Material and Methods

At the end of 1999 the Norwegian database consisted of data on 4 885 778 ringed birds and 97 628 recoveries and controls. Strictly speaking, a recovery is the finding of a dead bird (or a bird that is not released again), and a control is the reading of the ring number on a living bird. Nevertheless, we normally use the term recovery for the reading of the ring data on both living and dead birds. In other words, we allow the term recovery to also comprise controls. When in the text we distinguish between living and dead birds, they are described as recovery of a dead bird and control of a living bird respectively, in order to avoid confusion.

Recapture

By recapture we mean control of a bird less than 10 km from the ringing site, i.e. a ringed bird which is caught and controlled by a ringer or a group within the National Ringing Scheme. In Ringmerkerens håndbok *(*The Ringers Handbook*) (Runde 1991) it is stated that* All recaptures should be recorded by the ringer. If the ringer uses the forms that the Ringing Scheme has issued, then the recapture will be entered into the data base provided time allows for this. *This means that the material at Stavanger Museum only contains some of these recaptures, and we have therefore chosen not to include these in the presentations of the individual species. Recaptures provide important knowledge concerning how long birds remain at resting sites (stop-over times), and enable more exact calculation of flight speed during migration.*

Utilized material

Of the total of 97 628 recoveries stored in the data base, recaptures (see above) comprise 34 693 (35.5%). This implies that 62 935 recoveries (64.5%) contained in the data base are used as the basis for the species presentations. These are distributed among 59 739 different individuals, which corresponds to a mean recovery proportion of 1.2%.

Of the utilized recoveries, 32 986 (52.4%) were ringed as nestlings (pullus), 11 185 (17.8%) as juveniles in their first calendar year, and 18 759 (29.8%) in their second calendar year or later. There are also five birds of unknown age when ringed. A total of 44 985 (71.5%) birds are reported dead (or not released again), and 17 950 (28.5%) are controls of living birds.

Colour rings

Colour rings can be fixed on the bird's leg, but can also be placed around the neck of some large birds such as geese and swans. The individuals can be identified again either by the use of several rings of different colours, or by rings engraved with letters and numbers which can be read without capturing the bird. When colour combinations are used, it is common to utilize at least three rings in addition to the metal ring. There are also examples of using colour rings to indicate the year or the ringing site. In such cases the metal ring must also be read to identify the individual.

The purpose of colour ringing is to make it easier to find ringed birds so that it is not necessary to catch the individual bird for identification. The result is that one gains more controls of the individual, and the more controls of the bird, the more one can follow the bird's movements over time. In Norway many species have been colour-ringed, but often only for limited periods. In Appendix III there is a list of species presented in this volume that have been colour-ringed in Norway in addition to being marked with a metal ring. See also Internet page http://www.cr-birding.be/ *which presents many colour-ringing projects operating in Europe (European colour-ring Birding).*

In the species presentations, recoveries based on colour-ringing are included for as many species as possible. The problem here is that many such recoveries are not reported to the National Ringing Scheme, but are only registered in the archives of those running the projects.

Processing of the data

In the processing of the material and in the production of the maps, standard programs have been used in addition to both specially written and adapted programs. RECOVERY *(Bakken 1988) has been used as the basic program for treatment of the recovery files (RDT-files). The program has been developed further with routines to export to a file format which is compatible with ArcView (Geographical Information System), and which produces species-specific summaries of the recovery data.*

All maps and graphs have been produced with the aid of the geographical information system ArcView (ESRI Inc.) and exported as vectorised files (EPS format). In addition to the program itself we have used two supplementary modules (extensions): Animal Movement Analysis *developed at USGS-BRD, Alaska Biological Science Center (Hooge 1998), and also an* Atlas module *developed by ourselves which contains all the selection routines and drawing of the various maps that we required for the species presentations. The ready-to-print format was laid out in* Adobe InDesign *(Adobe Systems Inc.).*

Map projections and lines between two points

For the Norwegian maps, including Svalbard, we have used a UTM projection in zone 33 which is a transversal Mercator projection. For the remaining maps a normal Mercator projection has been used. This projection has the drawback that areas at high latitudes (far south and far north) are enlarged compared to areas near the equator. On the other hand the outline of a land or sea area will have approximately correct proportions independent of latitude. The lines traced between two points will often deviate somewhat from the shortest distance.

