a value

'EN' for endogamy in the place of Jorde's '1' in the program. ('EN' is calculated as above by the formula $(2p_{ii} - 1)$ from matrix P.)

The program reads in an input file giving:

1. The number of population subdivisions, and on the same line, the value of convergence (*i.e.* the value at which the matrix will not change from iteration to iteration). I have this constant for all my data, a value of 1,E-08.
2. The value of $S_k$ for each subdivision.
3. The total population sizes.
4. The values of EN (endogamy) for each subdivision.
5. The Raw Migration Matrix M.

The output file lists the results. I have also adjusted the format of the write statements from Jorde's original program.

## Materials.

For my analysis I used parent-offspring migration data. Father-offspring and mother-offspring data were considered separately; (it is possible then to compare the two and to test whether female is equivalent to male-migration – an important assumption of isonymy). Each parent was counted once for each of his/her children.

On the evidence of the raw migration data, isonymy, and the social history of the area, it appeared to be more appropriate to consider the occupational classes separately for each year, rather than taking the total populations of each town, for the varying levels of endogamy and markedly different patterns of migration between the rural and seafaring classes makes it clear that these are two separate communities.

As in the above example, six populations were considered for the fishermen. For the agricultural labourers and the farmers, the rural populations included in the matrix vary from the fishing villages. They are the localities of Hinderwell, Whitby, Fylingdales, Scarborough and Filey. These are refered to in the results as populations 1,2,3,4,5 and L.D. for long distance respectively.

I also tried using a category called 'local' for both the fisherman and the rural folk as respectively the 7th and 6th additional populations. It is a very large homogeneous colony, a composite of many villages surrounding the coast. It is defined as the area immediately outside the study region from which the remaining 90% of individuals originate. The area may extend to Cleveland from Staithes, and to Hull from Scarborough: it changes with each community. I attempted to include it as a population since it is comprised of such immediately neighbouring villages and it seemed that these did not comply with the notion of 'long distance' migrants, although they were outside my actual study area.

However, taking selected occupational groups from their specific villages (and the additional colony of 'local') posed several problems in estimating population size. At first the total population sizes of Staithes, Hinderwell, Whitby *etc.* were taken as they were given in the censuses. On the other hand, what is the population size of a large undefined (in terms of geographical boundaries) sub-group such as 'local'? Moreover, and particularly in Scarborough and Whitby, the fishing communities are but a tiny part of the complete town and, according to local history, an independent insular body occupying but one sector, socially distinct, and in reality a population within a population. Is it really correct therefore to take the total population size of each town?

The problem of the sub-group 'local' was solved by giving it a large arbitrary size of 100,000, for it is a large random area, encompassing (theoretically) a large homogeneous gene pool.

On account of the other query, it was decided to consider the problem from two perspectives. On the one hand, the total population sizes for each town and village were taken on the basis that the different occupational classes may potentially marry into the others: to take, for example, the fishing community only may artificially reduce the population size. On the other hand, given the hierarchical subdivision of the fishing villages/towns, this is likely considerably to over-estimate population size, dramatically reducing the potential for random genetic drift. Thus a second estimation of population size was made, taking only the appropriate occupational community.

In the first instance, population sizes were taken from the census records of 1851, 1861, 1871 and 1881 (table 6.7). In the second, the sizes were carefully estimated from my data using the SPSSX package. I ran four programs (using the fishing community as an example) to extract the following:

1. The total number of fishermen: this excludes all 'sons', but gives all the married and unmarried men, with and without children, resident in each town/village.
2. All the single or widowed fisherwomen: this excluded all wives and all daughters, but includes all the other women resident in each town/village, occupied as fish-net menders, *flitherers*, fishermen's widows *etc.*, and which are therefore part of the fisher community.
3. All married fisherwomen: this excludes the above (2) and all daughters, but gives the number of fisherwives resident in each town/village.
4. All fisher-children: this includes any male or female classified as a son or daughter in a fisherman's, fishwife's, or fishwidow's household. It also includes any person classified by occupation as a fisherman's son or daughter.

The size of each fishing community was determined by the total number of individuals drawn from all four categories. To take the fishermen of 1881 as an example once more, this is demonstrated in table 6.8.

TABLE 6.7 TOTAL POPULATION SIZES OF EACH TOWN/VILLAGE, AS GIVEN IN THE CENSUSES.

| | 1851 | 1861 | 1871 | 1881 |
|---|---|---|---|---|
| STAITHES | 1126 | 1325 | 1307 | 1330 |
| RUNSWICK | 335 | 430 | 369 | 285 |
| HINDERW. | 275 | 809 | 925 | 857 |
| WHITBY | 11674 | 11675 | 12749 | 13763 |
| R.H.B. | 867 | 900 | 732 | 707 |
| FYLINGD. | 884 | 822 | 826 | 735 |
| SCARBRO. | 44810 | 43061 | 44440 | 43103 |
| FILEY | 1500 | 1863 | 2235 | 2316 |
| LOCAL | 100000 | 100000 | 100000 | 100000 |

The one major weakness of this method is that the uniformity of the classifica-

TABLE 6.8 SELECTED POPULATION SIZES OF EACH FISHING COMMUNITY 1881.

| | 1 | 2 | 3 | 4 | TOTAL |
|---|---|---|---|---|---|
| STAITHES | 104 | 30 | 93 | 312 | 539 |
| RUNSWICK | 24 | 0 | 15 | 54 | 93 |
| WHITBY | 75 | 1 | 54 | 158 | 288 |
| R.H.B. | 14 | 0 | 9 | 14 | 37 |
| SCARBRO. | 330 | 27 | 290 | 801 | 1448 |
| FILEY | 137 | 31 | 123 | 329 | 620 |

tion of women's occupation from year to year and between the different registration districts is questionable, and could be a source of error. For example, fishwives may not always be marked down as such in the absence of their husbands; fishermen's widows are not necessarily recorded, especially if new the woman concerned found a new occupation; nor are occupations such as fish-net menders and *flitherers* continuously recorded – such jobs were frequently just considered part-and-parcel of a fisher-families life rather than as an actual 'occupation'. Thus it is likely that these estimates of population size under-estimate the whole, whereas the total populations are, in all probability, vast over-estimates of the population size of the fishing communities – that is, if one accepts that they are, to all intents and purposes, a population within a population.

By comparison, there is no real evidence of such hierarchical subdivision amongst the rural occupations and it is therefore likely that they marry into other occupations such as labourers, miners, shop assistants *etc.* Thus by taking a selected population size for these occupations, one is undoubtedly falsely reducing the real population size. However, bearing this in mind, it is perhaps worthwhile to try both population estimates so that the results may be contrasted to the results from the fishermen.

Finally, to conclude, I shall summarise the different aspects in which Malecot's migration matrix has been considered:

1. By sex: father-offspring data / mother-offspring data.
2. By occupation: fisherman-offspring data / fishwives-offspring data; agricultural labou

offspring data / agricultural wives-offspring data; farmer-offspring data / farmers' wives-offspring data.

3. By year: 1851; 1861; 1871; 1881.
4. Trials using an additional category of 'local' in addition to the 5 or 6 actual study villages
5. Trials with different population sizes: total sizes or selected sizes.

The year 1851 was taken as the starting point for the analysis.

## Results

### A. Father-offspring data

#### Fishermen-offspring 1851

The fishermen and their children were drawn from the total sample of father-offspring data for 1851. In the first instance I decided to try and assume as little as possible about the fishing communities. Thus I considered them to be a plausible part of the wider community and took the total population size for each town as given in the census. I also included 'local' as the seventh 'village', since, in geographical terms, this covers neighbouring villages which are also a potential source of mates.

The raw migration matrix is presented in table 6.9 and the results are given in table 6.10. Endogamy varies considerably between the villages, from 100% in Runswick, Whitby and Robin Hood's Bay, to a rather predictable low of .3333 within the amalgamated 'local'. In Scarborough endogamy is noticeably lower, .6757. This may be associated with the slightly higher value of systematic pressure (although in that case it is perhaps surprising to find Whitby with the highest systematic pressure value but a greater value of endogamy). On the other hand, Filey is also rather less endogamous than the first four populations, and this could well be associated with the comparatively greater gene flow between Scarborough and Filey.

The matrix reaches equilibrium within two generations. Imaizumi *et al.* (1970)

and Mielke (1976) have pointed out that if the values of systematic pressure are low, slow rates of convergence are to be expected. My results appear to contradict this. I can only assume that since the elements are mostly on the diagonal of the matrix and that there is therefore little migration between populations, convergence is obtained very rapidly.

The leading diagonal of the $\Phi$ matrix gives the kinship within populations $\Phi_{ii}$, whereas the other elements $\Phi_{ij}$ give the kinship between populations. Mielke (1976 p262) states that the 'predicted mean kinship within populations provides a generalised view of the relationship that exists through time in the whole (of the study area)'.

Mean kinship within the North Yorkshire fishing communities of 1851 is $2024 \times 10E7$, or, in other words, .0002024. However, within the array the local kinship $\Phi_{ii}$ of each population varies enormously, and only Staithes approximates the mean value. Robin Hood's Bay and Runswick in particular have much higher values of kinship, whereas, Filey, 'local' and Scarborough more predictably have much lower values. It is perhaps surprising to find Scarborough, however, with a lower estimate than 'local'. The combined effects of greater systematic pressure and the close relationship with Filey must account for this. The diagonal element in the R matrix is similar to the $\Phi$ matrix with the exceptions of Scarborough and 'local': in both cases kinship is reduced and here, as might be expected, kinship is lowest within 'local'. The extra consideration of population size in calculating the R matrix may well account for this.

The off-diagonal elements of $\Phi_{ij}$ of the $\Phi$ matrix indicate the kinship between populations: large values of $\Phi_{ij}$ indicates greater similarity between villages, and to the opposite extreme, zero values indicate that there is no relationship between two populations. From the $\Phi$ matrix it appears that Runswick, Whitby, and Robin Hood's Bay are completely unrelated to any other population within the array, including the category 'local'. Scarborough and Filey once more show signs of being closely related, indeed a higher estimate of kinship is obtained between them than within Scarborough itself. Perhaps surprisingly in terms of geographic distance, Scarborough, Filey, and Staithes are all related. Moreover Staithes and Scarborough are closer than Scarborough and 'local'. In fact 'local' shows the most surprising results: as a large amalgamated neighbouring category I expected much higher kinship between it and the other colonies. This perhaps confirms the relative insularity of the fishermen from the surrounding rural populations.

The R matrix off-diagonal elements offer a different picture, however. Staithes displays negative values of conditional kinship with all colonies except 'local', as does Filey with the four populations furthest away geographically, and again unexpectedly, 'local' does with all populations other than Staithes. (Once more 'local's' very large population size probably contributes to this). Robin Hood's Bay and Scarborough also display negative kinship. Otherwise all subdivisions appear to be related.

The real value of the R matrix, however, lies in its prediction of $F_{ST}$. For overall the matrix method is used to estimate the genetic relationship between colonies as given in the $\Phi$ and R matrices. However, $F_{ST}$ as an estimate of between subdivision genetic heterogeneity really summarises this information. As such I shall in future analyse only the $\Phi$ matrix and then refer to the value of $F_{ST}$ calculated from Harpending and Jenkins R.

Here the value of $F_{ST}$ is .00008 which is extremely low considering the generally high estimates of endogamy, low values of systematic pressure, and relatively low rates of migration between the colonies. It is lower than the estimate obtained by Swedlund *et al.* (1984) for the Connecticut valley population between 1790 and 1847 $[F_{ST} = .00026]$, which they explained in terms of high systematic pressure, high levels of migration between the subdivisions and large effective population sizes. From their argument, only the latter could explain the low value of $F_{ST}$ obtained, for the population of Whitby, Scarborough and 'local' are very large.

Since it is unlikely that the total geographical populations of Scarborough, Whitby, Staithes *etc.* are actually the true fishing communities, as I have argued above, I decided at this point to try taking the selected population sizes or rather the population sizes of the fishing communities only. The method is given above, and the sizes are given in table 6.11. ('Local' as a large, amalgamated but homogeneous category is once more assumed to be approximately 100,000).

The results are given in table 6.12. Notably the effective population sizes are much reduced with the exception of 'local'. Otherwise the data remain unaltered.

Convergence is again attained within two generations, and the $\Phi$ matrix shows the same pattern of relationship. However, the kinship within and between populations is rather higher, particularly within Scarborough and Whitby where population sizes have been dramatically reduced. Correspondingly the value of $F_{ST}$ is higher, (.00010), indicating that with reduced population size there is greater potential for local differentiation, stressing the major role of population size in determining genetic structure.

Despite this $F_{ST}$ is still lower than Swedlund *et al.*'s (1984) value of $F_{ST}$ and yet the three explanations they offered for low values of $F_{ST}$ fail to account for my findings: systematic pressure is much less, the effective population sizes are smaller and there is considerably less gene flow between the subpopulations.

Looking further afield, to Mielke's (1976) paper and an M.Sc. thesis by Hilary Constable (1980), it became apparent that the category 'local' may in fact have a misleading 'homogenising' effect. Constable remarked that 'heavy migration from a common source might make two populations related more quickly than would be expected from considering the exchange between these two populations above'. Mielke found that the predicted mean kinship values in the Åland Islands were all consistently higher when the city Mariehamn was excluded from the analysis. He suggested that because Mariehamn had a high effective size and high mate exchange with all other parishes, it had the effect of high long range migration in the island model and thus lowered kinship values (Mielke 1976 p261).

Looking back at my data and the original raw migration matrix (table 6.9) it was noted that the category 'local' had a very high effective population size and while gene flow from 'local' is not actually terribly high, it is relatively greater than between the other colonies (with the exception of the close relationship between Scarborough and Filey). It is likely therefore that it had the same effect on the results as the inclusion of Mariehamn did in the Åland Islands analysis.

'Local' as such is not within my study area. It was included since it bordered the area geographically. However, as I have argued for each town, the fishing communities were very largely endemic and regardless of geography, they were very likely to be distanced from neighbouring populations socially. To quote Malecot (1973 p119), long distance migration is 'migration from outside a defined region or from distance so great that conditional kinship (relative to the regional mean as estimated by bioassay) is negative'. The former, however, reinforced by the sociological information available here, I think justifies excluding 'local' as a population in the matrix, but including it as part of the long range migration or systematic pressure.

The results are presented in table 6.13. This time the values of systematic pressure differ. Staithes, Filey and in particular Scarborough, have higher values of systematic pressure which incorporates the 'local' outside migrations. Otherwise the data are exactly the same, only there are six study populations and not seven. The number of iterations to convergence is unchanged and the pattern of relationship between populations is of course unaltered. The elements of the $\Phi$ matrix are remarkably similar. The one major difference is that the value of $F_{ST}$ is much higher, suggesting much greater genetic heterogeneity between the populations. Thus proving that the inclusion of 'local' was a strong factor in homogenising the colonies.

In conclusion I would suggest that the third set of results are probably the closest approximation to reality. The sociology of the area strongly indicates that the fishing communities should be taken independently of their fellow townsmen. The social barrier was such that neighbouring villages of only two miles or more should be considered as 'long distance' rather than local migrants. (It is interesting to note that even when this was done, systematic pressure values were still relatively low).

My only hesitation rests in the possible inaccuracy of estimating the true population size of the fishing community, as discussed above. Assuming however that it is a reasonable approximation, I have only estimated $\Phi$, R and $F_{ST}$ by the third procedure for the fishermen in the years 1861, 1871 and 1881.

### Agricultural Labourers-offspring 1851

Having followed through several different trials for the fishermen, I decided simply to apply the most 'successful' procedure to the agricultural labourers, for this would pose the most appropriate way of comparing the two. Thus I considered only the five rural study populations in the raw migration matrix (table 6.14) and included 'local' migrants as long distance migrants. I also took the selected agricultural communities rather than the total geographical population of each town/village, following the same method as I had done for the fishermen (table 6.15).

The results are given in table 6.16. They offer a fine contrast to the fishermen. Systematic pressure values are very high (with the exception of Hinderwell). Endogamy is much lower, indeed negative values were obtained for Whitby and Scarborough. As shown by Morton (1973b) and Mielke (1976) negative endogamy is the consequence of the assumption that $P_{ii} \geq .50$ and it indicates heavy migration into these areas. The raw migration matrix itself (table 6.14) implies slightly more movement between colonies, but convergence once more occurs within two generations. Perhaps the large values of systematic pressure here account for this.

The mean 'local' kinship value of the $\Phi$ matrix is $37396. \times 10E7$. The actual kinship for each town varies widely. Hinderwell is closely inter-related, and gives approximately the same estimate of kinship as the fishing community of Runswick. This value raises the mean considerably, since all the others lie below the average. Fylingdales and Filey are less inter-related than either of their comparative fishing communities, but most notably, Scarborough and Whitby give negative values, indicating very high migration into the area which starkly contrasts with the fishermen.

Again in contrast, the rural villages to some extent, are all related to each other. Although with the agricultural labourers, Scarborough and Filey are the least close, and Hinderwell and Whitby are the most closely related populations. This really is the exact opposite of the situation for the fishermen, and while the latter is possibly understandable in terms of geography, the former is really quite surprising in terms of their physical proximity and considering the very close kinship between their fishing communities. Some of the other relationships also seem difficult to explain in the light of geography. For example, Filey is closer to Hinderwell than Scarborough; Fylingdales is closer to both Filey and Hinderwell than either of the 'in-between' populations; and Whitby is closer to Filey than Scarborough.

Finally the value of $F_{ST}$ obtained from the matrix was .00189, which is lower than the value for the fishermen but perhaps higher than might be predicted given the very high systematic pressure and very low values of endogamy. On the other hand, the effective population sizes are small (mean value is 59.12 as compared to the mean for the fishing villages of 92.9), and migration between the rural villages, while it is greater than between the fisher communities, is not actually very high.

However, there are several factors arising from the results which may question the suitability of the data to this actual model. For one thing the negative values of endogamy (calculated according to the formula $(2p_{ii} - 1)$) and kinship obtained for the rural populations of both Scarborough and Whitby, suggests that realistically the agricultural labourers and their families cannot be treated as a separate insular body apart from their total populations. The very low estimates of endogamy for Filey and Fylingdales are also indicative of this. Indeed ethnographic information does not give evidence of any rural subdivision of the population. Hence to take agricultural communities only is false, since they must be integrated with the miners, manual labourers, servants and other occupational groups of their respective villages.

Furthermore, from the social history of the area it is apparent that 19th century Yorkshire used an unusual hiring system for agricultural labour, so that individuals were extremely likely regularly to move from village to village. Hence the enormously high values of systematic pressure. Thus to consider the town or village even as a solid physical entity is a misconception. 'The population' was very much more fluid and physically undefined, incorporating not only the study villages but the surrounding local moorland villages also.

Hence while I have attempted to compare the results from 1851 fishermen and agricultural labourers, it has become apparent that they are in fact so different in terms of social structure that it is not practicable to apply the model to the agricultural labourers as I have done for the fishermen. One possibility might be, as I initially did for the fisherman, to take the total population sizes for each village as given in the censuses, and to consider 'local' as an additional sixth population. For this does not assume hierarchical segregation and does at least consider 'local' as a population.

I have presented the results in table 6.17. Total population sizes are much higher (given in table 6.7), and systematic pressure is now low with 'local' taken out. Endogamy, however, is unchanged since only migration between the agricultural labourers was considered. From the raw migration matrix (table 6.14) it is clear that the amalgamated 'local' category exchanges migrants heavily with all the others, and to a greater extent than between the other villages. This is not surprising since many of the villages within 'local' may well be closer geographically than the other study areas.

The $\Phi$ matrix again shows that all populations are related although more closely than when 'local' was excluded. It is interesting to note that kinship within Scarborough and Whitby is still less than between them and the other villages. Values of kinship $\Phi_{ij}$ appear to be highest between Hinderwell and 'local', and Hinderwell and Whitby and lowest between Scarborough and 'local', again Scarborough and Filey, and Whitby and Scarborough. The value of $F_{ST}$ is very low .00001 (and indeed lower than that obtained for the 1851 fishermen in the first run).

However, it is still apparent that the model is unsuitable. For again, although total population sizes were used, migration was considered between agricultural labourers only. Since they are part of a wider community I believe it would be better to consider migration between the whole communities.

However, from the matrix it is clear that considering migration between discrete colonies is erroneous. It is likely that migration was determined very largely by geographical distance and availability of work, rather than by social custom as with the fishermen. In conclusion therefore it is likely that a continuous model, such as isolation by distance, would be more appropriate in these circumstances. Therefore I have not gone on to apply the matrix to the agricultural populations of 1861, 1871 and 1881.

### Farmer-Offspring 1851

Partly to be consistent and partly since I thought it better not to pre-suppose that the farmers would follow the same pattern as the labourers, I applied the matrix to farmer-offspring data for 1851. Once more to compare the results to the fishermen, I used the same conditions as I had done for the fishermen on the third trial. Thus I selected just the farming population (table 6.18) by the method discussed above, and I considered 'local' as long distance migration. The results are given in table 6.19.

It is important to point out two things. Effective population sizes are very small, which will tend to boost estimates of kinship; and Filey is somewhat of an anomaly. The value of Ne for Filey is only eight and there are no fathers with offspring born in Filey (as can be seen from the raw migration matrix (table 6.20). All the parents and offspring resident in Filey in 1851 were born outside the study region. Hence the value of systematic pressure is one, and the value of endogamy $(2p_{ii} - 1)$ is correspondingly minus one. However, I have included Filey since there were farmers resident in the town in 1851, and since I wish to compare the results between the different occupational groups.

Systematic pressure is reasonably high, but is generally lower than for the agricultural labourers. With the exception of Hinderwell, endogamy is low and negative values are again obtained for Scarborough and Whitby, which (as with the labourers) suggests very high migration into the towns.

Equilibrium is once more attained within two generations. Predictably there is no kinship within or between Filey and the other villages. The highest within-village value of kinship was estimated for Hinderwell and is just below the value obtained for the labourers and Runswick fishermen. The high negative values $\Phi_{ij}$ obtained for Scarborough and Whitby indicate that the farmers are even less interrelated than the town labourers. Fylingdales follows the same trend. Turning to the off-diagonal elements, there is no kinship between any of the colonies other than a negative value between Scarborough and Whitby. (With the labourers the lowest estimate of kinship between colonies $\Phi_{ij}$ was also between these two towns). Overall the value of $F_{ST}$ calculated from the R matrix is also lower than that obtained for the agricultural labourers [.00152].

From these results it is fairly clear that in terms of social custom the farmers are similar to the labourers. They are not a segregated insular community either in terms of hierarchy or geography. Moreover, in terms of the population sizes and the problem of Filey, the model is very poorly suited to the farmer-offspring data. I shall not apply it to farmer-offspring data for 1861, 1871 and 1881.

### Fishermen-Offspring Distance 1861-1881

Using the third procedure applied to the fishermen of 1851, I applied the model to fishermen-offspring data for 1861, 1871 and 1881 to observe changes over time. Selected population sizes of each community were obtained by the same method used for 1851, and the sizes are given below in tables 6.21, 6.22 and 6.8. 'Local' was considered as long distance migrants.

The results are given in tables 6.23, 6.24 and 6.25. Population sizes fluctuate over time. Overall there is a general increase, Scarborough in particular multiplies in number over time. Robin Hood's Bay and, after 1861, Runswick are the exceptions to this; their decline being attributable to competition from the growing ports of

Scarborough, Hull and Grimsby.

In all periods systematic pressure values are low. In 1861 the four northern village values were lower than in 1851, and indeed Runswick and Robin Hood's Bay remain consistently at zero. There is some long range migration into Staithes in 1871, but by 1881 this has stopped once more. Migration into Whitby, on the other hand increases after 1861, and into Filey it increases from 1851, but drops slightly in 1881. Systematic pressure values for Scarborough increase substantially over time. Overall Scarborough and Whitby, as the two largest towns, attract the most long range migration. Filey draws the third highest number of migrants, possibly since it is so closely associated with Scarborough as evidence from social history, isonymy and as the 1851 matrix results have suggested.

Concomitant with changes in population size and systematic pressure, endogamy also fluctuates over time. Generally endogamy declines. Although Scarborough is more endogamous in 1861 than in 1851, latter decades see a steady decrease and throughout the period it is the least endogamous population. There is a sharp decline between the Whitby population of 1861 and 1871, but then in 1881 the value increase slightly. Staithes and Runswick follow a similar pattern. In Filey endogamy consistently declines. Robin Hood's Bay is the one major exception, for in both 1871 and 1881 it is completely insular.

From the raw migration matrices (tables 6.26, 6.27 and 6.1) it is clear that migration between the colonies is limited at all times. It is greatest from Filey to Scarborough, although this has lessened by 1871. Equilibrium is obtained within two iterations in each year.

As might be predicted, kinship $\Phi_{ii}$ within Robin Hood's Bay and Runswick increases over the decades, whereas kinship within all the other populations decreases over time. This is to be expected from the population sizes, systematic pressure and values of endogamy. While the decline of kinship is gradual in Filey and, after 1861, in Staithes, in both Scarborough and Whitby there is a sudden marked decrease between 1861 and 1871.

Kinship between the different colonies $\Phi_{ij}$ appears to vary from year to year.

For example, Staithes and Runswick, despite their physical proximity, remain completely unrelated in all years except for a freak high in 1861. Robin Hood's Bay is unrelated to all other populations in all years except for a very high value of kinship between it and Whitby in 1861. Suddenly in 1881 Whitby and Filey appear to be very closely related. To a much lesser extent slight fluctuations appear between Whitby and Scarborough in 1881 and Runswick and Scarborough in 1861.

There are only a few relatively consistent relationships between the populations. Runswick suddenly becomes closely related to Whitby in 1871, and this only drops slightly in 1881. Staithes is related to Scarborough and Filey throughout the period, although the actual values of kinship go up and down each decade. Scarborough and Filey are similarly related in all years but again kinship between them fluctuates, declining between 1851 and 1871 and then increasing slightly in 1881. It is noticeable that while they are consistently related, some of the freak values of kinship discussed above are much higher, which is surprising.

Overall the values of $F_{ST}$ calculated from the R matrix decline each decade. There is a sharp change between 1861 and 1871. Thus the populations are becoming more homogeneous over time. Looking at the populations individually it is possible to say that Runswick and Robin Hood's Bay become more insular and endogamous, concomitant with the reduction in population size. It is therefore the growth of the larger towns and in particular Scarborough that is responsible for the decline in genetic heterogeneity. One of the major contributions to the increase in systematic pressure into Scarborough and also to the increase in population size are the migrant fishermen from Norfolk.

### B. Mother-offspring data

### Fishwives-Offspring 1851.

Fishwives were obviously a part of the fishing communities and their social custom would have been therefore the same as their fathers, husbands and sons.

Thus they too were a part of a hierarchically and vertically segregated community. However, their pattern of movement may have differed from the men. To take one example, if they married outside their community, it might have been the custom for the women to move to their husband's place of residence and work. Hence I thought it would be interesting to compare fishwives and fishermen-offspring data to see if and how the patterns of migration were different.

Since they come from the same fishing communities I have followed the most appropriate procedure that I used for the fishermen – procedure three. Thus I have considered 'local' migrants as long distance migrants and I have taken the selected fishing population sizes (see before, table 6.11). The raw migration matrix is given in table 6.28 and the results are presented in table 6.29. Population size is identical to the fisherman in 1851. Systematic pressure is the same only for Robin Hood's Bay: in Staithes, Scarborough and Filey it is higher, and in the other two it is lower for the fishwives. Endogamy, however, is consistently much lower for the fishwives, only in Scarborough are the values similar. This shows that the wives must have been more mobile than their husbands (the offspring are obviously the same for both the fishermen and fishwives). From the raw migration matrix it is clear that there is a little more movement between the colonies than there was for the fishermen.

The $\Phi$ matrix confirms the overall greater mobility of the women. For, unlike the men, all colonies are related. Indeed the kinship between all of them is relatively high, particularly so between Runswick and Whitby, and Robin Hood's Bay and Filey. Kinship is still greatest within each colony $\Phi_{ii}$, but with the exception of Scarborough, the values are well below those obtained for the men. Finally the value of $F_{ST}$ from the R matrix is also rather lower than for the fisherman-offspring data.

### Fishwives-offspring 1861-1881.

To examine the temporal changes in kinship from the fishwives-offspring data and to compare this with the fishermen-offspring results, I have applied the model to fishwives-offspring data for the subsequent decades. (Again I have used procedure 3.) The raw migration matrices are shown in tables 6.30, 6.31, 6.32 and the results are given in tables 6.33, 6.34 and 6.35.

Selected population sizes are identical to the fishermen of 1861, 1871 and 1881. Values of systematic pressure vary, generally increasing towards 1871 but declining again in 1881. Overall the values are relatively low, the highest being for Robin Hood's Bay in 1871 which is somewhat of an anomaly since in all other years the value was zero. Like the fishermen, Scarborough, Whitby and then Filey attract the most long range migration. Estimates of endogamy also fluctuate, generally increasing in 1861, decreasing in 1871 and increasing again in 1881. Values are lower than for the fishermen but are still reasonably high. Robin Hood's Bay is again quite surprising here, for quite contrary to the fishermen, endogamy estimates are the lowest for this town, reaching an all time low of .3793 in 1871. Whereas decreasing population size caused the men to become more endogamous, with the women the reverse has occurred.

The values of kinship shown in the $\Phi$ matrices and indeed the estimates of $F_{ST}$ both seem to follow the same trend as the estimates of endogamy. The values increase in 1861, decrease in 1871 and slightly increase again in 1881. Hence values of kinship within the populations, $\Phi_{ii}$, all with the exception of Scarborough, increase in 1861. In 1871 the values of kinship drop in each town other than Runswick. By 1881 three of the villages are more inter-related than in the previous year.

Like 1851 all colonies in all years are related ($\Phi_{ij}$) to some extent, with the one exception of Runswick and Whitby in 1861. Kinship between colonies generally decreases in 1861, and increases again in 1871. Interestingly, in 1881 it is kinship between Scarborough and Filey and the rest of the population that decreases, while kinship between the other communities is higher.

The value of $F_{ST}$ is lowest in 1871 at .00226, but it increases slightly to .00280 in 1881. Thus from the point of view of fishermen and fishwives the communities are becoming less heterogeneous over time. Only for the fishermen, the decline in the value of $F_{ST}$ is progressive and continuous from decade to decade, without the hiccup at 1871. However, throughout the entire period estimates of $F_{ST}$ from the fishermen-offspring data are all higher than for the women.

With the fishermen-offspring data I found that despite the overall decline in kinship, Runswick and Robin Hood's Bay actually became more insular towards 1881. From the female orientated data, kinship $\Phi_{ii}$ within Runswick also increases over the four decades, while for Robin Hood's Bay, it decreases substantially in 1871 only to increase considerably again in 1881. Actual endogamy within Runswick follows the same pattern for both sets of data, declining sharply in 1871. However, the two sets of data give very different estimates of endogamy for Robin Hood's Bay (see above).

Thus in conclusion the fisherwomen are more mobile than the men, but in both cases kinship declined over time. Lastly I should mention that common to both sets of data 1871 seems the year of the greatest change and decline in kinship.

### Agricultural-labourers wives-offspring 1851

Although the agricultural-labourers wives have the same social structure as their husbands and the model is likely therefore to be inappropriate, they may not be as mobile as their husbands since it was the men who moved around in search of work. Thus despite the serious limitations of applying such data to the model, I have made just one attempt to see whether or not this is true.

I have used the same procedure as I followed for the fishwives and fishermen. Selected population sizes were given before in table 6.15 and local migrants are included under systematic pressure. The raw migration matrix is given in table 6.36 and the results are presented in table 6.37. The values of systematic pressure seem to alternate between being higher and lower between the male and female data, but the values of endogamy (with the exception of Fylingdales) are all higher. Unlike the men and fishwives, the colonies in the $\Phi$ matrix are not all related:

Hinderwell and Filey are completely isolated from each other. Kinship $\Phi_{ii}$ within Hinderwell, Whitby and Filey is also greater than the values obtained for the men. The other two, however, are much less closely related. On the other hand, the slightly higher value of $F_{ST}$ for the women suggests that overall they are not quite as mobile as their husbands.

### Farmers wives-offspring 1851.

Although I feel that the model is inappropriate for the farmer-offspring data, and therefore for their wives as well, I thought that it would be interesting to apply it just once to see if migration differed between the sexes as it has done for the fishing and labouring communities.

Again the third procedure was used, so that the selected population sizes were identical to the 1851 farmers (table 6.18), and 'local' migrants were taken as long distance migrants. The raw migration matrix is shown in table 6.38 and the results are presented in table 6.39.

Systematic pressure for the women seems to be higher for Hinderwell and Whitby, but lower for Robin Hood's Bay and Scarborough than for the men. Three of the five estimates of endogamy are lower for the women than for the men. Overall the pattern of relationship displayed in the $\Phi$ matrix is similar for both sexes. Hinderwell has a much lower estimate of kinship $\Phi_{ii}$ and Fylingdales is this time related to both neighbouring colonies. The overall similarity between the husband and wife offspring data is indicated in the very similar values of $F_{ST}$.

