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NATURE

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Front cover: The daily observing started at the sunrise and ended at the sunset from the shore at the mouth of the Unskaya Bay. From left A.V. Kondratyev and A. Lehikoinen.
Back cover: Members of the expedition and the crew of the ship Ecolog.
Cover photos: Jorma Pessa

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FOREWORD

The main purpose of the expedition in 2004 as with the earlier expedition in 1999 was to locate/relocate and confirm the most important staging areas and migration routes of the arctic bird species in the White Sea area. Expeditions like these are vitally important when it comes to protecting the staging areas along the flyway of the arctic birds. This time round the expedition had the added satisfaction of cementing bilateral research cooperation between Finnish and Russian ornithologists. All in all goals were met and the venture was a success.

Both expeditions took place within the same study area and during the same season i.e. September-October. The data collected during the three weeks at sea confirmed that the areas in the vicinity of Onega Bay and Dvina Bay are crucial staging areas. It also showed that these areas serve several channels or flyways which most of the migratory arctic waterbirds use. The collected data provides valuable background information essential to the cause of protecting these vitally important staging areas along the route from breeding areas to the wintering sites. Many staging areas are under threat from a number of risk factors, e.g. large oil spills close to the staging area may cause severe damage to bird populations. This is especially true during the moulting period when waterbirds are extremely vulnerable.

The target group included divers, swans, geese, ducks, waders and skuas, many of these are breeding in Northern Russia and migrating every year to and from their wintering grounds on Baltic Sea, North Sea, West Atlantic and Black Sea.

Observations from these two expeditions provide the only comprehensive data in the southern White Sea in recent years. The new data is available for a variety of purposes and for different user groups or stakeholders such as the environmental authorities and decision-makers in both Finland and Russia and also assist scientists in their work in the respective countries.

As head of the both expeditions I have the great pleasure of expressing my sincere gratitude to my fellow ornithologists, our partners and the crew of the vessel who made these expeditions possible. I hope the results and the data from these two expeditions presented here will be of some value in the protection of waterbirds and important staging areas.

Timo Asanti
Senior advisor, head of the expeditions
Helsinki, May 2005

Summary

The Finnish Environment Institute organized two ornithological expeditions to the White Sea in autumns 1999 and 2004. The main aims of these three week long expeditions were to determine the most important staging areas and the main migration routes of the arctic bird species in the White Sea. The expeditions covered most of the western and southern parts of the White Sea by vessel.

The expedition teams found many important staging areas, including concentrations of 55 000 wigeons, 20 000 geese, 10 000 common scoters and long-tailed ducks, 4 100 velvet scoters and 3 700 eiders. At least a few of these areas were evidently unknown previously. The greatest concentration of wigeons, 55 000 birds in Unskaya Bay, comprised about 4.6 % of the whole flyway population, which carry out the criteria of important bird areas (IBA) in Europe. Transect line counts revealed that densities of staging birds on the sea outside the concentrations were generally low.

Heavy migration of arctic birds was recorded often and huge database was collected including information from migration routes, directions, diurnal rhythm, phenology, age- and sex-ratios. With the help of recorded information the migration dynamics of arctic birds are described in the report. The numbers of recorded marine mammals are also mentioned.

Clear differences in migration routes between arctic species were found. Some species, such as brent goose and long-tailed duck, evidently preferred to follow coastlines, flying around the Onezhsky Peninsula via the Zhizhginski Strait, whereas some other species, like bean and white-fronted goose, flew across the Peninsula from the coast at Pertominsk, heading straight for the southern part of the White Sea. Black-throated divers and barnacle goose used both of these migration routes in big numbers. These two areas functioned as migration channels.

During both expeditions more than 600 000 arctic birds were observed. Nearly half of these were long-tailed ducks (*Clangula hyemalis*). However, the largest percentages of the estimated total flyway populations using the White Sea route were recorded for Branta geese (14–32 %).

The shortcomings of surveying arctic birds by the vessel included the slowness of the vessel, and problems reaching the shallow coastal waters. The benefits included long observation times for each recorded individual, good opportunities to observe the sparsely distributed species, and somewhat lower costs. However, intensive aerial surveys are still essential for research into important staging areas in the White Sea. Use of other possible study methods of bird migration in the White Sea area is discussed.

A good view of the most important staging areas, main migration routes and dynamics of the migration in the Baltic Sea – White Sea flyway can be gathered based on the results of the expeditions and other huge amount of data from Russia, Finland, Estonia, Sweden and Latvia. This database could be used in conservation measures for arctic migratory birds.

Резюме

Изучение видимой миграции и мест стоянок арктических птиц в южной части Белого моря осенью 1999 и 2004 гг.

Алекси Лехикойнен, Александр Кондратьев, Тимо Асанти, Еско Густафссон, Олли Ламминсало, Николай Лапшин, Йорма Песса и Пекка Русанен

Институт окружающей среды Финляндии при тесном сотрудничестве с Карельским Научным центром РАН организовали две экспедиции на Белое море. Эти экспедиции были проведены осенью 1999 и 2004 гг. в период с 21.09 по 10.10 на судне «Эколог», принадлежащем Институту водных проблем севера КарНЦ РАН. Главной целью трехнедельных экспедиций было определение важнейших мест стоянок и миграционных путей арктических птиц на акватории Белого моря. Маршрут экспедиций пролегал в Онежском заливе, в районе Соловецких островов, а также в Двинском заливе на участке от о. Жижгин до пос. Пертоминск. Стационарные наблюдения длительностью 2 – 7 дней проводили в Онежском заливе, Жижгинском проливе и в устье Унской губы Двинского залива в окрестностях пос. Пертоминск. В остальных местах были выполнены трансектные учеты в полосе 1000 м по обе стороны идущего судна, а также учет скоплений со сплошным подсчетом всех птиц. Видимую миграцию наблюдали с борта судна или с берега в течение всего светлого времени суток.

Во время этих двух экспедиций удалось обнаружить несколько крупных агрегаций водоплавающих птиц на акватории Белого моря, таких как 55-тысячная концентрация свиязей (Anas penelope) в Унской губе Двинского залива, 20-тысячная - гусей (большей частью - черных казарок – Branta bernicla) в районе деревень Сухое и Вирма в Онежском заливе, 10-тысячное скопление синьги (Melanitta nigra) и такое же - морянки (Clangula hyemalis) на Сорокском мелководье к юго-западу от Беломорска, концентрация в 4100 самцов турпана (Melanitta fusca) в районе острова Хедостров, а также обыкновенных гаг в 3700 и 3500 (Somateria mollissima) в районе острова Хедостров и перед входом в Унскую губу. Крупнейшая концентрация свиязей в 55 000 особей, найденная в Унской губе включает около 4,6% от всей популяции данного пролетного пути, что вполне соответствует критериям КОТР регионального (общеевропейского) значения. Трансектные учеты фиксированной ширины, проведенные по пути следования судна, выявили, что плотности птиц на акватории Белого моря вне плотных скоплений были сравнительно низкими.

Во время работы экспедиций был зарегистрирован интенсивный пролет арктических мигрантов, и собрана обширная база данных относительно путей, направлений, фенологии и суточного ритма пролета, а также динамики возрастного и полового состава у некоторых видов мигрантов. На основании анализа полученных материалов в отчете представлена и описана картина динамики пролета. Помимо этого, в отчете также приводятся данные по численности встреченных во время экспедиций морских млекопитающих.

В ходе наблюдений были выявлены места сужения транзитных потоков арктических водоплавающих, в частности, в устье Унской губы (пос. Пертоминск), в Жижгинском проливе, а также менее выраженное - вдоль западного побережья Онежской губы. Видовой состав мигрантов в этих районах в значительной степени различался. В устье Унской губы наиболее интенсивная миграция была отмечена у белощекой казарки

(Branta leucopsis - более 46 000 особей), речных уток (Anas spp. - более 30 000 особей), менее интенсивная у – белолобого гуся (Anser albifrons), гуменника (Anser fabalis), морской чернети (Aythya marila) и турпана. Здесь же был отмечен интенсивный пролет чернозобой гагары (Gavia arctica). В Жижгинском проливе наблюдался интенсивный пролет черной казарки (7000), морянки (более 150 000 особей) и краснозобой гагары (Gavia stellata).

Для многих видов было выявлена положительная корреляция величины стай и интенсивности миграции. Для свиязи и морянки выявлено возрастание доли самцов в стаях в связи с увеличением размера стай в период интенсивной миграции

У морской чернети отмечено заметное снижение доли самцов в стаях в ходе миграции.

В целом за время обеих экспедиций было учтено более 600 000 особей арктических видов птиц. Около половины всей этой численности составила морянка. Однако самый большой процент относительно общей численности популяций данного пролетного пути был выявлен у казарок (Branta sp.) – численность учтенных на Белом море птиц составила 14-32% от общей численности этих видов в пределах Северо-Атлантического пролетного пути.

К недостаткам судового учета арктической миграции можно отнести медленную скорость перемещения судна, а также проблемы с высадкой на берег в мелководных районах. Достоинствами таких учетов является возможность проведения продолжительных наблюдений за отдельными особями, хорошие возможности для учета дисперсно распределенных видов и относительно низкая стоимость работ. Однако, для обследования важнейших и крупнейших агрегаций птиц на Белом море наиболее предпочтительным методом все же следует признать интенсивно проводимые авиаучеты. В отчете обсуждаются плюсы и минусы других возможных методов проведения учетов мигрирующих птиц на Белом море.

Результаты данных экспедиций, а также собранный большим коллективом авторов в России, Финляндии, Эстонии, Швеции и Латвии обширный материал относительно мест распределения стоянок мигрирующих птиц, о путях и динамике миграции птиц, использующих Беломоро-Балтийский пролетный путь, может и должен быть положен в основу стратегии охраны мигрирующих птиц в пределах пролетного пути.

CONTENTS

Figure 1. Map of Finland and northwestern Russia with some sites visited during the expeditions.

1 Introduction

The Finnish Environment Institute (SYKE) organized two ornithological expeditions to the southern White Sea from 21st September to 10th October 1999 and 2004. The main aim of these expeditions was to identify the most important staging areas of migratory arctic waterfowl along their migration routes between wintering areas in the Baltic Sea region and breeding areas in the northern Russia (Leivo 1997a). Special attention is paid to marine species, e.g. divers and diving ducks, since they are the least known and most difficult to study of the arctic migratory waterfowl.

The White Sea is situated along the main migration route used by most of the arctic waterfowl and shorebird species that breed in northern Russia and winter in the Baltic and Atlantic regions (Fig. 1). The numbers of arctic birds using this important migration flyway are impressive – more than 10 million birds (Delany & Scott 2002).

The White Sea alone is an important staging area, where many of the arctic waterfowl and shorebirds rest before starting their final migration to their wintering areas in the Baltic Sea and elsewhere (Bianki et al. 1975, 1993). For some species, e.g. the nominate subspecies of the brent goose *Branta b. bernicla*, the White Sea has been shown to be a very important staging area where birds stage in the autumn for longer periods before a long non-stop flight to the Baltic Sea or even to the North Sea region (Leivo 1993, Madsen et al. 1999).

The importance of the White Sea as a staging and migration channel for arctic birds has been known for a long time by Russian ornithologists. Bianki et al. (1975, 1993) have published much information on the occurrence and migration of northern waterfowl in the area. However, the most detailed part of the data published (Bianki et al. 1975) was collected during the period of 1956–1963 when optical techniques were much less efficient than today, and at a time when identification skills were also poorer than nowadays. Additionally, considerable population changes have subsequently been recorded, for instance in many arctic goose species (Madsen et al. 1999).

Finnish ornithologists visited the western parts of the White Sea for the first time in recent decades, in 1992, to study the migration of arctic birds. They were surprised to encounter a single feeding flock of 70 000 brent geese (Leivo 1993, Kontiokorpi 2002), which in those days represented a third of the total population of dark-bellied brents. Since then Finnish ornithologists have visited coastal areas of the White Sea every year, particularly in autumn, but due to the bad condition of the road network along the western coast of White Sea, studies have only covered small part of the southern White Sea, mainly the area around the city of Belomorsk. Some of their findings have been published, e.g. Kontiokorpi (1996, 2002), Kontkanen (1996), Pöllänen et al. (1996) and Veijalainen & Kontiokorpi (1998).

In addition to these data, recent studies, which include also satellite telemetry data, of the bewick's swan (*Cygnus columbianus bewickii*) and brent goose in the White Sea have been published, e.g. by Andreev & Poot (1994), Green et al. (2002a, b), Nolet et al. (2001) and Klaassen et al. 2004 (see also Madsen et al. 1999). However, these works

have dealt only two species mainly with birds in the Dvina Delta, near the town of Arkhangel, and such studies have been conducted in the spring.