Weaknesses and uncertainties in the ringing and recovery material

Ringing recoveries can tell us how birds have moved, but the material does not necessarily tell the whole truth. The main reason for this is that we are dependent on the birds being found and reported to a ringing scheme. There is for instance small probability that birds living on the open sea, or in other areas where there is little human activity will ever be found and reported. In the presentation of the material it was therefore important to define a level of precision that corresponded to the accuracy that the reader would expect to find in the text, the maps and the tables. All ringing and recovery data in Norway are registered in a standard format built on EURING's system (Anon. 1979).

Ringers are normally careful in registering ringing data, and it is exceptional to discover shortcomings or inaccuracies in the basic material. The parameters that are recorded when the bird is ringed are ring number, species, sex, age, status, date, locality, coordinates, county/ municipality and ringer.

One problem can be identification of the species. Some, for example warblers, can be difficult to identify as to species even in adult birds. It is therefore a requirement that the ringers are able to use the most up to date literature for species identification, but errors can still occur. However, it is in ringing of nestlings that wrong identification most often occurs, such as in ringing of tits in nest-boxes or broods of warblers. Another problem is the ringing of young in mixed colonies, such as those of terns (Common and Arctic), and gulls (Herring Gull and Greater and Lesser Black-backed Gulls). If the ringer is not entirely sure of the species, then the bird must not be ringed, as stated in the Ringers' Handbook.

Such errors as to species can occasionally be corrected if the finder has been able to identify the species, or sends the bird to the Ringing Centre. This is however exceptional, as most reports only consist of the ring number and circumstances around the find. It cannot be concealed that during the course of years many birds have been registered under a wrong species. The total number is unknown, but we have some information on which species are concerned. Birds that are misidentified can be a serious source of error in the recovery material, especially if they comprise a significant proportion. Sometimes recoveries have to be omitted, because there is a suspicion that the bird has been misidentified.

Accurateness regarding date and locality of ringing and recovery is also important in relation to presentation of the material. If for instance a month or a season is specified for a recovery, it is important that doubt concerning the date does not allow for the possibility that the bird could in fact have been found in a different period. The most exact registering of time is by date and hour, for example date 12 July 2001, time 10 o'clock. This means that the bird was ringed or recovered on the recorded date, and in the time interval 10.00-11.00 o'clock. Other time intervals that can be specified are in the form of the day, ± one day, ± three days, ± one week, ± two weeks, ± six weeks and even up to ± some years. For example, for some recoveries we only have the date when the finder posted the letter, and the date when the bird was found can be the entire period when the bird was ringed to when the letter was sent. Our requirement is that, as regards season or month, the date must be specified to ± two weeks or better. Where recoveries of less exact dates are included on the maps, these are shown in white (see also next section). As to year, the reported date must be better than ± three months.

For ringing and recovery sites the data consist of geographic coordinates (latitude and longitude). These are specified in degrees and minutes, and are therefore exact to within 1852 metres in north-south direction (latitude), corresponding to one minute. In east-west direction (longitude) the distance is the same at the equator, otherwise the distance between two minutes of longitude can be calculated as: 1852m x (cosine av latitude). For example, the distance between two minutes of longitude at 60°N, which is Oslo's latitude, is 926 metres. As the distance between degrees of longitude decreases towards the poles, the accuracy improves nearer the poles. Positions can also be specified only as degrees, or with only one digit for minutes. In such cases the coordinates will be converted when the maps are drawn. If for example a latitude is given as 78°N, then this position will be shown on the maps as 78°35'. In other words, the rule is to replace the first missing digit in the minutes with "3", while the second is replaced with "5". Such uncertainties in the site information are taken into consideration in the selection and presentation of the ringing and recovery data.

The condition of a ringed bird which is found and reported is important in selecting and presenting the recovery data. It may for example have been found alive and then released, or found dead. A bird found dead may not be fresh, and there are several examples of only the ring being found. Nor is it certain that the bird died at the place where it was found, as it may have been transported by humans or by water (sea or rivers). This means that the bird may have died at an entirely different time of year, or at a different place than where it was found or reported from. In the data format all such recovery circumstances are coded if they are known, and they are therefore simple to exclude.