TABLE 6.9 Fishermen-offspring 1851. The Raw Migration Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 158 | 0 | 0 | 0 | 7 | 1 | 0 |
| 2 | 0 | 56 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 40 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 38 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 124 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 33 | 200 | 0 |
| 7 | 5 | 0 | 0 | 0 | 8 | 3 | 16 |
| L.D. | 4 | 5 | 1 | 0 | 36 | 7 | 0 |

```
FISHERMEN-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 1.

NE (TOTAL POPS.)      SYSTEMATIC PRESSURE      EN

1       375.3                 0.0239           0.9210
2       108.3                 0.0820           1.0000
3      3891.3                 0.2500           1.0000
4       294.7                 0.0              1.0000
5     14936.7                 0.1731           0.6757
6       500.0                 0.0332           0.8307
7     33333.3                 0.0              0.3333

SYMMETRIC MIGRATION MATRIX

1    158.     0.     0.     0.     4.     1.     3.
2      0.    56.     0.     0.     0.     0.     0.
3      0.     0.    40.     0.     0.     0.     0.
4      0.     0.     0.    38.     0.     0.     0.
5      4.     0.     0.     0.   124.    17.     4.
6      1.     0.     0.     0.    17.   200.     2.
7      3.     0.     0.     0.     4.     2.    16.

STOCHASTIC MIGRATION MATRIX

1   0.96049 0.0     0.0     0.0     0.02365 0.00229 0.10417
2   0.0     1.00000 0.0     0.0     0.0     0.0     0.0
3   0.0     0.0     1.00000 0.0     0.0     0.0     0.0
4   0.0     0.0     0.0     1.00000 0.0     0.0     0.0
5   0.02128 0.0     0.0     0.0     0.83784 0.07551 0.16667
6   0.00304 0.0     0.0     0.0     0.11149 0.91533 0.06250
7   0.01520 0.0     0.0     0.0     0.02703 0.00686 0.66667

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1   21113.      0.      0.      0.    614.    192.   3251.
2       0.  71545.      0.      0.      0.      0.      0.
3       0.      0.   1129.      0.      0.      0.      0.
4       0.      0.      0.  33908.      0.      0.      0.
5     614.      0.      0.      0.    459.   1779.    375.
6     192.      0.      0.      0.   1779.  12771.   1423.
7    3251.      0.      0.      0.    375.   1423.    786.

R MATRIX (X 10E7)

1   16953.  -1956.  -1893.  -1998.  -1580.  -3125.    809.
2   -1956.  71798.    311.    207.     11.  -1112.   -238.
3   -1893.    311.   1504.    270.     74.  -1049.   -175.
4   -1998.    207.    270.  34074.    -31.  -1154.   -280.
5   -1580.     11.     74.    -31.    232.    429.   -101.
6   -3125.  -1112.  -1049.  -1154.    429.  10299.   -175.
7     809.   -238.   -175.   -280.   -101.   -175.     62.

FST= 0.00007621
```

Table 6.10

TABLE 6.11 The population sizes of the fishing communities in 1851.

| | A | B | C | D | Total |
|---|---|---|---|---|---|
| Staithes | 63 | 49 | 69 | 233 | 409 |
| Runswick | 36 | 17 | 29 | 65 | 147 |
| Whitby | 27 | 6 | 19 | 47 | 99 |
| R.H.B. | 27 | 7 | 20 | 43 | 97 |
| Scarborough | 122 | 5 | 104 | 240 | 471 |
| Filey | 110 | 25 | 84 | 231 | 450 |
| 'Local' | - | - | - | - | 100000 |

```
FISHERMEN-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 2.

NE (SELECTED POPS.)    SYSTEMATIC PRESSURE    EN

1        136.3              0.0239            0.9210
2         49.0              0.0820            1.0000
3         33.0              0.2500            1.0000
4         32.3              0.0               1.0000
5        157.0              0.1731            0.6757
6        150.0              0.0332            0.8307
7      33333.3              0.0               0.3333


SYMMETRIC MIGRATION MATRIX

1     158.     0.     0.     0.     4.     1.     3.
2       0.    56.     0.     0.     0.     0.     0.
3       0.     0.    40.     0.     0.     0.     0.
4       0.     0.     0.    38.     0.     0.     0.
5       4.     0.     0.     0.   124.    17.     4.
6       1.     0.     0.     0.    17.   200.     2.
7       3.     0.     0.     0.     4.     2.    16.


STOCHASTIC MIGRATION MATRIX

1    0.96049 0.0     0.0     0.0     0.02365 0.00229 0.10417
2    0.0     1.00000 0.0     0.0     0.0     0.0     0.0
3    0.0     0.0     1.00000 0.0     0.0     0.0     0.0
4    0.0     0.0     0.0     1.00000 0.0     0.0     0.0
5    0.02128 0.0     0.0     0.0     0.83784 0.07551 0.16667
6    0.00304 0.0     0.0     0.0     0.11149 0.91533 0.06250
7    0.01520 0.0     0.0     0.0     0.02703 0.00686 0.66667


NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    58128.      0.      0.      0.   2588.    762.   9326.
2        0.157837.       0.      0.      0.      0.      0.
3        0.      0.132759.       0.      0.      0.      0.
4        0.      0.      0.306887.      0.      0.      0.
5     2588.      0.      0.      0.  18830.   8849.   7452.
6      762.      0.      0.      0.   8849.  43128.   5966.
7     9326.      0.      0.      0.   7452.   5966.   4801.


R MATRIX (X 10E7)

1    44147.  -4811.  -4712.  -4876.  -9464.  -9927.    -75.
2    -4811.162300.   4486.   4322.  -2855.  -1491.   -207.
3    -4712.   4486.137408.   4421.  -2756.  -1392.   -108.
4    -4876.   4322.   4421.311293.  -2919.  -1555.   -272.
5    -9464.  -2855.  -2756.  -2919.   8743.    121.      7.
6    -9927.  -1491.  -1392.  -1555.    121.  35780.   -116.
7      -75.   -207.   -108.   -272.      7.   -116.      1.


FST= 0.00010433
```

Table 6.12

```
FISHERMEN-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)    SYSTEMATIC PRESSURE   EN

1          136.3                0.0539           0.9210
2           49.0                0.0820           1.0000
3           33.0                0.2500           1.0000
4           32.3                0.0              1.0000
5          157.0                0.2115           0.6757
6          150.0                0.0474           0.8307

SYMMETRIC MIGRATION MATRIX

1     158.     0.     0.     0.     4.     1.
2       0.    56.     0.     0.     0.     0.
3       0.     0.    40.     0.     0.     0.
4       0.     0.     0.    38.     0.     0.
5       4.     0.     0.     0.   124.    17.
6       1.     0.     0.     0.    17.   200.

STOCHASTIC MIGRATION MATRIX

1    0.97531 0.0     0.0     0.0     0.02431 0.00230
2    0.0     1.00000 0.0     0.0     0.0     0.0
3    0.0     0.0     1.00000 0.0     0.0     0.0
4    0.0     0.0     0.0     1.00000 0.0     0.0
5    0.02160 0.0     0.0     0.0     0.86111 0.07604
6    0.00309 0.0     0.0     0.0     0.11458 0.92166

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    55352.       0.       0.       0.   2335.    680.
2        0.157837.       0.       0.       0.      0.
3        0.       0.132759.       0.       0.      0.
4        0.       0.       0.306887.       0.      0.
5     2335.       0.       0.       0.  17656.   8380.
6      680.       0.       0.       0.   8380.  42111.

R MATRIX (X 10E7)

1     38804.-16111.-10091.-20040. -7693.-15414.
2    -16111.142422. -9587.-19536. -9526.-15591.
3    -10091. -9587.129354.-13516. -3506. -9571.
4    -20040.-19536.-13516.283795.-13456.-19520.
5     -7693. -9526. -3506.-13456. 14231. -1120.
6    -15414.-15591. -9571.-19520. -1120. 26588.

FST= 0.00572675
```

Table 6.13

### TABLE 6.14 Agricultural labourer-offspring 1851: The Raw Migration Matrix.

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 28 | 0 | 0 | 0 | 0 |
| 2 | 4 | 6 | 0 | 0 | 4 |
| 3 | 0 | 4 | 13 | 1 | 0 |
| 4 | 0 | 0 | 0 | 10 | 0 |
| 5 | 0 | 0 | 0 | 0 | 14 |
| L.D. | 0 | 9 | 0 | 18 | 1 |

TABLE 6.15 SELECTED POPULATION SIZES OF EACH AGRICULTURAL COMMUNITY 1851.

| | A | B | C | D | TOTAL |
|---|---|---|---|---|---|
| Hinderwell | 40 | 3 | 15 | 45 | 103 |
| Whitby | 92 | 3 | 66 | 148 | 309 |
| Fylingdales | 63 | 7 | 16 | 32 | 118 |
| Scarborough | 97 | 0 | 53 | 112 | 262 |
| Filey | 26 | 1 | 16 | 52 | 95 |

```
AG.LABS.-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE   EN

1          34.3               0.0588           0.6000
2         103.0               0.8275          -0.6190
3          39.3               0.3500           0.2381
4          87.3               0.8642          -0.4595
5          31.7               0.5000           0.1429

SYMMETRIC MIGRATION MATRIX

1      28.     2.     0.     0.     0.
2       2.     6.     2.     0.     2.
3       0.     2.    13.     1.     0.
4       0.     0.     1.    10.     0.
5       0.     2.     0.     0.    14.

STOCHASTIC MIGRATION MATRIX

1    0.93333 0.16667 0.0     0.0     0.0
2    0.06667 0.50000 0.12903 0.0     0.12500
3    0.0     0.16667 0.83871 0.04762 0.0
4    0.0     0.0     0.03226 0.95238 0.0
5    0.0     0.16667 0.0     0.0     0.87500

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1  156035.   2904.   1567.      2.    959.
2    2904.    -83.    567.      7.    362.
3    1567.    567.  21055.    121.    487.
4       2.      7.    121.   -422.      1.
5     959.    362.    487.      1.  10398.

R MATRIX (X 10E7)

1  120146.-14007.-18189.-16378.-16944.
2  -14007.  2029.  -165.  2650.  1482.
3  -18189.  -165. 17485.   -81. -1238.
4  -16378.  2650.   -81.  2751.  1652.
5  -16944.  1482. -1238.  1652. 10530.

FST= 0.00189248
```

Table 6.16

```
AG.LABS.-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 1.

NE (TOTAL POPS.)     SYSTEMATIC PRESSURE      EN

1        91.7                 0.0              0.6000
2      3891.3                 0.1552          -0.6190
3       294.7                 0.0              0.2381
4     14936.7                 0.2222          -0.4595
5       500.0                 0.0278           0.1429
6     33333.3                 0.0              0.2486

SYMMETRIC MIGRATION MATRIX

1      28.     2.     0.     0.     0.     5.
2       2.     6.     2.     0.     2.    20.
3       0.     2.    13.     1.     0.     6.
4       0.     0.     1.    10.     0.    27.
5       0.     2.     0.     0.    14.     9.
6       5.    20.     6.    27.     9.   108.

STOCHASTIC MIGRATION MATRIX

1    0.80000 0.06349 0.0     0.0     0.0     0.02890
2    0.05714 0.19048 0.09524 0.0     0.08163 0.11272
3    0.0     0.06349 0.61905 0.01351 0.0     0.03179
4    0.0     0.0     0.02381 0.27027 0.0     0.15318
5    0.0     0.06349 0.0     0.0     0.57143 0.04913
6    0.14286 0.61905 0.26190 0.71622 0.34694 0.62428

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    43800.   3468.    559.    469.    567.   2504.
2     3468.    390.    560.    114.    320.    339.
3      559.    560.   4284.    219.    214.    507.
4      469.    114.    219.     56.    126.    120.
5      567.    320.    214.    126.   1584.    362.
6     2504.    339.    507.    120.    362.    320.

R MATRIX (X 10E7)

1    39941.   1367.  -1704.  -1449.  -1552.    418.
2     1367.     47.     55.    -47.    -40.     12.
3    -1704.     55.   3617.   -103.   -308.     17.
4    -1449.    -47.   -103.     79.    -51.    -24.
5    -1552.    -40.   -308.    -51.   1205.     17.
6      418.     12.     17.    -24.     17.      8.

FST= 0.00001310
```

Table 6.17

## TABLE 6.18 SELECTED POPULATION SIZES OF EACH FARMING COMMUNITY 1851.

| | A | B | C | D | TOTAL |
|---|---|---|---|---|---|
| Hinderwell | 17 | 2 | 13 | 36 | 68 |
| Whitby | 20 | 1 | 14 | 32 | 67 |
| Fylingdales | 72 | 6 | 57 | 166 | 301 |
| Scarborough | 29 | 0 | 22 | 64 | 115 |
| Filey | 7 | 0 | 5 | 13 | 25 |

```
FARMER-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE   EN

1          22.7                  0.3103           0.7778
2          22.3                  0.5000          -0.1724
3         100.3                  0.5170           0.3491
4          38.3                  0.8298          -0.8400
5           8.3                  1.0000          -1.0000

SYMMETRIC MIGRATION MATRIX

1      20.     0.     0.     0.     0.
2       0.     6.     0.     4.     0.
3       0.     0.    57.     0.     0.
4       0.     4.     0.     2.     0.
5       0.     0.     0.     0.     0.

STOCHASTIC MIGRATION MATRIX

1    1.00000 0.0       0.0       0.0       0.0
2    0.0     0.60000 0.0       0.66667 0.0
3    0.0     0.0       1.00000 0.0       0.0
4    0.0     0.40000 0.0       0.33333 0.0
5    0.0     0.0       0.0       0.0       1.00000

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1  131120.       0.       0.       0.       0.
2        0.  -1221.       0.  -1791.       0.
3        0.       0.    6770.       0.       0.
4        0.  -1791.       0.   -761.       0.
5        0.       0.       0.       0.       0.

R MATRIX (X 10E7)

1  103744.-11438.-15477.-11577.-11938.
2  -11438.  3325.   508.  2616.  4047.
3  -15477.   508.  3242.   369.     8.
4  -11577.  2616.   369.  3507.  3908.
5  -11938.  4047.     8.  3908.  3547.

FST= 0.00151824
```

Table 6.19

### TABLE 6.20 FARMER-OFFSPRING 1851 : RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 20 | 0 | 0 | 0 | 0 | 2 |
| 2 | 0 | 6 | 0 | 6 | 0 | 1 |
| 3 | 0 | 0 | 57 | 0 | 0 | 9 |
| 4 | 0 | 2 | 0 | 2 | 0 | 1 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 3 | 8 | 46 | 37 | 4 | 56 |

TABLE 6.21 Population sizes of the fishing communities in 1861

| | A | B | C | D | Total |
|---|---|---|---|---|---|
| 1 | 112 | 15 | 89 | 234 | 450 |
| 2 | 40 | 8 | 33 | 90 | 171 |
| 3 | 36 | 3 | 28 | 69 | 136 |
| 4 | 18 | 5 | 14 | 23 | 60 |
| 5 | 202 | 10 | 162 | 398 | 772 |
| 6 | 114 | 13 | 100 | 235 | 462 |

## TABLE 6.22 Population sizes of each fishing village in 1871

| | A | B | C | D | Total |
|---|---|---|---|---|---|
| 1 | 103 | 7 | 96 | 264 | 470 |
| 2 | 29 | 0 | 23 | 67 | 119 |
| 3 | 53 | 6 | 43 | 121 | 223 |
| 4 | 14 | 0 | 11 | 21 | 46 |
| 5 | 279 | 10 | 247 | 576 | 1112 |
| 6 | 153 | 24 | 134 | 315 | 626 |

```
FISHERMEN-OFFSPRING 1861 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)    SYSTEMATIC PRESSURE    EN

1        150.0              0.0               0.9872
2         57.0              0.0               0.9767
3         45.3              0.1803            0.9406
4         20.0              0.0               0.9487
5        257.3              0.2786            0.7516
6        154.0              0.0744            0.8132

SYMMETRIC MIGRATION MATRIX

1    232.     1.     0.     0.     1.     0.
2      1.    85.     0.     0.     0.     0.
3      0.     0.    49.     1.     0.     0.
4      0.     0.     1.    19.     0.     0.
5      1.     0.     0.     0.   208.    19.
6      0.     0.     0.     0.    19.   199.

STOCHASTIC MIGRATION MATRIX

1   0.99358 0.01163 0.0     0.0     0.00220 0.0
2   0.00428 0.98837 0.0     0.0     0.0     0.0
3   0.0     0.0     0.98990 0.02564 0.0     0.0
4   0.0     0.0     0.01010 0.97436 0.0     0.0
5   0.00214 0.0     0.0     0.0     0.91630 0.08506
6   0.0     0.0     0.0     0.0     0.08150 0.91494


NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1   64875.  2220.      0.      0.    180.     22.
2    2220.166738.      0.      0.      3.      0.
3      0.      0.115874.  10799.      0.      0.
4      0.      0.  10799.445892.      0.      0.
5    180.      3.      0.      0.  10437.   5036.
6     22.      0.      0.      0.   5036.  36318.

R MATRIX (X 10E7)

1   45439.-17174.-13000.-18766.  -9920.-15061.
2  -17174.147602.-12898.-18664.  -9995.-14982.
3  -13000.-12898.109483.  -1458.  -3602.  -8585.
4  -18766.-18664.  -1458.428283.  -9368.-14351.
5   -9920.  -9995.  -3602.  -9368.   9745.   -645.
6  -15061.-14982.  -8585.-14351.   -645.  25683.

FST= 0.00515176
```

Table 6.23

```
FISHERMEN-OFFSPRING 1871 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE    EN

1         156.7               0.0042             0.9381
2          39.7               0.0                0.8919
3          74.3               0.2232             0.7705
4          15.3               0.0                1.0000
5         370.7               0.3728             0.6835
6         208.7               0.1751             0.7978

SYMMETRIC MIGRATION MATRIX

1     235.     0.     0.     0.     5.     0.
2       0.    70.     3.     0.     0.     0.
3       0.     3.    81.     0.     0.     0.
4       0.     0.     0.    21.     0.     0.
5       5.     0.     0.     0.   266.     8.
6       0.     0.     0.     0.     8.   209.

STOCHASTIC MIGRATION MATRIX

1    0.98121 0.0     0.0     0.0     0.01616 0.0
2    0.0     0.95890 0.03571 0.0     0.0     0.0
3    0.0     0.04110 0.96429 0.0     0.0     0.0
4    0.0     0.0     0.0     1.00000 0.0     0.0
5    0.01879 0.0     0.0     0.0     0.95512 0.03687
6    0.0     0.0     0.0     0.0     0.02873 0.96313

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    57630.       0.       0.       0.    949.     49.
2        0.209687. 12327.       0.       0.       0.
3        0. 12327. 50562.       0.       0.       0.
4        0.       0.       0.641541.       0.       0.
5      949.       0.       0.       0.   5076.   1003.
6       49.       0.       0.       0.   1003.  21665.

R MATRIX (X 10E7)

1    41500.-15981.-10215.-16678. -6944.-10921.
2   -15981.194004.  2300.-16497. -7712.-10789.
3   -10215.  2300. 46322.-10731. -1946. -5023.
4   -16678.-16497.-10731.624703. -8409.-11486.
5    -6944. -7712. -1946. -8409.  5454. -1698.
6   -10921.-10789. -5023.-11486. -1698. 15899.

FST= 0.00376253
```

Table 6.24

```
FISHERMEN-OFFSPRING 1881 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE    EN

1          179.7              0.0                0.9590
2           31.0              0.0                0.8966
3           96.0              0.2568             0.7628
4           12.3              0.0                1.0000
5          482.7              0.3895             0.5710
6          206.7              0.1698             0.6824

SYMMETRIC MIGRATION MATRIX

1     239.     0.     0.     0.     5.     0.
2       0.    55.     3.     0.     0.     0.
3       0.     3.   104.     0.     0.     1.
4       0.     0.     0.    14.     0.     0.
5       5.     0.     0.     0.   324.    17.
6       0.     0.     1.     0.    17.   127.

STOCHASTIC MIGRATION MATRIX

1    0.98152 0.0     0.0     0.0     0.01304 0.0
2    0.0     0.94828 0.02791 0.0     0.0     0.0
3    0.0     0.05172 0.96744 0.0     0.0     0.00347
4    0.0     0.0     0.0     1.00000 0.0     0.0
5    0.01848 0.0     0.0     0.0     0.93913 0.11458
6    0.0     0.0     0.00465 0.0     0.04783 0.88194

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    51501.       0.       0.       0.     643.     102.
2        0.259794.   11222.       0.       1.      41.
3        0.   11222.   34674.       0.       8.     306.
4        0.       0.       0.794375.       0.       0.
5      643.       1.       8.       0.    3122.    1592.
6      102.      41.     306.       0.    1592.   16166.

R MATRIX (X 10E7)

1    36722.-14359.  -9005.-15011.  -6584.  -9314.
2   -14359.245986.   2663.-14570.  -6786.  -8934.
3    -9005.   2663.  31479.  -9216.  -1425.  -3316.
4   -15011.-14570.  -9216.779488.  -7439.  -9628.
5    -6584.  -6786.  -1425.  -7439.   3468.   -251.
6    -9314.  -8934.  -3316.  -9628.   -251.  12139.

FST= 0.00307850
```

Table 6.25

TABLE 6.26 FISHERMEN-OFFSPRING 1861 : RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 232 | 0 | 0 | 0 | 1 | 0 |
| 2 | 2 | 85 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 49 | 0 | 0 | 0 |
| 4 | 0 | 0 | 1 | 19 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 208 | 0 |
| 6 | 0 | 0 | 0 | 0 | 37 | 199 |

## TABLE 6.27 FISHERMEN-OFFSPRING 1871: RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 235 | 0 | 0 | 0 | 9 | 0 |
| 2 | 0 | 70 | 6 | 0 | 0 | 0 |
| 3 | 0 | 0 | 81 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 21 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 266 | 0 |
| 6 | 0 | 0 | 0 | 0 | 16 | 209 |

## TABLE 6.28 FISHWIVES-OFFSPRING 1851: RAW MIGRATION MATRIX.

|   | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 183 | 3 | 5 | 1 | 13 | 14 |
| 2 | 7 | 51 | 1 | 0 | 0 | 0 |
| 3 | 0 | 7 | 34 | 0 | 1 | 5 |
| 4 | 0 | 0 | 0 | 37 | 0 | 10 |
| 5 | 0 | 0 | 0 | 0 | 120 | 0 |
| 6 | 4 | 0 | 0 | 0 | 16 | 164 |

```
FISHWIVES-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)      SYSTEMATIC PRESSURE    EN

1          136.3               0.0762           0.7183
2           49.0               0.0615           0.6585
3           33.0               0.0244           0.5632
4           32.3               0.0              0.7412
5          157.0               0.2228           0.6666
6          150.0               0.1227           0.6482

SYMMETRIC MIGRATION MATRIX

1     183.     5.     3.     1.     7.     9.
2       5.    51.     4.     0.     0.     0.
3       3.     4.    34.     0.     1.     3.
4       1.     0.     0.    37.     0.     5.
5       7.     0.     1.     0.   120.     8.
6       9.     0.     3.     5.     8.   164.

STOCHASTIC MIGRATION MATRIX

1    0.88620 0.08333 0.05747 0.01176 0.04815 0.04775
2    0.02421 0.85000 0.09195 0.0     0.0     0.0
3    0.01211 0.06667 0.78161 0.0     0.00370 0.01326
4    0.00242 0.0     0.0     0.87059 0.0     0.02653
5    0.03148 0.0     0.01149 0.0     0.88889 0.04244
6    0.04358 0.0     0.05747 0.11765 0.05926 0.87003

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    34892.   8888.   7132.   2245.   3515.   4767.
2     8888.  87372.  27511.    260.    534.    978.
3     7132.  27511. 105360.   1240.   1621.   5457.
4     2245.    260.   1240. 177393.    822.  12537.
5     3515.    534.   1621.    822.  17783.   3657.
6     4767.    978.   5457.  12537.   3657.  24806.

R MATRIX (X 10E7)

1    20905.  -4897.  -7140. -14177.  -5404.  -7117.
2    -4897.  73896.  13488. -15936.  -8159. -10681.
3    -7140.  13488.  90932. -15440.  -7557.  -6683.
4   -14177. -15936. -15440. 158750. -10501.  -1741.
5    -5404.  -8159.  -7557. -10501.  13979.  -3128.
6    -7117. -10681.  -6683.  -1741.  -3128.  15077.

FST= 0.00341797
```

Table 6.29

TABLE 6.30 FISHWIVES-OFFSPRING 1861: RAW MIGRATION MATRIX.

|   | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 228 | 0 | 0 | 0 | 3 | 6 |
| 2 | 1 | 74 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 62 | 0 | 2 | 0 |
| 4 | 0 | 0 | 0 | 21 | 0 | 9 |
| 5 | 0 | 0 | 1 | 0 | 262 | 3 |
| 6 | 0 | 0 | 0 | 0 | 11 | 182 |

TABLE 6.31 FISHWIVES-OFFSPRING 1871: RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 220 | 0 | 0 | 0 | 7 | 8 |
| 2 | 11 | 59 | 3 | 0 | 0 | 0 |
| 3 | 0 | 0 | 91 | 0 | 1 | 0 |
| 4 | 0 | 0 | 0 | 10 | 0 | 9 |
| 5 | 0 | 0 | 0 | 0 | 361 | 8 |
| 6 | 0 | 0 | 0 | 0 | 20 | 209 |

## TABLE 6.32 FISHWIVES-OFFSPRING 1881: RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 272 | 0 | 0 | 0 | 5 | 3 |
| 2 | 5 | 40 | 4 | 0 | 0 | 0 |
| 3 | 0 | 0 | 127 | 0 | 3 | 0 |
| 4 | 0 | 0 | 0 | 11 | 0 | 5 |
| 5 | 1 | 0 | 2 | 0 | 527 | 9 |
| 6 | 0 | 0 | 2 | 0 | 8 | 244 |

```
FISHWIVES-OFFSPRING 1861 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE    EN

1         150.0                 0.0129             0.9571
2          57.0                 0.1290             0.9866
3          45.3                 0.0455             0.9528
4          20.0                 0.0                0.6471
5         257.3                 0.2102             0.9265
6         154.0                 0.0909             0.8524

SYMMETRIC MIGRATION MATRIX

1     228.      1.      0.      0.      2.      3.
2       1.     74.      0.      0.      0.      0.
3       0.      0.     62.      0.      2.      0.
4       0.      0.      0.     21.      0.      5.
5       2.      0.      2.      0.    262.      7.
6       3.      0.      0.      5.      7.    182.

STOCHASTIC MIGRATION MATRIX

1    0.97854 0.00671 0.0     0.0     0.00551 0.01527
2    0.00215 0.99329 0.0     0.0     0.0     0.0
3    0.0     0.0     0.97638 0.0     0.00551 0.0
4    0.0     0.0     0.0     0.82353 0.0     0.02290
5    0.00644 0.0     0.02362 0.0     0.96324 0.03562
6    0.01288 0.0     0.0     0.17647 0.02574 0.92621

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    58739.    919.     20.    436.    609.   2050.
2      919.113607.      0.      2.      4.     14.
3       20.      0.173776.     11.   1839.     87.
4      436.      2.     11.228738.    537.  19617.
5      609.      4.   1839.    537.  16986.   2256.
6     2050.     14.     87.  19617.   2256.  36553.

R MATRIX (X 10E7)

1    41371.-12511.-15975.-14727.-10314.-11815.
2   -12511.104284.-12000.-11167. -6925. -9858.
3   -15975.-12000.159385.-13722. -7652.-12349.
4   -14727.-11167.-13722.216065. -8124.  8032.
5   -10314. -6925. -7652. -8124. 12581. -5106.
6   -11815. -9858.-12349.  8032. -5106. 26281.

FST= 0.00453165
```

Table 6.33

```
FISHWIVES-OFFSPRING 1871 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE   EN

1          156.7              0.0494          0.8884
2           39.7              0.1061          0.7879
3           74.3              0.1532          0.9570
4           15.3              0.4445          0.3793
5          370.7              0.2610          0.9050
6          208.7              0.1931          0.8056

SYMMETRIC MIGRATION MATRIX

1     220.      6.      0.      0.      4.      4.
2       6.     59.      2.      0.      0.      0.
3       0.      2.     91.      0.      1.      0.
4       0.      0.      0.     10.      0.      5.
5       4.      0.      1.      0.    361.     14.
6       4.      0.      0.      5.     14.    209.

STOCHASTIC MIGRATION MATRIX

1    0.94421 0.08333 0.0     0.0     0.00923 0.01728
2    0.02361 0.89394 0.01613 0.0     0.0     0.0
3    0.0     0.02273 0.97849 0.0     0.00132 0.0
4    0.0     0.0     0.0     0.68966 0.0     0.01944
5    0.01502 0.0     0.00538 0.0     0.95251 0.06048
6    0.01717 0.0     0.0     0.31034 0.03694 0.90281

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    43900.   9972.    189.    220.    766.   1540.
2     9972.115523.   5473.     11.     76.    149.
3      189.   5473.  75863.      1.    206.     16.
4      220.     11.      1.  26475.    286.   6107.
5      766.     76.    206.    286.   9429.   1787.
6     1540.    149.     16.   6107.   1787.  17411.

R MATRIX (X 10E7)

1    31579.   -884.  -9926.  -5103.  -7089.  -7038.
2     -884.106215.  -3154.  -3827.  -6293.  -6945.
3    -9926.  -3154.  68025.  -3090.  -5417.  -6332.
4    -5103.  -3827.  -3090.  28191.   -544.   4555.
5    -7089.  -6293.  -5417.   -544.   6072.  -2299.
6    -7038.  -6945.  -6332.   4555.  -2299.  12609.

FST= 0.00225708
```

Table 6.34

```
FISHWIVES-OFFSPRING 1881 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)    SYSTEMATIC PRESSURE   EN

1         179.7             0.0576            0.9498
2          31.0             0.0244            0.7978
3          96.0             0.0559            0.9170
4          12.3             0.0               0.6296
5         482.7             0.2363            0.9482
6         206.7             0.1635            0.8951

SYMMETRIC MIGRATION MATRIX

1    272.     3.     0.     0.     3.     2.
2      3.    40.     2.     0.     0.     0.
3      0.     2.   127.     0.     3.     1.
4      0.     0.     0.    11.     0.     3.
5      3.     0.     3.     0.   527.     9.
6      2.     0.     1.     3.     9.   244.

STOCHASTIC MIGRATION MATRIX

1    0.97491 0.05618 0.0     0.0     0.00555 0.00583
2    0.00896 0.89888 0.01509 0.0     0.0     0.0
3    0.0     0.04494 0.95849 0.0     0.00462 0.00388
4    0.0     0.0     0.0     0.81481 0.0     0.00971
5    0.01075 0.0     0.01887 0.0     0.97412 0.03301
6    0.00538 0.0     0.00755 0.18519 0.01571 0.94757

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1    42174.   6470.    126.    133.    439.    546.
2     6470.194449.   9958.     11.     70.     77.
3      126.   9958.  74101.    182.    701.    707.
4      133.     11.    182.349395.    246.  13015.
5      439.     70.    701.    246.   8626.    936.
6      546.     77.    707.  13015.    936.  23301.

R MATRIX (X 10E7)

1    31891.  -3912.  -9998.  -9225.  -6287.  -7260.
2    -3912.184097.   -239.  -9425.  -6736.  -7808.
3    -9998.   -239.  64203.  -8992.  -5842.  -6915.
4    -9225.  -9425.  -8992.341190.  -5531.   6166.
5    -6287.  -6736.  -5842.  -5531.   5485.  -3290.
6    -7260.  -7808.  -6915.   6166.  -3290.  18009.

FST= 0.00279447
```

Table 6.35

TABLE 6.36 AG. WIVES-OFFSPRING 1851: RAW MIGRATION MATRIX

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 29 | 0 | 0 | 0 | 0 |
| 2 | 0 | 21 | 0 | 2 | 0 |
| 3 | 0 | 0 | 10 | 1 | 0 |
| 4 | 0 | 0 | 0 | 17 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 |

```
AG.WIVES-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX 3.

NE (SELECTED POPS.)     SYSTEMATIC PRESSURE   EN

1          34.3               0.1212           0.7059
2         103.0               0.6719           0.1053
3          39.3               0.5238           0.1111
4          87.3               0.7260          -0.2273
5          31.7               0.5530           0.4783

SYMMETRIC MIGRATION MATRIX

1       29.     0.     0.     0.     0.
2        0.    21.     0.     1.     0.
3        0.     0.    10.     1.     0.
4        0.     1.     1.    17.     0.
5        0.     0.     0.     0.    17.

STOCHASTIC MIGRATION MATRIX

1     1.00000 0.0     0.0     0.0     0.0
2     0.0     0.95455 0.0     0.05405 0.0
3     0.0     0.0     0.95238 0.02703 0.0
4     0.0     0.04545 0.04762 0.91892 0.0
5     0.0     0.0     0.0     0.0     1.00000

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1   165559.      0.      0.      0.      0.
2        0.    973.     12.     45.      0.
3        0.     12.   8314.    146.      0.
4        0.     45.    146.   -586.      0.
5        0.      0.      0.      0.  21383.

R MATRIX (X 10E7)

1   129858.-16870.-17670.-16378.-18807.
2   -16870.  2980.  1219.  2543.     70.
3   -17670.  1219.  8722.  1845.   -730.
4   -16378.  2543.  1845.  2404.    562.
5   -18807.     70.  -730.    562. 19521.

FST= 0.00200787
```

Table 6.37

TABLE 6.38 FARMERS WIVES-OFFSPRING 1851: RAW MIGRATION MATRIX.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 10 | 0 | 0 | 0 | 0 |
| 2 | 0 | 4 | 6 | 10 | 0 |
| 3 | 0 | 0 | 57 | 0 | 0 |
| 4 | 0 | 0 | 0 | 8 | 0 |
| 5 | 0 | 0 | 0 | 2 | 0 |

```
FARMERS WIVES-OFFSPRING 1851 : RESULTS FROM MALECOTS MIGRATION MATRIX

NE (SELECTED POPS.)    SYSTEMATIC PRESSURE   EN

1          22.7               0.6552          0.0811
2          22.3               0.7895         -0.5429
3         100.3               0.4615          0.2667
4          38.3               0.5556         -0.3600
5           8.3               1.0000         -1.0000

SYMMETRIC MIGRATION MATRIX

1      10.     0.     0.     0.     0.
2       0.     4.     3.     5.     0.
3       0.     3.    57.     0.     0.
4       0.     5.     0.     8.     1.
5       0.     0.     0.     1.     0.

STOCHASTIC MIGRATION MATRIX

1    1.00000 0.0     0.0     0.0     0.0
2    0.0     0.33333 0.05000 0.35714 0.0
3    0.0     0.25000 0.95000 0.0     0.0
4    0.0     0.41667 0.0     0.57143 1.00000
5    0.0     0.0     0.0     0.07143 0.0

NUMBER OF ITERATIONS TO CONVERGENCE = 2
PHI MATRIX AFTER CONVERGENCE(X 10E7)

1     5243.      0.      0.      0.      0.
2        0.   -843.    380.  -1973.     0.
3        0.    380.   6979.     65.     0.
4        0.  -1973.     65.  -4206.     0.
5        0.      0.      0.      0.      0.

R MATRIX (X 10E7)

1     5774.   1443.  -2556.   2185.   1149.
2     1443.   1513.  -1263.   1124.   2062.
3    -2556.  -1263.   1339.   -836.  -1937.
4     2185.   1124.   -836.   -367.   2804.
5     1149.   2062.  -1937.   2804.   1768.

FST= 0.00015607
```

Table 6.39

# Chapter 7.

# Isolation by Distance Analysis.

Isolation by distance is theoretically a continuous model of migration. As such it should provide a good comparison to the migration matrix approach, which assumes a population distributed in discrete colonies. From the latters results I thought that the isolation by distance model would be much more appropriate for the rural communities, whereas the matrix had been suitable for the fisher-populations. Moreover, using Malecot's formula (equation 1.7), I hoped to obtain a third prediction of kinship (parameter 'a' from equation 1.7) from this model to compare with the estimates calculated from isonymy and the matrix approach.

By using the formula given in Morton's 1977 paper (equation 1.8 and 1.9) I hoped to fulfil these objectives. I used father-offspring data for 1851 in the first instance. Once more the occupational categories of fishermen, farmers, and agricultural labourers were considered separately.

## Problems.

In order to estimate parameters a and b from equations 1.8 and 1.9 it was necessary to first calculate the parameter $m_e$ from equation 1.10. It emerged very early on that the distinction made in this formula (1.10) between 'long' (m) and 'short' (k) range migration posed a considerable problem for my data. Essentially there is no obvious cut-off point between the two. This is adequately illustrated by the map of Great Britain showing the distribution of birth places (figure 4.19): the density gradually lessens as distance from Yorkshire increases and there is no sudden jump in the frequency of migrants. The gradual cline of the graphs showing migration over distance (chapter 4) confirms this.

I decided first of all to consult a number of papers to see how others have tackled the problem. Table 7.1 summarises some of the different approaches to the question of 'long' and 'short' range migration. In the majority of cases the author took a concrete geographical unit (an island, a parish, a county) which made the distinction easy: long range migrants were simply those from outside that unit. The long line of Yorkshire villages that I have taken do not unfortunately comprise any part of a geographical unit. It exceeds the boundary of North Yorkshire and yet also is only a tiny part of that county. It exceeds a single parish boundary. I therefore had to look to other methods of distinguishing both long and short range migration.

Morton *et al.* (1973) has used a mathematical method to distinguish the two, which could be applied to my data since it is estimated from genetic data. Morton (1982a and 1982b) has discussed the distinction between long and short range migration further. He states that 'the distinction between long range and short range migration is arbitrary'. He suggests that if $\sigma^2$ is taken as $E(d^2)$ with all migrants included, then consistency with other evidence is obtained if $d \geq 4\sigma$ is defined as 'long range'. However, despite finally coming across this definition, it was apparent that whatever the distinction, the cut-off point was arbitrary and that overall there was no widely accepted and used procedure for distinguishing between the two. I tried a series of methods before arriving at a satisfactory solution. Unfortunately Morton's 1982 papers were not available to me before I had arrived at this final solution, although my trials do at least emphasise the difficulty of determining a cut-off point, and, in the end, my final solution (solution 5) is probably about as accurate a method as any that are available.

### Solution 1.

Initially I simply used the definition of long range migration that I have used throughout my work, namely long range migrants are the top 10% of all migrants, (*i.e.* those 10% who have migrated the furthest). From the frequency list of father-offspring distances obtained from SPSSX (for example, table 7.2 and 7.3) the top 10% were marked off individually for each occupational group in each town, from which I hoped to estimate m and k (equation 1.10) and the standard deviation so that I could estimate parameters 'a' and 'b'. A number of difficulties arose.