The aims of the White Sea expeditions 1999 & 2004 were:

(i) to obtain an idea of the general distribution of the major staging areas and identify any new areas in the southern part of the White Sea, and collect data of the yearly variations of concentrations in these areas;

(ii) to collect data on the densities of staging birds on the sea;

(iii) to observe the visible migration of arctic birds, in order to improve the knowledge of the migration patterns of arctic birds, and to use migration data as an indirect indicator of possible staging areas further to the nort-heast;

(iv) to evaluate the practicality of using vessels in research surveys of concentrations of arctic birds during migration.

A separate report has already been published concerning the main results of the 1999 expedition (Leivo et al. 2001) and this report follows nearly the same structure as the previous one. However, this paper accumulates observations and conclusions from both expeditions.

Research vessel Ecolog at the harbor of the city Kem. From here the three week long expedition started. Photo: Aleksi Lehikoinen

2 Material and methods

2.1

Study area

The area of the White Sea is fairly small, 90 000 km^2, which is about 1/5 of the area of the Baltic Sea. The average depth is 67 and the maximum depth is 340 meters (Koryakin et al. 2002). The White Sea consists of three larger bays namely almost in easterly direction is the Dvina Bay (Vienanlahti) and the city of Arkhangel in the bottom of the bay, the Onega Bay (Äänislahti) in South-Eastern direction and the Kandalaksha Bay (Kantalahti) to the North-West direction and the city of Kandalaksha in the bottom of the bay (Fig. 1).

The White Sea is connected to the Barents Sea through the White Sea Channel inclining towards a north-east direction (Fig. 1). The channel is about 160 kilometers long and about 50 kilometers broad. Approximately one third of the White Sea is shallow with depths of up to 30 meters which makes the area very suitable for bottom-diving ducks. The shallows in Onega Bay stretch far out from the coast and the tidal zone is several kilometers wide (see Fig. 2 & 3). These are the essential feeding areas for dabbling ducks and geese. The coastal zone and the shallow waters around the islands are the important staging areas for marine birds.

Hedostrov is a sandy island in the south eastern part of the Onega Bay with shallow waters around. Photo: Aleksi Lehikoinen

2.2

Arrangements and circumstances on the vessel

The both expeditions were jointly organised by SYKE and Karelian Research Centre in Petrozavodsk, Karelia, Russia. The ornithologists involved were all from SYKE in 1999, but in 2004 two Russian ornithologists were also involved. Members of the expeditions were Timo Asanti (head of the expeditions 1999 & 2004), Esko Gustafsson (2004), Jari Kontiokorpi (1999), Alexander V. Kondratyev (Biological Institute of Saint-Petersburg State University, 2004), Harri Kontkanen (1999), Olli Lamminsalo (2004), Nikolay V. Lapshin (Institute of Biology Karelia Research Centre Russian Academy of Sciences, 2004), Aleksi Lehikoinen (2004, head of research), Mauri Leivo (1999, head of research), Markku Mikkola-Roos (1999), Ari Parviainen (1999), Jorma Pessa (2004) and Pekka Rusanen (1999 & 2004). The coordinator from Russian partner NWPI, Vassili Kovalenko, also joined the 1999 expedition. The crew of the research vessel numbered seven people.

The name of the research vessel was ´Ekolog´, a 32-metre-long ship with 12 cabins, a sauna, two bathrooms, two lavatories, a kitchen and a dining/living room. The vessel was equipped with a GPS, radar and echolot, and weather forecasts were received twice a day.

All the daylight hours were normally dedicated to observation (normally about 10 hours a day). Sunrise was at 7:24 in the beginning of expeditions and 7:57 by the end, with sunset correspondingly at 19:34 and 18:38. There was also enough light to allow observation about half an hour before sunrise and after sunset.

During the mornings the vessel was anchored in the most suitable place available for observation, and the vessel was moving mainly during afternoon or the hours of darkness, when fewer birds were migrating or migration could not be recorded. The expedition took advantage of the vessel's movements by carrying out transect line counts along the route to survey staging arctic birds, or by observing birds through binoculars and telescopes.

A small boat was also used where shallow waters close to the shore were impossible to reach by vessel. The vessel's compass fixed on the top deck was used to determine exact compass points.

There are quite many rocky islands in the western part of the White Sea just outside city of Kem. Photo: Aleksi Lehikoinen

2.3

Routes, itineraries and weather conditions

The expeditions' itineraries are shown in Appendixes 1 & 2, and the routes followed across the White Sea in Figures 2 & 3.

The White Sea expeditions can be divided into three sections according to the geographical areas surveyed:

Year 1999

(i) research in Onega Bay, 24–30th September and 9th October.
(ii) research in the Pertominsk area and Dvina Bay, 1st–5th October.
(iii) research in the Zhizhginski Strait, 5–8th October.

Year 2004

(i) research in Onega Bay, 22nd–27th September and 7–9th October.
(ii) research in the Pertominsk area and Dvina Bay 27th September – 4th October.
(iii) research in Zhizhginski Strait, 4–7th October.

The Belomorsko – Baltickij canal closes for winter on 15th October, which is why expeditions needed to be conducted before that date so as to enable the research vessel to reach its home harbour of Petrozavodsk before the canal is closed.

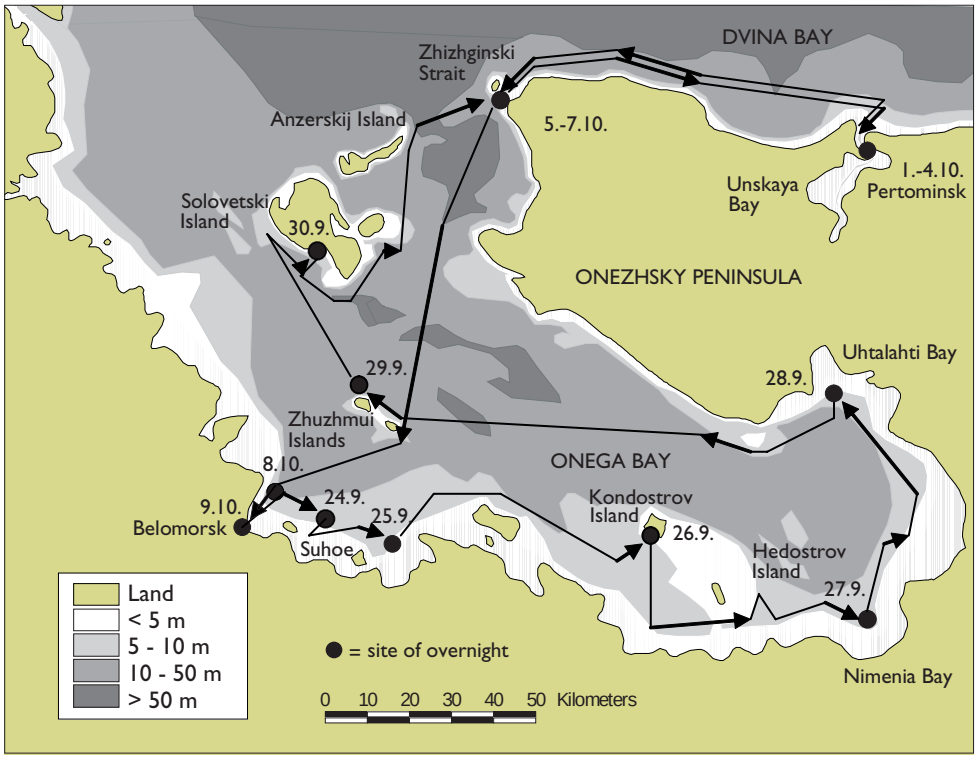


Figure 2. The route of the White Sea expedition 1999 and depths of the sea area roughly represented. Dates of the overnight are shown next to the black spots (24.9. = night 24.-25.9.).

Weather conditions were noticeably different during these two expeditions. In 1999 wind was usually light (five days with wind measuring at least 10 m/s) and there was little rain. By contrast, weather conditions in 2004 were windy (11 days with wind at least 10 m/s) and rather rainy (only four whole days without rain!). However, during both expeditions wind was blowing from a northerly direction which at least offered a few days of good tailwind for migrating birds. Daily weather conditions of the expeditions are described briefly in Appendixes 3 & 4.

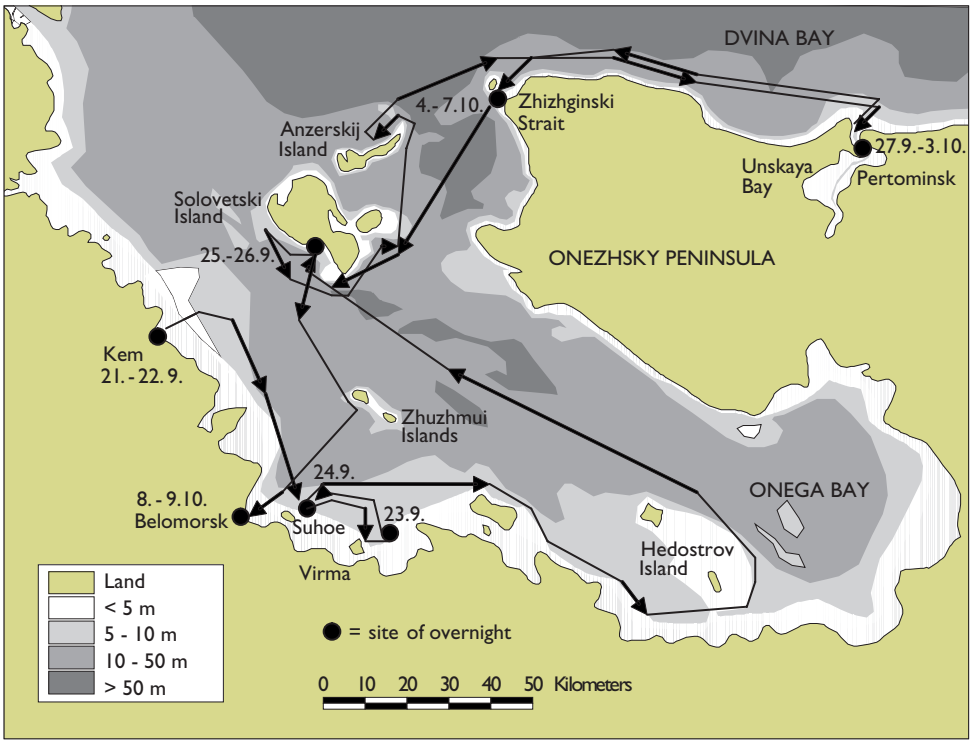


Figure 3. The route of the White Sea expedition 2004 and depths of the sea area roughly represented. Dates of the overnight are shown next to the black spots (24.9. = night 24.-25.9.).

2.4

Observation

Visual observation with binoculars and telescopes was the main method used to observe birds throughout the expeditions. Observation was carried out throughout the daylight, although on a few exceptional days with little migration an alternative programme was run.

The magnification of the binoculars used varied between 7 to 10. The "famous" Finnsticks (sticks approximately 50 cm long, fixed into the binoculars; Mikkola 1996) were used nearly all the time by all observers to keep binoculars steady, and to reduce muscle fatigue.

The most powerful telescopes had 20–60x zoom oculars and 80–100 mm objectives; others had oculars of constant magnification of 22x, 27x, 30x, 37x or 50x and objectives of 60 mm. Telescopes could be used on the ship deck in conditions of minor or moderate swell, but not in strong swell. To facilitate the use of telescopes, rubber pieces were fixed into the bottom end of tripod legs to dampen the effect of the vibration of the vessel when the engine was running.

Observing was daily conducted from the shore outside Pertominsk village. Observers from left Nikolay V. Lapsin, Olli Lamminsalo, Pekka Rusanen, Timo Asanti, Jorma Pessa and Esko Gustafsson. Photo: Aleksi Lehikoinen

Observation was mainly carried out from the stern on the middle deck of the vessel, about four meters above sea level. Thanks to the construction of the vessel, the observers were largely sheltered from the wind, and partly also from the rain. The distance that could reliably be observed from the middle deck was 2–4 km for birds on the sea, and 5–10 km in the air, except during bad weather (rain, fog, very strong wind etc.) when observable distances were greatly reduced.

Three ornithologist normally conducted observations on either side of the vessel at any time. This varied according to the rate of migration and variations in the rate on the different sides of the vessel. During heavy migration, one observer acted alternating as a full-time secretary allowing the others to announce their sightings uninterruptedly. This helped to reduce the numbers of errors and omissions, compared to the usual method of noting sightings at intervals.

Three basic methods were used to gather data about the migrating birds (i) visual observation of migration, (ii) mapping of the concentration areas and counts of the numbers of birds present, (iii) line transect counts.