In the case of controls of living birds, the ring may be read after the bird has been caught, or by the aid of a telescope or binoculars. This applies to both metal and colour rings. Reading the ring data by telescope or binoculars has become common in recent years, especially for gulls, and especially during the winter when many gulls are assembled. However, reading ring data in this way carries a greater risk of making mistakes than is the case when the bird is held in the hand.

The Norwegian Hunting and Fishing Society began ringing grouse in 1915. How many were ringed is unknown, nor do we know how many recoveries resulted from the ringing. Olstad (1926) supposed that somewhat more than 100 Willow Ptarmigan *have been reported as*

recovered. The Norwegian State Game Research Instiute originally concentrated on ringing gamebirds. Both the number ringed and number recovered were excluded from the normal statistics, and it is therefore quite certain that some of this material is now lost, at least it is not found in the archives of the National Ringing Scheme. Nor have we any recoveries from the release of ringed Grey Partridges (Jæren) and Common Pheasants (Jæren and Hedmark).

Multiple recoveries of the same bird

Some individual birds are reported more than once. There can be one or more controls of the living bird and finally one recovery of the dead bird. Of the almost 63 000 recoveries presented in this atlas, a total of 3196 (5.1%) are controls.

If a bird is controlled twice, then two recovery notifications are written. This means that the time from ringing to recovery, together with distance and direction to the recovery site, are in both cases calculated from the original ringing. There could also be written a third report based on the second control as ringing data *and the last as recovery data. There would then be a new set of calculations of distance, time and direction. Such recoveries can be named* bonus recoveries *(Anker-Nilssen 1993). If for example a ringed bird is controlled three times, then it gives three normal recoveries and also three* bonus recoveries*. In this atlas we have not included* bonus recoveries *as these are not yet dealt with by the programs used by the Ringing Scheme.*

Steel and aluminium rings

In the period from 1914 to the present day several different types of metal have been used in the rings. The earliest rings were mainly of poor quality, so they quickly became worn, the numbers could become illegible, or the rings could fall off.

Today rings are made of aluminium and stainless steel. Steel rings were first used in the 1970s. These are extremely durable and out-live the bird, even in those species that cause most wearing of the rings. Nevertheless, aluminium rings are still used on many species that do not wear out the rings.

For species that cause wearing of the rings it is difficult to compare recovery material based on steel rings and other kinds of rings. This is especially the case in comparing the proportion of recoveries or in calculation of survival rates. One often finds that birds with steel rings apparently live longer and have a higher survival rate, but this is usually more due to ring quality than to true differences.

Colour ringing

Recovery material based on colour-ringed birds has some advantages, but also several weaknesses, the most important of these being the possibility of biased geographical distribution of recoveries.

The probability of birds being recovered varies from one country to another. From some countries almost no recoveries are reported, even though it is known that several species have important resting and wintering sites there. This is true for example for several countries in Africa and Asia. There can be many reasons for this, but significant factors are probably differing population density and lack of knowledge as to how one reports the finding of a ringed bird. It can also simply be the case that the person finding the ring does not have the means of sending the information to the ringing scheme.

As regards reporting of colour-marked birds, there is even greater geographical concentration on areas with many bird enthusiasts and where many read the ring data. An example of this is colour-ringing of gulls. From some sites, mainly around the North Sea, there are many reports of data from colour-ringed birds. Many controls are necessary if the aim is to follow the movements of populations or of individual birds through the year, but if for instance the aim is to determine the proportion that winter in different areas, then recoveries based on colour-marked birds can give a biased and incorrect distribution. In addition to large and chance concentrations of recoveries at a few sites, also changes in the fieldwork of one or a few persons can suddenly change the picture of the geographical distribution. Another uncertainty is the durability of colour rings compared to the normal rings of aluminium and rust-free steel.

Errors in the ringing and recovery files

All recoveries and about 2.5 million ringing data are registered in the digital files. Most of this material has been entered into the files from manual lists. In addition, much of the manual data has undergone up to several manual transfers before it was registered digitally. For each manual step in this process, the probability has increased for errors that were not necessarily discovered during the proof-reading. This implies that in today's versions of the ringing and recovery files there can be many errors.

By means of developing error-searching programs it will be possible to discover some errors in the ringing and recovery data. The RING *program has good verification routines for many of the parameters. It can for example check that the geographical coordinates are not in conflict with the registered counties (Appendix I) and municipalities in Norway.*