Foremost, as for Hinderwell agricultural labourers in 1851, the top category of distance actually included the top 11.6% rather than the top 10% . More seriously for the 1851 fishermen of Staithes, Runswick, Whitby and Filey there was so little migration that the top 10% included all migrants, leaving no short distance category and no standard deviation, making the estimation of a and b impossible. (In Robin Hood's Bay there were no immigrants amongst the fishermen and thus estimation of isolation by distance for this community does not apply).

By taking 90% as a cut-off point, it assumes the same proportion of short to long range migration for every community where this may not be applicable. For all these reasons the method was thought to be inappropriate.

### Solution 2.

I went back to re-consider the idea of using the parish boundary. For Hinderwell for example, short range migration could be considered as that between the villages of the parish and long range migration as all migrants beyond the parish boundary. However, for Filey where the village is the parish this was obviously not viable. Moreover, for the agricultural communities it would, unrealistically in my opinion, make the frequency of long range migrants top heavy, and perhaps leave no short range migrants in some cases. (Migration between the fishing community of Staithes and rural Hinderwell was very negligible).

### Solution 3.

If one assumes, as indicated by the general map of Great Britain (figure 4.19), that migration declines with distance, I thought it possible to plot a normal distribution curve of migration distances and from that determine the cut-off point. Thus rather than taking the top 10% of individuals, one is taking the top migration distances. I wrote a program to plot the normal distribution (figure 7.1), according to the formula;

$$n(x;\mu,\sigma) = \frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})} \qquad for \qquad -\infty \leq x \leq \infty$$

where $\mu$ is the mean, $\sigma$ is the standard deviation, and x is the distance. I then hoped to determine the cut-off point as .10 to the right of the area under the curve. However, I soon discovered that in most cases the standard deviation was large and the mean was often small (for example, Scarborough fishermen in 1851: $\mu = 46.5 \quad and \quad \sigma = 102.3$), so that negative values of x were required to complete the bell-shaped curve. I was unhappy with this as it suggested negative values of distance which are unrealistic, and if not impossible, it was beyond my powers to alter the fortran program to cope with it. Furthermore it also became clear to me that the cut-off point, while statistically valid, was again arbitrary. This attempt too was therefore abandoned.

### Solution 4

At this point I decided that rather than take a certain % of either the individuals or the distances migrated, which assumes that there is a cut-off point, I should take two arbitrary km values, of 10km and 20km, and to compare these to show what sort of difference the value of $m_e$ actually makes to the final values of a and b.

I selected one community only; Scarborough fishermen-offspring in 1851. From the SPSSX list of migrated distance frequencies (table 7.2) it was possible to estimate the standard deviation, and the proportion of long and short range migration and feed the information into the computer program. Population size was the same as the figure finally used in the migration matrix (*i.e.* just the fisher-folk of Scarborough, the sampled population size). The results are given in figures 7.2 and 7.3.

From the results it is evident that the value of $m_e$ (which depends upon m and k, equation 1.10) greatly influences the value of b. Since b is a function of migration this is not surprising. Short range migration (k) is particularly important since it determines the value of the standard deviation.

It may be said of Scarborough that kinship (a) is relatively low and that kinship declines rapidly over distance (b). Indeed the value of b exceeds all other estimates, the closest being 1.724 from Tomiai village Japan (Imaizumi 1971). I suggest that here this is due to mis-definition of long range migration: 10km+ obviously includes many short range migrants.

While the results using the 20km cut-off point are viable, the estimation of b is high. The question remains; Is the estimation of b truly indicative of migration into Scarborough? Or is it falsely high due to a mis-representation of long and short range migration? Of greater importance, however, these results have clearly shown that the distinction between long and short range migration is crucial to the estimation of parameter b.

Therefore while the distinction between m and k is doubtlessly arbitrary it greatly affects the results and some care should be taken in distinguishing between the two. While it is possible to try another abstract distance of say 50km as a cut off point, it becomes clear from looking at the migration frequency distribution for each community (tables 7.2 and 7.3), that every one has its own character and very likely, its own individual cut-off points. Moreover by taking an abstract figure one is 'guessing' and the validity of such results therefore questionable.

### Solution 5.

Finally I returned to the graphs showing the cumulative % frequency of migrants against distance (chapter 4). By fitting a polynomial of order three to such data, and then by differentiation of that curve and finally by the use of a quadratic equation, it is possible to estimate the turning points of the original curve and thus determine the most likely 'cut-off' point.

In order to do this I first obtained a frequency list of father-offspring distances from SPSSX, which I then edited to leave two columns, one of distances, and the second of the cumulative % . The Durham University program 'Curvefit' fitted a polynomial of the form $y = A0 + A1x + A2x^2 ... + ANx^n$ to my data, from which I was able to differentiate (see, for example, figure 7.4).

I should mention that I did in fact try using the ordinary frequency against distance as well as the cumulative frequency for all fishermen in 1851 (figures 7.4 and 7.5). The two give quite different results. However, from the graphs I think that the cumulative % frequency gives the better fit. For this reason I shall only use the cumulative % frequency data.

It is also clear from the first graph, however, that the cumulative polynomial is still a rather poor fit to the data. This exemplifies beautifully that the distinction between 'short' and 'long' range migration is unrealistic. On the other hand, however, the method does give a cut off point which is actually related to the data and it is in my opinion, the best solution. Thus I decided to use this method to determine between long and short range migration.

As I mentioned above, it is clear from the distance frequency lists (tables 7.2 and 7.3) that each community has its own character. For example, there is no migration at all into the fishing population of Robin Hood's Bay in 1851, whereas Scarborough's fisherfolk come from numerous different locations, many over 100km, up to 481km. For this reason I think that it is necessary to calculate the 'cut-off' point separately for each community. In my view the only real drawback of this method is that it is very time-consuming.

## Results

### Agricultural labourer-offspring 1851

The Polynomial least squares fit is presented in figures 7.5 and 7.6, and the values of the curve are given in the graphs. The turning points were worked out following exactly the same method that was presented in figure 7.4. This method was followed for all the subsequent isolation by distance analysis. I have taken the lower turning point as the change-over from short to long range migration in each case.

Only for Hinderwell and Fylingdales are the curves a reasonably good fit to the data and in both these there are relatively few data points. Generally the data forms a smooth curve. Once more we are reminded of the arbitrary distinction between long and short range migration.

It will also be noticed that the turning points vary considerably from town to town, the larger communities of Scarborough and Whitby with the highest cut-off points. (Thus a random figure of 20km would prove very unsatisfactory in a number of cases.) With the results from curve fit it was possible to estimate 'a' and 'b' for the five rural populations. The results are presented in tables 7.4 and 7.5.

The results for Hinderwell show that kinship (a) is relatively high and it declines quite rapidly over distance. In Fylingdales too, 'b' is relatively high, although kinship here is lower. For the other three communities, however, 'b' is much lower as is kinship, particularly in Scarborough (the very large population size probably accounts for 'a'). I have only presented the isolation by distance curve for Hinderwell and Filey to show the comparison between the two extremes of 'b' for the rural communities.

## Fishermen-offspring 1851.

Looking down the migration frequency lists for the fishing communities (table 7.2) it becomes immediately obvious that it is impossible to fit a polynomial of order three to three of the populations. As mentioned above there is no migration into Robin Hood's Bay at all, and migrants into Runswick and Whitby immigrate from only one other location. Thus any distinction between short and long range migration cannot be made and the isolation by distance model according to Morton's 1977 formula is inapplicable for these three communities. However, the least squares fit graphs are presented for Scarborough, Filey and Staithes (figures 7.6 and 7.7).

There was only one 'turning point' for Scarborough and it was considerably higher than either of the other towns and indeed much greater than the 20km selected earlier. I should mention also that the polynomial curve for Filey is a particularly poor fit to the data.

From these results from curvefit it was possible to estimate '$m_e$' and consequently the parameters 'a' and 'b'. The results for the three towns are given in table 7.7. For all the fishing communities kinship (a) is greater than in the agricultural village, (with the exception of Hinderwell which is a slightly higher value than the Scarborough fishermen). On the other hand both Staithes and Filey are considerably more interbred than the larger, more metropolitan town of Scarborough. Indeed kinship for these two smaller fishing villages is well within values estimated for isolates, islands and hunter-gatherer populations.

The value of 'b' for Scarborough's sea-faring community is just lower than any of the other North Yorkshire populations looked at so far; Whitby, Scarborough and Filey's rural populations are just higher than this: all fall well within the range of values given in other studies (see table 1.1). They show a gradual decline of kinship with distance (see figure 7.9). On the other hand all the other populations examined show a relatively rapid decline of kinship with distance and therefore higher values of 'b'. Staithes shows the quickest decline of kinship over distance, although this is similar to the Filey fishermen (figures 7.9 and 7.10). Both these values only fall within the region of estimates from Imaizumi's study of Japanese populations (1971).

The suitability of the isolation by distance model to the fishing populations is questionable. It is not possible to estimate 'a' and 'b' for three of the villages and only for Scarborough is a clear and gradual decline of kinship over distance observed. It is also interesting that the relatively isolated moorland parishes of Hinderwell and Fylingdales give similar results of 'b' to that of the two fishing communities, although they are very much less inbred.

## Farmer-offspring 1851.

The SPSSX frequency list of father-offspring distances for the 1851 farmers is given in table 7.3. Notably, Filey's small sample renders immigrants from only two other locations making it impossible to fit a polynomial of order three to the data. Thus Filey has been excluded from this part of the analysis. The Polynomial least squares fit graphs are presented for the other four towns in figures 7.7 and 7.8. Here the polynomials fit the data particularly badly: if joined, the data points would form a relatively smooth curve, completely misrepresented by the polynomial. On the other hand for three of the four towns (Hinderwell excluded) the estimated cut off points did appear to fall within a 'natural break' in the data. For example the cut off point for Whitby was calculated as 101km. and there is a gap in the distances migrated into Whitby between 37km and 216km. Thus it seems plausible indeed that 216km and 277km should be considered as 'long range' distances and the rest as 'short range'. The cut-off points are all grouped around 100km with the exception of Hinderwell, which is much lower at 25km.

Values of 'a' and 'b' are given in tables 7.5 and 7.6. Estimates of kinship (a) are well within the range of values calculated for the agricultural labourer-offspring data. Indeed all estimates are within .002 of each other. On the other hand, farmers are much less inter-related than the fishermen of Staithes and Filey. Alike the agricultural labourers, values of 'a' for Scarborough and Whitby's farmers are low, but then the very large population sizes will account for this. Fylingdales and Hinderwell are within the 'average' range taken from former studies (table 1.1).

By contrast for the farmer-offspring data, kinship declines rather more rapidly over distance than it did for the agricultural labourers-offspring data, although it is only slightly increased. Fylingdales, however, proves the exception here with a much slower decline for the farmer-offspring data. Thus for the farming community in 1851 all values of 'b', except that estimated for Hinderwell, lie well within the range calculated from previous studies (table 1.1).

## Change over time?

### Agricultural labourer-offspring 1861-1881.

I thought it would be interesting to look at the subsequent decades to see if parameters ‘a’ and ‘b’ changed significantly over time. From my earlier results I expected to find a gradual decline in kinship over the years and perhaps an accompanying decrease in the value of ’b’ or, in other words, a slower decline in kinship over distance, with people migrating perhaps a little further.

The graphs showing the polynomial least squares fit for the towns in 1861 are presented in figure 7.11. Comparing that the cut off points for the two years 1851 and 1861 it is clear that they are radically different. Is this because the polynomial least squares fit method that I have used is in fact so inappropriate it yields wild and unreliable results, or was the agricultural population of the 19th century in a state of flux?

The SPSSX frequency distributions of father-offspring distances are presented for the agricultural labourers of 1861 in table 7.8. They are very different from the parallel distributions given for 1851. With the exception of Fylingdales, all the populations have decreased considerably with Filey at the extreme with a drop in the number of father-offspring cases by forty-one. Fylingdales, on the other hand gained a notable twenty into its population. All in all, the data suggests that these rural populations had fluctuated considerably over ten years. I suggest that either historical factors were responsible for this, or, the census records distinguished incorrectly between ‘farmer’ and ‘agricultural labourer’.

In Selsey, West Sussex, (Sherren 1983) the distinction between farmer and agricultural labourer was clear-cut, since farm holdings were sizeable. In the 19th century North Yorkshire, however, farm holdings were often quite small and the distinction between labourer and farmer more subtle. It is relatively straightforward to see whether or not this could account for the fluctuations observed. For example, in 1851 Fylingdales had a comparatively large number of farmers with offspring (149) and a relatively small number of labourers with children (31). By 1861 the labourers had grown to a figure of 71; Had the number of farmers proportionally decreased? In other words could the increase of labourers in 1861 simply be due to a misclassification of the 1851 farmers? The SPSSX frequency list of father-offspring distances for the farming communities of 1861 are given in table 7.8. The number of farmer-offspring cases for Fylingdales in 1861 stands at 168, an increase on the 149 of 1851. Thus both rural occupations increased during this period, making misrepresentation a very unlikely reason for the larger number of labourers with children.

The reasons for such fluctuations must therefore be historical. Looking at the SPSSX frequency lists for 1871 and 1881 (tables 7.8 and 7.9) it is clear that the numbers continue to jostle throughout the period. I know of no major historical event either materially or locally that can adequately account for this. Generally over the 19th century there was a national decline in farming and indeed the overall trend with my data is downwards. The building of Port Mulgrave during the 1850's could account for the slump in Hinderwell's labouring population in 1861. Similarly, the establishment of the Grinkle mine company in 1875 might have contributed to the second decline in Hinderwell by 1881. On the other hand the establishment of the larger iron ore company at Loftus coincides with a slight increase in 1871.

Doubtless, however, the most reasonable explanation must lie in the agricultural hiring system used in Yorkshire at this time. Agricultural labourers were a transient community with only yearly contracts. Labourers would come and go from their native parishes and thus it was unlikely that both father and son would have necessarily been born in the same parish. Hence, the relatively low levels of 0.0 distances, and what is more, the fluctuating numbers within this distance category underlines the fluidity of this society. The data presented in the SPSSX lists consists only of those agricultural labourers who were also fathers and moreover, only those fathers whose children were present with them at the time of census taking. Thus the data do not include these bachelors, widows and the childless who may otherwise have 'evened' the numbers. Furthermore with the success and failure of crops it is likely that farmers would hire more and then less workers respectively.

Looking at the cut-off points determined for each decade (given in the results in tables 7.10, 7.11, 7.12 and 7.13) it is also clear that these alternate without any apparent relation to the changing sizes of the data in each census year. Only in Filey does the increased sample coincide with a wider range for short range migration. In Hinderwell the situation is reversed, and in the two large towns the cut-off point varies irrespective of the gradual decline in numbers over time. This perhaps adds yet more weight to my argument that the hiring system of Yorkshire implied a transient life-style upon the agricultural labourers of that age.

Looking at the polynomial least squares fit for all the villages in 1861 up to 1881 (figures 7.11, 7.12, 7.13 and 7.14), it appears that there are one or two anomalies that should be mentioned. On the whole it becomes more obvious that with fewer data points the curve becomes more obscure. For example, this is true of Filey in 1861, and Hinderwell in 1881. On the other hand in Fylingdales in 1881 and 1861, where there were a larger number of cases, the smooth curve that was drawn gave a good fit to the data, but this meant that the turning point was undeterminable and the graphs have therefore not been presented for these data since 'a' and 'b' cannot be determined for these samples. Once more I should note the tenuous distinction between 'long' and 'short' range migration, although generally speaking, the 'fit' isn't 'too bad' for the agricultural labourers compared (as we shall see) to the farmers and the fishermen.

Given the fluctuating nature of the cut-off points and the data itself, it is likely that the values of 'a' and 'b'will also alternate from decade to decade. The results for all the agricultural communities from 1861-1881 are given in tables 7.10, 7.11, 7.12 and 7.13. There are no results for Filey in 1861. Here the cut-off point was determined as 17km. However, there was only one instance where a father and child were born apart at less than 17km distance, making the estimation of the standard deviation ($\sigma'$), and therefore 'a' and 'b' as well, impossible.

As predicted, the results for Hinderwell, Fylingdales and Filey are not comparable to those from 1851 and they do indeed vary from decade to decade. Scarborough and Whitby, on the other hand, are relatively stable with only minor fluctuations in the values of 'a' and 'b'. Generally both towns have a low reading for kinship which relates to their respective population sizes. ‘b’, or the decline of kinship over distance, is well within the range of estimates from previous studies (table 1.1).

Kinship in Filey drops very low in 1871, although it is still greater than in either of the two towns. By 1881 it has recovered to a value consistent with other studies, but ‘b’ is much higher. The decline of kinship here is at a similar rate to that estimated for the Filey fishermen of 1851. While ‘b’ for Fylingdales in 1851 was of a similar value, by 1871 its value was much nearer that calculated for Scarborough and Whitby. Hinderwell is perhaps the most changeable population. On the whole ‘b’ is relatively ‘high’, more similar to the fishing villages than the other rural populations, but it does dramatically increase and decrease from a high of .20784 in 1871 to a low of .04601 in 1881, which is nearer estimations for most of the other agricultural communities. Kinship, on the other hand, is only notably higher than the other rural communities in 1851. Finally I should perhaps note that in 1881 the values of ‘b’ are remarkably similar in all the villages with the exception of Filey.

I can only explain these fluctuations in terms of the agricultural hiring system. However, I think that in general, despite the occasional ‘highs’ and ‘lows’ it is fair to say that for the agricultural labourers kinship (a) and the decline of kinship with distance (b) are similar to values estimated for many modern populations, with one major exception. Values of kinship (a) for Whitby and particularly Scarborough are well below any other estimate that I have come across. Using the total population sizes of these towns when only a very selected sample of the population is used to estimate migration, must have some bearing on this.

## Farmer-Offspring 1861-1881.

A farmer is responsible for cultivating a plot of land, whether it is his own or rented. An agricultural labourer is one who is employed to work or help out on a farm. The farmer requires a knowledge of that particular plot of land, - what soil, drainage problems *etc.*, while the latter requires a more general practical working knowledge of the industry. Thus the farmer is likely to lead a rather more sedentary way of life, tied to the land or husbandry, which the latter does not necessarily involve (as we have seen above). Thus on the one hand, it might be expected that the farming community of North Yorkshire would not follow the 'ups' and 'downs' of the agricultural labourers, but would show much greater continuity from decade to decade. On the other hand, the 1851 results for the farmers were remarkably similar to the agricultural labourers of 1851.

The SPSSX frequency distributions for all the farmers and their offspring for 1861-1881 are presented in tables 7.14 and 7.15. The polynomial least squares fit for each community are given in figures 7.15, 7.16, 7.17 and 7.18. The sample sizes fluctuate. To some extent this may be due to the natural turn-over of births, deaths and marriages, or it could suggest that mobility patterns change. Given that the fluctuations are quite considerable and moreover the distances between the fathers' and childrens' birthplace seem to change (particularly in the 50km+ range), it would suggest that the farming communities were not as sedentry as their occupation at first implied.

It is difficult to know why the farmers were not a more stable group. On the whole they do not seem to follow the same fluctuations as the agricultural labourers, although since the hiring process is completely random, mis-definition of occupation by the census enumerator still offers a possible solution. On the other hand, if farming was declining in North Yorkshire at this time (a possibility, given the national crisis in farming in the latter part of the 19th century), it is likely that some may have moved away and if land was subsequently cheap, others may have been attracted into the area. Alternatively, while a farmer may remain on the same farm all his life, and a son may take over from him, there is no reason for the other children not to move away.

While they bear no relation to the 'ups' and 'downs' of the sample sizes, the cut-off points also fluctuate substantially. The only common factor is that all the turning points in 1871 are substantially lower than in any other census year. The fit between the data and the curve is poor, particularly for Hinderwell, Whitby and Filey. Many of these graphs are similar, for as with the 1851 farmers there seems to be a natural break in the data between one very long distance point and the next, and it is at this juncture that the curve goes wild. Inevitably the juncture should form a smooth and gradual line. However, since the results yield a cut off which actually falls within the natural data break, the data must be considered suitable for the purpose of distinguishing between long and short range migration. Filey in 1861 and 1871 and Hinderwell in 1871 remain the exception and in Filey's case this is mainly due to the paucity of the data. I should lastly mention that I could find no solution to the quadratic equation for Hinderwell in 1861 and 'a' and 'b' will therefore not be calculated for this population.

The estimates of 'a' and 'b' are given in tables 7.16, 7.17, 7.18, 7.19 and 7.20. Similar to the agricultural labourers, values of 'a' and 'b' tend to fluctuate from decade to decade without following any particular upwards or downwards trend. However, these fluctuations are much more gentle, with only slight increases or decreases from year to year. The lower cut off points in 1871 are reflected by peak values of 'b' for all the villages except Whitby, where there is not such a marked difference in the 1871 and 1881 turning point. Whitby is also unique in that the value of 'b' is the only one to change consistently from decade to decade.

While values of kinship are within the range of most modern populations for Hinderwell and Fylingdales, they are low for the other three towns. This does appear to be related to population size: Scarborough, with the largest population, has the lowest value of kinship; Whitby has a larger population size than Filey and kinship is consequently higher in Filey; in Hinderwell and Fylingdales where the population size peters around 200-300, kinship is highest. However, it is clear that population size is not the sole determinant, for in 1861 Fylingdales the estimate of 'a' is 'high' at .019 and yet the population size is the same as in 1871 when 'a' was .007.

The decline of kinship with distance (b) is only within the range of values estimated from other modern populations (table 1.1) for Fylingdales and Scarborough.

Otherwise the values of 'b' are high, well above most isolate or modern populations, comparable with some of the Japanese populations and indeed the Otmoor villages (Imaizumi 1971 and Imaizumi*et al.* 1970). More particularly 'b' for the farmers is comparable to the 1851 estimates for the fishing villages of Staithes and Filey. Kinship only is markedly different between these two fishing villages and the three farming populations.

Kinship for the farming data is similar to values obtained for the agricultural labourers, but values of 'b' are much higher. The movement implied by the hiring system obviously meant that individuals were related over greater distances. Indeed looking at the SPSSX frequency lists it is clear that there was a greater tendency for the farmers and their children to be born within the same parish than there was for the labouring families.

On the other hand, as I have already mentioned, 'b' is much lower for Fylingdales and Scarborough's farmer-offspring data. The estimates are on a par with those calculated for the agricultural labourers. It is interesting that for the most part the sample sizes are much larger for these two populations. It is easier to see why Scarborough, as a metropolitan town situated on a fertile plain, may have attracted farmers from further afield, but it is difficult to reason why this was the case for Fylingdales.

In summary then, the farming communities were not closely related, as the labourers were not. For three of the five villages it appears that kinship declined rapidly over distance, implying, I think, that father and son were born within a fairly small radius of each other. In this sense it can be said that the farmers were less mobile than the agricultural labourers as, their professions would seem to suggest.

## Fisherman-Offspring 1861-1881.

The SPSSX frequency lists of father-offspring distances for all the fisher towns from 1861 to 1881 are given in tables 7.21 and 7.22. They are unlike both the other rural populations in that they are much more stable. Generally there is either a continued increase or decrease in sample size. The most striking and important difference, however, is the vast difference in the numbers of fathers and children born within the same parish. Regardless of the size of the town or the number of the migrants into it, the majority of the fathers and their children were born within the same district. This varies from just over one half the cases in 1881 Scarborough, to the entire sample of Robin Hood's Bay in all decades.

The data for the fishermen present a completely new perspective. In a sense it involves two similar, but rather different types of settlement: the smaller inshore fishing villages and the larger herring ports of Scarborough, Filey and Whitby. While both are much more stable than the rural populations (in the above sense), remarkably few men from the inshore fishing villages or their children have migrated from outside their parish. So much so that it is actually impossible to calculate a cut-off point for Robin Hood's Bay or Runswick in any census year because there are simply too few data points. For Staithes in 1851 and 1881 there are just enough to determine a turning point, although the data are so scanty these must be approached cautiously. Essentially, Staithes is in the same bracket as Runswick and Robin Hood's Bay. Perhaps one of the more interesting things about Staithes is that it remains self-contained throughout the period despite the continued increase in sample size. (For the most part the increase is obviously natural and not caused by immigrants into the town; there was apparently little incentive to leave).

As we have seen, Scarborough's fishermen were closely involved with the herring industry which flourished during this time, and is was the first Northern port to use the trawler, which meant that it shared in the success of the subsequent boom in this part of the fishing industry. Migrant fishermen from Norfolk, suffering from the depletion of their own crab stocks, were attracted by Scarborough's prosperity and consequently moved north. All this is reflected by the consistently large increase in Scarborough's population size. Filey, always closely inter-connected with Scarborough's fishing industry, was also caught up in this turn of events – although on a much reduced scale. Although, Whitby did not attract many migrants from Norfolk, its harbour also served as a herring port and its fishing industry also enjoyed prosperity during this period. Given the greater population sizes for these towns, it was possible to determine the turning points and thus estimate the parameters 'a' and 'b'.

The polynomial least square fit graphs are presented for the three towns and Staithes [1881] in figures 7.19 and 7.20. In four cases (all towns in 1861 and Whitby in 1881) there was no solution to the quadratic equation and the curves have not been presented for this reason, for parameters 'a' and 'b' cannot be calculated for these populations.

The lowest turning point for Filey in 1881 is 5km, while the upper one is 351km. Either way it leaves a very small range for short range or long range migration. I should probably take the 5km cut off to be consistent with the previous studies. On the other hand, I thought that it left a range of short range migration that was very small and that was perpaps rather artificial. Hence in this case I chose the upper turning point.

It is interesting that with the data for the fishermen and their offspring, the curve produced by curvefit is on the whole relatively smooth and in the case of Scarborough, smoother than the line formed by the data itself. Once more we are reminded of the artificial distinction between long and short range migration.

Finally parameters 'a' and 'b' were estimated only for Whitby, Scarborough and Filey in 1871, and Scarborough, Filey and Staithes in 1881. The results are presented in tables 7.23 and 7.24. Putting Staithes aside for the moment, it will be noticed that the rest have relatively large standard deviations - much larger than those obtained for either the farmers or the agricultural labourers. Yet the values of long and short range migration (m and k) are no higher than those obtained for the rural populations, stressing once more the much higher numbers of fathers and children born in the same village.

Values of 'a' and 'b' for Scarborough fluctuate. Overall 'b' decreases, so that by 1871 and 1881 the decline of kinship over distance is the slowest rate any of the North

Yorkshire populations studied. The sampled 'fisher' population of Scarborough, however, renders an 'average' value of kinship for 1871 and a surprisingly 'high' value in 1881, rather than the extreme values obtained for the farmers and agricultural labourers.

Filey is interesting in that in 1851 I considered it to share the characteristics of the inshore fishing village of Staithes. By 1871 and 1881 this situation had changed. The values of kinship reflect the same pattern as Scarborough. The 1881 values are lower in fact than both values of 'a' calculated for Staithes, but the difference is more pronounced between the equivalent 1881 values. The 1881 estimates are well above estimates from some modern island populations, for example, the Åland Islands 1850-1899 (Mielke *et al.* 1976) and Barra (Morton *et al.* 1976). The considerable decrease in the value of 'b' between 1871 and 1881 Filey is, I think, distorted for I took the upper turning point to estimate the standard deviation, m and k. It would have been no better, however, had I taken the lower turning point, since the standard deviation would then have been misleadingly low giving a very high reading for 'b'. The more likely value of 'b' for 1871 Filey is below the 1851 estimate or values obtained for Staithes. Thus overall, it can be said that Filey was not as insular towards the end of the century. I suggest that this is due to the influence of Scarborough.

The decline of kinship over distance in 1871 Whitby is relatively slow. The value of 'b' is between those obtained for the Scarborough and Filey fisher populations. Whitby's larger port attracted migrants too. Kinship, however, is much higher than the adjacent 1871 estimates for Scarborough and Filey. Indeed 'a' is higher than their 1881 values, although these are closer. Whitby's considerably smaller population size may account for this.

The results obtained for Staithes are very different from these larger fisher towns. Kinship is very high, (higher than 1871 Whitby despite the fact that 1881 Staithes has a larger population size than 1871 Whitby). Kinship estimated for Staithes is above most other 'isolate' populations, including hunter-gatherer populations. The value of 'b' is higher than in 1851. It is comparable to the farming communities, but it far exceeds estimates from the fishing towns. (See figure 7.21 which shows the two extremes, Scarborough in 1881 with the lowest value of 'b' for all the populations studied here, and Staithes in 1881 with the highest). Staithes does indeed appear to have been highly inter-related and insular, just as the inshore fishing villages are portrayed historically.

Thus overall the fisher communities do seem to fall into two sub-groups. Firstly, the small, inshore fishing villages, to which it is really impracticable to try and apply the isolation by distance model in this form. Secondly, the larger town ports (in which Filey is included on account of it s'connections to Scarborough) for which the isolation by distance model is rather apt.

## Postscript.

In retrospect, it was very worthwhile to try and analyse each community for each census year, since the four decades together gave a much more accurate picture of what was actually happening. For example, by taking the four years it was possible to establish that the farmers were in fact quite different from the agricultural labourers, which had not appeared the case in 1851 alone. On the other hand, there are certain drawbacks to the method I have used for determining long and short range migration, and on which the results therefore rest. For one, it is extremely time consuming. More to the point, it is not really foolproof. On the whole the curves are an extremely poor fit to the data. While I have tried to defend this, there are doubtlessly some dubious cases (for example Hinderwell farmers 1881 and Filey fishermen 1851). For these reasons I have decided not to apply the method to the mother-offspring data. Moreover from previous work it is clear that this data is not strictly different from the father-offspring statistics. They vary only in as much that the fishermen's wives are just a little more mobile than their husbands and *vice versa* for the agricultural labourers. I feel it unlikely that the same data would produce very different trends for the isolation by distance model, (unless of course, the method really is hopeless!).

I must clarify what I mean by the method not being foolproof. I do not believe that the least squares fit program is really inappropriate. It is no more inappropriate than any other method I have attempted to use or, indeed, than any of the methods listed in table 7.1. The problem lies, I believe, in trying to distinguish between 'long' and 'short' range migration at all. The distinction is false. I obtained a poor fit to my data because on the whole the data formed a smooth curve showing a gradual lessening of migration over distance. Rarely was there a point where migration obviously trailed off.

In view of these problems, I could not resist changing Morton's method a little so that the distinction between long and short range migration was not made. I did this simply by omitting equation 1.10, which estimates the parameter $m_e$, and substituting instead my own estimate of $m_e$. I simply took the proportion of all migrants from the sample and divided it by the total number in the sample to give the proportion of migration, $m_e$ as the 'effective migration' rate. (Effective migration is usually defined as being a third of all migrants: Here my sample consisted only of selected individuals anyway, so I did not then further subdivide it).

Without doubt this method has its pitfalls. For a start it does not account theoretically for systematic pressure. However, I have presented comparable results for the 1851 fishermen and agricultural labourers. They are presented in tables 7.25, 7.26 and 7.27. These results are highly dubious and only to be swallowed with a pinch of salt. Generally the method lowers considerably the values of 'b' and to a lesser extent the values of 'a'. I suggest that the decrease in the values of 'b' are due to the increased standard deviation (which is now, of course, the standard deviation of the entire sample, whereas before the long distance migrants were excluded from the standard deviation.)

Despite the unreliability of such results, I think, however, I have made my point. There is perhaps room for a formula to estimate isolation by distance which does not distinguish between long and short migration. After all the whole point of isolation by distance is that it does not assume a population which is geographically distributed in a colony(s), but a population which is uniformly distributed without 'boundaries' and where migration depends solely upon distance.