2.5

Visual observation of migration

The basic method used during the expedition was observation with binoculars and telescopes. Details of the observation and data gathering are given in the sections 2.4. and 2.8., respectively.

This method produces the basic data on the migration of arctic birds. This enables researches to understand the magnitude, patterns, diurnal rhythms, routes, directions and other details of migration, and also provides indirect information on possible staging areas.

Since birds mainly start their migration at a certain time of the day (Alerstam 1990), by studying daily patterns of migration it is possible to estimate the likely location of their last departure area, using existing information on the direction, flight speed of the species and the accurate wind conditions in question.

By studying the plumages of migrating birds, additional information on the possible moulting areas of the arctic birds can also be obtained. Given that most individuals of species passing an observation point had moulted from their breeding plumage

into winter plumage, for instance, the conclusion can be drawn that an important moulting area may lie nearer their breeding area. Furthermore, since drakes of many arctic duck species migrate earlier in autumn than females or juveniles – as is notably case with scoters (Cramp & Simmons 1977) and long-tailed duck (Pietiläinen & Leivo 1993) – by studying the plumages of these birds, estimates of the current migration situation can be made. For example, if observed migration of ducks is strongly male biased the main migration season of females and juveniles are still on their way. Still another benefit of the gathering data on plumages is the information on the proportion of young birds, which reflects breeding success. For identification of different age- and sex-plumages see Mullarney et al. (2001). In age- or sex-ratio analysis daily proportions were counted when more than 20 individuals were aged or sexed.

2.6

Mapping of concentration areas

Right throughout the expeditions attempt were made to find important staging areas, mainly by observing birds along the route of the vessel. Some shallow waters, considerable likely to be important staging areas on the basis of maps inspection, were more carefully explored with the small boat.

When large gatherings of birds were recorded, the boundaries of the area occupied by the staging birds were mapped, and abundance of different species was counted. All areas with more than hundred birds were mapped in this way. The most important areas were also marked in to GPS in 2004. This method produces direct data on staging areas, and is thus the most valuable method.

2.7

Line transect counts

Komdeur et al. (1992) described a method for surveys of birds by vessel (or aeroplane). Briefly described, the method is based on the designation of adjacent 50 or 100 metre wide sectors, at distances of 0–300 meters from the vessel, inside which all birds are identified and counted. This method has also been used in the survey of the most important marine areas for wintering birds in the Baltic (Durick et al. 1994). However, due to the lack of the necessary tools for estimating the distances and any previous experience of the method, a simplified version of the basic methods was applied during the expeditions.

In our application we used a single sector of 500 meters in width. This sector was determinate by the radar of the vessel or by GPS and it was calibrated as often as possible. Counting along this sector for sections of two kilometres resulted in figures for survey areas of one square kilometre, which simplified calculations of the bird densities. An estimate was made, that the error in measuring the 500 m width sector was ±100 m, and therefore the counting area of the transect line could vary between 0.8–1.2 km^2. However, the results are measured by using 1 km^2 of the area of each transect line count. Whenever possible, two groups of surveys, one group on either side of vessel, counted transect lines at the same time. In the analysis of results, the data produced by both counting groups was summed to average values for each line. In some cases, however, counting was only possible on one side of the vessel, mostly due to unfavourable conditions on the other side (e.g. reflected glare from the sunshine on the sea), and in such cases results from one-sided counts were used as density values for the whole transect line.

Counts lasted 6–10 minutes for each distance of 2 km (1 km^2), depending on the speed of the vessel. When the speed was 10 knots (i.e. 18.53 km/h) a distance of 2 km, required by the method, took 6 minutes and 29 seconds. In 2004 GPS was used to determinate the position of the transect lines and distances of 2 km. In 2004 four transect lines of 2 km were mainly on each side of the vessel continuously (covering 8 km^2) along the route with regular intervals. Only staging waterbirds (divers, waterfowls and auks) were counted. Gulls were not counted, since they tended to follow the vessel. Transect line counts can also be used for marine mammals (e.g. Hiby & Hammond 1989, Hiby & Lovell 1998, Palka & Pollard 1999) and all the mammals were also counted in 2004.

Counting groups consisted of three people: a counter, a secretary and assistant. The counter concentrated on detecting, identifying and counting birds inside the survey sectors, using binoculars. Determining whether birds were inside the sector was sometimes a considerable task. The secretary noted all the data the counter announced, and helped in identifying birds and estimating distances. The assistant used a telescope, and mainly helped with identification, especially of birds taking flight or diving away from the vessel. Attempts were generally made to detect birds before they tried to avoid the vessel, so particular attention was paid to record birds ahead of the vessel.

The most important areas were marked in to GPS in 2004. Transect line countings are conducted by Alexander V. Kondratyev from left and Pekka Rusanen.
Photo: Aleksi Lehikoinen

Transect line counts could be done in conditions of minor or moderate swell (up to a wind speed of about 9 m/s). During stronger wind, sectors could not be surveyed reliably.

Transect line counts produce data on the densities of birds staging on the sea. They also give a rough idea of the number of birds in a larger area of the sea. This is especially useful when birds are dispersed over the sea, and not concentrated in larger flocks.

2.8

Data gathering

All sightings were normally entered or logged on to special form for 30-minute periods. The form had three sections, to facilitate the noting of sightings:

(i) the most numerous and important arctic water birds species, e.g. divers, geese and many diving duck species
(ii) other water birds and shore birds, e.g. dabbling ducks, waders and skuas
(iii) other birds, e.g. raptors and passerines, marine mammals

The basic way to enter sightings was: species, numbers of individuals; age; sex; direction of migration; side of the vessel; distance (see Uusivuosi 1977a, b). In addition to the basic data, information on the weather (see Appendices 3–4), the time of sunrise and sunset etc. was recorded.

Daily data were computerized in the evening i.e. documented on an excel-program. Finally, sightings of all species were noted on daily-total form, with flight directions, plumages, number of flocks, and other details mentioned whenever appropriate.

Another type of form was used for the transect line counts. Data of the sightings and counts of birds inside the counting sector were noted on these forms. General information noted here included the weather, the speed of the vessel, the counting period, and a line code and in 2004 GPS-points of the line.

Arctic Skuas (*Stercorarius parasiticus*) migrating. Photo: Aleksi Lehikoinen.

3 Results

3.1

Number of birds

The total number of arctic birds recorded during the expedition 1999 were 608 000 and in 2004 630 000. The most abundant species during both expeditions was the long-tailed duck (*Clangula hyemalis*), which accounted for nearly half of all the birds recorded. However, the highest percentages of the total White Sea flyway populations were recorded for barnacle (26–32 %) and brent geese (14–22 %). The percentage of the total long-tailed duck population recorded was relatively low (5–7 %).

The numbers and the percentages of total White Sea flyway populations for the most important arctic species recorded are shown in Table 1. The records of the each observed species during the expeditions are shortly summarized (inc. total numbers, the greatest migrations, concentrations, migration routes etc.) in Appendix 5. The daily total numbers of the target species during the expeditions are shown in Appendixes 6–7.

The flock size of migrating arctic birds was analyzed in most abundant group of species: geese and Anas ducks, but not in divers and long-tailed ducks since the boundaries of the flocks in these species are not easy to determinate especially during heavy migration. In geese and Anas ducks the average flock size was larger when the migration was more intensive in logarithmic (Figs 4–5).

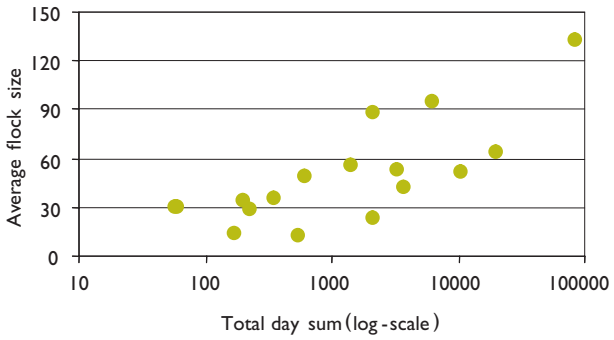


Figure 4. Average flock size of geese according to intensity of migration (daily sums in logarithmic scale). All geese species are united in the figure, because they often tend to migrate in mixed flocks (n = 136 139 birds, 1 615 flocks).

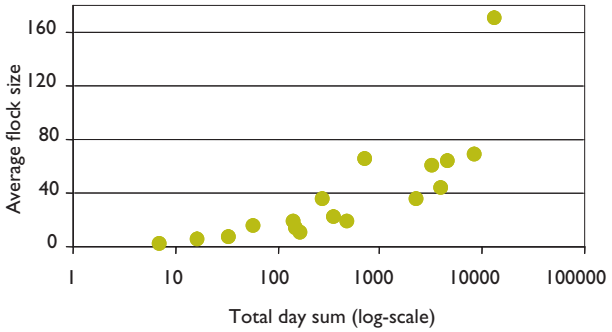


Figure 5. Average flock size of Anas-ducks according to intensity of migration (daily sums in logarithmic scale). All Anas-duck species are united in the figure, because they often tend to migrate in mixed flocks (n = 38 586 birds, 605 flocks).

Barnacle Goose (*Branta leucopsis*) was the most abundant goose species during expeditions in 1999 and 2004. Photo: Aleksi Lehikoinen

Table 1. The estimate of wintering populations (Delany & Scott 2002) of the most important arctic species, which migrate wholly or mainly through the White Sea during the autumn migration, and the numbers of birds recorded during the White Sea expeditions 1999 and 2004 and the proportions of these of the whole migration population.

Species	Pop. (ind.)	Exp. 1999		Exp. 2004	
		Ind.	Percentages	Ind.	Percentages
Bean goose *Anser fabalis* [B)]	700 000	5 810	0.8 %	5 940	0.8 %
White-fronted goose *A. albifrons* [B)]	1 000 000	20 260	2.0 %	3 120	0.3 %
Barnacle goose *Branta leucopsis* [A)]	360 000	93 820	26.1 %	116 600	32.4 %
Brent goose *B. bernicla* [A & C)]	215 000	47 210	22.0 %	31 200	14.5 %
Scaup *Aythya marila* [D)]	310 000	1 230	0.4 %	6 150	2.0 %
Long-tailed duck *Clangula hyemalis* [D)]	4 600 000	311 000	6.8 %	232 000	5.0 %
Common scoter *Melanitta nigra* [D)]	1 600 000	15 000	0.9 %	43 200	2.7 %
Velvet scoter *M. fusca* [D)]	1 000 000	3 830	0.4 %	13 450	1.3 %
Red-throated diver *Gavia stellata* [E)]	150 000–300 000[F)]	13 570	4.5–9.0 %	12 800	4.3–8.5 %
Black-throated diver *G. arctica* [E)]	300 000–600 000[F)]	24 780	4.1–8.3 %	40 700	6.8–13.6 %

[A)] Figures for unidentified geese were added to the identified totals of each species according to the respective proportions of each species amongst the geese identified.
[B)] As noted [I)], except that also the proportions of unidentified *Anser geese* were added to the identified totals of each species.
[C)] 20 000 geese recorded in the evening flight above Suhoe Bay during the 2004 expedition were added to numbers of brent goose, while this area is known to be important staging area of brent's.
[D)] Figures of unidentified ducks were added to the identified totals of each species according to the respective proportions of each species amongst the ducks identified.
[E)] Figures for unidentified divers were added to the identified totals of each species according to the respective proportions of each species amongst the divers identified.
[F)] Measured from Hagemeijer and Blair 1997.

Note: The estimates for the numbers of unidentified birds allocated to any species totals were calculated on a daily basis.

3.2

Identification of birds

Table 2 lists the percentages of birds of the most abundant species groups that were specifically identified. Identification percentages were highest among ducks and waders in 1999. Overall, 69.1 % in 1999 and 70.2 % in 2004 of all the arctic birds observed were specifically identified.

Table 2. Numbers of birds and proportions of identified birds out of all recorded birds in some species groups of arctic migrants.

	No. of birds		% specifically identified	
Species	Exp. 1999	Exp. 2004	Exp. 1999	Exp. 2004
Geese [A)]	183 977	156 989	37.1 %	37.3 %
Ducks	375 000	416 642	88.9 %	87.4 %
Divers	38 374	53 500	36.0 %	34.1 %
Waders	3 460	2 368	63.3 %	38.6 %
Skuas	630	468	46.8 %	53.0 %

[A)] Numbers of *Anser geese* not specifically identified have been added into the total numbers of identified geese.

3.3

Migration

Overwhelming majority of the data was obtained from visual observation of migration. As described in section 2.5., this method provides basic data on the migration of arctic birds, and gives indirect information on possible staging areas.

3.3.1

Age and sex ratios during the migration

Proportions of individuals, which are identified to age and sex in different species during expedition 2004 are shown in Tables 3 & 4.

Table 3. Number of aged individuals and proportion of young on 11 arctic bird species during the expedition 2004.

Species	Adults	Juveniles	Juv. %
Whooper swan *Cygnus cygnus*	114	2	2 %
Brent goose *Branta bernicla*	101	72[A)]	42 %
White-fronted goose *Anser albifrons*	53	17	24 %
Red-throated diver *Gavia stellata*	1905[B)]	356	16 %
Black-throated diver *Gavia arctica*	4781	300[C)]	6 %
Dunlin *Calidris alpina*	9	331	97 %
Arctic skua *Stercorarius parasiticus*	235[D)]	9	4 %
Common gull *Larus canus*	981	558	36 %
Black guillemot *Cepphus grylle*	315	141	31 %

[A)] Included 18 broods with average brood size of 3.1 juveniles,
[B)] 1805 adults in breeding plumage and 100 adults in winter plumage,
[C)] juveniles or (sub)adults in non-breeding plumage,
[D)] 234 pale morphs and one dark morph.

Table 4. Number of sexed individuals and proportion of female-plumaged birds in seven arctic specis during the expedition 2004.

Species	Adult ♂♂	♀-plumage	♀-plum. %
Wigeon *Anas penelope*	982	2824	74 %
Scaup *Aythya marila*	253	440	63 %
Long-tailed duck *Clangula hyemalis*	4105	4310	51 %
Common scoter *Melanitta nigra*	52	1670	97 %
Velvet scoter *M. fusca*	212	83	28 %
Common eider *Somateria mollissima*	7106	1610	18 %
Goldeneye *Bucephala clangula*	125	28	18 %

The daily proportion of adult wigeon males did not show any seasonal trend during the expedition 2004. The proportion of migrating adult long-tailed duck males was higher in bigger flocks in (Fig. 6, one-way ANOVA $F = 3.50$, $p = 0.008$, $n = 365$). Long-tailed ducks flying eastern direction included only a small proportion of adult males (4 % males $n = 290$) comparing to birds flying to western direction (50 % males $n = 8\,368$).

The daily proportion of adult scaup males decreased remarkably during the expedition 2004 from 68 % in 24th Sep to 0 % in 8th Oct.

The daily proportion of adult red-throated divers significantly decreased during expedition 2004 (Fig. 7, $rs = -0.89$, $p < 0.001$, $n = 16$) and proportion of adult red-throated in winter plumage significantly increased during expedition (Fig. 8, $rs = 0.82$, $p < 0.001$, $n = 16$). In black-throated diver however, the proportions of adults in breeding plumage did not change remarkably. Similarly, the proportion of adult common gulls did not show significant change during the expedition 2004.

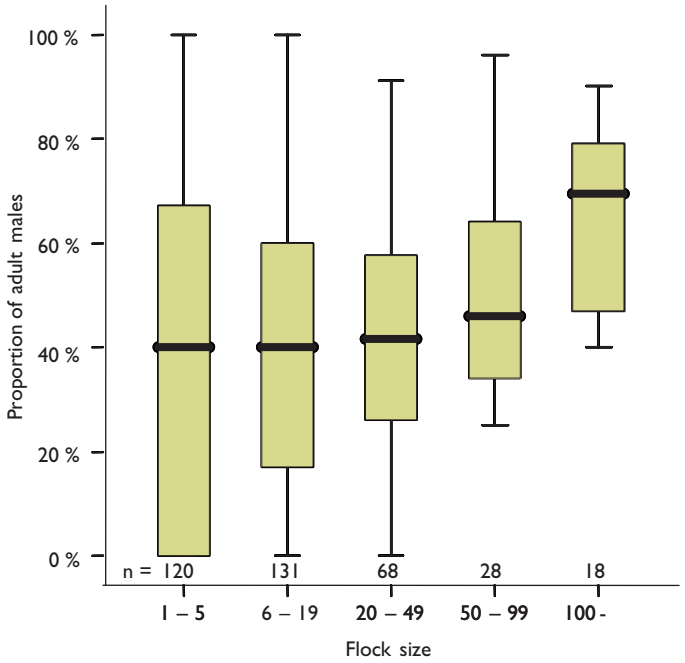


Figure 6. Proportion of adult male long-tailed ducks in migrating flocks of different size of in Zhizhginski on 4.-7.10.2004. Median is shown on bolded black bar. Grey bars show the 25-75 % confident intervals and thin bars show 5-95 % the confident intervals.

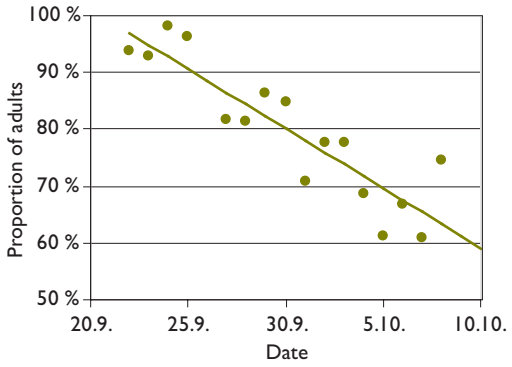


Figure 7. Daily proportions of adult red-throated divers of migrating red-throated divers during the White Sea expedition 2004 (n = 2 332).

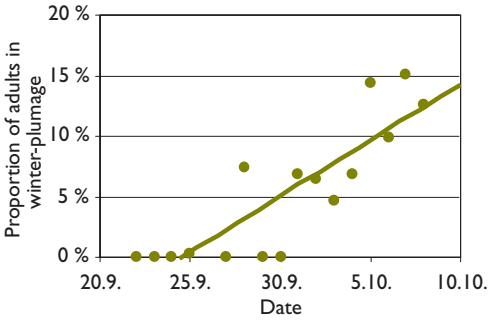


Figure 8. Daily proportions of adult red-throated divers in winter plumage of migrating red-throated divers during the White Sea expedition 2004 (n = 2 332).

3.3.2

Diurnal patterns of migration

Examples of the diurnal patterns of migration of arctic birds are shown in Figures 9–20.

Figure 9 show the patterns of diver migration (mainly black-throated divers, see 3.3.3.) at Pertominsk on 30th Sep–4th Oct 2004 and Figures 10 & 11 show the patterns on 3rd–4th Oct 99. The diver migration at Zhizhginski on 6th Oct 99 is shown in Figure 12. The timing of peak migration varied strongly during each day. At least three (four) different peaks can be determinate: early morning peak immediately after dawn, forenoon peak around 10:00–12:00 and afternoon peak 14:00–16:00. One possible different peak observed on 3rd Oct 04 during 12:30–13:30. Overall the forenoon peak seems to be the strongest of these peaks. The migration was stronger during (side) tail-wind than weak head-wind (Fig. 9). Red-throated diver migration showed two clear peaks in 1999: forenoon peak 8:30–10:30 and 12:30–15:30 (Fig. 13).

Patterns of geese migration at Pertominsk on 3rd Oct 99 and at Zhizhginski on 6th Oct 99 are shown in Figures 10 & 12. Patterns of barnacle geese and unidentified geese migration at Pertominsk in 2004 are united in Figure 14, since nearly all the identified geese were barnacles unlike heavy goose migration in 1999. On 3rd Oct 99 the barnacle migration peaked around noon 11:00–14:00, but in 2004 peaks of geese migration occurred in the afternoon 13:00–17:00. However during the heavy migration day on 1st Oct 04 the migration was intensive throughout the whole day as well as in weaker migration day on 2nd Oct 04 (Fig. 14). The heavy Anser geese migration peaked twice on 3rd Oct 99: 12:30-14:30 and 17:00-18:30 (Fig. 10). Like the divers the migration of geese was stronger during the (side)tail-wind (30th Sep-2nd Oct 04) (Fig. 14).

Lesser Black-backed Gulls (*Larus heuglini*) were observed few during the expedition.
Photo: Aleksi Lehikoinen

In 1999 long-tailed duck migration was heaviest in the morning (Fig. 15), but several peaks were recorded during a single migration day (Fig. 12) as was the case also on 4th–7th Oct 2004 at Zhizhginski (Fig. 16): early morning peak on 5th Oct 04 (and weak in 6th), midday peak on 4th and 7th and afternoon peak(s) on 4th and late evening peak on 4th and 5th. In 1999 the heaviest migrations were observed during almost calm weather (6th Oct) or good tail wind (NE, 7th Oct) (Appendix 3). In 2004 the wind was head-wind during nearly the whole period at Zhizhginski (on 7th some side wind) and the migration of long-tailed ducks was strongest during the weaker head-wind or side wind (Appendix 4, Fig. 16).

Wigeon migration was heavy early in the morning and especially late in the evening and migration was poor around noon. The heaviest migrations at Pertominsk were observed during strong NW–NNW wind (Fig. 17).

Scaup migration was intensive early in the morning and migration intensity decreased clearly after 9:00 (Fig. 18). Intensity of common scoter migration was fairly stable showing only a slight late evening peak (Fig. 19) unlike velvet scoter, which has clear, but fairly long lasting forenoon and evening peaks (Fig. 20).

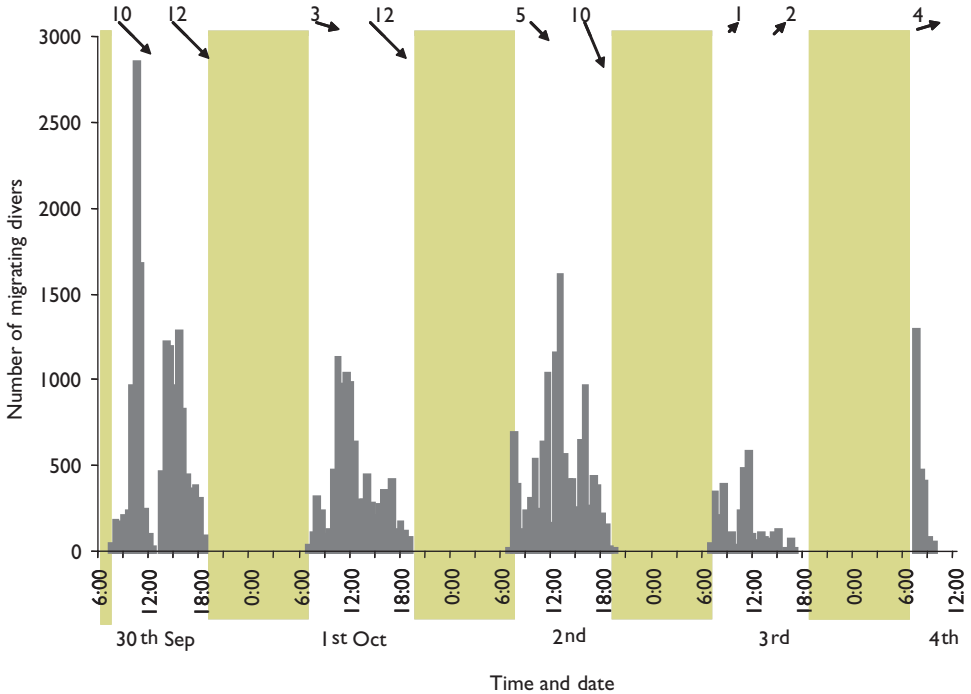


Figure 9. Migration patterns of divers in 30-minute-periods and average wind direction (↑ is south wind) and speed (m/s) on 30th Sep – 4th Oct 2004 in Pertominsk. Dark non-observation time is shown on green. Note different timings of peak migration each day (n = 40 555).