Table 7.1: Methods of distinguishing long range and short range migration.

| **Paper** | **Study area** | **Definition of 'long range' migrants** |
|---|---|---|
| Roberts *et al.* 1981b | Cumbria | All those from outside the county boundary. |
| Relethford *et al.* 1981 | Ireland | Definition is unclear - those from outside Ireland? |
| Morton *et al.* 1976 | Barra | All those from mainland Scotland (excepting the Highlands). |
| Morton *et al.* 1973c | Switzerland | Long range migrants are distinguished from short range migrants at the point which $(1 - L)ae^{-bd} + L = 0$ |
| Mielke *et al.* 1976 | Åland Islands | All those from outside the Åland Islands. |
| Jorde 1982a | Utah Mormons | All those from outside Utah. |
| Swedlund *et al.* 1984 | Connecticut Valley | All those from outside the study area. |
| Jorde 1982b | Iceland | All those from outside Iceland. |
| Relethford and Brennan 1982 | Orkney | All those from outside the island. |
| Morton 1973a | Micronesia | All those fathers and mothers (parent-offspring data) who come from outside the population child was born in. |
| Roberts 1982 | N. England | All those from outside the study region. |

```
SPSSX FREQUENCY LIST OF FISHERMEN - OFFSPRING DISTANCES 1851.

STAITHES

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00        160     94.1     94.1     94.1
                                     5.00          5      2.9      2.9     97.1
                                    28.00          1       .6       .6     97.6
                                    29.00          3      1.8      1.8     99.4
                                    35.00          1       .6       .6    100.0
                                             -------  -------  -------
                                    TOTAL        170    100.0    100.0
VALID CASES         170           MISSING CASES      0

RUNSWICK

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00         56     91.8     91.8     91.8
                                    69.00          5      8.2      8.2    100.0
                                             -------  -------  -------
                                    TOTAL         61    100.0    100.0
VALID CASES          61           MISSING CASES      0

WHITBY

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00         45     97.8     97.8     97.8
                                   331.00          1      2.2      2.2    100.0
                                             -------  -------  -------
                                    TOTAL         46    100.0    100.0
VALID CASES          46           MISSING CASES      0

ROBIN HOODS BAY

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00         38    100.0    100.0    100.0
                                             -------  -------  -------
                                    TOTAL         38    100.0    100.0
VALID CASES          38           MISSING CASES      0

SCARBOROUGH

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00        133     59.1     59.1     59.1
                                     2.00          2       .9       .9     60.0
                                     5.00          1       .4       .4     60.4
                                    14.00          5      2.2      2.2     62.7
                                    15.00         33     14.7     14.7     77.3
                                    30.00          3      1.3      1.3     78.7
                                    35.00          7      3.1      3.1     81.8
                                    47.00          5      2.2      2.2     84.0
                                    60.00          2       .9       .9     84.9
                                   152.00          1       .4       .4     85.3
                                   178.00          1       .4       .4     85.8
                                   184.00          1       .4       .4     86.2
                                   189.00          2       .9       .9     87.1
                                   192.00          9      4.0      4.0     91.1
                                   205.00          1       .4       .4     91.6
                                   238.00          2       .9       .9     92.4
                                   249.00          5      2.2      2.2     94.7
                                   315.00          1       .4       .4     95.1
                                   353.00          2       .9       .9     96.0
                                   362.00          4      1.8      1.8     97.8
                                   363.00          1       .4       .4     98.2
                                   412.00          1       .4       .4     98.7
                                   439.00          1       .4       .4     99.1
                                   481.00          2       .9       .9    100.0
                                             -------  -------  -------
                                    TOTAL        225    100.0    100.0
VALID CASES         225           MISSING CASES      0

FILEY

                                                              VALID     CUM
VALUE LABEL                         VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                                      .00        200     94.8     94.8     94.8
                                     5.00          3      1.4      1.4     96.2
                                    15.00          2       .9       .9     97.2
                                    24.00          1       .5       .5     97.6
                                    51.00          1       .5       .5     98.1
                                   202.00          4      1.9      1.9    100.0
                                             -------  -------  -------
                                    TOTAL        211    100.0    100.0
VALID CASES         211           MISSING CASES      0
```

Table 7.2

```
SPSSX FREQUENCY LIST OF AGRICULTURAL LABOURER - OFFSPRING DISTANCES 1851.

HINDERWELL

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       20    00.0    60.1    63.1
                        0.00        4     0.1     0.3    74.4
                       12.00        4     0.1     0.3    03.7
                       34.00        1     2.3     2.3    63.0
                       33.00        1     2.3     2.3    00.4
                       40.00        0    11.4    11.0   100.0
                           .        1     2.3  MISSING
                                  -------  -------  -------
                       TOTAL       44   100.0   100.0
VALID CASES       43   MISSING CASES      1

WHITBY

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       20    10.3    21.4    21.4
                        1.00        1      .7      .0    22.1
                        4.00        4     2.0     3.1    26.2
                        6.00        2     1.4     1.6    23.7
                        7.00        0     0.2     0.0    33.0
                        0.00        3     2.1     2.3    23.0
                        0.00       11     7.0     0.4    44.3
                       11.00        2     1.4     1.6    46.0
                       12.00        7     4.0     0.3    01.1
                       13.00        0     4.1     4.0    63.7
                       14.00        0     4.1     4.0    60.3
                       16.00        2     1.4     1.6    01.0
                       16.00        1      .7      .0    02.0
                       17.00        2     1.4     1.6    04.1
                       10.00        1      .7      .0    04.0
                       10.00        1      .7      .0    63.0
                       20.00        1      .7      .0    63.4
                       21.00        2     1.4     1.6    07.0
                       23.00        1      .7      .0    00.7
                       24.00        2     1.4     1.6    70.2
                       23.00        0     6.6     0.1    70.3
                       27.00        2     1.4     1.6    77.0
                       20.00        3     2.1     2.3    60.8
                       30.00        2     1.4     1.6    01.7
                       33.00        1      .7      .0    02.4
                       30.00        0     4.1     4.0    07.0
                       40.00        1      .7      .0    07.0
                       41.00        2     1.4     1.6    63.3
                       43.00        1      .7      .0    60.1
                       60.00        1      .7      .0    60.0
                       03.00        3     2.1     2.3    00.1
                      110.00        2     1.4     1.6    04.7
                      133.00        1      .7      .0    63.4
                      240.00        1      .7      .0    63.2
                      209.00        1      .7      .0    63.0
                      320.00        3     2.1     2.3    63.2

                      416.00        1      .7      .0   100.0
                           .       14     0.7  MISSING
                                  -------  -------  -------
                       TOTAL      140   100.0   100.0
VALID CASES      131   MISSING CASES     14

FYLINGDALES

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       16    40.4    40.4    40.4
                        2.00        1     3.2     3.2    01.0
                        3.00        1     3.2     3.2    64.0
                        6.00        4    12.0    12.0    67.7
                        7.00        4    12.0    12.0    60.0
                        0.00        3     0.7     0.7    60.3
                       16.00        1     3.2     3.2    30.0
                       20.00        2     0.0     0.0   100.0
                                  -------  -------  -------
                       TOTAL       31   100.0   100.0
VALID CASES       31   MISSING CASES      0

SCARBOROUGH

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       12    10.7    11.0    11.0
                        2.00        1      .0      .0    11.0
                        3.00        0     6.4     6.6    17.4
                        4.00        1      .0      .0    10.3
                        6.00        2     1.0     1.0    20.2
                        0.00        1      .0      .0    21.1
                        7.00        2     1.0     1.0    22.0
                        0.00        0     4.6     4.0    27.5
                       10.00        1      .0      .0    20.4
                       11.00        6     4.6     4.0    33.0
                       12.00        1      .0      .0    33.0
                       14.00        2     1.0     1.0    33.0
                       10.00        3     2.7     2.0    30.5
                       17.00        2     1.0     1.0    40.4
                       10.00        2     1.0     1.0    42.2
                       20.00        2     1.0     1.0    44.0
                       22.00        2     1.0     1.0    46.0
                       23.00        1      .0      .0    43.0
                       20.00        0     5.4     6.6    52.3
                       23.00        2     1.0     1.0    54.1
                       27.00        6     4.6     4.0    50.7
                       32.00        2     1.0     1.0    60.0
                       33.00        2     1.0     1.0    62.4
                       34.00        3     2.7     2.0    66.1
                       33.00        4     3.0     3.7    00.0
                       37.00        1      .0      .0    60.7
                       41.00        3     2.7     2.0    72.5
                       43.00        2     1.0     1.0    74.3
                       43.00        2     1.0     1.0    70.1
                       01.00        3     2.7     2.0    70.0
                       07.00        0     6.4     6.6    04.4
                       71.00        2     1.0     1.0    63.2
                       73.00        1      .0      .0    07.2
                       60.00        1      .0      .0    00.1
                      111.00        1      .0      .0    60.0
                      120.00        1      .0      .0    60.0
                      202.00        2     1.0     1.0    01.7
                      263.00        2     1.0     1.0    03.0
                      303.00        3     2.7     2.0    63.3
                      311.00        2     1.0     1.0    00.2
                      420.00        2     1.0     1.0   100.0
                           .        3     2.7  MISSING
                                  -------  -------  -------
                       TOTAL      112   100.0   100.0
VALID CASES      103   MISSING CASES      3

FILEY

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       20    30.6    44.4    44.4
                        0.00        1     1.0     2.2    43.7
                       20.00        1     1.0     2.2    40.0
                       23.00        6     0.0    11.1    60.0
                       27.00        2     3.0     4.4    64.4
                       32.00        6     0.0    11.1    70.0
                       33.00        3     6.0     0.7    02.2
                       30.00        4     7.7     0.0    01.1
                       63.00        2     3.0     4.4    63.0
                       01.00        1     1.0     2.2    07.0
                      140.60        1     1.0     2.2   100.0
                           .        7    13.6  MISSING
                                  -------  -------  -------
                       TOTAL       52   100.0   100.0
VALID CASES       45   MISSING CASES      7
```

```
SPSSX FREQUENCY LIST OF FARMER - OFFSPRING DISTANCES 1851.

HINDERWELL

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       22    01.1    01.1    01.1
                        6.00        2     0.0     0.0    63.7
                        6.00        1     2.0     2.0    63.4
                       13.00        1     2.0     2.0    72.2
                       20.00        2     0.0     0.0    77.0
                       33.00        1     2.0     2.0    60.0
                      123.00        1     2.0     2.0    03.3
                      120.60        0    13.7    13.7   100.0
                                  -------  -------  -------
                       TOTAL       33   100.0   100.0

VALID CASES       33   MISSING CASES      0

WHITBY

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00        7    20.3    20.3    20.3
                        4.00        1     3.3     3.3    23.7
                        6.00        2     0.7     0.7    30.3
                        0.00        6    13.7    13.7    60.0
                       12.00        1     3.3     3.3    63.3
                       17.00        6    20.0    20.0    73.3
                       22.00        2     0.7     0.7    60.0
                       23.00        1     3.3     3.3    03.3
                       24.00        1     3.3     3.3    63.7
                       31.00        1     3.3     3.3    60.0
                       37.00        1     3.3     3.3    63.3
                      210.00        1     3.3     3.3    63.7
                      277.00        1     3.3     3.3   100.0
                                  -------  -------  -------
                       TOTAL       30   100.0   100.0

VALID CASES       30   MISSING CASES      0

FYLINGDALES

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00       62    41.0    41.0    41.0
                        2.00        7     4.7     4.7    43.3
                        3.00        1      .7      .7    47.0
                        3.00       16    10.1    10.1    07.0
                        0.00        6     3.4     3.4    00.4
                        7.00        3     2.0     2.0    02.4
                       11.00        3     2.0     2.0    04.4
                       12.00        1      .7      .7    05.1
                       13.00        2     1.3     1.3    63.4
                       14.00        1      .7      .7    07.1
                       16.00        7     4.7     4.7    71.0
                       20.00        1      .7      .7    72.0
                       21.00        3     2.0     2.0    74.0
                       22.00        6     3.4     3.4    77.0
                       23.00        6     3.4     3.4    01.2
                       24.00        6     3.4     3.4    04.0
                       23.00        1      .7      .7    63.2
                       32.00        1      .7      .7    63.0
                       34.00        1      .7      .7    63.0
                       33.00        1      .7      .7    07.2
                       33.00        4     2.7     2.7    63.0
                       01.00        3     2.0     2.0    01.0
                      204.00        1      .7      .7    02.0
                      402.00       11     7.4     7.4   100.0
                                  -------  -------  -------
                       TOTAL      140   100.0   100.0
VALID CASES      140   MISSING CASES      0

SCARBOROUGH

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00        2     3.1     3.2     3.2
                        3.00        1     1.0     1.0     4.0
                        4.00        2     3.1     3.2     7.0
                        6.00        6     7.0     7.0    10.0
                        6.00        2     3.1     3.2    10.0
                        0.00        2     3.1     3.2    22.2
                       10.00        0    12.0    12.7    34.0
                       12.00        1     1.0     1.0    63.0
                       16.00        2     3.1     3.2    63.7
                       17.00        1     1.0     1.0    41.3
                       20.00        0     0.4     0.0    60.0
                       22.00        0     0.4     0.0    63.3
                       24.00        0    14.1    14.3    74.0
                       41.00        6     7.0     7.0    02.0
                       40.00        4     0.3     0.3    63.0
                      140.00        1     1.0     1.0    60.0
                      160.00        1     1.0     1.0    02.1
                      163.00        4     0.3     0.3    63.4
                      224.00        1     1.0     1.0   100.0
                           .        1     1.0  MISSING
                                  -------  -------  -------
                       TOTAL       64   100.0   100.0
VALID CASES       63   MISSING CASES      1

FILEY

                                               VALID     CUM
VALUE LABEL            VALUE  FREQUENCY PERCENT PERCENT PERCENT

                         .00        4    33.0    33.0    30.0
                        7.00        4    33.0    33.0    61.6
                       62.00        6    30.0    30.6   100.0
                                  -------  -------  -------
                       TOTAL       13   100.0   100.0

VALID CASES       13   MISSING CASES      0
```

Table 7.3

```
C         PROGRAM : TO ESTIMATE THE COORDINATES OF A NORMAL CURVE.

      DOUBLE PRECISION E,F,S,GX(101),H(101),P(101),Q(101),R(101),UN(10
     1,CPIE,V(101)
      WRITE (6,10)
10    FORMAT ('&ENTER THE MEAN')
      READ (5,*) AMEAN
      WRITE (6,20)
20    FORMAT ('&ENTER THE STANDARD DEVIATION')
      READ (5,*) BSD

      CPIE=3.1415927D0

      S=DSQRT(2.0D0*CPIE)*BSD

      F=1.0D0/S

      DO 30 J=1,101
      GX(J)=J
      H(J)=GX(J)-AMEAN
      P(J)=H(J)/BSD
      Q(J)=P(J)*P(J)
      R(J)=Q(J)/(2D0)
      V(J)=DEXP(-R(J))
      UN(J)=F*V(J)
30    CONTINUE

      WRITE (6,40) (GX(J),UN(J),J=1,101)
      WRITE (7,40) (GX(J),UN(J),J=1,101)
40    FORMAT (5X,F5.0,5X,F20.10)

      STOP
      END
```

Figure 7.1

MALECOTS (1977) a & b PARAMETERS: SCARBRO FIS.-OFFSPRING 1851.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.39560 |
| SHORT RANGE MIG (k) | 0.01330 |
| EFFECTIVE POPULATION SIZE (Ne) | 157.00000 |
| STANDARD DEVIATION | 0.48990 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.40868 |
| LOCAL KINSHIP (a) | 0.00388 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 1.84544 |

LONG DISTANCE =10Km +

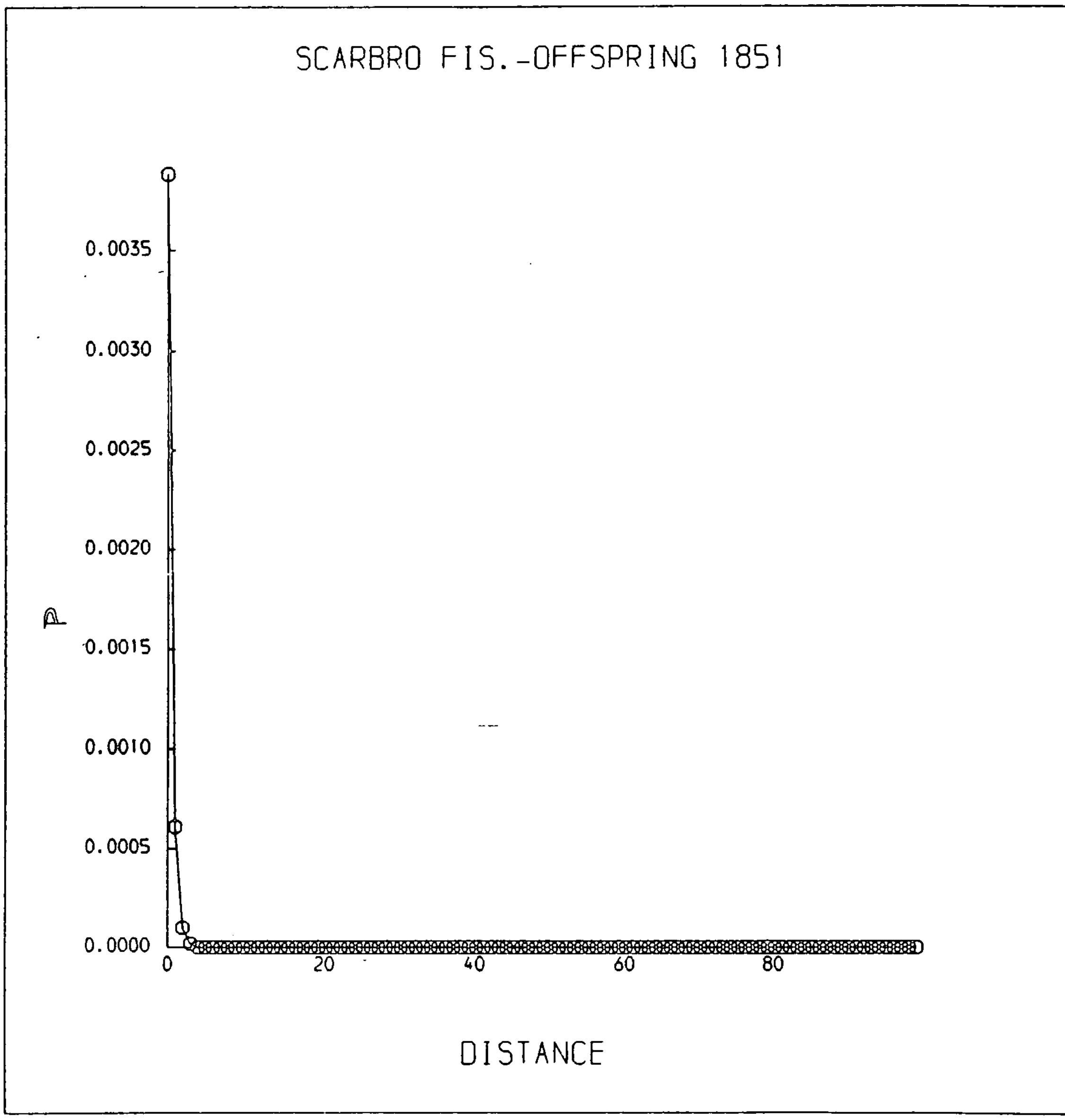


Figure 7.2

MALECOTS (1977) a & b PARAMETERS: SCARBRO FIS 1851

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.22670 |
| SHORT RANGE MIG (k) | 0.18220 |
| EFFECTIVE POPULATION SIZE (Ne) | 157.00000 |
| STANDARD DEVIATION | 6.15050 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.36606 |
| LOCAL KINSHIP (a) | 0.00433 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.13912 |

(LONG DISTANCE MIGRATION = 20 km +)

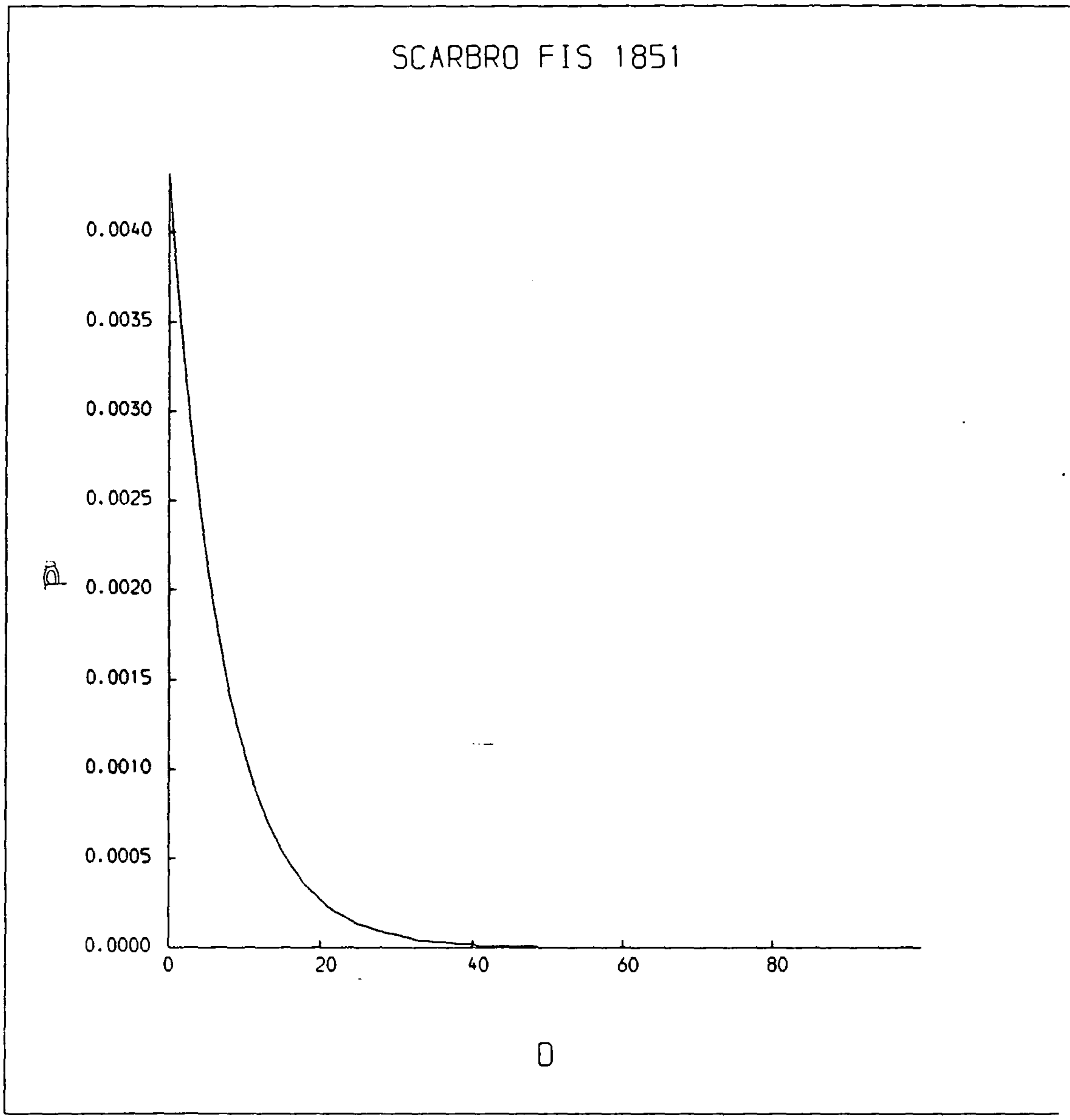


Figure 7.3

Figure 7.4 The calculation of the long distance cut-off point for the 1851 fisherme

– estimated from the cumulative % data.

$$y = A0 + A1x + A2x^2 + \dots ANx^n$$

$$A0 = 87.1283$$

$$A1 = .122791$$

$$A2 = -.00048563$$

$$A3 = .000000638$$

$$y = 87.1283 + .122791x - .00048563x^2 + .000000638x^3$$

*Differentiate*

$$\frac{dy}{dx} = .122791 - .00097126x + .000001914x^2$$

*Quadratic equation*

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{.00097126 \pm \sqrt{.000000943 - .00000094}}{.000003828}$$

$$x = \frac{.00097126 + .000054772}{.000003828} \quad or \quad \frac{.00097126 - .000054772}{.000003828}$$

$$x = 268.03 \quad or \quad 239.417$$

## 7.4 The calculation of the long distance cut-off point for the 1851 fishermen – estimated from the normal frequency data

$y = A0 + A1x + A2x^2 + \ldots ANx^n$

$A0 = 119.346$

$A1 = -2.62$

$A2 = .0133831$

$A3 = -.0000189$

$y = 119.346 - 2.62x + .0133831x^2 - .0000189x^3$

*Differentiate*

$$\frac{dy}{dx} = 2.62 + .0267662x - .00005661x^2$$

*Quadratic equation*

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

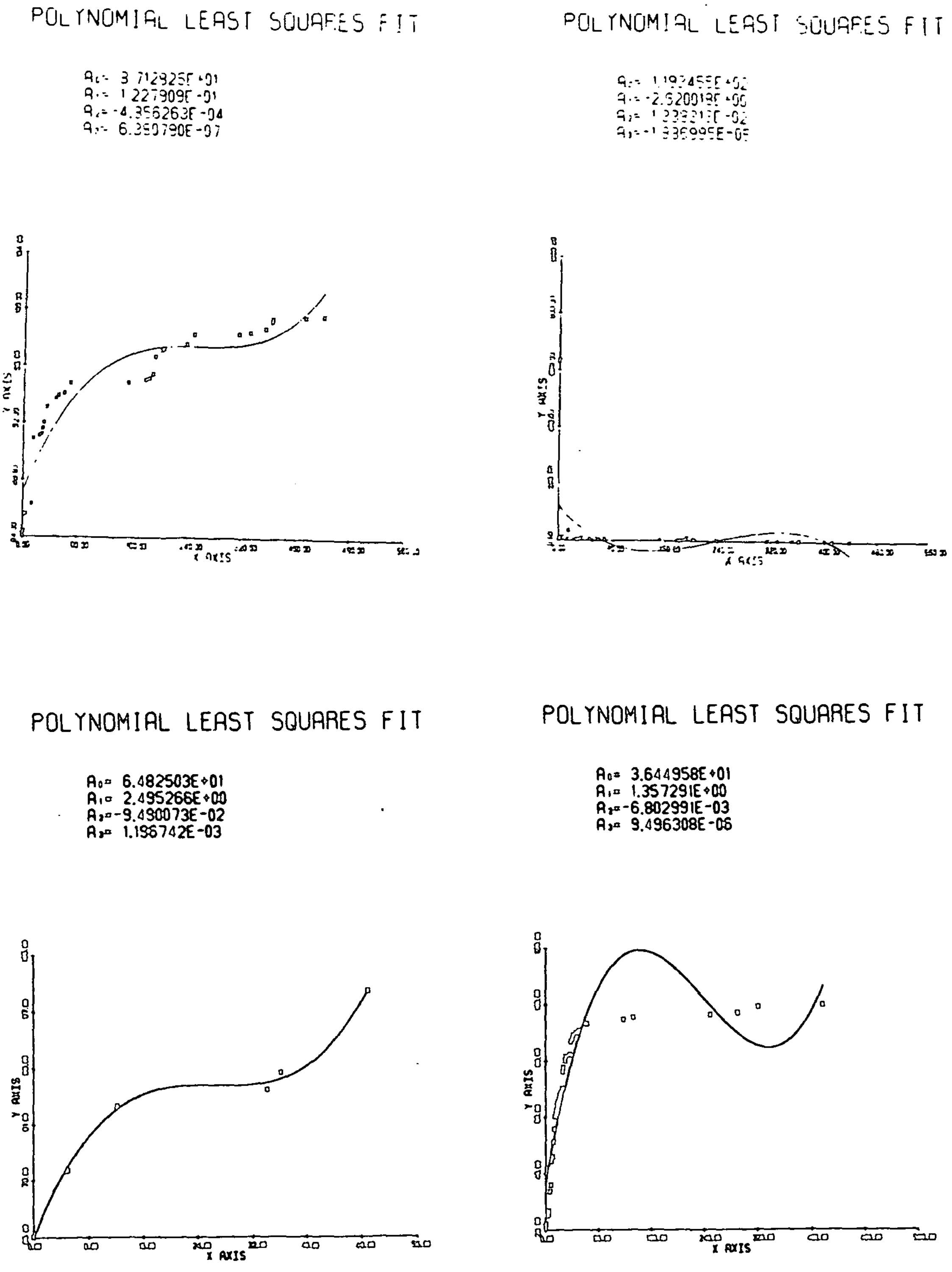
$$x = \frac{-.0267662 \pm \sqrt{.000716418 - .00059328}}{-.00011322}$$

$$x = \frac{-.0267662 + .011096891}{-.00011322} \quad or \quad \frac{-.0267662 - .011096891}{.00011322}$$

$x = 139.39 \quad or \quad 334.425$

ALL FISHERMEN 1851
POLYNOMIAL FITTED TO THE CUMULATIVE FREQUENCY DISTRIBUTION

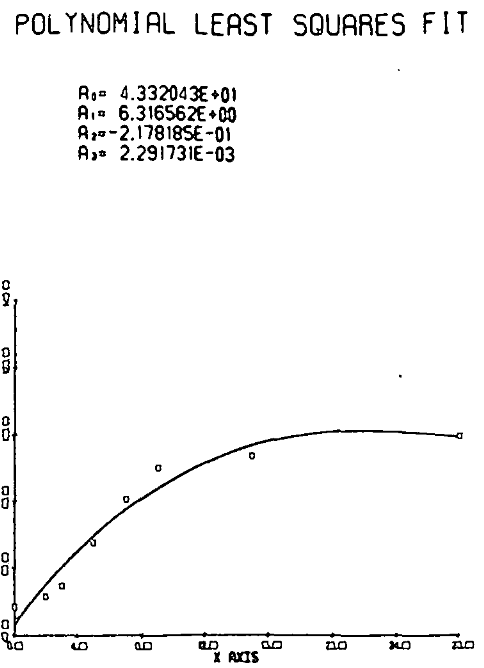
ALL FISHERMEN 1851
POLYNOMIAL FITTED TO THE NORMAL FREQUENCY DISTRIBUTION



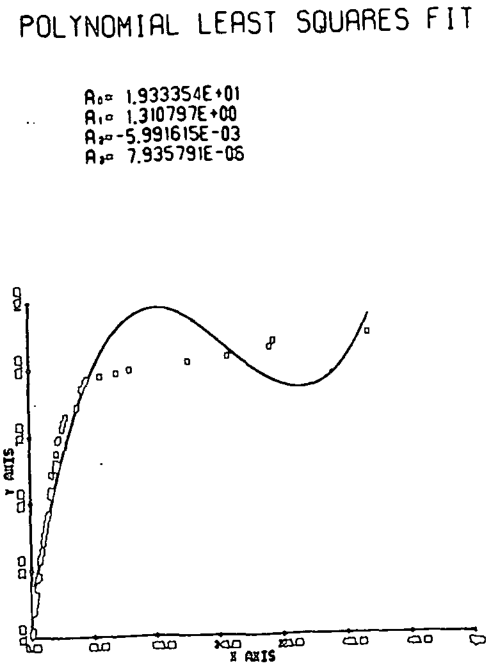
HINDERWELL AGL. LAB.-OFFSPRING 1851.

WHITBY AGL. LAB. - OFFSPRING 1851

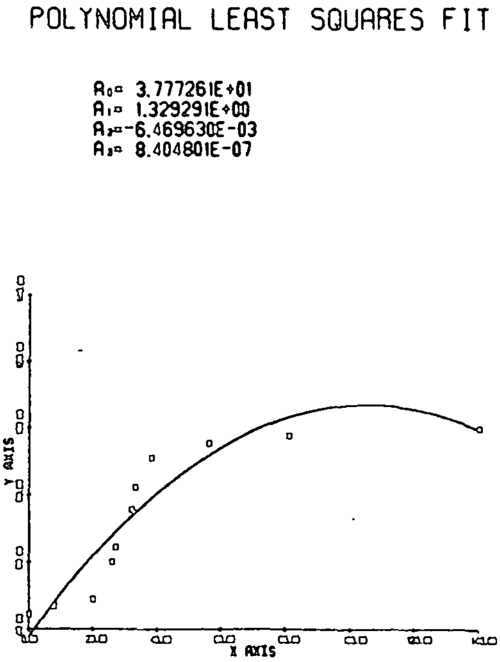
Figure 7.5



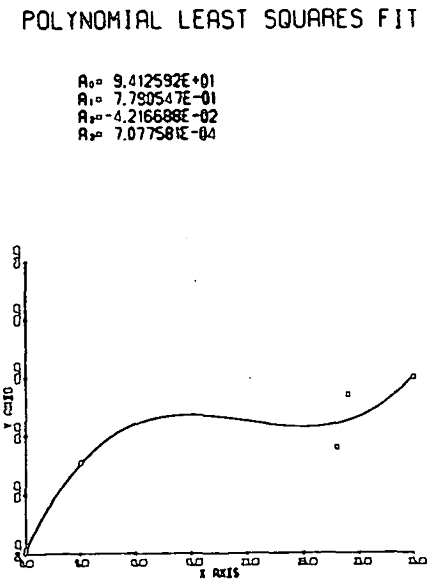
FYLINGDALES AGL. LAB.-OFFSPRING IOSL



SCARBOROUGH AGL. LAB.-OFFSPRING IOSL



FILEY AGL. LAB.- OFFSPRING IOSL

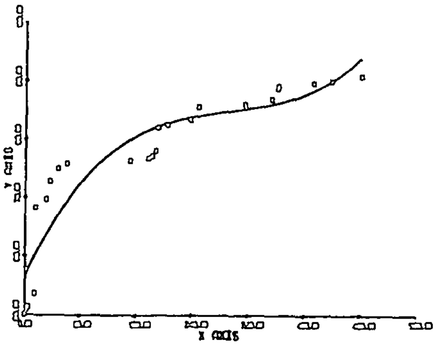


STAITHES FISHERMEN - OFFSPRING IOSI

Figure 7.6

POLYNOMIAL LEAST SQUARES FIT

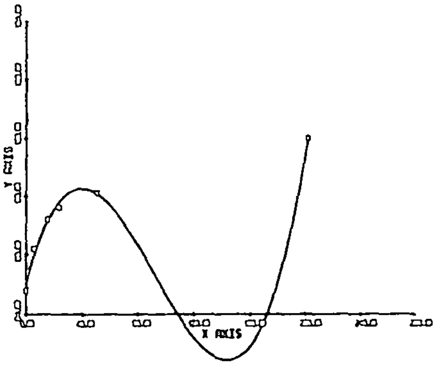
$A_0$= 6.565611E+01
$A_1$= 2.563922E-01
$A_2$=-8.179699E-04
$A_3$= 9.281771E-07



SCARBOROUGH FISHERMEN - OFFSPRING 1851

POLYNOMIAL LEAST SQUARES FIT

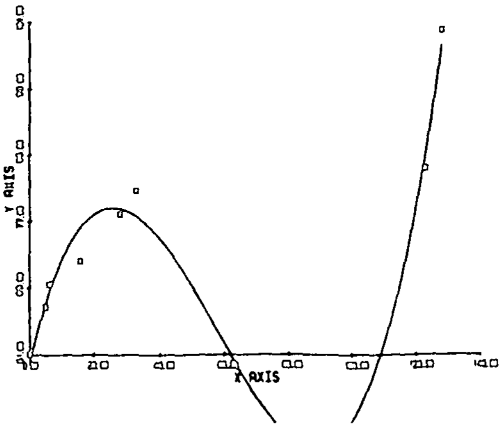
$A_0$= 9.505276E+01
$A_1$= 1.773853E-01
$A_2$=-2.851083E-03
$A_3$= 1.036728E-05



FILEY FISHERMEN - OFFSPRING 1851

POLYNOMIAL LEAST SQUARES FIT

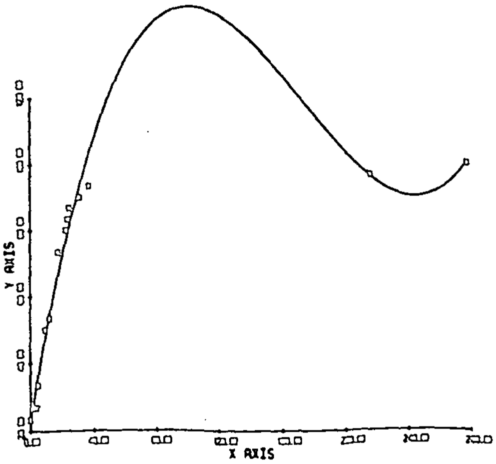
$A_0$= 6.006773E+01
$A_1$= 1.587646E+00
$A_2$=-3.974270E-02
$A_3$= 2.317698E-04



HINDERWELL FARMER - OFFSPRING 1851

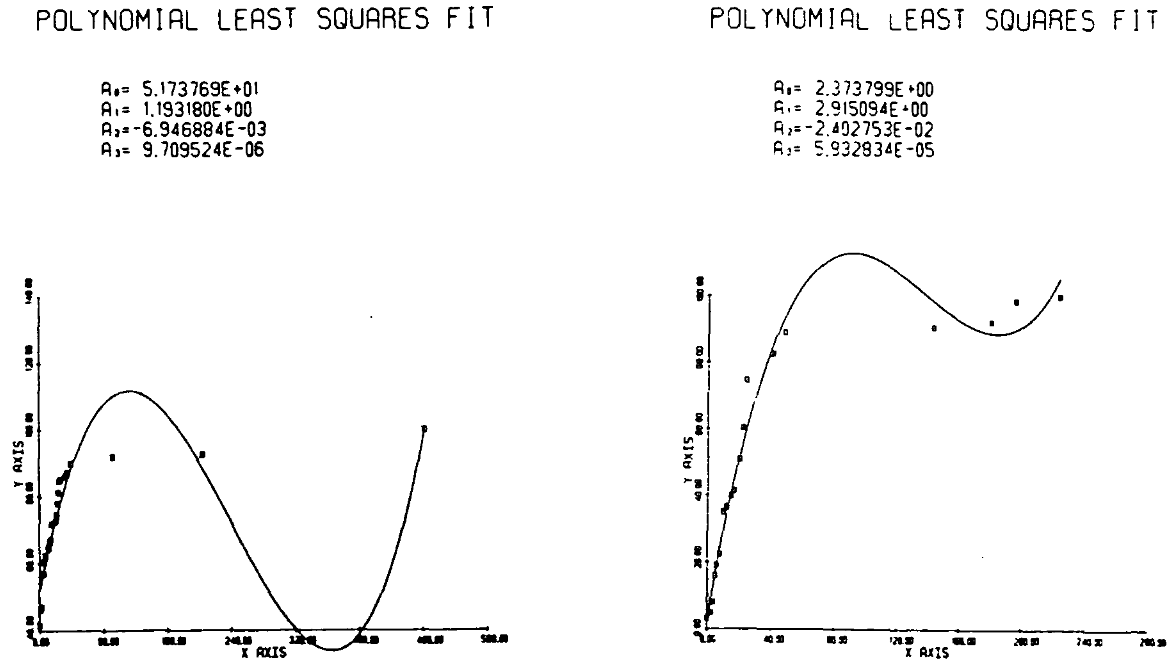
POLYNOMIAL LEAST SQUARES FIT

$A_0$= 2.291190E+01
$A_1$= 2.859715E+00
$A_2$=-2.000655E-02
$A_3$= 3.859437E-05



WHITBY FARMER - OFFSPRING 1851

Figure 7.7



FYLINGDALES FARMER - OFFSPRING 1851

SCARBOROUGH FARMER - OFFSPRING 1851

Figure 7.8

MALECOTS (1977) a & b PARAMETERS: HINDERWELL AG. LABS.-OFFSPRING 1851

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.16280 |
| SHORT RANGE MIG (k) | 0.18600 |
| EFFECTIVE POPULATION SIZE (Ne) | 91.70000 |
| STANDARD DEVIATION | 3.95530 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.29507 |
| LOCAL KINSHIP (a) | 0.00915 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.19422 |

(Long Distance = 24+ km , as determined for Hinderwell from Curvefit.