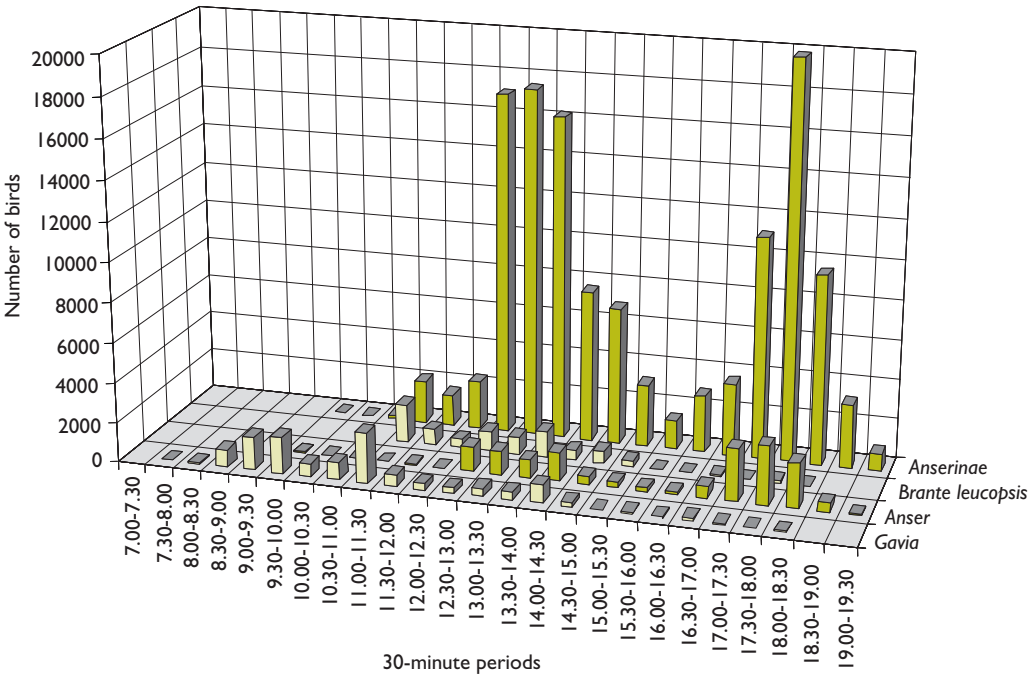


Figure 10. Geese and diver migration in 30-minute-periods on 3rd Oct 1999 at Pertominsk (divers n = 11 920, Anser-geese n = 14 606, barnacle geese n = 6 148, unidentified geese n = 91 836).

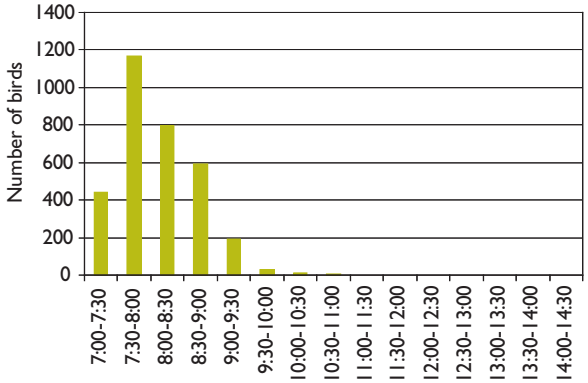


Figure 11. Diver migration in 30-minute- periods on 4th Oct 1999 at Pertominsk (n = 3 329).

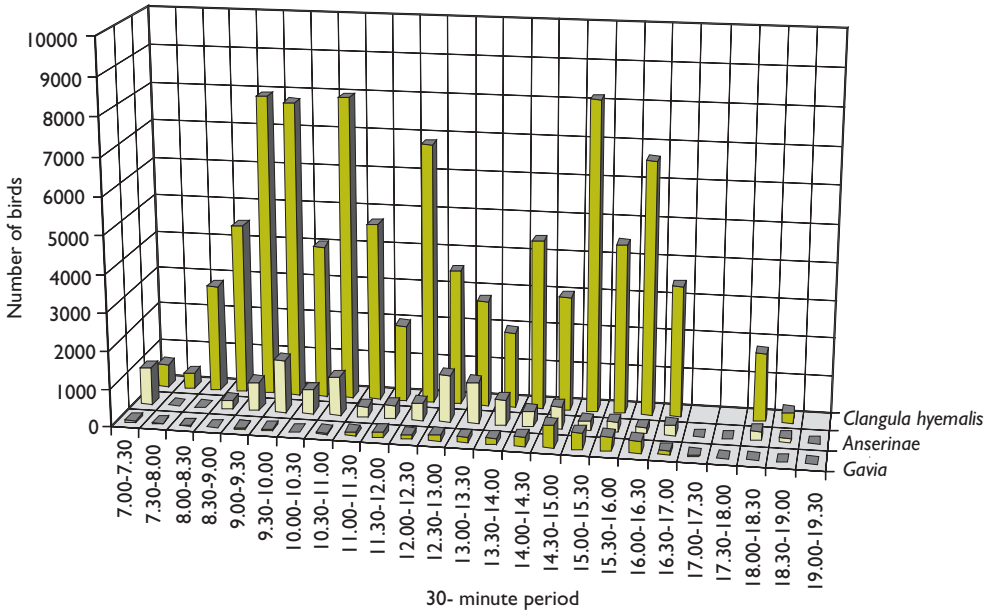


Figure 12. Diver, geese and long-tailed duck migration in 30-minute-periods on 6th Oct 1999 at Zhizhginski (divers n = 3 166, geese n = 11 339, long-tailed duck n = 89 509).

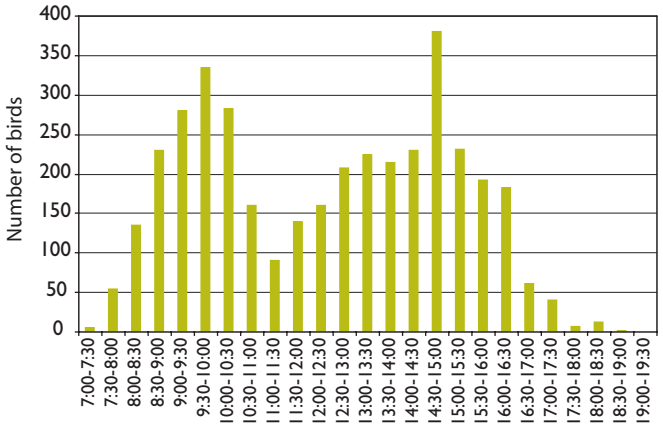


Figure 13. Migration of red-throated diver in 30-minute-periods during the White Sea expedition 1999 (n = 4637, most at Zhizhginski).

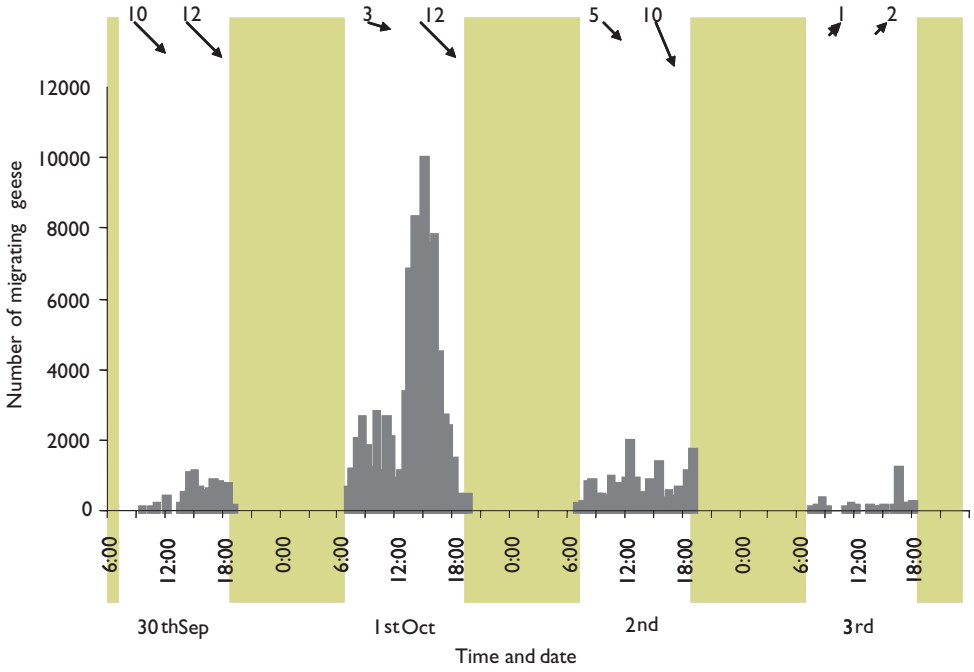


Figure 14. Migration patterns of barnacle and un-identified geese in 30-minute-periods and average wind direction (↑ is south wind) and speed (m/s) on 30th Sep – 4th Oct 2004 in Pertominsk. Dark non-observation time is shown on green (n = 111 900).

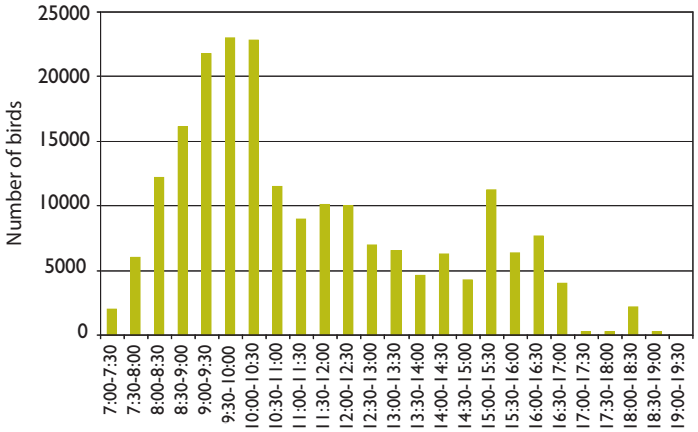


Figure 15. Migration of long-tailed duck in 30-minute-periods during the White Sea expedition 1999 (n = 262 699, most at Zhizhginski)

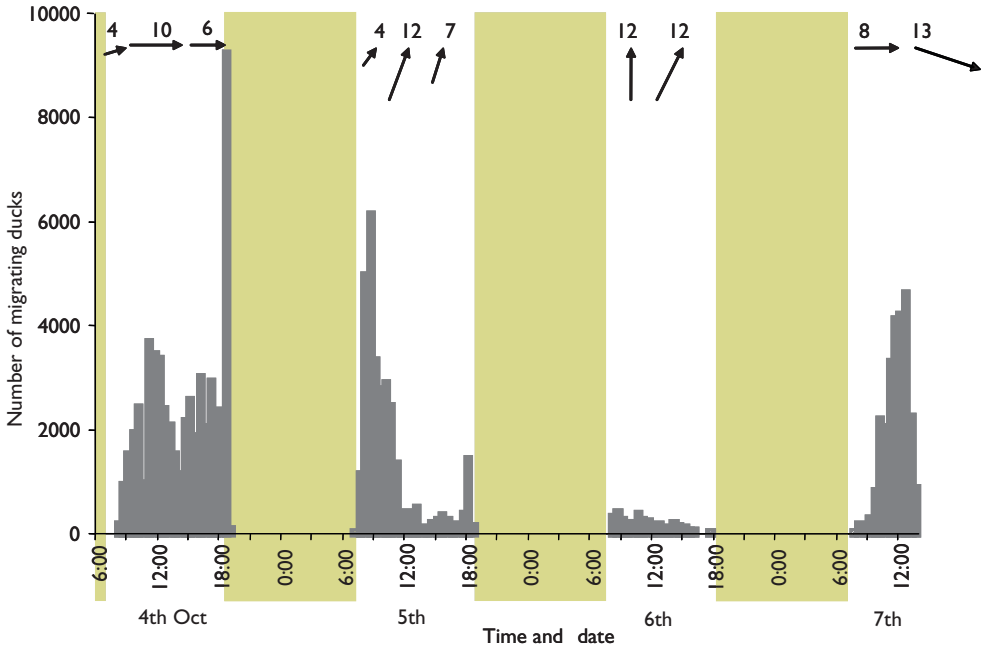


Figure 16. Migration patterns of long-tailed ducks in 30-minute-periods and average wind direction (↑ is south wind) and speed (m/s) on 4 – 7th Oct 2004 in Zhizhginski (on 4th during the journey from Pertominsk to Zhizhginski). Dark non-observation time is shown on green (n = 112 687).

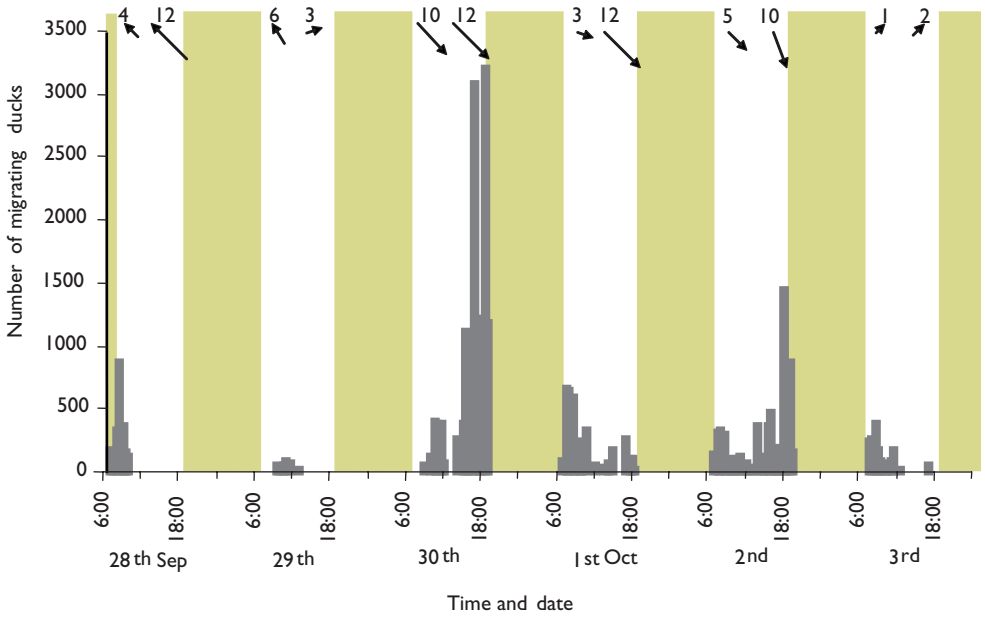


Figure 17. Migration patterns of wigeon in 30-minute-periods and average wind direction (↑ is south wind) and speed (m/s) on 28th Sep – 4th Oct 2004 in Pertominsk. Dark non-observation time is shown on green. n = 26 786.

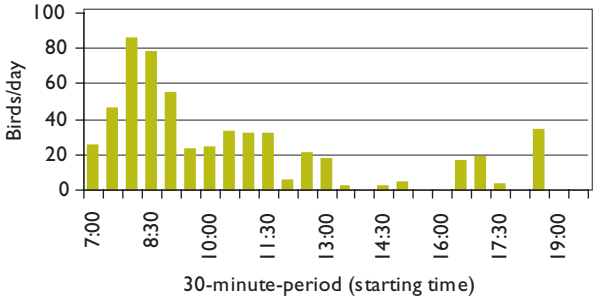


Figure 18. Migration day rhythm of scaup on 30th Sep - 4th Oct 2004 at Pertominsk and Zhizhginski (n = 3 127). Figures are corrected for variable observation activity.

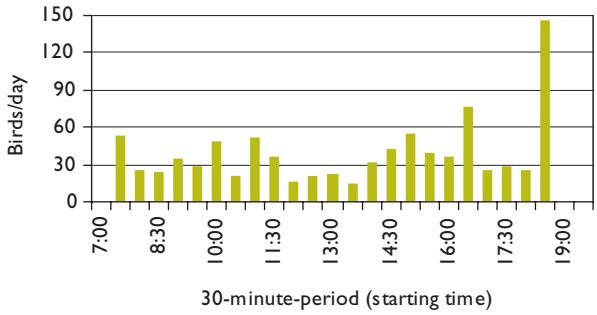


Figure 19. Migration day rhythm of common scoter on 30th Sep - 4th Oct 2004 at Pertominsk and Zhizhginski (n = 4 211). Figures are corrected for variable observation activity.

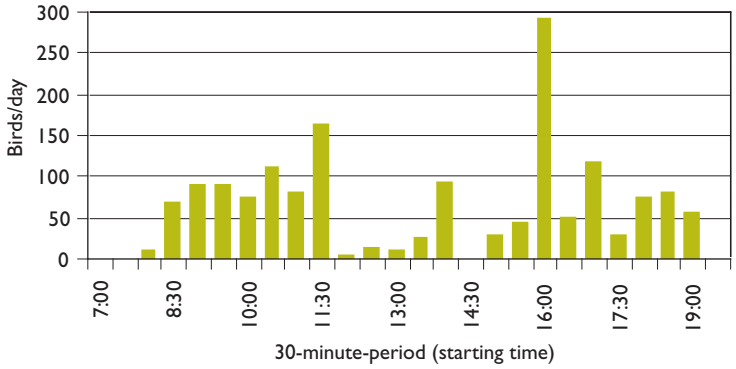


Figure 20. Migration day rhythm of velvet scoter at Pertominsk on 30th Sep - 3rd Oct 2004 (n = 6 153). Figures are corrected for variable observation activity.

3.3.3

Migration routes

Data on differences in the selection of migration routes between arctic species were collected during the expedition. Figures 21–32 show the numbers migrants and directions of migration and concentrations of abundant arctic bird species. Bean and white-fronted goose, wigeon, scaup and velvet scoter were found to be much abundant in Pertominsk area (Figs 21–22, 25–26 & 29), whereas red-throated diver, brent goose, long-tailed duck and common scoter (Fig. 24, 27–28 & 30) were much more abundant along the Zhizhginski route. Black-throated diver and barnacle goose did not show any clear preference between either of these routes (Fig. 23 & 31). Arctic skua seemed to have two different kind of migrating routes at Pertominsk: east-southeast along the coast line and southwest over the Unskaya Bay. Small numbers of arctic skuas were migrating along southern coast of Onega Bay (Fig. 32).

3.4

Staging areas

Important staging areas for brent goose, ducks and black guillemot are shown in Table 5 and on Figure 33 (see also Figs 24–25, 27–29, 34–35 and red-breasted merganser *Mergus serrator* Fig. 36). The largest concentrations of birds were 55 000 wigeon in Unskaya Bay, 20 000 (brent) geese and 6 000 ducks in Suhoe and Virma Bays, 13 100 ducks off Hedostrov Island, 11 500 ducks off the coast at Pertominsk, 10 000 long-tailed ducks in the Osinka area, 10 000 common scoters of Mjagostrov Island and 10 000 wigeons in Uhtalahti Bay. Nearly all the concentrations were situated in shallow waters (< 10 metres; Fig. 33).

The densities of birds in staging areas were calculated by dividing the total numbers of birds by the total surface area of the staging birds (Table 5). Although the boundaries of staging areas could only be quite roughly defined, indicative density values were nevertheless obtainable by this method. The highest densities of birds counted in any staging area were 1 375 wigeons/km^2 on the NW Unskaya Bay (2004), 809 long-tailed ducks/km^2 in Osinka Island area (1999) and 780 wigeons/km^2 on Uhtalahti Bay (1999). The densities of scoters and eiders were much lower up to 357 birds/km^2.

Unskaya Bay is a very shallow bay and turned out to be very important staging area for wigeons (approx. 55 000 ind.). Alexander V. Kondratyev standing at the bottom and counting the birds. Photo: Aleksi Lehikoinen

Table 5. Important staging areas of arctic ducks found during the expeditions in the White Sea (Fig. 33). The sites (with the surface areas) and species (with the numbers of staging birds) are shown.

N:o	Location	Area (km^2)	Year	Species (number of staging birds)
1.	Suhoe and Virma Bays	c. 70	1999	(Brent) goose 2 200, waterfowl (wigeon) 3 000
		c. 70	2004	(Brent) goose 20 000, Waterfowl (wigeon) 6 000
2.	Outer Archipelago of Suhoe and Virma (inc. Osinka Island area)	12	1999	Long-tailed duck 10 000
		46	2004	Common scoter 4 200
3.	NW Mjagostrov	28	2004	Common scoter 10 000
4.	Hedostrov Island area	56	1999	Eider 3 700, velvet scoter 1 700
		157	2004	Eider 2 900, velvet scoter 4 100, common scoter 6 100
5.	Uhtalahti Bay	13	1999	Wigeon 10 000
6.	East coast of Zhuzhmui Islands	13	1999	Eider 1 500
7.	Southern coast of Solovetski Island	117	1999	Eider 2 250, black guillemot 260
		277	2004	Eider 2 000, black guillemot 310
8.	Eastern coast of Anzerskij Island	6	1999	Black guillemot 220
		53	2004	Black guillemot 90
9.	Zhizhginski Strait	20	1999	Eider 1 300
10.	Coastal area between Letniv Navolok and Lopsenga	94	2004	Eider 1 400, long-tailed duck 8 400
11.	Off Pertominsk	52	1999	Eider 3 500, long-tailed duck 1 000, common scoter 2 500
		52	2004	Eider 2 700, long-tailed duck 1 000, common scoter 7 400
12.	Northwest part of Unskaya Bay	2	1999	Wigeon 3 000
		32	2004	Wigeon 44 000
13.	Northeast part of Unskaya Bay	9	2004	Wigeon 11 000

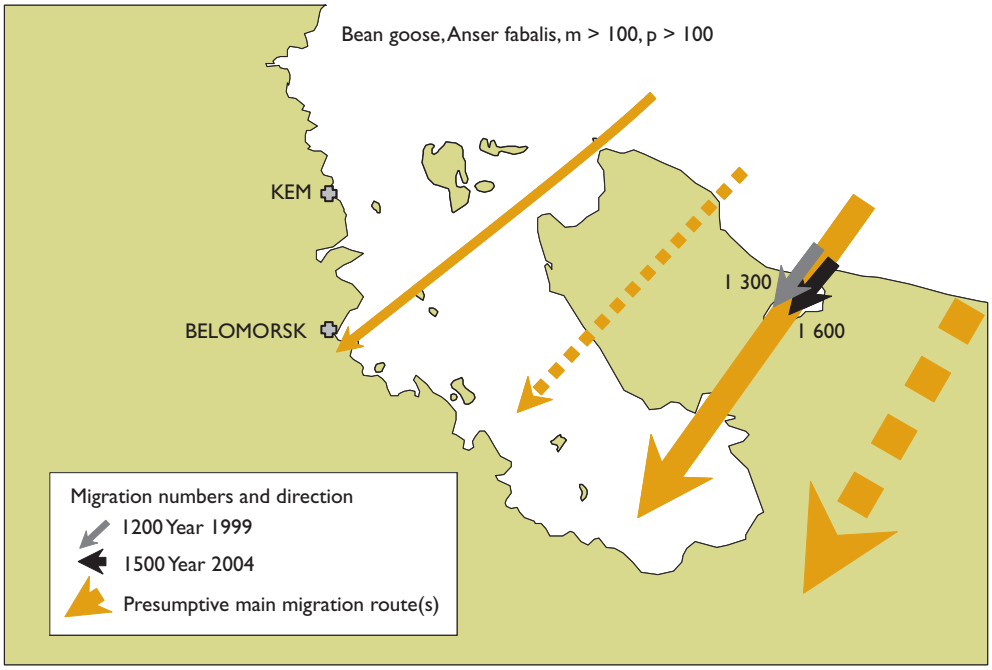


Figure 21. Positions of observed migration numbers (> 100 ind.) of bean goose during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions). Any important staging areas (> 100 ind.) were not recorded.

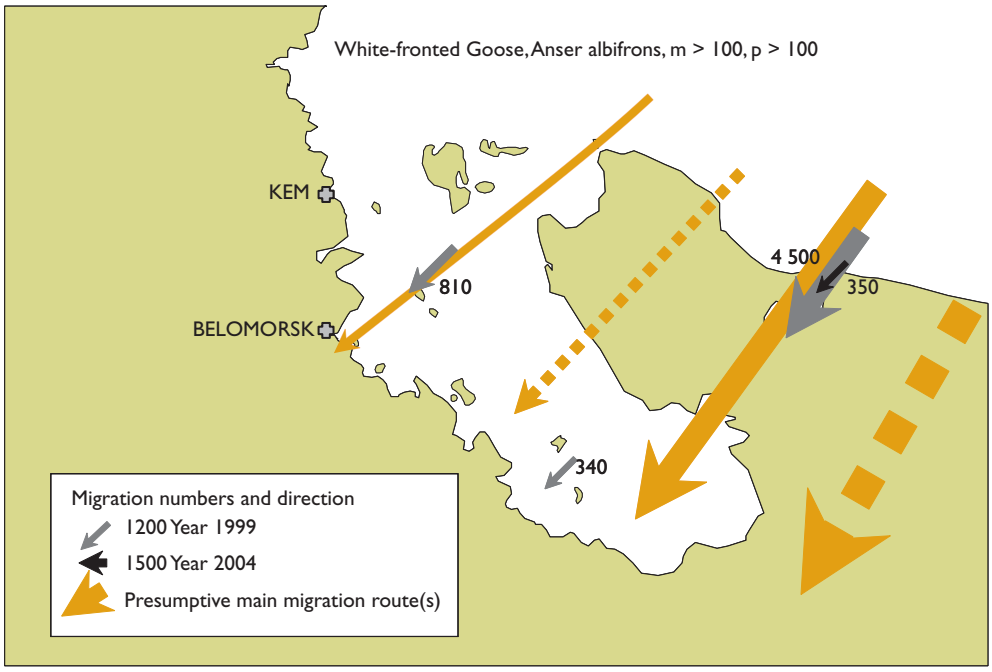


Figure 22. Positions of observed migration numbers (> 100 ind.) of white-fronted goose during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions). Any important staging areas (> 100 ind.) were not recorded.