MALECOTS (1977) a & b PARAMETERS: WHITBY AG. LABS.-OFFSPRING 1851

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.04580 |
| SHORT RANGE MIG (k) | 0.74050 |
| EFFECTIVE POPULATION SIZE (Ne) | 3891.00000 |
| STANDARD DEVIATION | 22.02650 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.26444 |
| LOCAL KINSHIP (a) | 0.00024 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.03302 |

(Long Distance = 141+ km, as determined for Whitby by Curvefit.)

MALECOTS (1977) a & b PARAMETERS: FYLINGDALES AG. LABS.-OFFSPRING 185

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.06450 |
| SHORT RANGE MIG (k) | 0.45160 |
| EFFECTIVE POPULATION SIZE (Ne) | 294.69995 |
| STANDARD DEVIATION | 4.07870 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.24983 |
| LOCAL KINSHIP (a) | 0.00338 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.17331 |

(Long Distance = 22+ km, as determined for Fylingdales by Curvefit.)

Table 7.4

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH AG. LABS.-OFFSPRING 185

LONG RANGE MIGRATION (m)                       0.10090
SHORT RANGE MIG (k)                            0.78900
EFFECTIVE POPULATION SIZE (Ne)             14936.69922
STANDARD DEVIATION                            25.50000


EFFECTIVE MIGRATION (Me)                       0.41158
LOCAL KINSHIP (a)                              0.00004
DECLINE OF KINSHIP WITH DISTANCE (b)           0.03558

(Long Distance = 160+ km, as determined for Scarborough by Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: FILEY AG. LABS.-OFFSPRING 1851

LONG RANGE MIGRATION (m)                       0.02220
SHORT RANGE MIG (k)                            0.53330
EFFECTIVE POPULATION SIZE (Ne)               500.00000
STANDARD DEVIATION                            19.89999


EFFECTIVE MIGRATION (Me)                       0.15547
LOCAL KINSHIP (a)                              0.00321
DECLINE OF KINSHIP WITH DISTANCE (b)           0.02802

(Long Distance = 104+ km, as determined for Filey by Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: HINDERWELL FARMER - OFFSPRING 1851

LONG RANGE MIGRATION (m)                       0.27780
SHORT RANGE MIG (k)                            0.11110
EFFECTIVE POPULATION SIZE (Ne)                91.70000
STANDARD DEVIATION                             3.48000


EFFECTIVE MIGRATION (Me)                       0.37269
LOCAL KINSHIP (a)                              0.00726
DECLINE OF KINSHIP WITH DISTANCE (b)           0.24809

(Long Distance = 26+ km , as determined for Hinderwell from Curvefit.
```

Table 7.5

### MALECOTS (1977) a & b PARAMETERS: WHITBY FARMER - OFFSPRING 1851.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.06670 |
| SHORT RANGE MIG (k) | 0.70000 |
| EFFECTIVE POPULATION SIZE (Ne) | 3891.00000 |
| STANDARD DEVIATION | 10.20000 |
| EFFECTIVE MIGRATION (Me) | 0.31278 |
| LOCAL KINSHIP (a) | 0.00021 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.07754 |

(Long Distance = 101+ km , as determined for Whitby from Curvefit.)

### MALECOTS (1977) a & b PARAMETERS: FYLINGDALES FARMER - OFFSPRING 185

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.08050 |
| SHORT RANGE MIG (k) | 0.50340 |
| EFFECTIVE POPULATION SIZE (Ne) | 294.69995 |
| STANDARD DEVIATION | 16.13000 |
| EFFECTIVE MIGRATION (Me) | 0.29585 |
| LOCAL KINSHIP (a) | 0.00286 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.04769 |

(Long Distance = 112+ km , as determined for Fylingdales from Curvefi

### MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FARMER - OFFSPRING 185

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.11110 |
| SHORT RANGE MIG (k) | 0.84130 |
| EFFECTIVE POPULATION SIZE (Ne) | 14936.69922 |
| STANDARD DEVIATION | 13.34000 |
| EFFECTIVE MIGRATION (Me) | 0.44641 |
| LOCAL KINSHIP (a) | 0.00004 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.07083 |

(Long Distance = 90+ km , as determined for Scarborough from Curvefi

Table 7.6

## MALECOTS (1977) a & b PARAMETERS: STAITHES FISHERMEN 1851

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.02940 |
| SHORT RANGE MIG (k) | 0.02940 |
| EFFECTIVE POPULATION SIZE (Ne) | 136.30000 |
| STANDARD DEVIATION | 0.85970 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.05092 |
| LOCAL KINSHIP (a) | 0.03477 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.37121 |

(Long distance = 15 km + as determined for Staithes by 'Curvefit'.)

## MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FISHERMEN 1851

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.05330 |
| SHORT RANGE MIG (k) | 0.35560 |
| EFFECTIVE POPULATION SIZE (Ne) | 157.00000 |
| STANDARD DEVIATION | 62.80000 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.20186 |
| LOCAL KINSHIP (a) | 0.00783 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.01012 |

(Long distance = 294 km + as determined for Scarborough by 'Curvefit'

## MALECOTS (1977) a & b PARAMETERS: FILEY FISHERMEN 1851

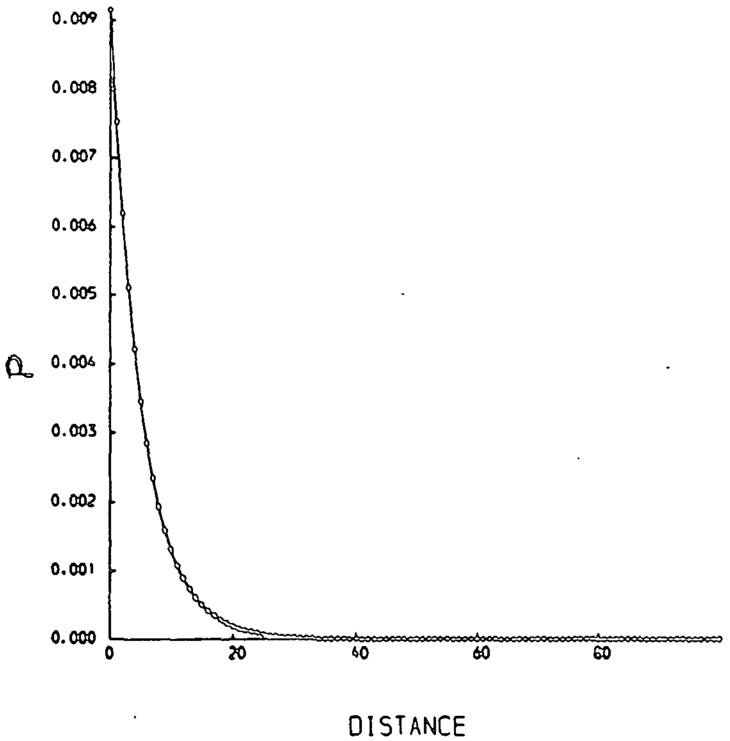
| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.02370 |
| SHORT RANGE MIG (k) | 0.02840 |
| EFFECTIVE POPULATION SIZE (Ne) | 150.00000 |
| STANDARD DEVIATION | 2.29300 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.04368 |
| LOCAL KINSHIP (a) | 0.03675 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.12890 |

(Long distance = 38 km + as determined for Filey by 'Curvefit'.)

Table 7.7

HINDERWELL AGL. LAB. - OFFSPRING 1851.



FILEY AGL. LAB. - OFFSPRING 1851.

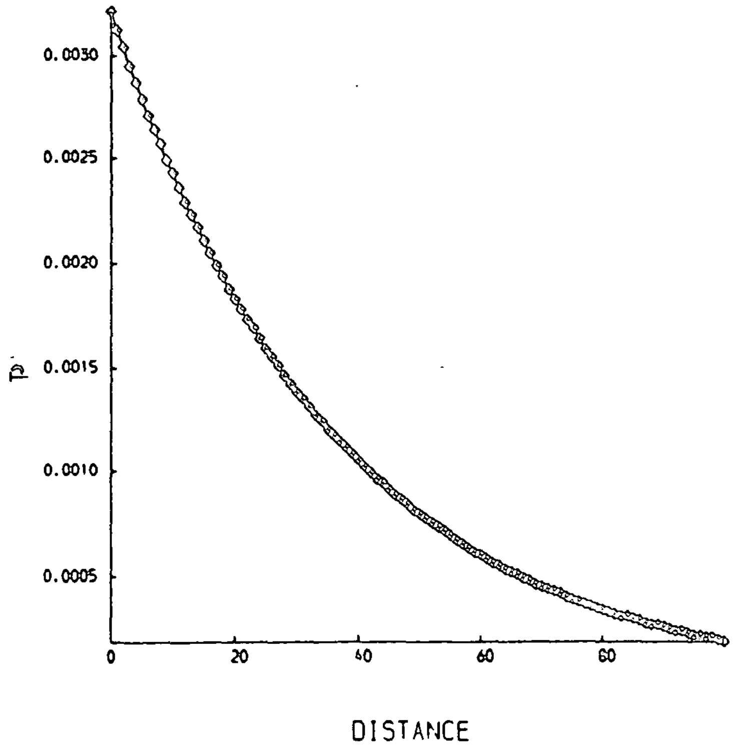


Figure 7.9

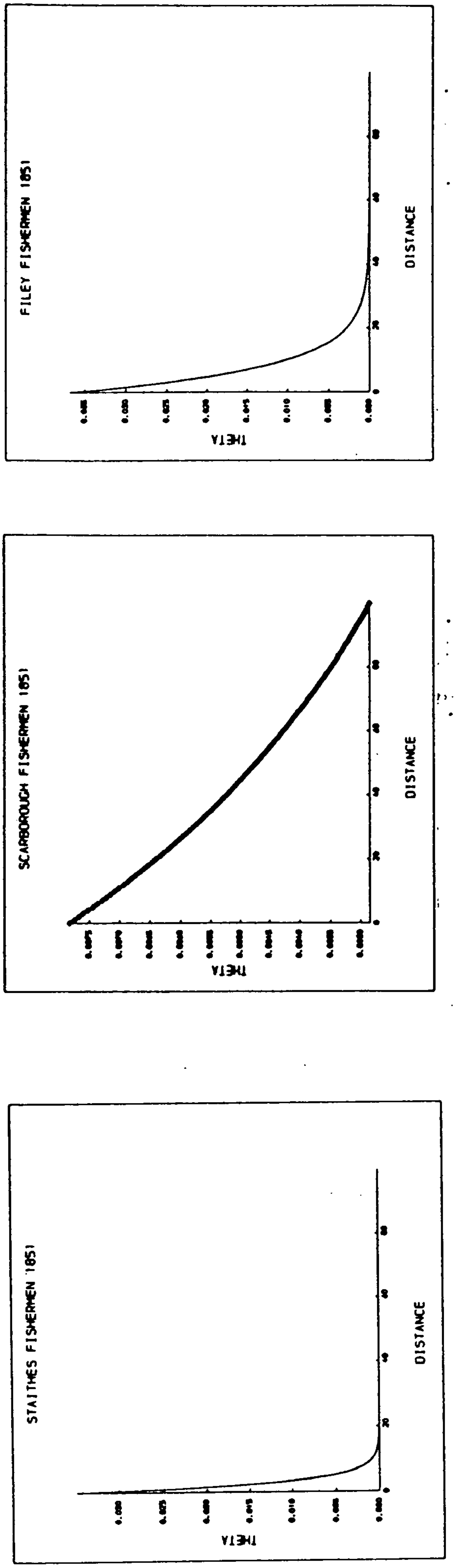

FILEY FISHERMEN 1851
THETA
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
DISTANCE
0
20
40
60
80
SCARBOROUGH FISHERMEN 1851
THETA
DISTANCE
0
20
40
60
80
STAITHES FISHERMEN 1851
THETA
0.030
0.025
0.020
0.015
0.010
0.005
0.000
DISTANCE
0
20
40
60
80

Figure 7.10

```
SPSSX FREQUENCY LIST OF AGRICULTURAL LABOURER - OFFSPRING DISTANCES 1871

HINDERWELL
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00          2      5.9      5.9      5.9
                           1.00          1      2.9      2.9      8.8
                           3.00          1      2.9      2.9     11.8
                           5.00         10     29.4     29.4     41.2
                           7.00          2      5.9      5.9     47.1
                           8.00          1      2.9      2.9     50.0
                           9.00          2      5.9      5.9     55.9
                          12.00          4     11.8     11.8     67.6
                          13.00          1      2.9      2.9     70.6
                          14.00          3      8.8      8.8     79.4
                          17.00          2      5.9      5.9     85.3
                          63.00          1      2.9      2.9     88.2
                          74.00          1      2.9      2.9     91.2
                          76.00          1      2.9      2.9     94.1
                          77.00          2      5.9      5.9    100.0
                                   -------  -------  -------
                          TOTAL         34    100.0    100.0

VALID CASES      34      MISSING CASES      0

WHITBY
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         10     13.3     14.3     14.3
                           1.00          1      1.3      1.4     15.7
                           2.00          3      4.0      4.3     20.0
                           3.00          2      2.7      2.9     22.9
                           4.00          2      2.7      2.9     25.7
                           5.00          3      4.0      4.3     30.0
                           6.00          3      4.0      4.3     34.3
                           7.00          4      5.3      5.7     40.0
                           8.00          5      6.7      7.1     47.1
                          11.00          2      2.7      2.9     50.0
                          15.00          6      8.0      8.6     58.6
                          18.00          8     10.7     11.4     70.0
                          21.00          4      5.3      5.7     75.7
                          24.00          2      2.7      2.9     78.6
                          25.00          1      1.3      1.4     80.0
                          28.00          1      1.3      1.4     81.4
                          31.00          3      4.0      4.3     85.7
                          43.00          1      1.3      1.4     87.1
                          74.00          1      1.3      1.4     88.6
                          76.00          2      2.7      2.9     91.4
                         203.00          1      1.3      1.4     92.9
                         213.00          3      4.0      4.3     97.1
                         330.00          2      2.7      2.9    100.0
                              .          5      6.7  MISSING
                                   -------  -------  -------
                          TOTAL         75    100.0    100.0
VALID CASES      70      MISSING CASES      5

FYLINGDALES
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         25     38.5     38.5     38.5
                           1.00          3      4.6      4.6     43.1
                           2.00          1      1.5      1.5     44.6
                           4.00          2      3.1      3.1     47.7
                           5.00          4      6.2      6.2     53.8
                           6.00          7     10.8     10.8     64.6
                           7.00          4      6.2      6.2     70.8
                           8.00          1      1.5      1.5     75.4
                          10.00          2      3.1      3.1     78.5
                          13.00          1      1.5      1.5     80.0
                          14.00          3      4.6      4.6     84.6
                          15.00          3      4.6      4.6     89.2
                          20.00          1      1.5      1.5     90.8
                          22.00          2      3.1      3.1     93.8
                          25.00          2      3.1      3.1     96.9
                          30.00          1      1.5      1.5     98.5
                         170.00          1      1.5      1.5    100.0
                                   -------  -------  -------
                          TOTAL         65    100.0    100.0

VALID CASES      65      MISSING CASES      0

SCARBOROUGH
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00          8      9.5      9.5      9.5
                           2.00          4      4.8      4.8     14.3
                           5.00          1      1.2      1.2     15.5
                           7.00          4      4.8      4.8     20.2
                           8.00          3      3.6      3.6     23.8
                          10.00          8      9.5      9.5     33.3
                          11.00          1      1.2      1.2     34.5
                          12.00          5      6.0      6.0     40.5
                          13.00          1      1.2      1.2     41.7
                          14.00          6      7.1      7.1     48.8
                          15.00          3      3.6      3.6     52.4
                          17.00          2      2.4      2.4     54.8
                          20.00          8      9.5      9.5     64.3
                          25.00          2      2.4      2.4     66.7
                          30.00          1      1.2      1.2     67.9
                          32.00          2      2.4      2.4     70.2
                          35.00          1      1.2      1.2     71.4
                          40.00          1      1.2      1.2     72.6
                          45.00          3      3.6      3.6     76.2
                         102.00          1      1.2      1.2     77.4
                         104.00          5      6.0      6.0     83.3
                         105.00          2      2.4      2.4     85.7
                         153.00          1      1.2      1.2     86.9
                         182.00          2      2.4      2.4     89.3
                         210.00          1      1.2      1.2     90.5
                         222.00          2      2.4      2.4     92.9
                         281.00          2      2.4      2.4     95.2
                         340.00          1      1.2      1.2     96.4
                         390.00          3      3.6      3.6    100.0
                                   -------  -------  -------
                          TOTAL         84    100.0    100.0

VALID CASES      84      MISSING CASES      0

FILEY
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         14     28.0     28.0     28.0
                           2.00          2      4.0      4.0     32.0
                           5.00          1      2.0      2.0     34.0
                           8.00          1      2.0      2.0     36.0
                          10.00          2      4.0      4.0     40.0
                          11.00          2      4.0      4.0     44.0
                          12.00          1      2.0      2.0     46.0
                          14.00          4      8.0      8.0     54.0
                          16.00          4      8.0      8.0     62.0
                          18.00          1      2.0      2.0     64.0
                          30.00          1      2.0      2.0     66.0
                          44.00          4      8.0      8.0     74.0
                          63.00          2      4.0      4.0     78.0
                          73.00          1      2.0      2.0     80.0
                          83.00          1      2.0      2.0     82.0
                         120.00          2      4.0      4.0     86.0
                         150.00          1      2.0      2.0     88.0
                         234.00          6     12.0     12.0    100.0
                                   -------  -------  -------
                          TOTAL         50    100.0    100.0

VALID CASES      50      MISSING CASES      0
```

```
SPSSX FREQUENCY LIST OF AGRICULTURAL LABOURER - OFFSPRING DISTANCES 1881

HINDERWELL
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00          1      3.3      3.7      3.7
                           1.00          4     13.3     14.8     18.5
                           3.00          2      6.7      7.4     25.9
                           6.00          5     16.7     18.5     44.4
                          12.00          3     10.0     11.1     55.6
                          15.00          1      3.3      3.7     59.3
                          17.00          4     13.3     14.8     74.1
                          21.00          3     10.0     11.1     85.2
                          42.00          1      3.3      3.7     88.9
                          54.00          1      3.3      3.7     92.6
                          57.00          1      3.3      3.7     96.3
                          77.00          1      3.3      3.7    100.0
                              .          3     10.0  MISSING
                                   -------  -------  -------
                          TOTAL         30    100.0    100.0

VALID CASES      27      MISSING CASES      3

WHITBY
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         21     20.0     20.2     20.2
                           1.00          3      2.9      2.9     23.1
                           3.00          9      8.6      8.7     31.7
                           6.00          2      1.9      1.9     33.7
                           7.00         11     10.5     10.6     44.2
                           8.00          1      1.0      1.0     45.2
                           9.00          4      3.8      3.8     49.0
                          10.00          3      2.9      2.9     51.9
                          11.00          2      1.9      1.9     53.8
                          12.00          8      7.6      7.7     61.5
                          13.00          3      2.9      2.9     64.4
                          16.00          9      8.6      8.7     73.1
                          18.00          5      4.8      4.8     77.9
                          21.00          3      2.9      2.9     80.8
                          25.00          1      1.0      1.0     81.7
                          30.00          1      1.0      1.0     82.7
                          33.00          1      1.0      1.0     83.7
                          35.00          1      1.0      1.0     84.6
                          38.00          1      1.0      1.0     85.6
                          40.00          1      1.0      1.0     86.5
                          50.00          1      1.0      1.0     87.5
                          61.00          3      2.9      2.9     90.4
                          75.00          1      1.0      1.0     91.3
                          87.00          1      1.0      1.0     92.3
                         168.00          1      1.0      1.0     93.3
                         183.00          1      1.0      1.0     94.2
                         192.00          6      5.7      5.8    100.0
                              .          1      1.0  MISSING

                                   -------  -------  -------
                          TOTAL        105    100.0    100.0

VALID CASES     104      MISSING CASES      1

FYLINGDALES
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         47     65.3     66.2     66.2
                           1.00          5      6.9      7.0     73.2
                           5.00          2      2.8      2.8     76.1
                           6.00          2      2.8      2.8     78.9
                           7.00          4      5.6      5.6     84.5
                           8.00          1      1.4      1.4     85.9
                          20.00          5      6.9      7.0     93.0
                          33.00          5      6.9      7.0    100.0
                              .          1      1.4  MISSING
                                   -------  -------  -------
                          TOTAL         72    100.0    100.0

VALID CASES      71      MISSING CASES      1

SCARBOROUGH
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                            .00         20     19.4     21.5     21.5
                           1.00          2      1.9      2.2     23.7
                           2.00          4      3.9      4.3     28.0
                           3.00          3      2.9      3.2     31.2
                           4.00          2      1.9      2.2     33.3
                           5.00          8      7.8      8.6     41.9
                           8.00          2      1.9      2.2     44.1
                           9.00          4      3.9      4.3     48.4
                          13.00          3      2.9      3.2     51.6
                          15.00          3      2.9      3.2     54.8
                          17.00          1      1.0      1.1     55.9
                          18.00          2      1.9      2.2     58.1
                          25.00          1      1.0      1.1     59.1
                          28.00          1      1.0      1.1     60.2
                          34.00          5      4.9      5.4     65.6
                          35.00          2      1.9      2.2     67.7
                          38.00          1      1.0      1.1     68.8
                          40.00          2      1.9      2.2     71.0
                          41.00          3      2.9      3.2     74.2
                          42.00          1      1.0      1.1     75.3
                          43.00          1      1.0      1.1     76.3
                          45.00          1      1.0      1.1     77.4
                          48.00          4      3.9      4.3     81.7
                          50.00          1      1.0      1.1     82.8
                          73.00          4      3.9      4.3     87.1
                          76.00          1      1.0      1.1     88.2
                          80.00          2      1.9      2.2     90.3
                          84.00          1      1.0      1.1     91.4
                         110.00          1      1.0      1.1     92.5
                         150.00          1      1.0      1.1     93.5
                         212.00          1      1.0      1.1     94.6
                         222.00          3      2.9      3.2     97.8
                         228.00          1      1.0      1.1     98.9
                         234.00          1      1.0      1.1    100.0
                              .         10      9.7  MISSING
                                   -------  -------  -------
                          TOTAL        103    100.0    100.0

VALID CASES      93      MISSING CASES     10

FILEY
                                                       VALID      CUM
VALUE LABEL               VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                          12.00          1     25.0     25.0     25.0
                          28.00          1     25.0     25.0     50.0
                          29.00          1     25.0     25.0     75.0
                          33.00          1     25.0     25.0    100.0
                                   -------  -------  -------
                          TOTAL          4    100.0    100.0
VALID CASES       4      MISSING CASES      0
```

Table 7.8

```
SPSSX FREQUENCY LIST OF AGRICULTURAL LABOURER - OFFSPRING DISTANCES 1881

HINDERWELL

                                                              VALID     CUM
VALUE LABEL                   VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                                .00          2      16.7      16.7      16.7
                               3.00          1       8.3       8.3      25.0
                               4.00          1       8.3       8.3      33.3
                               6.00          5      41.7      41.7      75.0
                              72.00          1       8.3       8.3      83.3
                             100.00          1       8.3       8.3      91.7
                             632.00          1       8.3       8.3     100.0
                                       -------   -------   -------
                              TOTAL         12     100.0     100.0

VALID CASES        12      MISSING CASES      0

WHITBY

                                                              VALID     CUM
VALUE LABEL                   VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                                .00          6      14.6      15.4      15.4
                               4.00          3       7.3       7.7      23.1
                               7.00          1       2.4       2.6      25.6
                               8.00          5      12.2      12.8      38.5
                              11.00          5      12.2      12.8      51.3
                              14.00          4       9.8      10.3      61.5
                              21.00          3       7.3       7.7      69.2
                              27.00          5      12.2      12.8      82.1
                              28.00          1       2.4       2.6      84.6
                              44.00          5      12.2      12.8      97.4
                             127.00          1       2.4       2.6     100.0
                                  .          2       4.9   MISSING
                                       -------   -------   -------
                              TOTAL         41     100.0     100.0

VALID CASES        39      MISSING CASES      2

FYLINGDALES

                                                              VALID     CUM
VALUE LABEL                   VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                                .00         20      41.7      41.7      41.7
                               3.00          3       6.3       6.3      47.9
                               6.00          6      12.5      12.5      60.4
                               7.00          4       8.3       8.3      68.8
                               8.00          4       8.3       8.3      77.1
                               9.00          4       8.3       8.3      85.4
                              11.00          3       6.3       6.3      91.7
                              23.00          2       4.2       4.2      95.8
                              24.00          1       2.1       2.1      97.9
                              83.00          1       2.1       2.1     100.0
                                       -------   -------   -------
                              TOTAL         48     100.0     100.0

VALID CASES        48      MISSING CASES      0

SCARBOROUGH

                                                              VALID     CUM
VALUE LABEL                   VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                                .00         19      29.7      30.2      30.2
                               2.00          1       1.6       1.6      31.7
                               3.00          1       1.6       1.6      33.3
                               6.00          2       3.1       3.2      36.5
                               7.00          3       4.7       4.8      41.3
                               8.00          1       1.6       1.6      42.9
                              10.00          1       1.6       1.6      44.4
                              12.00          7      10.9      11.1      55.6
                              14.00          1       1.6       1.6      57.1
                              16.00          2       3.1       3.2      60.3
                              17.00          4       6.3       6.3      66.7
                              21.00          2       3.1       3.2      69.8
                              28.00          4       6.3       6.3      76.2
                              33.00          2       3.1       3.2      79.4
                              34.00          1       1.6       1.6      81.0
                              45.00          1       1.6       1.6      82.5
                              47.00          1       1.6       1.6      84.1
                              48.00          3       4.7       4.8      88.9
                              52.00          1       1.6       1.6      90.5
                              55.00          1       1.6       1.6      92.1
                              72.00          1       1.6       1.6      93.7
                              83.00          1       1.6       1.6      95.2
                             109.00          2       3.1       3.2      98.4
                             150.00          1       1.6       1.6     100.0
                                  .          1       1.6   MISSING
                                       -------   -------   -------
                              TOTAL         64     100.0     100.0

VALID CASES        63      MISSING CASES      1

FILEY

                                                              VALID     CUM
VALUE LABEL                   VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

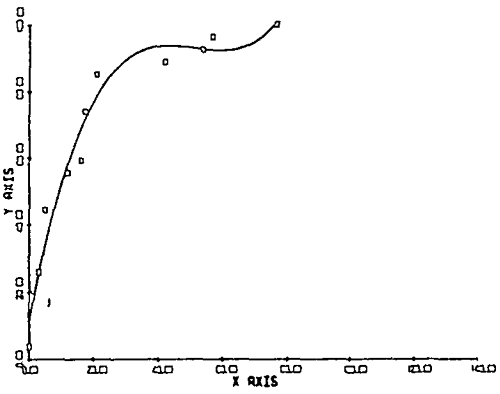
                                .00          5      45.5      55.6      55.6
                               6.00          1       9.1      11.1      66.7
                               7.00          1       9.1      11.1      77.8
                              14.00          1       9.1      11.1      88.9
                              83.00          1       9.1      11.1     100.0
                                  .          2      18.2   MISSING
                                       -------   -------   -------
                              TOTAL         11     100.0     100.0

VALID CASES         9      MISSING CASES      2
```

Table 7.9

POLYNOMIAL LEAST SQUARES FIT

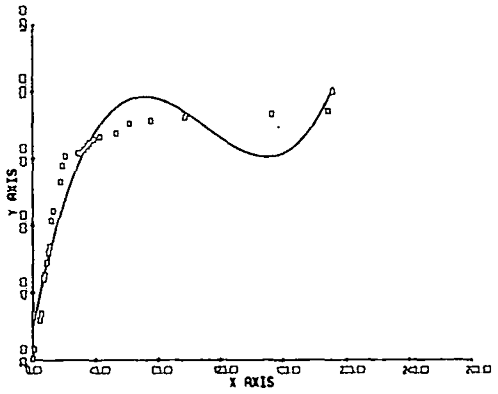
$A_0$= 1.136501E+01
$A_1$= 5.045458E+00
$A_2$=-1.010403E-01
$A_3$= 6.572253E-04



HINDERWELL AGL. LAB - OFFSPRING 1861

POLYNOMIAL LEAST SQUARES FIT

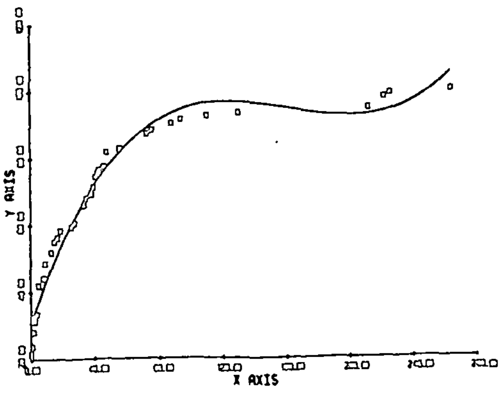
$A_0$= 2.933438E+01
$A_1$= 2.319482E+00
$A_2$=-2.411415E-02
$A_3$= 7.286495E-05



WHITBY AGL. LAB. - OFFSPRING 1861

POLYNOMIAL LEAST SQUARES FIT

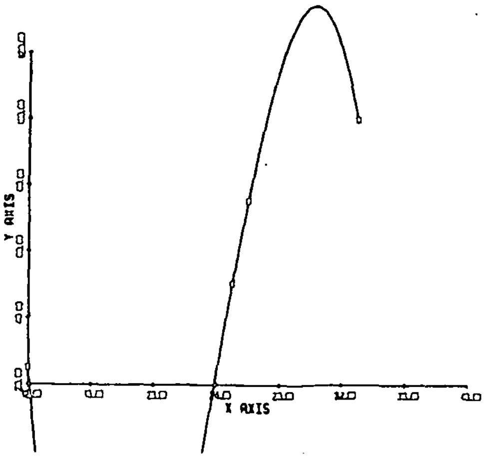
$A_0$=-3.068393E+01
$A_1$= 1.348215E+00
$A_2$=-8.816555E-03
$A_3$= 1.811294E-05



SCARBOROUGH AGL. LAB - OFFSPRING 1861

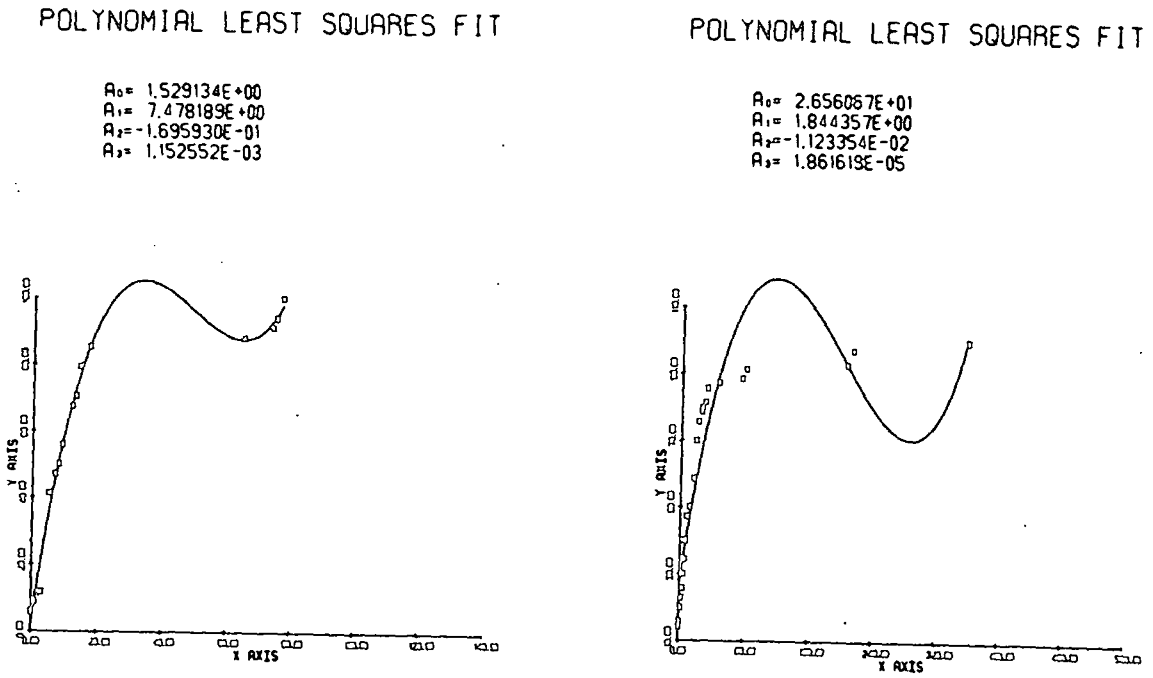
POLYNOMIAL LEAST SQUARES FIT

$A_0$= 2.103571E+03
$A_1$=-3.180933E+02
$A_2$= 1.462912E+01
$A_3$=-2.060439E-01



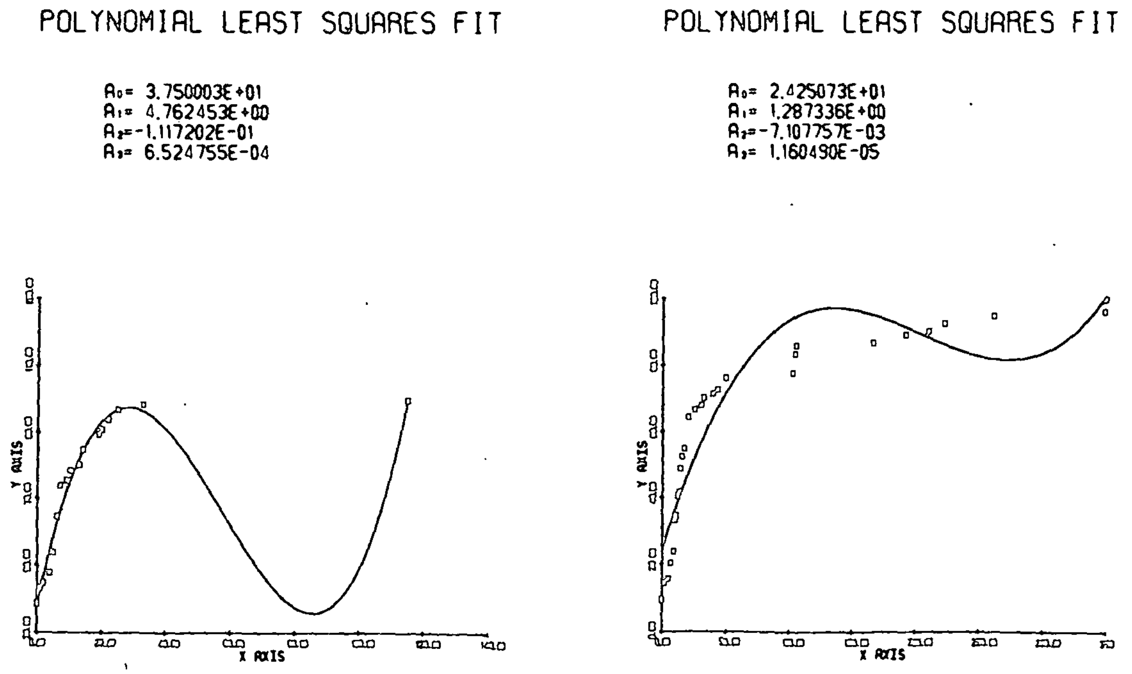
FILEY AGL LAB. - OFFSPRING 1861

Figure 7.11



HINDERWELL AGL. LAB. - OFFSPRING 1871

WHITBY AGL. LAB. - OFFSPRING 1871



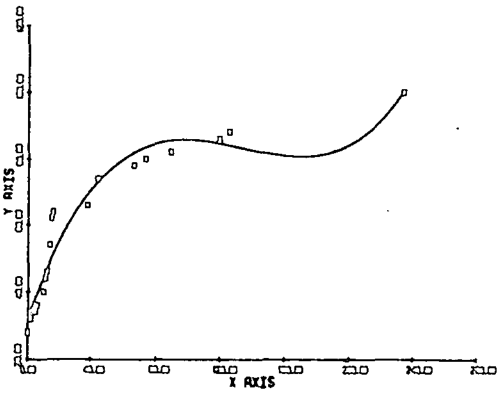
FYLINGDALES AGL LAB. OFFSPRING 1871

SCARBOROUGH AGL. LAB. - OFFSPRING 1871

Figure 7.12

POLYNOMIAL LEAST SQUARES FIT

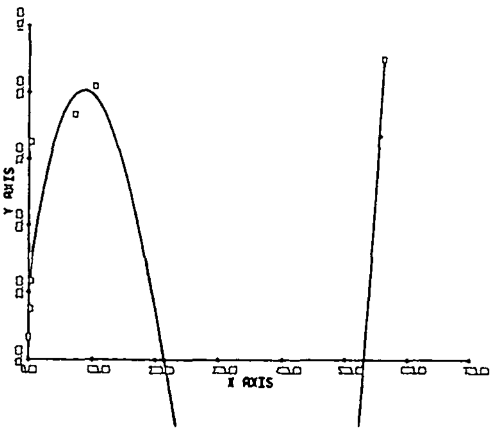
$A_0 = 3.195074E+01$
$A_1 = 1.362592E+00$
$A_2 = -1.099109E-02$
$A_3 = 2.742991E-05$



FILEY AGL. LAB. - OFFSPRING 1871

POLYNOMIAL LEAST SQUARES FIT

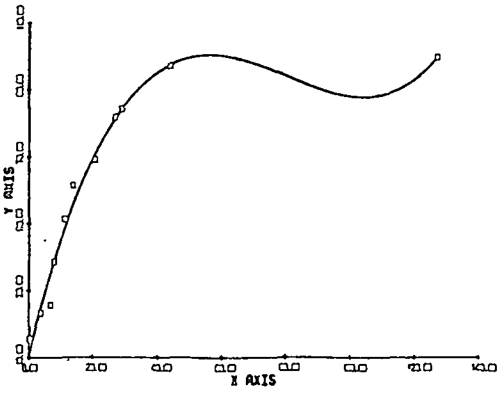
$A_0 = 3.249283E+01$
$A_1 = 1.463627E+00$
$A_2 = -1.038413E-02$
$A_3 = 1.422344E-05$



HINDERWELL AGL. LAB. - OFFSPRING 1881

POLYNOMIAL LEAST SQUARES FIT

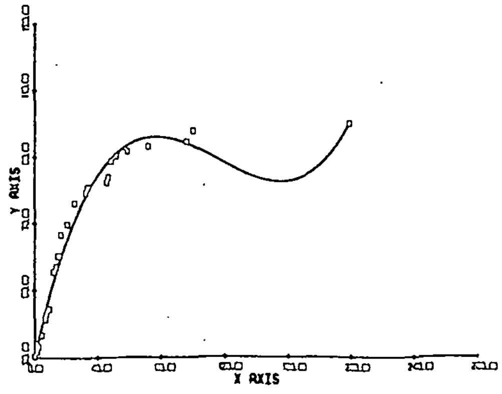
$A_0 = 1.068307E+01$
$A_1 = 3.918178E+00$
$A_2 = -5.394167E-02$
$A_3 = 2.254074E-04$



WHITBY AGL. LAB. - OFFSPRING 1881

POLYNOMIAL LEAST SQUARES FIT

$A_0 = 2.988281E+01$
$A_1 = 2.069906E+00$
$A_2 = -2.003543E-02$
$A_3 = 5.734975E-05$

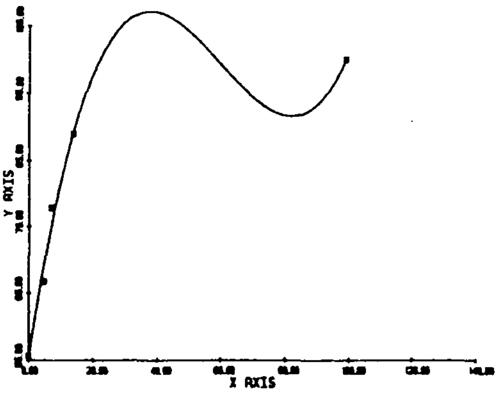


SCARBOROUGH AGL. LAB. - OFFSPRING 1881

Figure 7.13

POLYNOMIAL LEAST SQUARES FIT

$A_0$= 5.505798E+01
$A_1$= 3.256586E+00
$A_2$=-6.307733E-02
$A_3$= 3.511915E-04



RILEY AGL. LAB. - OFFSPRING 1881

Figure 7.14