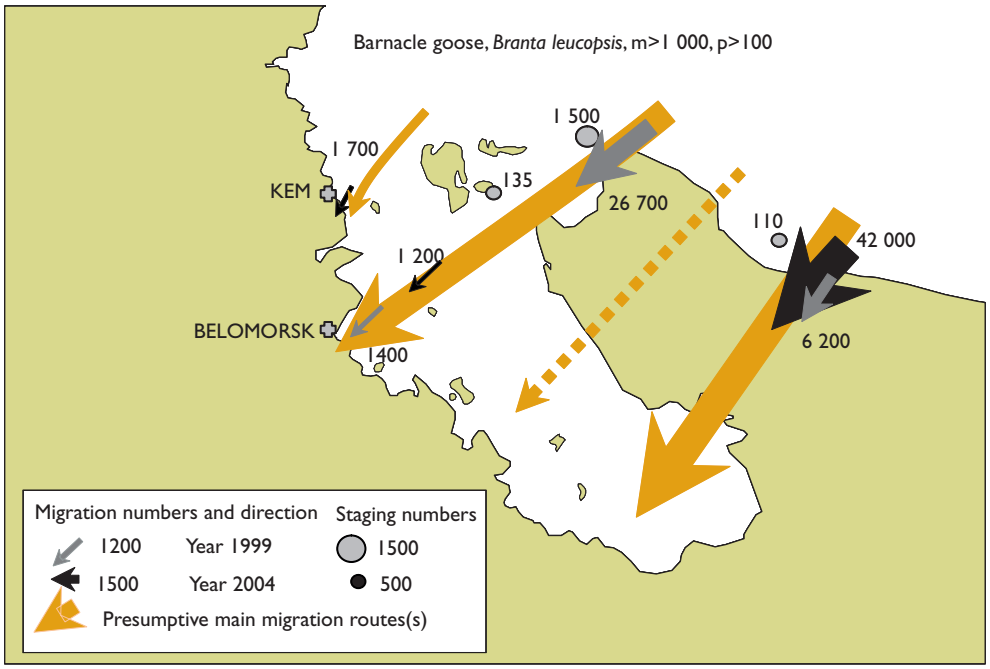


Figure 23. Positions of observed migration (> 1000 ind.) and staging (> 100 ind.) numbers of barnacle goose during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions).

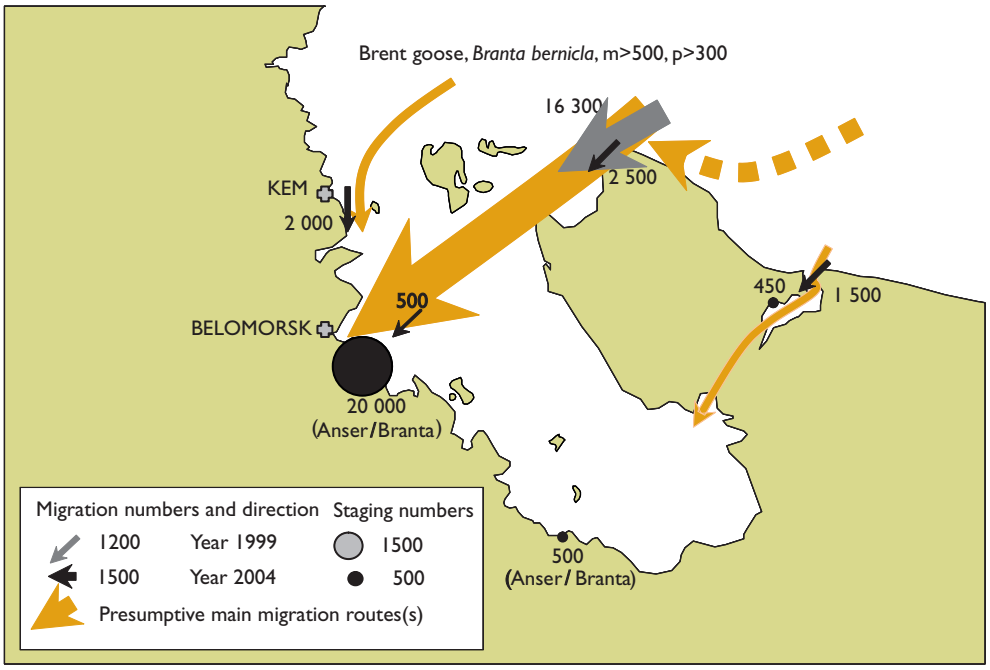


Figure 24. Positions of observed migration (> 500 ind.) and staging (> 300 ind.) numbers of brent goose during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions). Two concentrations of unidentified geese are show also in the figure, because most likely they were brents geese.

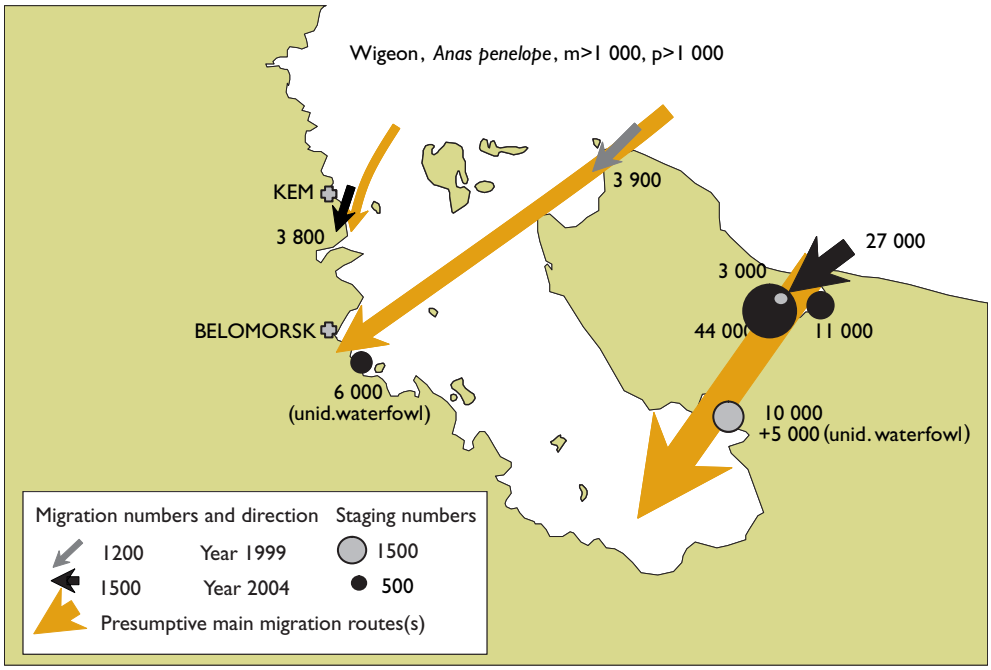


Figure 25. Position of observed migration (> 1000 ind.) and staging (> 1000 ind.) numbers of wigeon during the White Sea expeditions 1999 and 2004 and presumed migration routes.

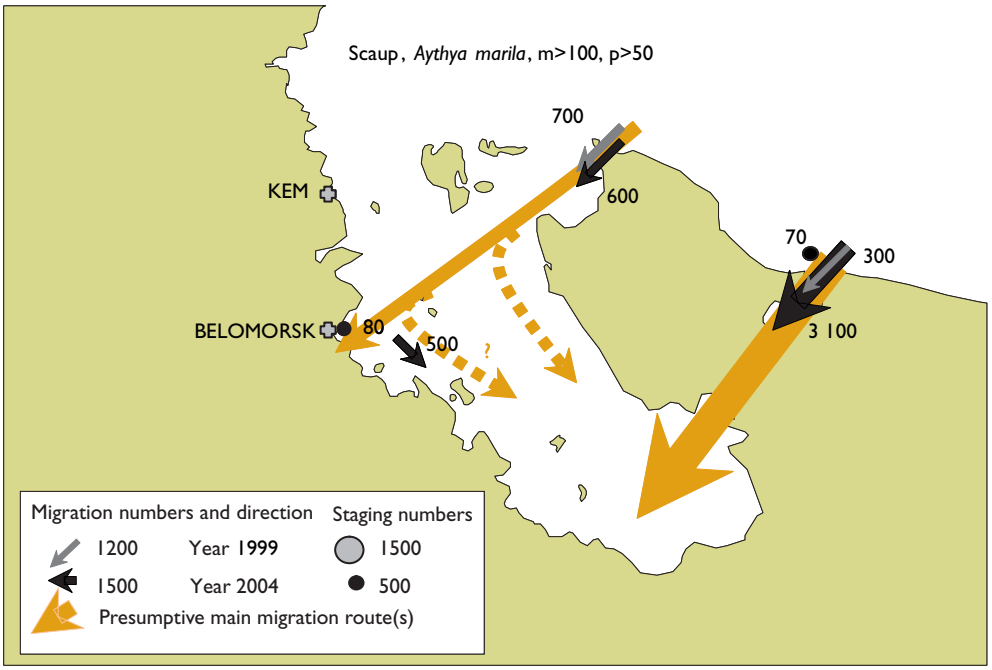


Figure 26. Positions of observed migration (> 100 ind.) and staging (> 50 ind.) numbers of scaup during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions).

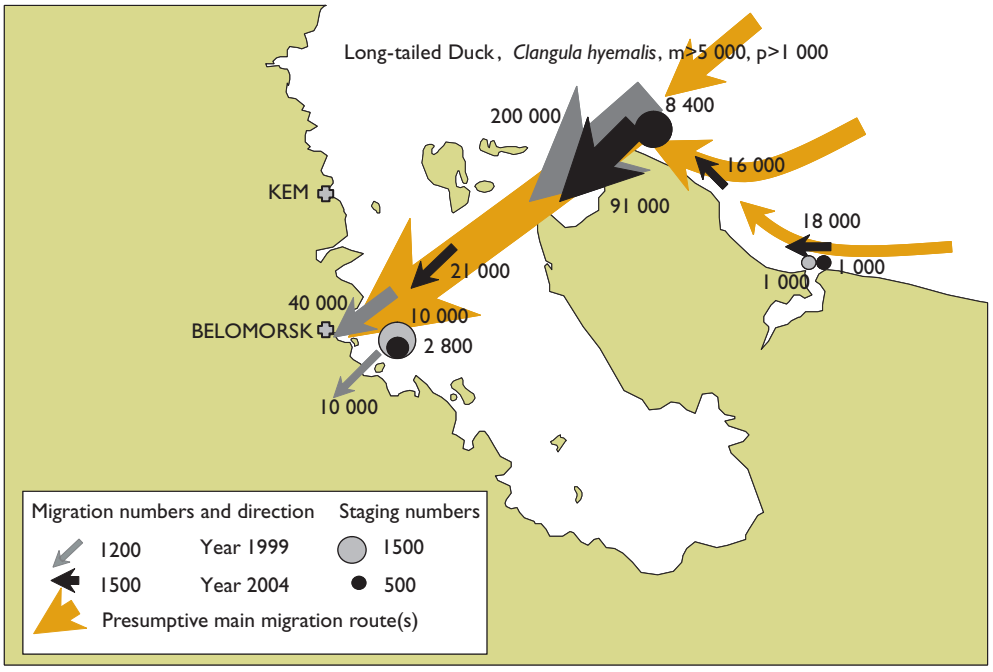


Figure 27. Positions of observed migration (> 5000 ind.) and staging (> 1000 ind.) numbers of long-tailed duck during the White Sea expeditions 1999 and 2004 and presumed migration routes.

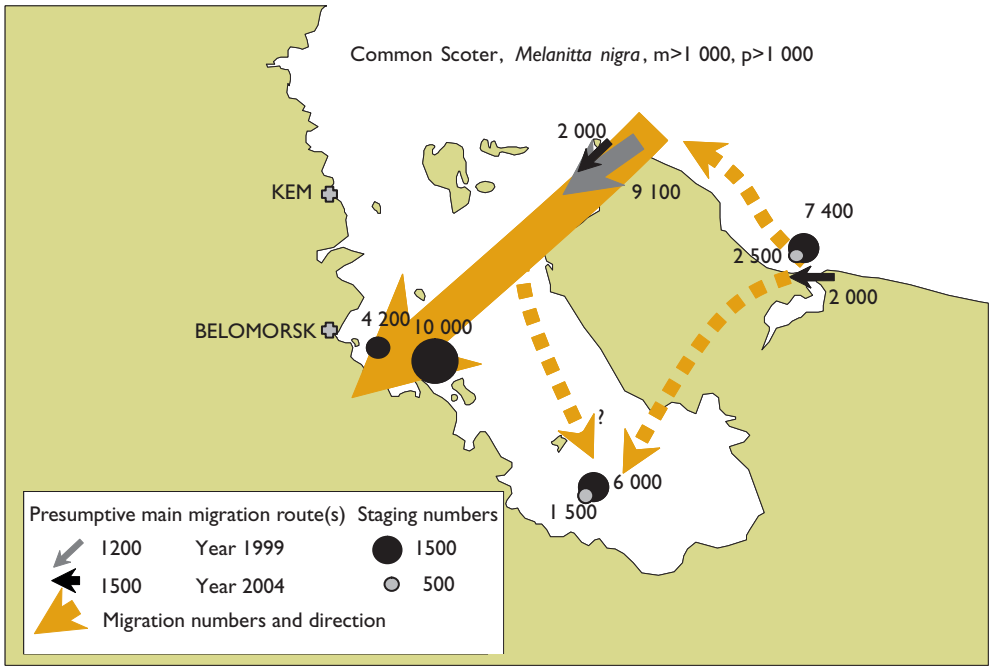


Figure 28. Positions of observed migration (> 1000 ind.) and staging (> 1000 ind.) numbers of common scoter during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions).