```
MALECOTS (1977) a & b PARAMETERS: HINDERWELL AGL. LAB.- OFFSPRING 186

LONG RANGE MIGRATION (m)                       0.11110
SHORT RANGE MIG (k)                            0.85190
EFFECTIVE POPULATION SIZE (Ne)               269.65991
STANDARD DEVIATION                             9.90000


EFFECTIVE MIGRATION (Me)                       0.44904
LOCAL KINSHIP (a)                              0.00206
DECLINE OF KINSHIP WITH DISTANCE (b)           0.09572

(Long Distance = 43+ km , as determined for Hinderwell from Curvefit.
```

```
MALECOTS (1977) a & b PARAMETERS: HINDERWELL AGL. LAB. - OFFSPRING 18

LONG RANGE MIGRATION (m)                       0.14710
SHORT RANGE MIG (k)                            0.79410
EFFECTIVE POPULATION SIZE (Ne)               308.30005
STANDARD DEVIATION                             4.83650


EFFECTIVE MIGRATION (Me)                       0.50524
LOCAL KINSHIP (a)                              0.00160
DECLINE OF KINSHIP WITH DISTANCE (b)           0.20784

(Long distance = 33+ km, as determined for Hinderwell from Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: HINDERWELL AGL. LAB.- OFFSPRING 18

LONG RANGE MIGRATION (m)                       0.16670
SHORT RANGE MIG (k)                            0.66670
EFFECTIVE POPULATION SIZE (Ne)               285.60010
STANDARD DEVIATION                            21.73680


EFFECTIVE MIGRATION (Me)                       0.50007
LOCAL KINSHIP (a)                              0.00175
DECLINE OF KINSHIP WITH DISTANCE (b)           0.04601

(Long distance = 86+ km, as determined for Hinderwell from Curvefit.)
```

Table 7.10

### MALECOTS (1977) a & b PARAMETERS: WHITBY AGL. LAB.- OFFSPRING 1861.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.09620 |
| SHORT RANGE MIG (k) | 0.70190 |
| EFFECTIVE POPULATION SIZE (Ne) | 3891.65991 |
| STANDARD DEVIATION | 13.70000 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.37987 |
| LOCAL KINSHIP (a) | 0.00017 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.06362 |

(Long Distance = 71+ km , as determined for Whitby from Curvefit.)

### MALECOTS (1977) a & b PARAMETERS: WHITBY AGL. LAB. - OFFSPRING 1871

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.08570 |
| SHORT RANGE MIG (k) | 0.77140 |
| EFFECTIVE POPULATION SIZE (Ne) | 4249.60156 |
| STANDARD DEVIATION | 17.19881 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.37358 |
| LOCAL KINSHIP (a) | 0.00016 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.05026 |

(Long distance = 115+ km, as determined for Whitby from Curvefit.)

### MALECOTS (1977) a & b PARAMETERS: WHITBY AGL.LAB.- OFFSPRING 1881

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.02560 |
| SHORT RANGE MIG (k) | 0.82050 |
| EFFECTIVE POPULATION SIZE (Ne) | 4587.60156 |
| STANDARD DEVIATION | 14.02400 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.20655 |
| LOCAL KINSHIP (a) | 0.00026 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.04583 |

(Long distance = 56+ km, as determined for Whitby from Curvefit.)

Table 7.11

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH AGL. LAB.- OFFSPRING 1861

LONG RANGE MIGRATION (m)                       0.07530
SHORT RANGE MIG (k)                            0.70970
EFFECTIVE POPULATION SIZE (Ne)             14353.66016
STANDARD DEVIATION                            26.80000


EFFECTIVE MIGRATION (Me)                       0.33549
LOCAL KINSHIP (a)                              0.00005
DECLINE OF KINSHIP WITH DISTANCE (b)           0.03056

(Long Distance = 122+ km , as determined for Scarborough from Curvefit.
```

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH AGL. LAB.- OFFSPRING 1871

LONG RANGE MIGRATION (m)                       0.14290
SHORT RANGE MIG (k)                            0.76190
EFFECTIVE POPULATION SIZE (Ne)             14813.30078
STANDARD DEVIATION                            30.53551


EFFECTIVE MIGRATION (Me)                       0.48803
LOCAL KINSHIP (a)                              0.00003
DECLINE OF KINSHIP WITH DISTANCE (b)           0.03235

(Long distance = 136+ km, as determined for Scarborough from Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH AGL. LAB.- OFFSPRING 1881

LONG RANGE MIGRATION (m)                       0.06350
SHORT RANGE MIG (k)                            0.63490
EFFECTIVE POPULATION SIZE (Ne)             14367.60156
STANDARD DEVIATION                            17.94940


EFFECTIVE MIGRATION (Me)                       0.29097
LOCAL KINSHIP (a)                              0.00006
DECLINE OF KINSHIP WITH DISTANCE (b)           0.04250

(Long distance = 77+ km, as determined for Scarborough from Curvefit.)
```

Table 7.12

```
MALECOTS (1977) a & b PARAMETERS: FYLINGDALES AGL. LAB.- OFFSPRING 18

LONG RANGE MIGRATION (m)                       0.03080
SHORT RANGE MIG (k)                            0.58460
EFFECTIVE POPULATION SIZE (Ne)               275.30005
STANDARD DEVIATION                            13.89310


EFFECTIVE MIGRATION (Me)                       0.19225
LOCAL KINSHIP (a)                              0.00470
DECLINE OF KINSHIP WITH DISTANCE (b)           0.04463

(Long distance = 28+ km, as determined for Fylingdales from Curvefit.
```

```
MALECOTS (1977) a & b PARAMETERS: FILEY AGL. LAB.- OFFSPRING 1881

LONG RANGE MIGRATION (m)                       0.11110
SHORT RANGE MIG (k)                            0.33330
EFFECTIVE POPULATION SIZE (Ne)               772.00000
STANDARD DEVIATION                             5.14780


EFFECTIVE MIGRATION (Me)                       0.29394
LOCAL KINSHIP (a)                              0.00110
DECLINE OF KINSHIP WITH DISTANCE (b)           0.14894

(Long distance = 38+ km, as determined for Filey from Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: FILEY AGL. LAB.- OFFSPRING 1871

LONG RANGE MIGRATION (m)                       0.18000
SHORT RANGE MIG (k)                            0.54000
EFFECTIVE POPULATION SIZE (Ne)               745.00000
STANDARD DEVIATION                            23.17570


EFFECTIVE MIGRATION (Me)                       0.47624
LOCAL KINSHIP (a)                              0.00070
DECLINE OF KINSHIP WITH DISTANCE (b)           0.04211

(Long distance = 98+ km, as determined for Filey from Curvefit.)
```

Table 7.13

```
SPSSX FREQUENCY LIST OF FATHER - OFFSPRING DISTANCES 1861.

HINDERWELL

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         19     52.8     52.8     52.8
                        2.00          2      5.6      5.6     58.3
                        6.00          2      5.6      5.6     63.9
                        8.00          3      8.3      8.3     72.2
                       23.00          4     11.1     11.1     83.3
                       30.00          6     16.7     16.7    100.0
                                -------  -------  -------
                       TOTAL         36    100.0    100.0

VALID CASES      36      MISSING CASES      0

WHITBY

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         10     37.0     37.0     37.0
                        2.00          3     11.1     11.1     48.1
                        4.00          1      3.7      3.7     51.9
                        6.00          3     11.1     11.1     63.0
                        8.00          7     25.9     25.9     88.9
                       10.00          2      7.4      7.4     96.3
                       63.00          1      3.7      3.7    100.0
                                -------  -------  -------
                       TOTAL         27    100.0    100.0

VALID CASES      27      MISSING CASES      0

FYLINGDALES

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00        138     79.8     82.1     82.1
                        1.00          1       .6       .6     82.7
                        4.00          4      2.3      2.4     85.1
                        6.00          2      1.2      1.2     86.3
                        8.00          1       .6       .6     86.9
                        9.00          1       .6       .6     87.5
                       10.00          1       .6       .6     88.1
                       16.00          1       .6       .6     88.7
                       20.00          2      1.2      1.2     89.9
                       23.00          2      1.2      1.2     91.1
                       24.00          3      1.7      1.8     92.9
                       25.00          2      1.2      1.2     94.0
                       28.00          4      2.3      2.4     96.4
                       30.00          2      1.2      1.2     97.6
                       31.00          3      1.7      1.8     99.4
                      203.00          1       .6       .6    100.0
                           .          5      2.9  MISSING

                                -------  -------  -------
                       TOTAL        173    100.0    100.0

VALID CASES     168      MISSING CASES      5

SCARBOROUGH

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00          7     13.0     14.0     14.0
                        1.00          4      7.4      8.0     22.0
                        2.00          1      1.9      2.0     24.0
                        3.00          2      3.7      4.0     28.0
                        5.00         11     20.4     22.0     50.0
                        6.00          2      3.7      4.0     54.0
                       10.00          2      3.7      4.0     58.0
                       15.00          1      1.9      2.0     60.0
                       20.00          4      7.4      8.0     68.0
                       21.00          1      1.9      2.0     70.0
                       24.00          2      3.7      4.0     74.0
                       40.00          1      1.9      2.0     76.0
                       50.00          1      1.9      2.0     78.0
                       55.00          1      1.9      2.0     80.0
                       60.00          4      7.4      8.0     88.0
                       65.00          1      1.9      2.0     90.0
                       80.00          1      1.9      2.0     92.0
                      202.00          2      3.7      4.0     96.0
                      280.00          2      3.7      4.0    100.0
                           .          4      7.4  MISSING
                                -------  -------  -------
                       TOTAL         54    100.0    100.0

VALID CASES      50      MISSING CASES      4

FILEY

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00          7     30.4     30.4     30.4
                        7.00         12     52.2     52.2     82.6
                       52.00          2      8.7      8.7     91.3
                       72.00          1      4.3      4.3     95.7
                      163.00          1      4.3      4.3    100.0
                                -------  -------  -------
                       TOTAL         23    100.0    100.0

VALID CASES      23      MISSING CASES      0
```

```
SPSSX FREQUENCY LIST OF FATHER - OFFSPRING DISTANCES 1871.

HINDERWELL

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         17     58.6     58.6     58.6
                        2.00          3     10.3     10.3     69.0
                       41.00          1      3.4      3.4     72.4
                       46.00          3     10.3     10.3     82.8
                       60.00          4     13.8     13.8     96.6
                      260.00          1      3.4      3.4    100.0
                                -------  -------  -------
                       TOTAL         29    100.0    100.0

VALID CASES      29      MISSING CASES      0

WHITBY

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         12     44.4     44.4     44.4
                        2.00          2      7.4      7.4     51.9
                        5.00          4     14.8     14.8     66.7
                        6.00          1      3.7      3.7     70.4
                        8.00          1      3.7      3.7     74.1
                       14.00          1      3.7      3.7     77.8
                       18.00          1      3.7      3.7     81.5
                       60.00          5     18.5     18.5    100.0
                                -------  -------  -------
                       TOTAL         27    100.0    100.0

VALID CASES      27      MISSING CASES      0

FYLINGDALES

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         66     48.2     48.9     48.9
                        1.00          4      2.9      3.0     51.9
                        4.00          5      3.6      3.7     55.6
                        6.00         10      7.3      7.4     63.0
                        7.00          6      4.4      4.4     67.4
                        8.00          1       .7       .7     68.1
                        9.00          9      6.6      6.7     74.8
                       13.00          9      6.6      6.7     81.5
                       14.00          8      5.8      5.9     87.4
                       17.00          3      2.2      2.2     89.6
                       18.00          6      4.4      4.4     94.1
                       20.00          2      1.5      1.5     95.6
                       23.00          2      1.5      1.5     97.0
                       24.00          1       .7       .7     97.8
                       28.00          1       .7       .7     98.5
                       30.00          2      1.5      1.5    100.0

                           .          2      1.5  MISSING
                                -------  -------  -------
                       TOTAL        137    100.0    100.0

VALID CASES     135      MISSING CASES      2

SCARBOROUGH

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00         21     30.9     31.8     31.8
                        1.00          1      1.5      1.5     33.3
                        2.00          7     10.3     10.6     43.9
                        3.00          5      7.4      7.6     51.5
                        4.00          2      2.9      3.0     54.5
                        5.00          8     11.8     12.1     66.7
                        6.00          2      2.9      3.0     69.7
                       11.00          2      2.9      3.0     72.7
                       21.00          1      1.5      1.5     74.2
                       27.00          5      7.4      7.6     81.8
                       33.00          2      2.9      3.0     84.8
                       40.00          1      1.5      1.5     86.4
                       43.00          1      1.5      1.5     87.9
                       47.00          1      1.5      1.5     89.4
                       60.00          2      2.9      3.0     92.4
                       63.00          1      1.5      1.5     93.9
                       67.00          1      1.5      1.5     95.5
                      130.00          3      4.4      4.5    100.0
                           .          2      2.9  MISSING
                                -------  -------  -------
                       TOTAL         68    100.0    100.0

VALID CASES      66      MISSING CASES      2

FILEY

                                                   VALID     CUM
VALUE LABEL            VALUE  FREQUENCY  PERCENT  PERCENT  PERCENT

                         .00          2     18.2     18.2     18.2
                        7.00          7     63.6     63.6     81.8
                       27.00          1      9.1      9.1     90.9
                       78.00          1      9.1      9.1    100.0
                                -------  -------  -------
                       TOTAL         11    100.0    100.0

VALID CASES      11      MISSING CASES      0
```

Table 7.14

```
SPSSX FREQUENCY LIST OF PARISH - OFFSPRING DISTANCES 1881.

HINDERWELL

                                                        VALID     CUM
VALUE LABEL              VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                           .00         13      39.4      39.4      39.4
                          7.00          1       3.0       3.0      42.4
                          8.00          1       3.0       3.0      45.5
                          9.00         12      36.4      36.4      81.8
                         10.00          3       9.1       9.1      90.9
                         [illegible]          2       6.1       6.1      97.0
                         [illegible]          1       3.0       3.0     100.0
                                  -------   -------   -------
                         TOTAL         33     100.0     100.0

VALID CASES        33      MISSING CASES       0

WHITBY

                                                        VALID     CUM
VALUE LABEL              VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                           .00         28      48.3      48.3      48.3
                          2.00          2       3.4       3.4      51.7
                          3.00          4       6.9       6.9      58.6
                          4.00          2       3.4       3.4      62.1
                          5.00         12      20.7      20.7      82.8
                          6.00          4       6.9       6.9      89.7
                         10.00          1       1.7       1.7      91.4
                         18.00          4       6.9       6.9      98.3
                         40.00          1       1.7       1.7     100.0
                                  -------   -------   -------
                         TOTAL         58     100.0     100.0

VALID CASES        58      MISSING CASES       0

FYLINGDALES

                                                        VALID     CUM
VALUE LABEL              VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                           .00        106      62.4      62.7      62.7
                          2.00          1        .6        .6      63.3
                          4.00          1        .6        .6      63.9
                          5.00          4       2.4       2.4      66.3
                          6.00          7       4.1       4.1      70.4
                          7.00          3       1.8       1.8      72.2
                          8.00          3       1.8       1.8      74.0
                          9.00          9       5.3       5.4      79.4
                         12.00          1        .6        .6      80.0
                         13.00          2       1.2       1.2      81.2
                         14.00          5       2.9       3.0      84.2
                         17.00          2       1.2       1.2      85.4
                         18.00          5       2.9       3.0      88.4
                         19.00          1        .6        .6      89.0
                         21.00          3       1.8       1.8      90.8
                         25.00         10       5.9       5.9      96.7
                         26.00          1        .6        .6      97.3
                         30.00          3       1.8       1.8      99.1
                         [illegible]          1        .6        .6     100.0
                              .          1        .6   MISSING
                                  -------   -------   -------
                         TOTAL        170     100.0     100.0

VALID CASES       169      MISSING CASES       1

SCARBOROUGH

                                                        VALID     CUM
VALUE LABEL              VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                           .00          4       [illegible]       [illegible]       [illegible]
                          4.00          1       [illegible]       [illegible]       [illegible]
                          7.00          1       [illegible]       [illegible]       [illegible]
                         10.00          4       [illegible]       [illegible]       [illegible]
                         14.00          3       [illegible]       [illegible]       [illegible]
                         17.00          6       [illegible]       [illegible]       [illegible]
                         19.00          1       [illegible]       [illegible]       [illegible]
                         27.00          6       [illegible]       [illegible]       [illegible]
                         [illegible]          4       [illegible]       [illegible]       [illegible]
                         [illegible]          1       [illegible]       [illegible]       [illegible]
                         [illegible]          3       [illegible]       [illegible]       [illegible]
                         [illegible]          1       [illegible]       [illegible]       [illegible]
                         [illegible]          2       [illegible]       [illegible]       [illegible]
                        107.00          1       [illegible]       [illegible]       [illegible]
                         [illegible]          4       [illegible]       [illegible]       [illegible]
                        204.00          3       [illegible]       [illegible]       [illegible]
                         [illegible]          4       [illegible]       [illegible]       [illegible]
                         [illegible]          1       [illegible]       [illegible]     100.0
                                  -------   -------   -------
                         TOTAL         [illegible]     100.0     100.0

VALID CASES        [illegible]      MISSING CASES       0

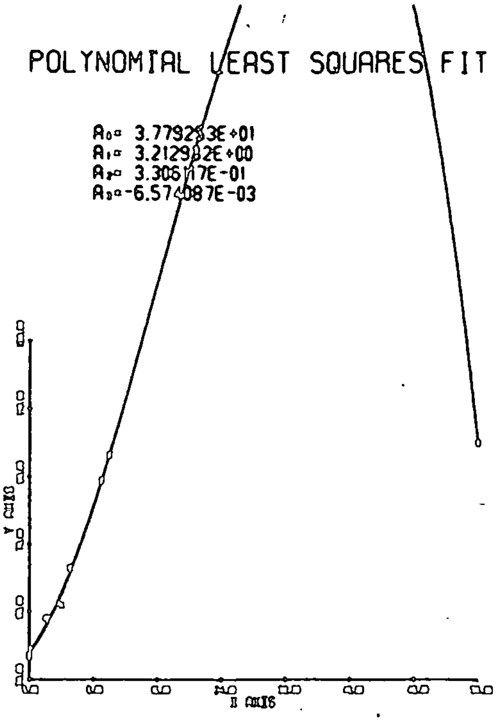
FILEY

                                                        VALID     CUM
VALUE LABEL              VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

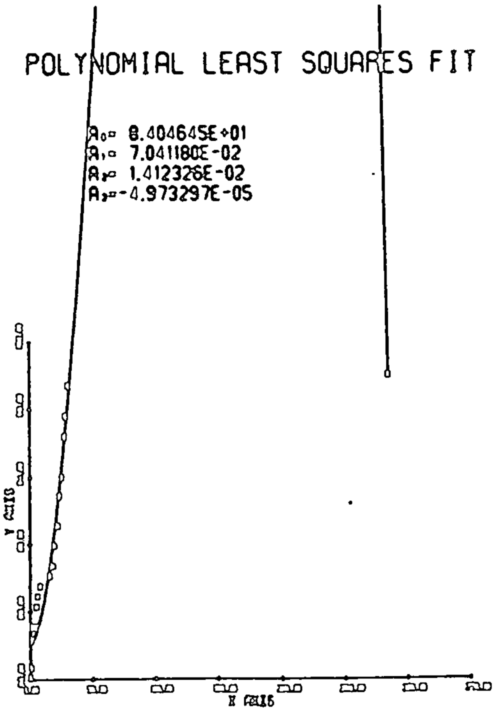
                           .00          [illegible]       [illegible]       [illegible]       [illegible]
                          7.00          4       [illegible]       [illegible]       [illegible]
                         11.00          [illegible]       [illegible]       [illegible]       [illegible]
                         [illegible]          [illegible]       [illegible]       [illegible]       [illegible]
                         [illegible]          1       [illegible]       [illegible]     100.0
                              .          1       [illegible]   MISSING
                                  -------   -------   -------
                         TOTAL         [illegible]     100.0     100.0

VALID CASES        [illegible]      MISSING CASES       1
```

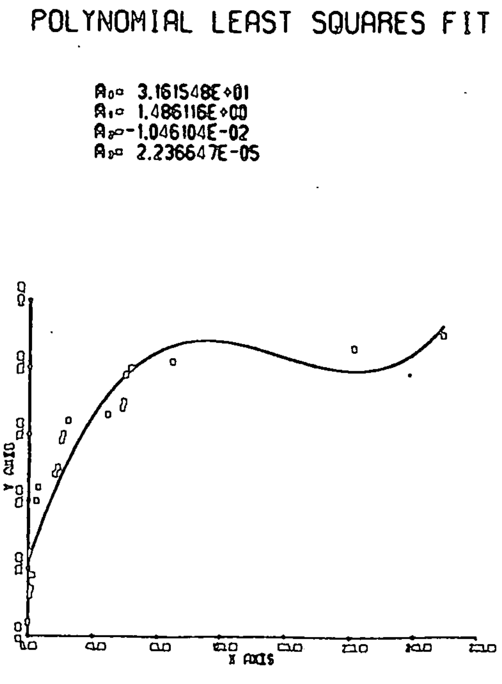
Table 7.15



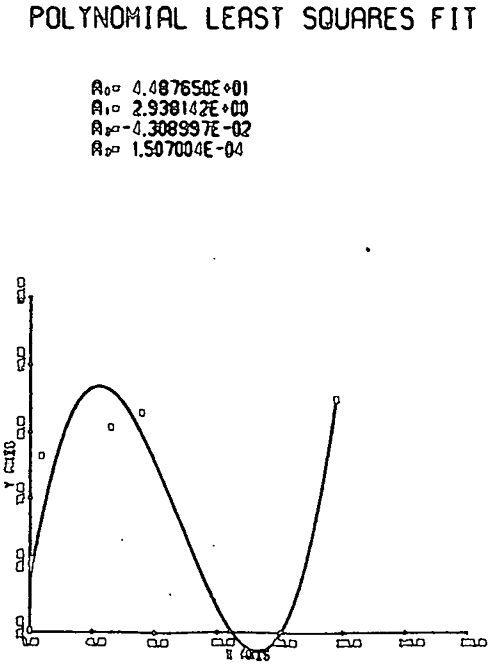
WHITBY FARMER - OFFSPRING 1851



[illegible] . FARMER - OFFSPRING 1851

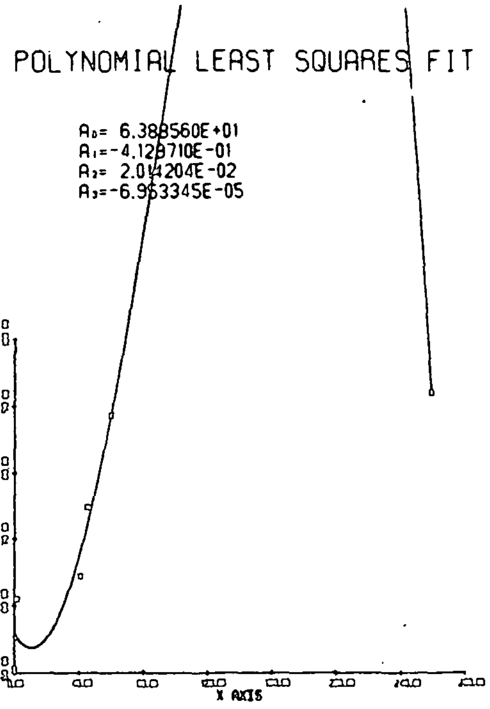


SCARBOROUGH FARMER - OFFSPRING 1851

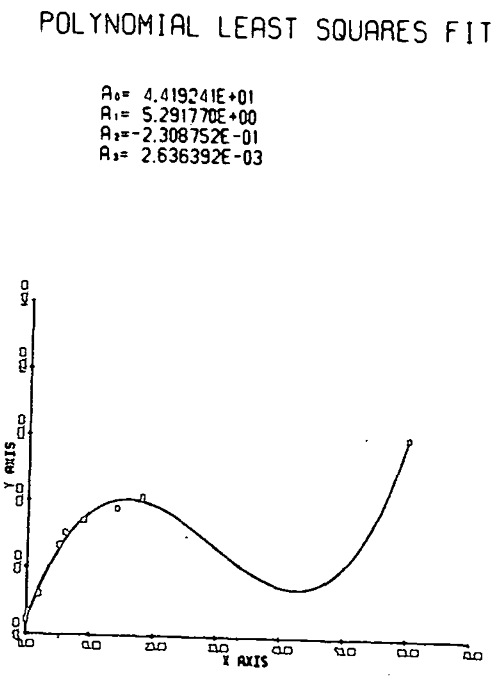


FILEY FARMER - OFFSPRING 1851

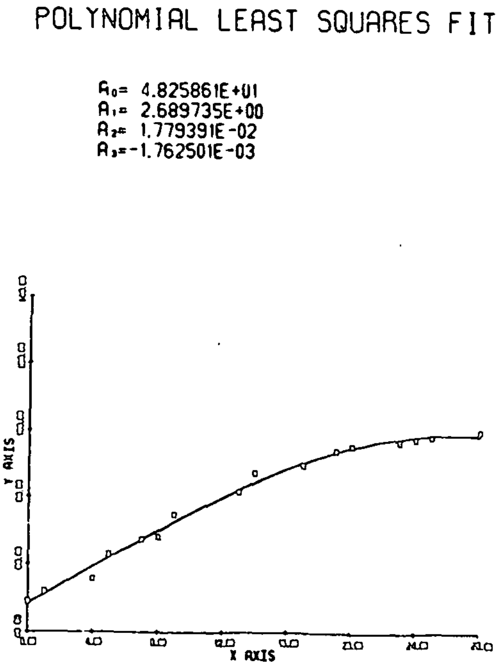
Figure 7.15



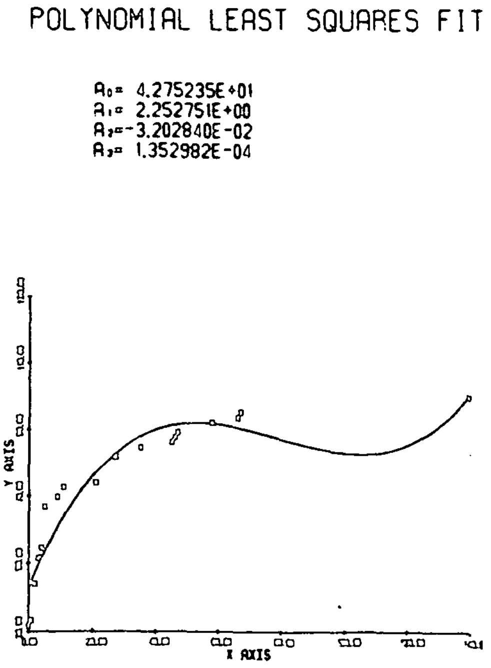
HINDERWELL FARMER - OFFSPRING 1871



WHITBY FARMER - OFFSPRING 1871

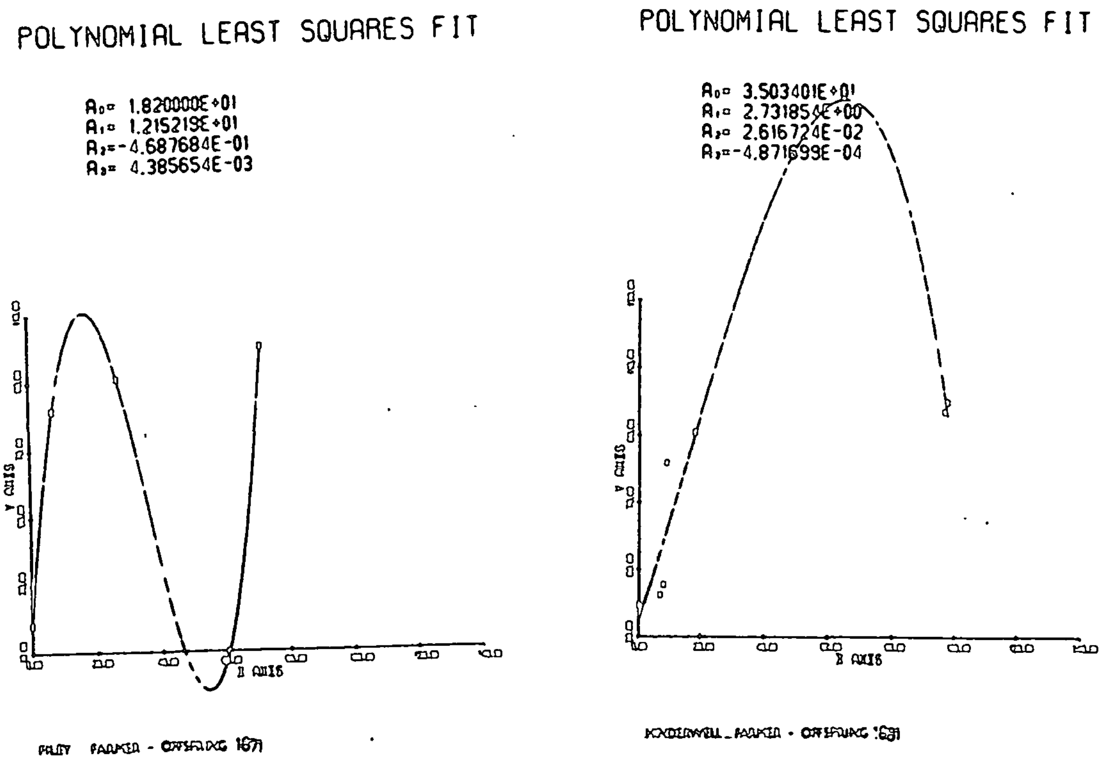


FYLINGDALES FARMER - OFFSPRING 1871



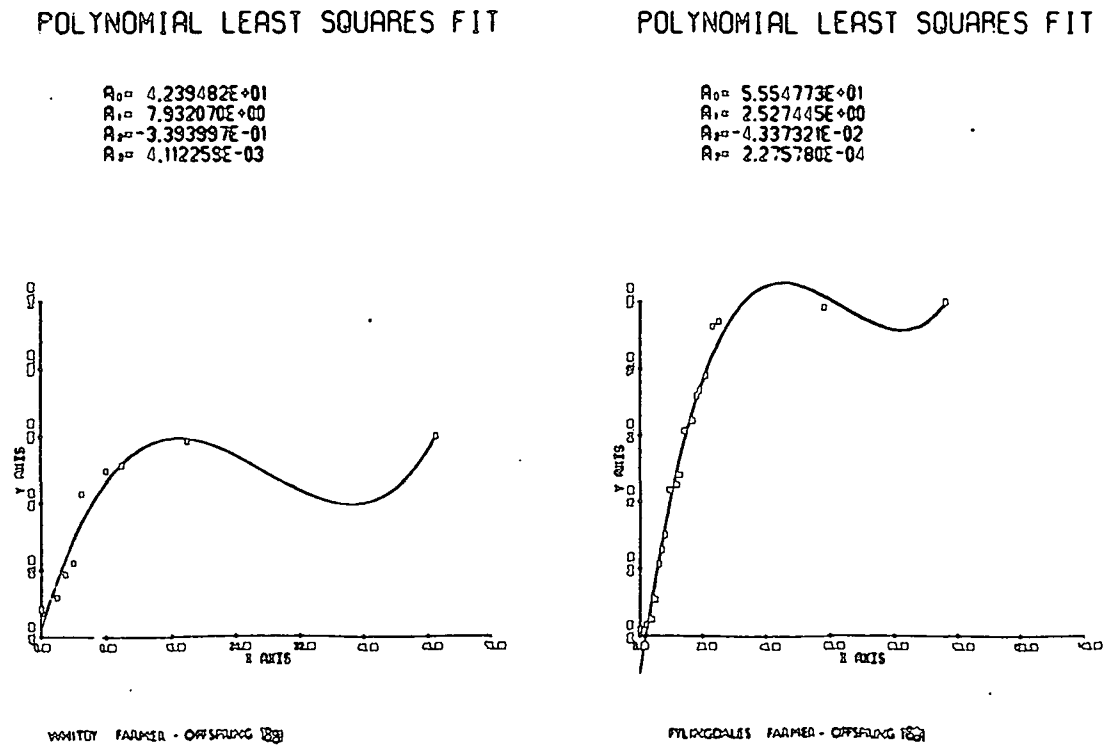
SCARBOROUGH FARMER - OFFSPRING 1871

Figure 7.16



[illegible] FARMER - OFFSPRING 1671

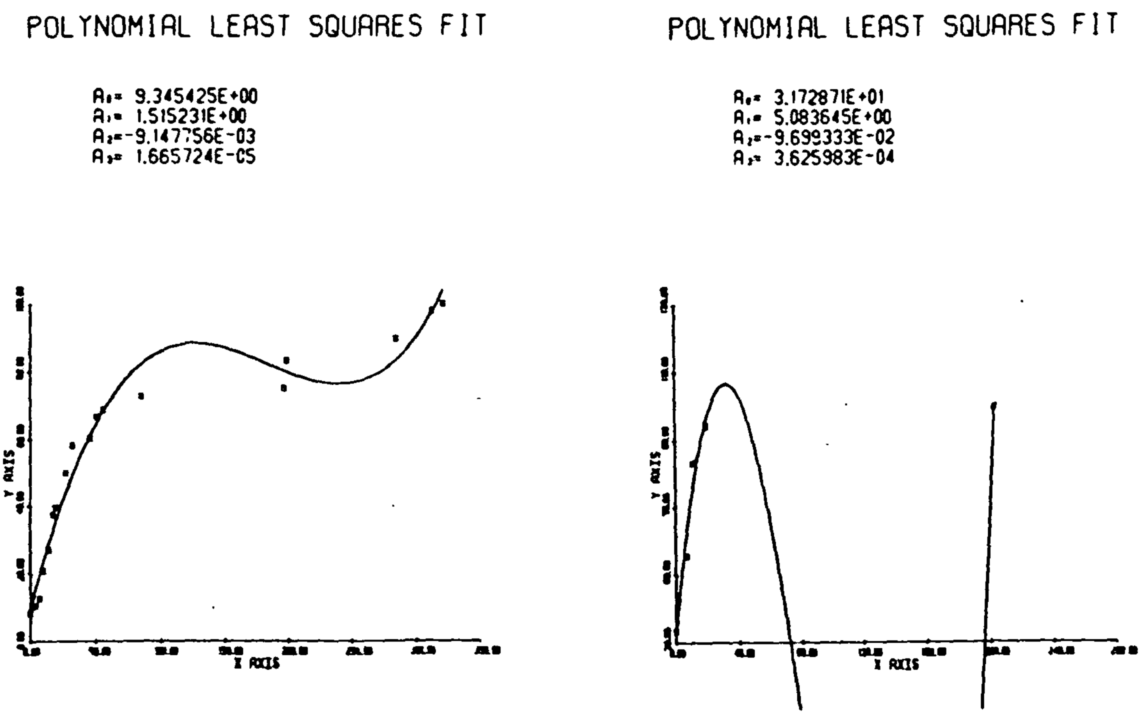
[illegible] FARMER - OFFSPRING 1691



WHITBY FARMER - OFFSPRING 1691

FYLINGDALES FARMER - OFFSPRING 1691

Figure 7.17



POLYNOMIAL LEAST SQUARES FIT

$A_0$= 9.345425E+00
$A_1$= 1.515231E+00
$A_2$=-9.147756E-03
$A_3$= 1.665724E-CS

SCARBOROUGH FARMER - OFFSPRING 1881

POLYNOMIAL LEAST SQUARES FIT

$A_0$= 3.172871E+01
$A_1$= 5.083645E+00
$A_2$=-9.699333E-02
$A_3$= 3.625983E-04

FILEY_ FARMER - OFFSPRING 1881

Figure 7.18

## MALECOTS (1977) a & b PARAMETERS: HINDERWELL FARMER - OFFSPRING 1871.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.31030 |
| SHORT RANGE MIG (k) | 0.10340 |
| EFFECTIVE POPULATION SIZE (Ne) | 308.30005 |
| STANDARD DEVIATION | 0.73270 |
| | |
| EFFECTIVE MIGRATION (Me) | 0.40057 |
| LOCAL KINSHIP (a) | 0.00202 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 1.22160 |

(Long Distance = 11+ km , as determined for Hinderwell from Curvefit.

## MALECOTS (1977) a & b PARAMETERS: HINDERWELL FARMER - OFFSPRING 1881.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.09090 |
| SHORT RANGE MIG (k) | 0.51520 |
| EFFECTIVE POPULATION SIZE (Ne) | 285.60010 |
| STANDARD DEVIATION | 5.90940 |
| | |
| EFFECTIVE MIGRATION (Me) | 0.31926 |
| LOCAL KINSHIP (a) | 0.00273 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.13522 |

(Long Distance = 65+ km , as determined for Hinderwell from Curvefit.)

Table 7.16

```
MALECOTS (1977) a & b PARAMETERS: WHITBY FARMER - OFFSPRING 1861.

LONG RANGE MIGRATION (m)                             0.03700
SHORT RANGE MIG (k)                                  0.59260
EFFECTIVE POPULATION SIZE (Ne)                    3891.65991
STANDARD DEVIATION                                   4.10550


EFFECTIVE MIGRATION (Me)                             0.21265
LOCAL KINSHIP (a)                                    0.00030
DECLINE OF KINSHIP WITH DISTANCE (b)                 0.15885

(Long Distance = 38+ km , as determined for Whitby from Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: WHITBY FARMER - OFFSPRING 1871.

LONG RANGE MIGRATION (m)                             0.22220
SHORT RANGE MIG (k)                                  0.33330
EFFECTIVE POPULATION SIZE (Ne)                    4249.60156
STANDARD DEVIATION                                   3.78970


EFFECTIVE MIGRATION (Me)                             0.44440
LOCAL KINSHIP (a)                                    0.00013
DECLINE OF KINSHIP WITH DISTANCE (b)                 0.24877

(Long Distance = 16+ km , as determined for Whitby from Curvefit.)
```

```
MALECOTS (1977) a & b PARAMETERS: WHITBY FARMER - OFFSPRING 1881.

LONG RANGE MIGRATION (m)                             0.08620
SHORT RANGE MIG (k)                                  0.43100
EFFECTIVE POPULATION SIZE (Ne)                    4587.60156
STANDARD DEVIATION                                   2.88380


EFFECTIVE MIGRATION (Me)                             0.28589
LOCAL KINSHIP (a)                                    0.00019
DECLINE OF KINSHIP WITH DISTANCE (b)                 0.26221

(Long Distance = 17+ km , as determined for Whitby from Curvefit.)
```

Table 7.17

MALECOTS (1977) a & b PARAMETERS: FYLINGDALES FARMER - OFFSPRING 1861

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.00600 |
| SHORT RANGE MIG (k) | 0.17260 |
| EFFECTIVE POPULATION SIZE (Ne) | 274.00000 |
| STANDARD DEVIATION | 8.38320 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.04590 |
| LOCAL KINSHIP (a) | 0.01949 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.03614 |

(Long Distance = 192+ km , as determined for Fylingdales from Curvefi

MALECOTS (1977) a & b PARAMETERS: FYLINGDALES FARMER - OFFSPRING 1871

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.01480 |
| SHORT RANGE MIG (k) | 0.49630 |
| EFFECTIVE POPULATION SIZE (Ne) | 274.30005 |
| STANDARD DEVIATION | 7.04450 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.12210 |
| LOCAL KINSHIP (a) | 0.00741 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.07015 |

(Long Distance = 26+ km , as determined for Fylingdales from Curvefit

MALECOTS (1977) a & b PARAMETERS: FYLINGDALES FARMER - OFFSPRING 1881

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.02380 |
| SHORT RANGE MIG (k) | 0.36900 |
| EFFECTIVE POPULATION SIZE (Ne) | 275.30005 |
| STANDARD DEVIATION | 7.59120 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.13465 |
| LOCAL KINSHIP (a) | 0.00670 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.06836 |

(Long Distance = 45+ km , as determined for Fylingdales from Curvefit

Table 7.18

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FARMER - OFFSPRING 186


LONG RANGE MIGRATION (m)                        0.08000
SHORT RANGE MIG (k)                             0.78000
EFFECTIVE POPULATION SIZE (Ne)              14353.66016
STANDARD DEVIATION                             23.44991



EFFECTIVE MIGRATION (Me)                        0.36222
LOCAL KINSHIP (a)                               0.00005
DECLINE OF KINSHIP WITH DISTANCE (b)            0.03630


(Long Distance = 109+ km , as determined for Scarborough from Curvefi
```

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FARMER - OFFSPRING 1871


LONG RANGE MIGRATION (m)                        0.10600
SHORT RANGE MIG (k)                             0.57580
EFFECTIVE POPULATION SIZE (Ne)              14813.30078
STANDARD DEVIATION                             12.90440



EFFECTIVE MIGRATION (Me)                        0.36511
LOCAL KINSHIP (a)                               0.00005
DECLINE OF KINSHIP WITH DISTANCE (b)            0.06622


(Long Distance = 53+ km , as determined for Scarborough from Curvefit
```

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FARMER - OFFSPRING 1881


LONG RANGE MIGRATION (m)                        0.27080
SHORT RANGE MIG (k)                             0.64580
EFFECTIVE POPULATION SIZE (Ne)              14367.60156
STANDARD DEVIATION                             21.50729



EFFECTIVE MIGRATION (Me)                        0.65046
LOCAL KINSHIP (a)                               0.00003
DECLINE OF KINSHIP WITH DISTANCE (b)            0.05303


(Long Distance = 127+ km , as determined for Scarborough from Curvefi
```

Table 7.19

MALECOTS (1977) a & b PARAMETERS: FILEY FARMER - OFFSPRING 1861.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.17390 |
| SHORT RANGE MIG (k) | 0.52170 |
| EFFECTIVE POPULATION SIZE (Ne) | 621.00000 |
| STANDARD DEVIATION | 3.46920 |
| EFFECTIVE MIGRATION (Me) | 0.46010 |
| LOCAL KINSHIP (a) | 0.00087 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.27651 |

(Long Distance = 44+ km , as determined for Filey from Curvefit.)

MALECOTS (1977) a & b PARAMETERS: FILEY FARMER - OFFSPRING 1871.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.18180 |
| SHORT RANGE MIG (k) | 0.63640 |
| EFFECTIVE POPULATION SIZE (Ne) | 745.00000 |
| STANDARD DEVIATION | 3.08670 |
| EFFECTIVE MIGRATION (Me) | 0.51424 |
| LOCAL KINSHIP (a) | 0.00065 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.32855 |

(Long Distance = 17+ km , as determined for Filey from Curvefit.)

MALECOTS (1977) a & b PARAMETERS: FILEY FARMER - OFFSPRING 1881.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.05560 |
| SHORT RANGE MIG (k) | 0.61110 |
| EFFECTIVE POPULATION SIZE (Ne) | 772.00000 |
| STANDARD DEVIATION | 6.43120 |
| EFFECTIVE MIGRATION (Me) | 0.26654 |
| LOCAL KINSHIP (a) | 0.00121 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.11353 |

(Long Distance = 32+ km , as determined for Filey from Curvefit.)

Table 7.20

```
STAITHES

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00        227   [illegible].0   [illegible].0   [illegible].0
                              3.00          1        .4        .4     100.0
                                      -------   -------   -------
                             TOTAL        228     100.0     100.0

VALID CASES      228       MISSING CASES      0

RUNSWICK

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00   [illegible]      07.7   [illegible].0   [illegible].0
                              2.00          1       1.1       1.2     100.0
                                 .          1       1.1   MISSING
                                      -------   -------   -------
                             TOTAL         07     100.0     100.0

VALID CASES   [illegible]       MISSING CASES      1

WHITBY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00         80      70.4      70.4      70.4
                              7.00          1       1.0       1.0      01.0
                              0.00          1       1.0       1.0      02.0
                             27.00          1       1.0       1.0      04.1
                             93.00          4       0.3       0.3   [illegible].0
                             70.00          0       0.0       0.0     100.0
                                      -------   -------   -------
                             TOTAL         03     100.0     100.0

VALID CASES       03       MISSING CASES      0

ROBIN HOODS BAY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00         10   [illegible].0     100.0     100.0
                                 .          1       0.0   MISSING
                                      -------   -------   -------
                             TOTAL         20     100.0     100.0

VALID CASES       10       MISSING CASES      1

SCARBOROUGH

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00        220      80.7      90.0   [illegible].0
                              3.00          1        .3        .3      90.0
                              0.00          4       1.1       1.1      01.0
                              0.00          4       1.1       1.1      02.1
                             12.00          2        .0        .0      02.0
                             14.00          2        .0        .0      03.1
                             10.00         37       0.0      10.0      73.2
                             21.00          3        .0        .0      74.0
                             27.00          4       1.1       1.1      70.1
                             20.00          1        .3        .3      70.3
                             33.00          0       1.3       1.4      70.7
                             30.00          1        .3        .3      77.0
                             23.00          1        .3        .3      77.2
                             33.00          3        .0        .0      70.0
                             40.00          0       1.3       1.4      70.4
                             93.00          1        .3        .3      70.7
                            113.00          1        .3        .3      70.0
                            192.00          0       1.3       1.4      01.3
                            170.00          3        .0        .0      02.1
                      1[illegible].00          2        .9        .0      02.7
                            102.00         11       2.0       3.0   [illegible].0
                            103.00          2        .0        .0   [illegible].2
                            201.00          1        .3        .3   [illegible].4
                            202.00          1        .3        .3   [illegible].7
                            203.00          1        .3        .3      07.0
                      2[illegible].00          1        .3        .3      07.3
                      2[illegible].00          1        .3        .3      07.0
                            210.00          0       1.3       1.4   [illegible].0
                            210.00          3        .0        .0   [illegible].7
                            223.00          1        .3        .3   [illegible].0
                            234.00         13       3.0       3.0   [illegible].0
                      2[illegible].00         10       2.7       2.7   [illegible].2
                            330.00          1        .3        .3   [illegible].0
                            332.00          3        .0        .0      07.3
                            333.00          3        .0        .0   [illegible].1
                            433.00          1        .3        .3   [illegible].4
                            444.00          3        .0        .0   [illegible].2
                            401.00          3        .0        .0     100.0
                                 .          0       1.0   MISSING
                                      -------   -------   -------
                             TOTAL        370     100.0     100.0

VALID CASES   [illegible]       MISSING CASES      0

FILEY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00   1[illegible]   [illegible].0      02.0      02.0
                              2.00          4       1.0       1.0      04.4
                            104.00          7       3.2       3.3      07.7
                            210.00          1        .0        .0   [illegible].1
                            346.00          4       1.0       1.0     100.0
                                 .          4       1.0   MISSING
                                      -------   -------   -------
                             TOTAL        210     100.0     100.0

VALID CASES      210       MISSING CASES      4
```

Table 7.21

```
STAITHES

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00        232   [illegible].3      07.0      07.0
                              3.00          0       3.1       3.1   [illegible].0
                              0.00          1        .4        .4     100.0
                                 .          3       1.2   MISSING
                                      -------   -------   -------
                             TOTAL        241     100.0     100.0

VALID CASES      230       MISSING CASES      3

RUNSWICK

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00   [illegible]      07.0      07.0      07.0
                      [illegible].00          2       3.0       3.0     100.0
                                      -------   -------   -------
                             TOTAL         07     100.0     100.0

VALID CASES       07       MISSING CASES      0

WHITBY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00   [illegible]      73.0      73.0      73.0
                             10.00          0       0.0       0.0      70.0
                             37.00          3       2.0       2.0      01.0
                             32.00          1        .0        .0      01.0
                      [illegible].00          1        .0        .0      02.0
                             72.00          2       1.7       1.7      04.3
                             73.00          1        .0        .0   [illegible].1
                             70.00          3       2.0       2.0      07.0
                            103.00          1        .0        .0      03.4
                            140.00          4       3.3       3.3      01.7
                            211.00          0       0.0       0.0   [illegible].3
                            403.00          2       1.7       1.7     100.0
                                      -------   -------   -------
                             TOTAL        121     100.0     100.0

VALID CASES      121       MISSING CASES      0

ROBIN HOODS BAY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00         21     100.0     100.0     100.0
                                      -------   -------   -------
                             TOTAL         21     100.0     100.0

VALID CASES       21       MISSING CASES      0

SCARBOROUGH

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00   2[illegible]      83.0      83.0   [illegible].0
                              2.00          3        .0        .0      07.1
                              0.00          2        .4        .4      07.0
                             12.00          1        .2        .2      07.7
                             10.00         10       3.1       3.1   [illegible].0
                             17.00          1        .2        .2      01.1
                             20.00          0       1.0       1.0      02.0
                             27.00          0       1.0       1.0      03.0
                             20.00          2        .4        .4      03.4
                             33.00         11       2.1       2.2   [illegible].0
                             23.00          0       1.7       1.0      07.3
                      [illegible].00          0       1.2       1.2      00.9
                             01.00          1        .2        .2      00.7
                             04.00          4        .0        .0   [illegible].0
                             71.00          1        .2        .2   [illegible].7
                             02.00          2        .4        .4      70.1
                             03.00          1        .2        .2      70.3
                      [illegible].00          2        .4        .4      70.0
                            104.00          1        .2        .2      70.0
                            113.00          1        .2        .2      71.0
                            122.00          2        .4        .4      71.4
                            160.00          1        .2        .2      71.0
                            162.00          0       1.7       1.0      73.4
                      1[illegible].00          4        .0        .0      74.2
                            101.00          4        .0        .0      70.0
                            173.00          1        .2        .2      70.1
                            104.00          3        .0        .0      70.7
                            107.00          0       1.0       1.0      77.3
                            101.00          1        .2        .2      77.0
                            102.00          4        .0        .0      70.3
                      1[illegible].00          4        .0        .0      70.1
                      1[illegible].00         13       2.0       2.0      01.0
                            200.00          1        .2        .2      01.0
                            204.00          2        .4        .4      02.2
                            210.00          1        .2        .2      02.4
                            212.00          3        .0        .0      03.0
                            210.00         13       2.0       2.0   [illegible].0
                            210.00          0       1.7       1.0      07.3
                            220.00          3        .0        .0      07.0
                            220.00          2        .4        .4   [illegible].3
                            220.00          7       1.3       1.4   [illegible].0
                            234.00          0       1.2       1.2   [illegible].0
                            240.00          7       1.3       1.4      02.2
                            267.00          4        .0        .0      03.0
                            260.00          1        .2        .2      03.2
                      2[illegible].00          1        .2        .2      03.3
                            314.00          4        .0        .0      04.1
                            310.00          3        .0        .0      04.7
                            391.00          3        .0        .0   [illegible].3
                            339.00          0       1.2       1.2   [illegible].6
                            332.00          1        .2        .2   [illegible].7
                            330.00          0       1.0       1.0      07.7
                            370.00          3        .0        .0   [illegible].2
                            300.00          1        .2        .2   [illegible].4
                      4[illegible].00          0       1.2       1.2   [illegible].0
                            401.00          2        .4        .4     100.0
                                 .          0       1.7   MISSING
                                      -------   -------   -------
                             TOTAL        520     100.0     100.0

VALID CASES      511       MISSING CASES      0

FILEY

                                                            VALID     CUM
VALUE LABEL                  VALUE  FREQUENCY   PERCENT   PERCENT   PERCENT

                               .00        210      70.0      70.0      70.0
                              2.00          3       1.0       1.0      01.0
                             10.00          2        .7        .7      02.6
                             12.00          2        .7        .7      03.2
                             16.00          4       1.4       1.6      04.7
                             10.00          7       2.5       2.0      07.2
                             23.00          1        .4        .4      07.0
                             27.00          1        .4        .4   [illegible].0
                             20.00          1        .4        .4   [illegible].3
                             30.00          0       1.0       1.0   [illegible].1
                             44.00          1        .4        .4   [illegible].0
                      [illegible].00          1        .4        .4   [illegible].0
                      [illegible].00          2        .7        .7      01.0
                      1[illegible].00          2        .7        .7      02.3
                            174.00          1        .4        .4      02.7
                            104.00          2        .7        .7      03.4
                      1[illegible].00          1        .4        .4      03.0
                            202.00          3       1.1       1.1      04.0
                            200.00          2        .7        .7   [illegible].0
                            210.00          3       1.1       1.1   [illegible].7
                      2[illegible].00          2        .7        .7      07.4
                            314.00          1        .4        .4      07.0
                            373.00          0       2.2       2.2     100.0
                                 .          4       1.4   MISSING
                                      -------   -------   -------
                             TOTAL        270     100.0     100.0

VALID CASES      274       MISSING CASES      4
```

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SPSSX FREQUENCY LIST OF FISHERMEN - OFFSPRING DISTANCES 1881

STAITHES
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT

                           .00     239      98.4    98.4    98.4
                          8.00       1        .4      .4    98.8
                         35.00       1        .4      .4    99.2
                        277.00       2        .8      .8   100.0
                                 -------  ------- -------
                         TOTAL     243     100.0   100.0

VALID CASES     243      MISSING CASES    0

RUNSWICK
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT

                           .00      54     100.0   100.0   100.0
                                 -------  ------- -------
                         TOTAL      54     100.0   100.0

VALID CASES      54      MISSING CASES    0

WHITBY
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT

                           .00     111      70.3    70.3    70.3
                         10.00       6       3.8     3.8    74.1
                         24.00       3       1.9     1.9    75.9
                         30.00       1        .6      .6    76.6
                         43.00       5       3.2     3.2    79.7
                         60.00       1        .6      .6    80.4
                         70.00       3       1.9     1.9    82.3
                        181.00       4       2.5     2.5    84.8
                        184.00       1        .6      .6    85.4
                        211.00       3       1.9     1.9    87.3
                        212.00       2       1.3     1.3    88.6
                        293.00       7       4.4     4.4    93.0
                        300.00       1        .6      .6    93.7
                        332.00       4       2.5     2.5    96.2
                        338.00       6       3.8     3.8   100.0
                                 -------  ------- -------
                         TOTAL     158     100.0   100.0

VALID CASES     158      MISSING CASES    0

ROBIN HOODS BAY
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT
                           .00      14     100.0   100.0   100.0
                                 -------  ------- -------
                         TOTAL      14     100.0   100.0

VALID CASES      14      MISSING CASES    0

SCARBOROUGH
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT

                           .00     527      82.0    84.1    84.1
                          1.00       4        .6      .6    84.7
                          2.00       2        .3      .3    85.0
                          3.00       1        .2      .2    85.2
                          5.00       2        .3      .3    85.5
                          6.00       4        .6      .6    86.1
                         10.00       3        .5      .5    86.6
                         13.00       2        .3      .3    86.9
                         15.00      38       5.9     6.1    93.0
                         18.00       2        .3      .3    93.3
                         26.00       2        .3      .3    93.6
                         27.00       6        .9     1.0    94.6
                         30.00       3        .5      .5    95.1
                         32.00       4        .6      .6    95.7
                         35.00       9       1.4     1.4    97.1
                         46.00       2        .3      .3    97.4
                         48.00      11       1.7     1.8    99.2
                         54.00       2        .3      .3    99.5
                         58.00       2        .3      .3    99.8
                         64.00       3        .5      .5   100.3
                         80.00       4        .6      .6    80.1
                         81.00       1        .2      .2    80.3
                         83.00       1        .2      .2    80.4
                         92.00       1        .2      .2    80.6
                         97.00       2        .3      .3    80.9
                        103.00       2        .3      .3    69.2
                        105.00       3        .5      .5    69.7
                        123.00       4        .6      .6    70.3
                        144.00       4        .6      .6    71.0
                        152.00       6        .9     1.0    71.9
                        163.00       2        .3      .3    72.2
                        175.00       3        .5      .5    72.7
                        187.00      11       1.7     1.8    74.5
                        191.00       6        .9     1.0    75.4
                        192.00       9       1.4     1.4    76.9
                        196.00      14       2.2     2.2    79.1
                        201.00       3        .5      .5    79.6
                        202.00       2        .3      .3    79.9
                        210.00       4        .6      .6    80.5
                        212.00       8       1.2     1.3    81.8
                        213.00       2        .3      .3    82.1
                        216.00       1        .2      .2    82.3
                        218.00       6        .9      .9    83.2
                        219.00      20       3.1     3.2    86.4
                        220.00       9       1.4     1.4    87.8
                        234.00      14       2.2     2.2    90.1
                        237.00       3        .5      .5    90.6
                        241.00       6        .9     1.0    91.5
                        245.00       2        .3      .3    91.9
                        248.00       3        .5      .5    92.3
                        267.00       1        .2      .2    92.5
                        281.00       2        .3      .3    92.8
                        304.00       6        .9     1.0    93.8
                        310.00      10       1.6     1.6    95.4
                        318.00       9       1.4     1.4    96.8
                        343.00       1        .2      .2    97.0
                        353.00       8       1.2     1.3    98.2
                        392.00       2        .3      .3    98.6
                        393.00       4        .6      .6    99.2
                        397.00       5        .8      .8   100.0
                        503.00       1        .2      .2   100.0
                             .      16       2.5  MISSING
                                 -------  ------- -------
                         TOTAL     643     100.0   100.0

VALID CASES     627      MISSING CASES   16

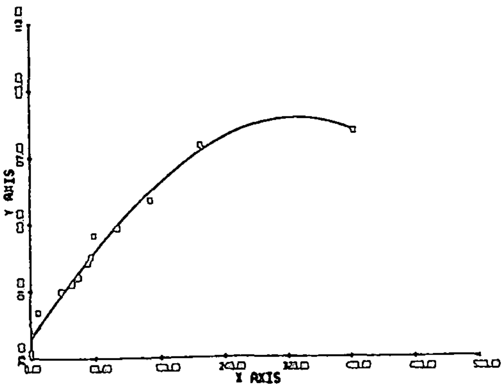
FILEY
                                                  VALID     CUM
VALUE LABEL              VALUE  FREQUENCY PERCENT PERCENT PERCENT

                           .00     174      82.1    82.1    82.1
                          2.00       2        .9      .9    83.0
                         16.00       4       1.9     1.9    84.9
                         22.00       1        .5      .5    85.4
                         27.00       1        .5      .5    85.8
                        103.00       1        .5      .5    86.3
                        126.00       6       2.8     2.8    89.2
                        174.00       3       1.4     1.4    90.6
                        184.00       1        .5      .5    91.0
                        203.00       7       3.3     3.3    94.3
                        210.00       4       1.9     1.9    96.2
                        281.00       1        .5      .5    96.7
                        290.00       4       1.9     1.9    98.6
                        374.00       3       1.4     1.4   100.0
                                 -------  ------- -------
                         TOTAL     212     100.0   100.0
VALID CASES     212      MISSING CASES    0
```

Table 7.22

POLYNOMIAL LEAST SQUARES FIT

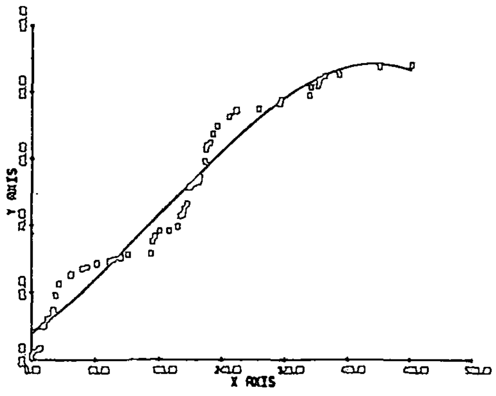
$A_0$= 7.531194E+01
$A_1$= 1.424579E-01
$A_2$=-1.460220E-04
$A_3$=-1.356989E-07



WHITBY FISHERMEN - OFFSPRING 1971.

POLYNOMIAL LEAST SQUARES FIT

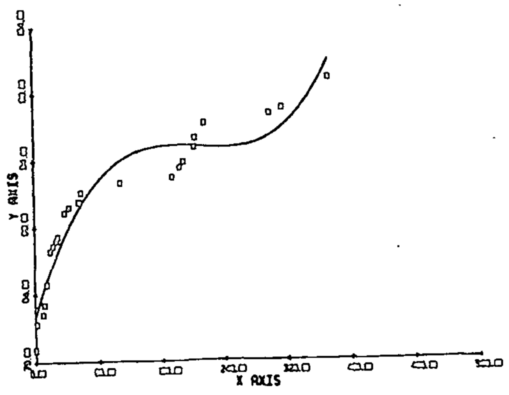
$A_0$= 5.997890E+01
$A_1$= 8.095366E-02
$A_2$= 2.645699E-04
$A_3$=-5.479015E-07



SCARBOROUGH FISHERMEN - OFFSPRING 1971.

POLYNOMIAL LEAST SQUARES FIT

$A_0$= 8.228947E+01
$A_1$= 1.940255E-01
$A_2$=-9.623715E-04
$A_3$= 1.553952E-06

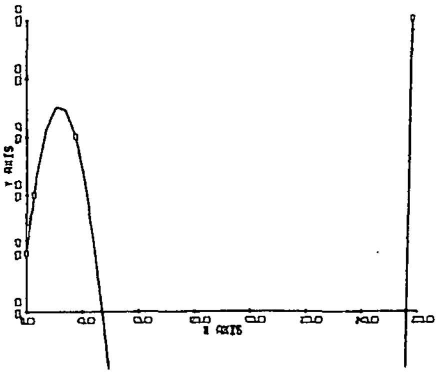


FILEY FISHERMEN - OFFSPRING 1971.

Figure 7.19

POLYNOMIAL LEAST SQUARES FIT

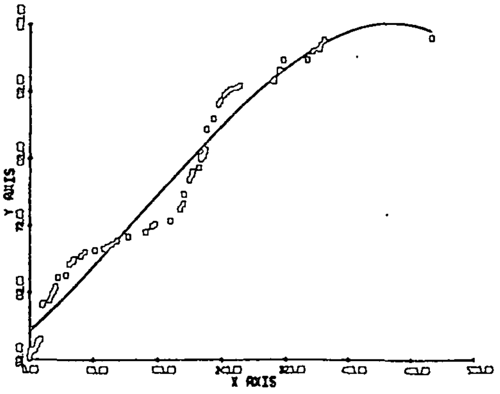
```
A0= 9.839999E+01
A1= 9.070385E-02
A2=-2.174494E-03
A3= 6.743306E-06
```



STAITHES FISHERMEN - OFFSPRING 1881

POLYNOMIAL LEAST SQUARES FIT

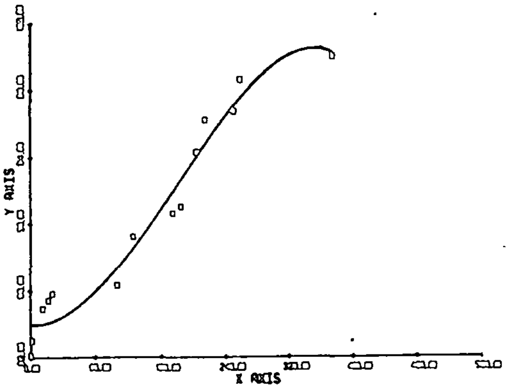
```
A0= 5.625807E+01
A1= 1.097529E-01
A2= 1.860555E-04
A3=-4.513963E-07
```



SCARBOROUGH FISHERMEN - OFFSPRING 1881.

POLYNOMIAL LEAST SQUARES FIT

```
A0= 8.396370E+01
A1=-4.301656E-03
A2= 4.253080E-04
A3=-7.953453E-07
```



FILEY FISHERMEN - OFFSPRING 1881

Figure 7.20

### MALECOTS (1977) a & b PARAMETERS: WHITBY FISHERMEN 1871.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.01650 |
| SHORT RANGE MIG (k) | 0.24790 |
| EFFECTIVE POPULATION SIZE (Ne) | 74.33330 |
| STANDARD DEVIATION | 59.67059 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.09194 |
| LOCAL KINSHIP (a) | 0.03529 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.00719 |

(Long distance = 332 km + as determined for Whitby by 'Curvefit'.)

### MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FISHERMEN 1871.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.01570 |
| SHORT RANGE MIG (k) | 0.41880 |
| EFFECTIVE POPULATION SIZE (Ne) | 370.66675 |
| STANDARD DEVIATION | 106.88361 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.11574 |
| LOCAL KINSHIP (a) | 0.00579 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.00450 |

(Long distance = 435 km + as determined for Scarborough by 'Curvefit'.

### MALECOTS (1977) a & b PARAMETERS: FILEY FISHERMEN 1871.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.07660 |
| SHORT RANGE MIG (k) | 0.12410 |
| EFFECTIVE POPULATION SIZE (Ne) | 208.66670 |
| STANDARD DEVIATION | 13.37030 |

| | |
|---|---|
| EFFECTIVE MIGRATION (Me) | 0.15773 |
| LOCAL KINSHIP (a) | 0.00754 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.04201 |

(Long distance = 174 km + as determined for Filey by 'Curvefit'.)

Table 7.23

### MALECOTS (1977) a & b PARAMETERS: STAITHES FISHERMEN 1881.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.01230 |
| SHORT RANGE MIG (k) | 0.00410 |
| EFFECTIVE POPULATION SIZE (Ne) | 179.66670 |
| STANDARD DEVIATION | 0.32270 |
| | |
| EFFECTIVE MIGRATION (Me) | 0.01588 |
| LOCAL KINSHIP (a) | 0.08057 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.55224 |

(Long distance = 23 km + as determined for Staithes by 'Curvefit'.)

### MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FISHERMEN 1881.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.00160 |
| SHORT RANGE MIG (k) | 0.47690 |
| EFFECTIVE POPULATION SIZE (Ne) | 482.66675 |
| STANDARD DEVIATION | 110.78999 |
| | |
| EFFECTIVE MIGRATION (Me) | 0.03910 |
| LOCAL KINSHIP (a) | 0.01307 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.00252 |

(Long distance = 454 km + as determined for Scarborough by 'Curvefit'

### MALECOTS (1977) a & b PARAMETERS: FILEY FISHERMEN 1881.

| | |
|---|---|
| LONG RANGE MIGRATION (m) | 0.01420 |
| SHORT RANGE MIG (k) | 0.16510 |
| EFFECTIVE POPULATION SIZE (Ne) | 206.66670 |
| STANDARD DEVIATION | 65.89200 |
| | |
| EFFECTIVE MIGRATION (Me) | 0.06993 |
| LOCAL KINSHIP (a) | 0.01700 |
| DECLINE OF KINSHIP WITH DISTANCE (b) | 0.00568 |

(Long distance = 351 km + as determined for Filey by 'Curvefit'.)

Table 7.24

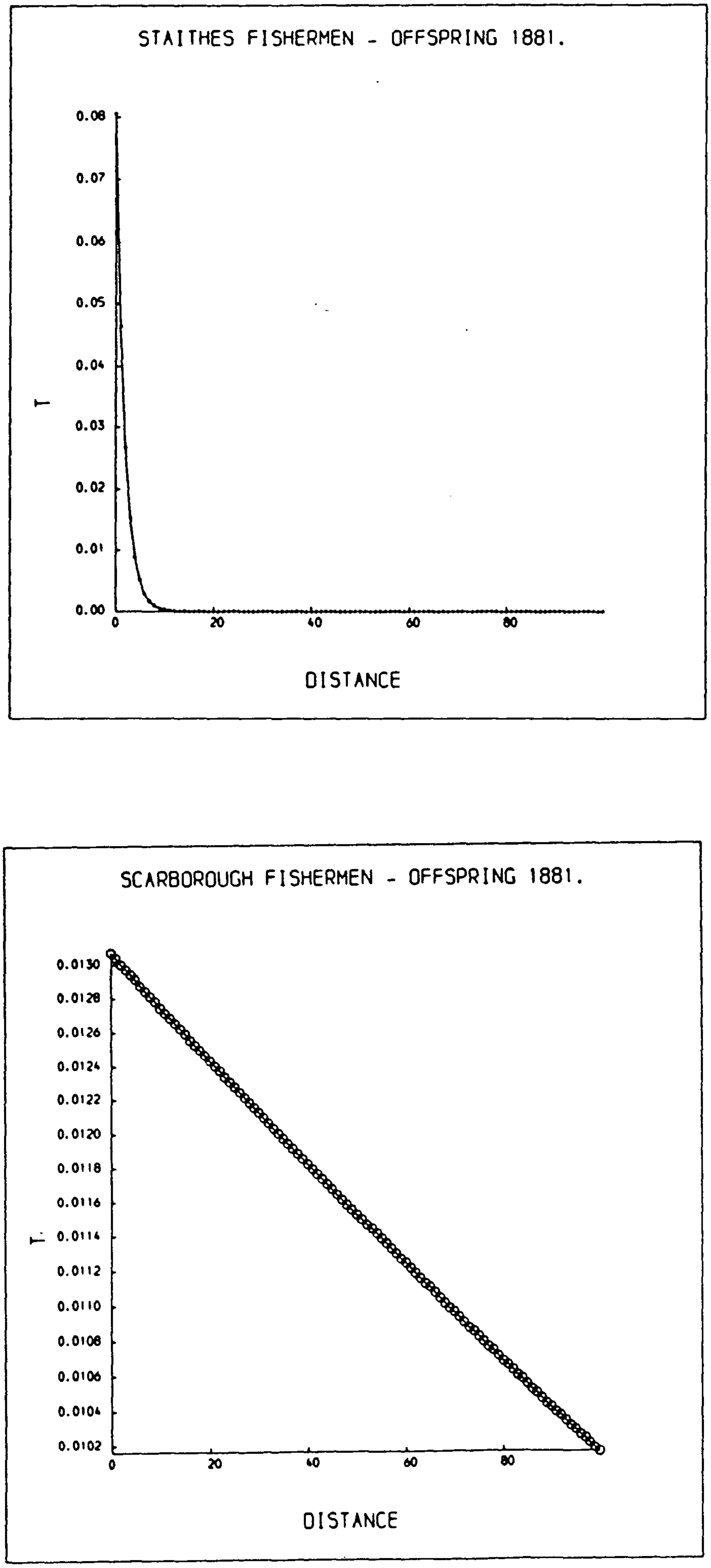

STAITHES FISHERMEN - OFFSPRING 1881.
T
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
DISTANCE
SCARBOROUGH FISHERMEN - OFFSPRING 1881.
T
0.0130
0.0128
0.0126
0.0124
0.0122
0.0120
0.0118
0.0116
0.0114
0.0112
0.0110
0.0108
0.0106
0.0104
0.0102
0
20
40
60
80
DISTANCE

**Figure 7.21**

```
MALECOTS (1977) a & b PARAMETERS: HINDERWELL AG. LABS.-OFFSPRING 1851.

EFFECTIVE MIGRATION (Me)                        0.34880
EFFECTIVE POPULATION SIZE (Ne)                 91.70000
STANDARD DEVIATION                             16.70000


LOCAL KINSHIP (a)                               0.00776
DECLINE OF KINSHIP WITH DISTANCE (b)            0.05001

(No distinction is made between short and long range migration: Me is
is estimated as the proportion of all migrants into the population.)
```

```
MALECOTS (1977) a & b PARAMETERS: WHITBY AG.LABS-OFFSPRING 1851.

EFFECTIVE MIGRATION (Me)                        0.78630
EFFECTIVE POPULATION SIZE (Ne)               3891.00000
STANDARD DEVIATION                             67.60001


LOCAL KINSHIP (a)                               0.00008
DECLINE OF KINSHIP WITH DISTANCE (b)            0.01855

(No distinction is made between short and long range migration: Me is
is estimated as the proportion of all migrants into the population.)
```

```
MALECOTS (1977) a & b PARAMETERS: FYLINGDALES AG. LABS.-OFFSPRING 185

EFFECTIVE MIGRATION (Me)                        0.51610
EFFECTIVE POPULATION SIZE (Ne)                294.69995
STANDARD DEVIATION                              7.30000


LOCAL KINSHIP (a)                               0.00164
DECLINE OF KINSHIP WITH DISTANCE (b)            0.13917

(No distinction is made between short and long range migration: Me is
is estimated as the proportion of all migrants into the population.)
```

Table 7.25

```
MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH AG. LABS.-OFFSPRING 18

EFFECTIVE MIGRATION (Me)                          0.88990
EFFECTIVE POPULATION SIZE (Ne)                14936.69922
STANDARD DEVIATION                               88.60001


LOCAL KINSHIP (a)                                 0.00002
DECLINE OF KINSHIP WITH DISTANCE (b)              0.01506

(No distinction is made between short and long range migration: Me i
is estimated as the proportion of all migrants into the population.)
```

```
MALECOTS (1977) a & b PARAMETERS: FILEY AG. LABS.-OFFSPRING 1851.

EFFECTIVE MIGRATION (Me)                          0.55560
EFFECTIVE POPULATION SIZE (Ne)                  500.00000
STANDARD DEVIATION                               26.80000


LOCAL KINSHIP (a)                                 0.00090
DECLINE OF KINSHIP WITH DISTANCE (b)              0.03933

(No distinction is made between short and long range migration: Me is
is estimated as the proportion of all migrants into the population.)
```

```
MALECOTS (1977) a & b PARAMETERS: STAITHES FIS.-OFFSPRING 1851.

EFFECTIVE MIGRATION (Me)                          0.05880
EFFECTIVE POPULATION SIZE (Ne)                  136.30000
STANDARD DEVIATION                                5.10000


LOCAL KINSHIP (a)                                 0.03025
DECLINE OF KINSHIP WITH DISTANCE (b)              0.06724

(No distinction is made between short and long range migration: Me is
is estimated as the proportion of all migrants into the population.)
```

Table 7.26

```
MALECOTS (1977) a & b PARAMETERS: FILEY FIS.-OFFSPRING 1851.


EFFECTIVE MIGRATION (Me)                          0.05210
EFFECTIVE POPULATION SIZE (Ne)                  150.00000
STANDARD DEVIATION                               27.80000



LOCAL KINSHIP (a)                                 0.03100
DECLINE OF KINSHIP WITH DISTANCE (b)              0.01161

(No distinction is made between short and long range migration: Me i
is estimated as the proportion of all migrants into the population.)





MALECOTS (1977) a & b PARAMETERS: SCARBOROUGH FIS.-OFFSPRING 1851.


EFFECTIVE MIGRATION (Me)                          0.40890
EFFECTIVE POPULATION SIZE (Ne)                  157.00000
STANDARD DEVIATION                              102.30000



LOCAL KINSHIP (a)                                 0.00388
DECLINE OF KINSHIP WITH DISTANCE (b)              0.00884

(No distinction is made between short and long range migration: Me i
is estimated as the proportion of all migrants into the population.)
```

Table 7.27

# Chapter 8.

## The Stepping-Stone model: Method and Results

One of the principal concerns of this thesis is the practical application and evaluation of the one dimensional linear stepping-stonetone model. For, to date, very little work has been done on this aspect of the subject. The Yorkshire coastal settlements of Staithes, Runswick, Whitby, Robin Hood's Bay, Scarborough and Filey comply with the principal constraint of the model: they are discrete settlements linearly arranged and are but a few links in a much longer chain of coastal settlements. On the surface they seem the ideal material for the practical application of the stepping-stone model. The model can then be evaluated, in the first instance, by seeing to what extent its assumptions are met. In the second instance, it is possible to compare the prediction of kinship, $f_\phi$ with estimates from alternative sources to see how close they are, maybe even in spite of violated assumptions.

Throughout this work the rural communities have been examined as a direct control and comparison to the fishing settlements. Migration between the chains of adjacent maritime and rural populations was found to be very different. The stepping-stonetone model is a good approximation to the migration patterns of the fishermen: it is a poor representation of trends amongst the agricultural labourers and farmers. An examination of the assumptions of the model in the light of the data and results of this research will illustrate this.

### 1. The population is subdivided into discrete units, distributed linearly.

The fishing villages theoretically meet this criterion. They are distributed along the coast, isolated on one side by the sea, and on the other, by the moors. Their geographical position is reinforced by their cultural reserve – not only with the inland villages, but also between themselves.

The farmers and agricultural labourers, however, are quite different. I have chosen to study a chain of settlements which lie in a line adjacent to the coast. In reality this line is an abstraction. Located on the edge of the moors, and often in a river valley, mobility is not necessarily inhibited in any immediate direction. There are villages to the north and south, east and west. (Fylingdales is the only possible exception here with its surrounding moorland). Moreover, the agricultural labourers are diffuse in a cultural sense also, since the 19th century system of employment encouraged yearly migrations. These communities therefore are not integrated, discrete settlements either vertically or horizontally and as such do not meet the constraints of the model.

**2. Migrants are exchanged only between adjacent colonies.**

From the demographic information (chapter 4) it is clear that fishing communities are highly stable. In other words, very high percentages of those populations were born, and lived in the same village. From the map showing the distribution of birthplaces (fig 4.20), it is also seen that the majority of migrants come from along the coast and not from the nearby inland villages when migration is examined more specifically between adjacent settlements in the study area, it is apparent that exchange between the smaller fishing villages is very infrequent, and that only Scarborough regularly receives immigrants from Filey (see chapter 6). Generally migration represented on the map is long distance migration: Scarborough draws the largest numbers, and then, and only to a much lesser extent, do Filey and Whitby. The individual maps showing the distribution of birthplaces for each village clearly illustrates this (figures 4.23, 4.24, 4.25, 4.26, 4.27 and 4.28).

Thus in its strictest sense this assumption is broken: migration does not only occur between neighbouring colonies. However, the model does allow for systematic pressure which is usually estimated as the rate of long range migration, since this generally outweighs the effects of selection and mutation. With this consideration the assumption is violated only rarely. Migration into the fishing community of Scarborough, for example, is from Filey or long distance, and only occasionally is it from other coastal populations in the chain.

The migration pattern for the agricultural labourers and farmers is very different. Mobility amongst these populations was a process of random diffusion, the majority of which took place within a radius of 50km. Distance rather than culture would appear to be the predominant factor here. The map showing the distribution of birthplaces for the rural populations clearly illustrates this (fig 4.21). The assumption that migrants are only exchanged with neighbouring colonies along a given line is quite obviously unfulfilled.

These first two assumptions are fundamental to the model but the data from the rural populations do not fulfil either of them. For this reason, the stepping-stone model will be applied only to the coastal fishing communities. There are a number of other important assumptions upon which the model also rests:

**3. The mendelian populations are of equal size.**

From the demographic data it is clear that the total population sizes of the coastal settlements are not equal. It was hoped that by selecting the fishing communities only, that these differences would be reduced. To a certain extent they are; for example, there is a reduction of the vast discrepancy between the sizes of Runswick and Scarborough.

**4. There is random mating within each colony.**

It is not in the scope of this thesis to prove the above. However, it is highly likely that there was random mating within most of the fishing communities. Historically these people preferred to marry fisher-folk and furthermore, folk from within their village (chapter 2). I have taken these basic social units as my colonies. There is no evidence to suggest that there would have been non-random mating within this unit. There does not appear to have been a strong avoidance of consanguineous marriage, such as between second or first cousins (chapter 2).

The only exception could perhaps be Scarborough in the latter decades of the century. History does remark on the tension between the new trawler-men and the traditional long-shore fishermen (chapter 2). It is possible that there was an avoidance of marriage between families practising these two different modes of fishing, but I have no direct evidence of it.

**5. Populations are infinitely distributed.**

From the map (figure 4.22) which locates all the major fishing ports of England, it is apparent that the North Yorkshire coastal villages are but a part of a chain of ports distributed right around the coasts of Britain (and indeed Scotland, though it is not marked on the map). Moreover, it is as well to note that the land between the larger ports is punctuated with smaller villages such as Staithes and Runswick, for example.

**6. The exchange of migrants between neighbouring colonies is equal.**

Strictly speaking we know that this is untrue for the North Yorkshire coast from the raw migration matrices (chapter 6). For example, migration from Filey to Scarborough is high; *vice versa* it is negligible. On the other hand, differences in distance between adjacent colonies are diminished by the use of the sea as a means of travelling,and in actual fact overall migration between neighbouring colonies is so infrequent that in the majority of cases exchange is zero in both directions! So that 'on average' it could be argued that the exchange rate is more or less equal.

**7. Migration rates are constant.**

Comparison of the migration matrices from the different decades shows that migration between the different decades varies, although the mainstream trends are upheld (see chapter 6).

Thus overall the majority of these assumptions are not held true for the fishing villages of North Yorkshire. However, the fundamental structure and nature of these communities does seem appropriate material for the application of the stepping-stone model. At this juncture either one abandons the model on the basis of its divergence from reality, or one can turn the problem around. How far are the results affected if such assumptions are relaxed?

It is possible to examine this problem. The stepping-stone model predicts kinship. To be precise, using equation 1.2 or 1.3 (chapter 1), it predicts the mean kinship coefficient of one cluster which is also an approximation to the standardised variance of gene frequencies of neighbouring clusters. Isonymy, isolation by distance, and Malecot's migration matrix give alternative measures of kinship. Comparison of such individual estimates may be used to determine the accuracy of the stepping-stone model results. Furthermore, using these results as a control, it should be possible to change the values of the stepping-stone model's parameters in order to ascertain which of the assumptions has most influence on the results. Therefore a computer program (appendix 2) was written to estimate equation 1.2.

This equation was used in preference to equation 1.3, which applies only when long range migration is less than the migration rate between colonies; and this does not hold true for my data. Estimation of the parameters was not straight-forward:

### 1. Population Size (N).

N is the mendelian population size of each colony. Since all populations are theoretically of equal size this should be a single value. The populations of North Yorkshire are all different sizes. The problem was solved by taking the mean effective population size for each census year. Once more, only the selected fishing communities population size were considered (given before in table 6.8).

### 2. The Migration rate between neighbouring colonies only (m).

The migration rate varied in either direction (*i.e.* migration from father's birthplace to that of the offspring's or *vice versa*) and between the different sets of colonies. Thus m was taken as the mean migration rate between adjacent colonies. Father-offspring migration only was considered so that the results would be directly comparable to previous estimates of kinship. Using the fishermen-offspring migration matrix for each census year, it was possible to calculate the migration rate from one colony to the next. The migration rate was estimated by dividing the number of individuals by the total number in the sample size. Migration between colonies was considered twice to account for mobility in both directions. From example in 1851, the only migration that occurred between adjacent colonies was thirty-three fathers born in Filey whose children were born in Scarborough. Dividing 33 by the total number of fathers born in Filey (208) it gave .1586. The migration rate from Scarborough to Filey and between all other colonies in both directions was 0. The average migration rate was therefore .0159

### 3. Systematic pressure/long range migration (b).

All migration from any other source than that between adjacent colonies was considered as long range migration. The only difficulty here was that there was occasional migration between non-adjacent colonies. Specifically this includes, a handful of fathers born in Staithes whose offspring were born in Filey and Scarborough (1851 census); one father from Staithes whose child was born in Scarborough (1861 census); nine fishermen who followed exactly the same pattern (1871 census); finally in the 1881 census there were a number doing exactly the same, but also one instance of gene flow in the opposite direction, there was also one father born in Whitby whose son was born in Filey. Overall this is a very small percentage of the total number of migrants. For practical purposes I have included them as long range migrants.

In the father-offspring migration matrices, 'local' and 'long distance'were considered as two distinct categories; here I have included them both in the one category. The matrices also distinguish between migration from the father's birthplace to the offspring's birthplace and *vice versa.* Here I have only considered long range migration from the father's birthplace to the offspring's birthplace, since I thought it better to examine migration only in the one direction through time.

The rate of long range migration was estimated by dividing the number of migrants by the total number of fathers born in that village. Inevitably the values of 'b' varied for each town. To obtain the single value required I once more took the mean value. These values could then be fed into the computer. Their results are given in table 8.1. They show a marked decline in kinship over time.

One thing that emerged during the course of these calculations was that I was once more dealing with two rather different types of community. Scarborough, Filey and Whitby on the one hand, ports of the herring fishery and subsequently recipients of a high proportion of long range migrants. Then on the other hand the other smaller long-shore fishing villages whose populations were very insular and immobile. Considering the degree of their social and physical isolation, one wonders whether the island model might not be more applicable to these villages, (such as Runswick?). However, they are part of a chain of coastal settlements and the potential for gene flow along that chain from a more heterogeneous gene pool like Scarborough cannot be ignored. It is clear, though, that in estimating the parameters in this way, the inclusion of Scarborough and Filey greatly affects the values obtained. The final comparison of kinship values and thus the conclusive evaluation of the stepping-stone model shall be dealt with in the next and final chapter.

## TABLE 8.1: THE RESULTS OF THE STEPPING-STONE MODEL.

```
FISHERMEN - OFFSPRING 1851.

     Population size= 92.9000
     Systematic pressure=  0.0763
     Migration between adjacent colonies=  0.0159

Kinship within one colony, Fo =   0.0518


FISHERMEN - OFFSPRING 1861.

     Population size=113.9000
     Systematic pressure=  0.0887
     Migration between adjacent colonies=  0.0132

Kinship within one colony, Fo =   0.0434


FISHERMEN - OFFSPRING 1871.

     Population size=144.2000
     Systematic pressure=  0.1312
     Migration between adjacent colonies=  0.0088

Kinship within one colony, Fo =   0.0348


FISHERMEN - OFFSPRING 1881.

     Population size=168.0000
     Systematic pressure=  0.1401
     Migration between adjacent colonies=  0.0105

Kinship within one colony, Fo =   0.0267
```

# Chapter 9.

# Discussion and Conclusions.

In examining the population structure of North Yorkshire, four methodologies have been followed namely:– isonymy, the migration matrix approach, isolation by distance, and the stepping-stone model. All four analyses have produced various estimates of kinship. It was hoped that by comparing these estimates that it would be possible to evaluate the methods used – in particular the stepping-stone model.

Yasuda and Morton's diagram (1966 figure 1.1) is the essential key to the relationship between the various values of kinship estimated from the different migration models. As stated above (chapter 1), $F_{ST}$ may be defined as mean local kinship or random inbreeding. It is analagous (or at least nearly so) to the alternative estimates of kinship and relationship predicted by the models used in this study.'$f_0$' estimated by the stepping-stone model, predicts the mean kinship coefficient of one cluster, and it is analogous to $F_{ST}$ (Jorde 1980 p.145). The isolation by distance model predicts values of local kinship 'a' which is equal to $F_{ST}$ if *a priori* kinship is used (Relethford 1980a p.70). The diagonal elements of Malecot's migration matrix '$\phi_{ii}$' are comparable to values of 'a' predicted from isolation by distance (Morton 1982b p.125), and also therefore to values of $F_{ST}$ (Jorde 1980 p.145). The first phi matrix that is calculated from Malecot's recurrance equation calculates *a priori* kinship whereas Harpending and Jenkin's R matrix estimates conditional kinship: the former matrix will therefore be used as it provides a direct comparison to the values of '$f_0$' and 'a' also estimated using *a priori* kinship. Isonymy is usually thought to predict conditional kinship, or in other words, kinship relative to the contempory gene pool rather than to the ancestral array as in *a priori* kinship. However, it is clear that Lasker's 1977 measurement of 'Ri' (the coefficient of relationship) is the same as Crow and Mange's (1965) estimation of random inbreeding, $F_{ST}$, except that it is twice as big as that for inbreeding since the estimate is of general relationship. Thus Ri divided by two is also equivalent to $F_{ST}$. Since surnames consider all kinship relative to the founding of the use of surnames, the historical perspective is included. Hence, in summary, it is true to say that

$$F_{ST} = f_0 = a = \phi_{ii} = (Ri \div 2)$$

For the stepping-stone model a single value of $f_0$ was calculated for all the fishing communities in each census year. For all the other analyses, kinship was estimated for each occupational group in each community. Since it was my intention to directly compare estimates to the results from the stepping-stone model, only the values of kinship for the fisher populations in each census year were selected. In order to obtain a single comparative value, the mean of the six values for the six fishing communities in each census year were calculated. See table 9.1 for the comparative results.

Table 9.1

Comparison of kinship estimated by each model.

| | Stepping-Stone Model | Migration Matrix | Isolation by Distance | Isonymy |
|---|---|---|---|---|
| | of $f_0$ | Mean value of $\phi_{ii}$ | Mean value of a | Mean value of Ri÷2 |
| 1851 | .0518 | .0119 | .0265 | .0192 |
| 1861 | .0434 | .0140 | Null | .0198 |
| 1871 | .0348 | .0165 | .0162 | .0233 |
| 1881 | .0267 | .0193 | .0369 | .0289 |

It is clear from table 9.1 that the results of the stepping-stone model are consistently the 'odd ones out' except perhaps in the year 1881. The mean values of kinship estimated from the isolation by distance model do, however, exclude three of the more insular villages in each case (see chapter 7) and might therefore be expected to rather underestimate the true value of kinship; although since all the isolation by distance results are based on the rather dubious distinction between 'long' and 'short' range migration, they should be regarded with caution. Isonymy is usually renowned to over-estimate values of kinship, particularly when sample sizes are small (see chapter 5), and yet here the values compare reasonably well to estimates obtained from the migration matrix approach. On the whole, the results from Malecot's matrix are probably the most reliable for it does not appear to suffer from any intrinsic peculiarities.

One factor which is of undoubted importance is the effective population size. For the stepping-stone model, isolation by distance and the migration matrix a selected sample comprising of only the fisher-communities was used. It is quite likely that the effective population size of these communities may in fact have been slightly larger than the numbers estimated from the census returns, for the censuses were not always consistent in recording occupation and it is possible that gene flow was not entirely constrained within the recorded fisher-population. Given a potentially larger population size it is likely that these values of kinship could in fact be slightly over-estimating the real values – hence the concordance with the isonymy results?

The higher values of kinship for the stepping-stone model may be due to the fact that the second major assumption that the model assumes exchange only between neighbouring colonies was violated. Non-adjacent migration was included in the study under 'long range' migration, and thus gene flow between non-adjacent colonies in the study area was not accounted for. From the matrices in chapter 6 it was clear that non-adjacent migration between colonies was minimal, but it may have been enough to just taint the values of kinship obtained.

What conclusions can be drawn about the stepping-stone model? In its favour it can be said that it is quite the simplest and quickest method of approximating population structure out of any of the four methods I have used. On the other hand, it is very specific. It is clear from my results that the two major assumptions of the model have to be met if it is going to give viable results. It is thus necessary to have a linearly distributed population which does exchange migrants with only its neighbouring colonies. Given that these two assumptions are met, or that some sort of compensation is allowed for in cases where gene flow takes place between non-adjacent colonies in the study area, the model would appear to give a satisfactory approximation of population structure. The obvious drawback is that the number of cases where such a situation pertains is limited.

As regards the other models, it is clear that the isolation by distance model calculated according to Morton's 1977 formula is really unsatisfactory. On the more positive side I can at least say that I have really shown just how impracticable it is to try to distinguish between 'long' and 'short' range migration. It is true that the method of non-linear regression used by Jorde and his colleagues (see table 1.1) does give variable results, but is not a continuous model, which is what I wanted to use in comparison to the matrix approach as a suitable model for the agricultural labourers. In retrospect Wright's Neighbourhood model would have been more suitable.

The results obtained from isonymy and Malecot's matrix approach are both reasonably satisfactory. Isonymy inevitably suffers from the difficulty of polyphyleticism and the possibility that relationship through the female line is not proportional to the relationship through the male line. Both these circumstances tend to over-estimate kinship, but from my results and previous studies (Lasker 1978a and Relethford 1986c) it is, in my opinion, likely that as a relative and approximate measure of genetic relatedness, the method is both viable and relatively simple and economical to use. The migration matrix method requires more detailed data and is not quite so straightforward to estimate as isonymy. On the other hand, this particular method does take into consideration genetic drift and it does predict values of *a priori* and conditional kinship, comparable with alternative genetic and migration data. The major drawback of this approach is that migration rates are assumed to be constant over time. On the whole, however, the isonymy and matrix results compare quite well and have produced quite plausible results.

Turning to the more general aim of this thesis, what do these results tell us about the genetic structure of the North Yorkshire coast? For a start it is clear that the agricultural communities are very different to the fisher folk. The isonymy analysis showed that each fishing community was clustered away from the agricultural labourers and also from the other fishing villages. The migration matrix and isolation by distance analyses confirmed the difference in mobility between the two occupations. The insularity of the fishing villages so strongly suggested by local history was endorsed, and contrasted well with the fluidity of the rural villages.

Comparison of father-offspring and mother-offspring data revealed that there were differences in gene flow according to sex. The fisher-women were more mobile and the wives of the agricultural labourers were less migratory.

When the fishing communities were examined more closely, it was clear that really they consisted of two types of settlement: the small inshore fishing villages, on the one hand, where endemicity was extraordinarily high, and the larger herring ports on the other, which grew considerably during the nineteenth century with a consequent decline in kinship.

It was clear that the larger towns of Whitby and particularly Scarborough, were not as inter-related as the smaller villages, in spite of taking the occupations separately. Overall they were much more cosmopolitan and attracted more immigration into both the agricultural and fishing communities in their midst. Generally speaking kinship declined over time. Only places like Robin Hood's Bay and Runswick actually became more inbred. This was undoubtedly due to the major economic depression caused by competition for the inshore fishing industry and also in Fylingdales the closure of the alum mine: people left in search of work with a tendency for only the traditional inter-related families to remain. The increase of kinship in such villages, however was enough to give an overall increase in kinship when the mean values for all the fishing settlements were considered.

In my introduction I suggested that one of my intentions was to see if the insularity of the fisherfolk was such that it actually affected the genetic structure of the area. In other words, just how high were the values of kinship? - was there potential for random genetic drift? Tables 9.2, 9.3 and 9.4 below present a select number of comparative results from other studies for isonymy, Malecot's migration matrix and isolation by distance.

### Table 9.2
### Comparison of isonymy results

| Mean value of Ri between Populations | Mean value of Ri within Populations | Location | Author |
|---|---|---|---|
| .0049 | .00057 | Reading | Lasker *et al.* 1980 |
| | .00259 | Northumberland 1655-1758 | Lasker and Roberts 1982 |
| .00131 | .01278 | Otmoor 1851-1950 | Kuchemann *et al.* 1979 |
| .01189 | | Scilly Isls. 1851 | Raspe and Lasker 1980 |
| .0009 | .0384 | Yorkshire fishing villages 1851 | |

### Table 9.3
### Comparison of migration matrix results

| Mean predicted kinship $\phi$ within populations | Location | Author |
|---|---|---|
| .00841 | Åland 1850-1899 (excl. Mariehamn) | Mielke *et al.* 1976 |

| | | |
|---|---|---|
| | Utah Mormons | Jorde 1982 |
| .0000078 | Salt Lake Stake | |
| .0001561 | Beaver Stake | |
| .0119 | Yorkshire Fishermen 1851 | |

| $F_{ST}$ | Location | Author |
|---|---|---|
| .00802 | Åland<br>1982b | Jorde *et al.* |
| .00000290 | Utah Mormons 1876-1885 (all stakes) | Jorde 1982 |
| .000374 | Iceland (migration data) | Jorde *et al.* 1982a |
| .00026 | Connecticut Valley | Swedlund *et al.* 1984 |
| .00572675 | Yorkshire Fishermen 1851 | |

## Table 9.4

## Comparison of Isolation by Distance Results.

| a | b | Location | Author |
|---|---|---|---|
| .005 | .005 | Iceland (migration data) | Jorde *et al.* 1982a |
| .005 | .862 | Otmoor | Imaizumi *et al.* 1970 |

| | | | |
|---|---|---|---|
| .015 | 1.724 | Tomai village Japan | Imaizumi 1971 |
| .000007 | .0077 | Utah Mormons 1876-1885 | Jorde 1982 |
| .005 | .04 | Åland 1850-1899 | Mielke *et al.* 1976 |
| .0161 | .1557 | Irish isolates 1890's | Relethford 1980a |
| .0265 | .1701 | Yorkshire Fishermen (mean for 1851) | |

I have used 1851 as a yardstick to compare the values for the Yorkshire fishing villages to the other results. No comparison is made with the results from the stepping-stone model, since other results are simply not available.

From the contrasting values of Ri in table 9.2 it is apparent that the mean value of Ri between the fishing populations of 1851 is considerably lower than values of Ri between other communities. Partly this could be explained by the fact that all of the other studies listed in table 9.2, consider settlements which are geographically clustered in space, whereas my settlements are distributed linearly with approximately 50-60km. separating Hinderwell and Filey. However it also is true that the value of Ri between neighbouring Runswick and Staithes in 1851 is only .0007, much lower than comparative values. Scarborough and Filey are the exception, with a value of Ri of .0043 in 1851. With this exception it would seem that the fishing villages were independent of each other as was suggested by their history (see chapter 2). The mean within value of Ri for the 1851 Yorkshire fishermen is also high relative to the figures given in table 9.2. While this may indicate close inter-relationship, it is as well to bear in mind the distortion imposed by small sample sizes (see chapter

1).

In table 9.3 I have compared both *a priori* estimates of kinship, $\phi_{ii}$, and values of $F_{ST}$ calculated from the conditional R matrix. In both instances the values obtained for the 1851 Yorkshire fishermen are considerably higher, indicating higher levels of kinship within each colony and greater potential for random genetic drift. The value of $F_{ST}$ for the Åland islands is the only value to exceed or even nearly match the value of $F_{ST}$ obtained for Yorkshire. Similarly in table 9.4 the values of a and b that most closely approximate those obtained for the Yorkshire fisherman of 1851, are the values calculated for the Irish isolates during the 1890's.

Overall therefore the results suggest that the high values of kinship estimated for the fisher populations of Yorkshire are on a par with those obtained for isolates rather than modern western populations. In view of dichotomy between the larger ports and the smaller fishing villages, it is likely that the values of kinship for Runswick, Robin Hood's Bay and Staithes, were above the means given in the tables 9.2, 9.3 and 9.4, while Scarborough's values of kinship were obviously lower. It could be interesting to see how the island model would apply to some of the smaller inshore villages.

At any rate the smaller communities must, at least, be viewed in the light of their geographical and social insularity. However, these results also depend upon the methods and data that I have employed. The problems of the sampled population size and the difficulty of distinguishing between 'long' and 'short' range migration in the isolation by distance analysis should be borne in mind. Despite such warnings it is clear that the genetic structure of the area does bear testimony to its history.

The agricultural labourers and farmers have provided a good control and comparison. Their high levels of mobility were clear from the raw migration analysis in chapter 4. Isonymy indicated that they were less closely clustered than the fishermen. Using both the migration matrix and isolation by distance models proved to be troublesome for the rural communities. The difficulty arose from the impracticability of selecting the 'agricultural labourers' and 'farmers' out of the wider sample, to be considered as communities by themselves. I did this to compare with the fishermen, but in reality these peoples were very obviously a part of the surrounding populace. Moreover their mobility seemed to be determined more by geographical distance than occupational ties as in the case of the fishermen. It seems to me that it would be better to take a geographical cluster of rural parishes and examine the kinship between the villages rather than the occupational communities. The matrix approach would be plausible in this context. Lastly I feel strongly that a truly continuous model of migration would be the most fitting way of examining the population structure of these peoples.

This thesis set out to evaluate the linear stepping-stone model of migration, and more broadly, to examine the genetic structure of the North Yorkshire coast. The first aim was achieved. This was very much in keeping with more recent developments in the subject (summarised in the conclusion to chapter 1), expressly, to try and test the assumptions and theoretical bases upon which the models that predict genetic structure rest. The broader concern of this study was to look at the interaction between culture and biology. Cohen in his introduction to *Belonging* (1982b) draws attention to the misleading concept of the 'homogenous nature of the British Isles' portrayed by the mass media. Different communities in the British Isles differ from each other as 'cultural entities': each locality experiences and expresses its difference from others, and their sense of difference becomes incorporated into and informs the nature of their social organisations (Cohen 1982b p2). Certainly the inshore fishing communities' arduous and dangerous way of life seems to have profoundly shaped their cultural identity, right down to the very roots of their society – truly isolating them from the immediately surrounding populations. While this phenomenon of cultural isolation is well recognised amongst religious sects, such as the Samaritans, Ashkenazi Jews and Old Order Amish, for example, it is not quite such a widely recognised phenomenon amongst the populace of mainland nineteenth century Britain. Surely such a finding must offer an opportunity for future complementary research to take place between social and biological anthropology?

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```
c     APPENDIX 1.

C     PROGRAMM TO ESTIMATE MALECOTS 'ISOLATION BY DISTANCE' MODEL
C             ACCORDING TO THE FORMULA ' PHI(d) = ae(-bd)'
C
      REAL ETH(101)
      INTEGER DIST(101)
      WRITE (6,10)
10    FORMAT ('&ENTER PARAMETER a')
      READ (5,*) AKIN
      WRITE (6,20)
20    FORMAT ('&ENTER PARAMETER b')
      READ (5,*) BDEC

      E=EXP(1.0)

      DIST(1)=0.0
      ETH(1)=(AKIN*E**(-BDEC*DIST(1)))
      DO 50 J=2,101
      DIST(J)=1.0+DIST(J-1)
      ETH(J)=(AKIN*E**(-BDEC*DIST(J)))
50    CONTINUE

      WRITE (6,60)
60    FORMAT (//,5X,'              a                b                e
      WRITE(6,70) AKIN,BDEC,E
70    FORMAT (//,10X,3(5X,F10.5),//)

      WRITE (6,80)
80    FORMAT (1H ,'DISTANCE         PHI',//)

      WRITE (6,90) (DIST(J),ETH(J),J=1,101)
      WRITE (7,90) (DIST(J),ETH(J),J=1,101)
90    FORMAT (5X,I5,5X,F10.5)


      STOP
      END
```

## Appendix 2: Program used to estimate the Stepping-Stone Model.

```
C
C
      CHARACTER TITLE*60
      PRINT*,
      PRINT*,
      PRINT'(1H&,A)','ENTER POPULATION SIZE'
      READ(5,*) POP
      PRINT'(1H&,A)','ENTER SYSTEMATIC PRESSURE'
      READ(5,*) PRESS
      PRINT'(1H&,A)','ENTER MIGRATION RATE BETWEEN ADJACENT COLONIES
      READ(5,*) COLMIG

      F=1/(1+(4*(POP*PRESS))*(SQRT(2*COLMIG/PRESS)))

      PRINT*,'ENTER TITLE'
      READ'(A60)',TITLE
      CALL FTNCMD('ASSIGN 7=-DAT;')
     WRITE (7,10) TITLE
           WRITE (6,10) TITLE
10    FORMAT (10X,A60,//)
     WRITE (6,20) POP
     WRITE (7,20) POP
20    FORMAT (15X,'Population size=',F8.4)
     WRITE (6,30) PRESS
     WRITE (7,30) PRESS
30    FORMAT (15X,'Systematic pressure=',F8.4)
     WRITE (6,40) COLMIG
     WRITE (7,40) COLMIG
40    FORMAT (15X,'Migration between adjacent colonies=',F8.4,//)
     WRITE (6,50) F
     WRITE (7,50) F
50    FORMAT (10X,'Kinship within one colony, Fo =',F9.4)
      PRINT*
      PRINT*,'-DAT CONTAINS A COPY OF THE RESULTS'
      STOP
      END
```

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