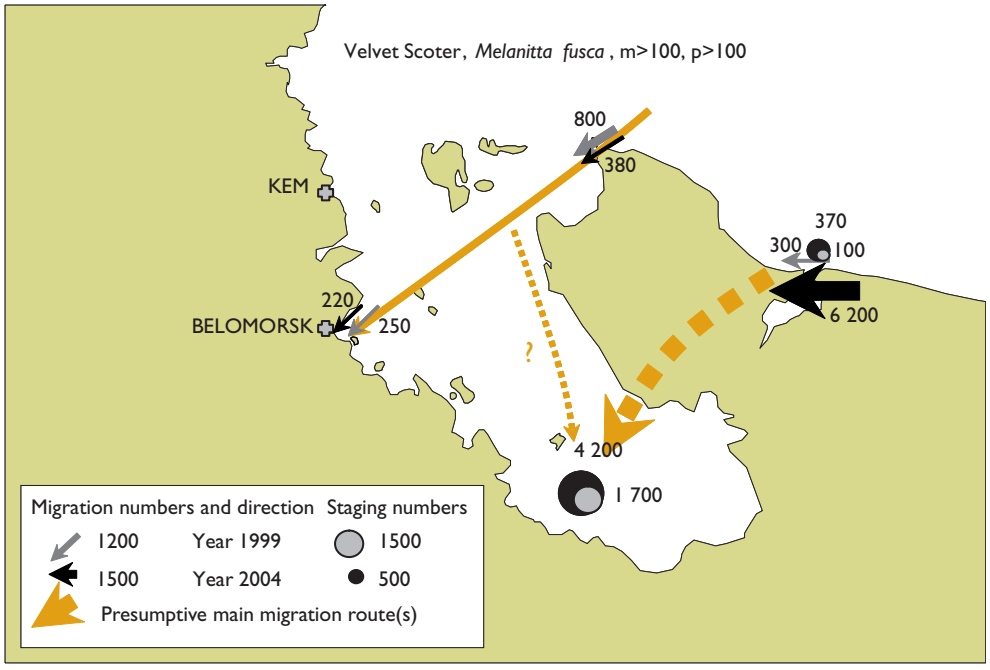


Figure 29. Positions of observed migration (> 100 ind.) and staging (> 100 ind.) numbers of velvet scoter during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions).

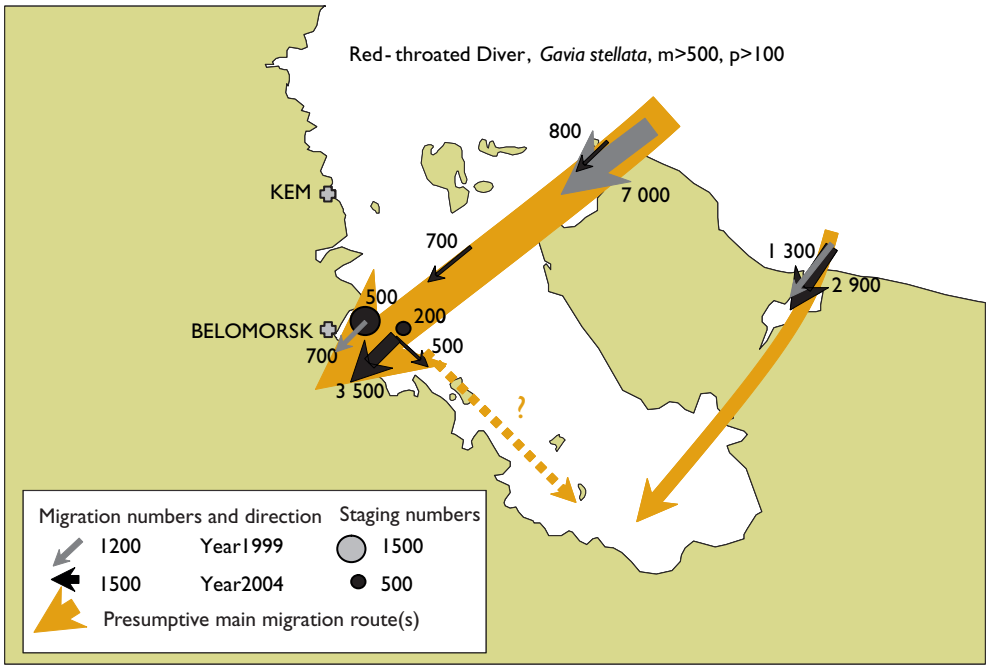


Figure 30. Positions of observed migration (> 500 ind.) and staging (> 100 ind.) numbers of red-throated diver during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions). Figures for unidentified divers were added to the identified totals according to the respective proportions of species amongst the divers identified.

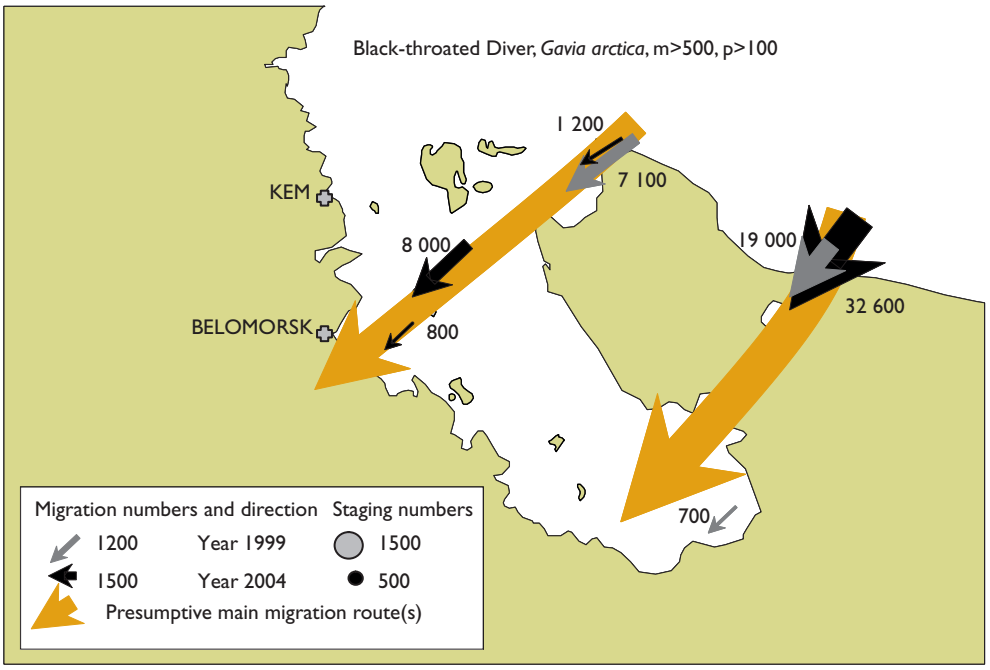


Figure 31. Positions of observed migration (> 500 ind.) and staging (> 100 ind.) numbers of black-throated diver during the White Sea expeditions 1999 and 2004 and presumed migration routes. Figures for unidentified divers were added to the identified totals according to the respective proportions of species amongst the divers identified.

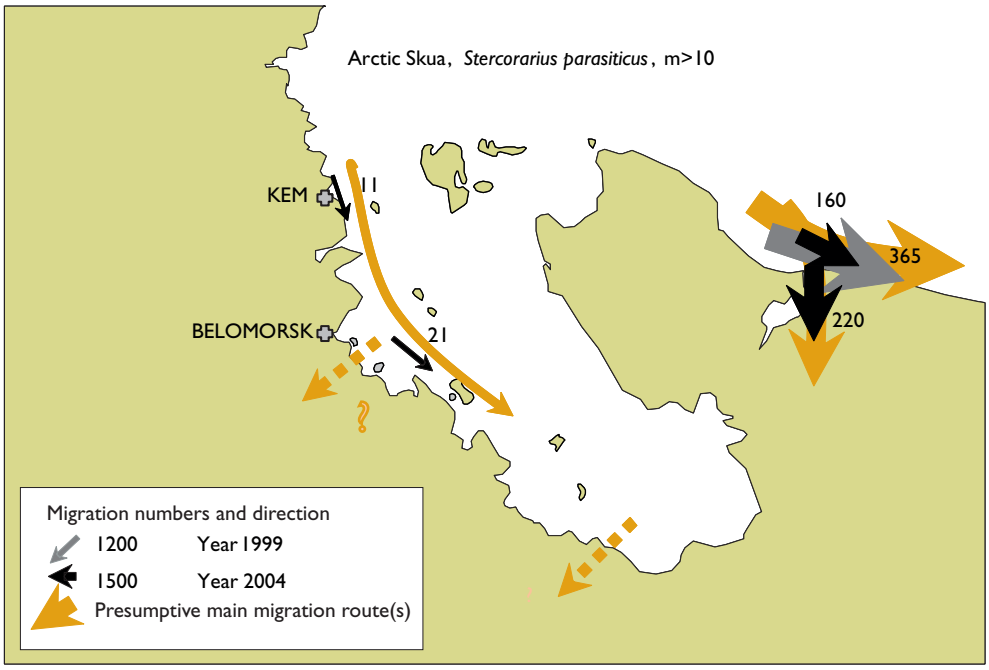


Figure 32. Positions of observed migration numbers (> 10 ind.) of arctic skua during the White Sea expeditions 1999 and 2004 and presumed migration routes (routes with broken line are not confirmed by data of expeditions). Figures for unidentified skuas were added to the identified totals according to the respective proportions of species amongst the skuas identified.

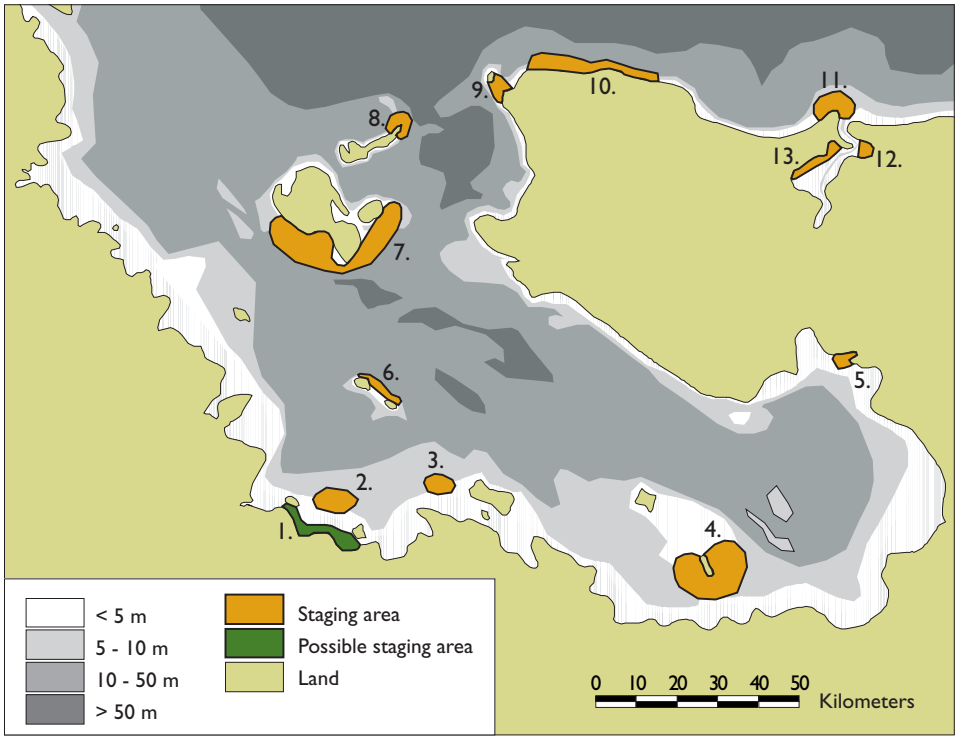


Figure 33. Important staging areas found during the White Sea expeditions 1999 and 2004 (Table 5). Staging area of Suhoe and Virma Bays is marked separately, because it was not possible to determinate the accurate boundaries of the area.

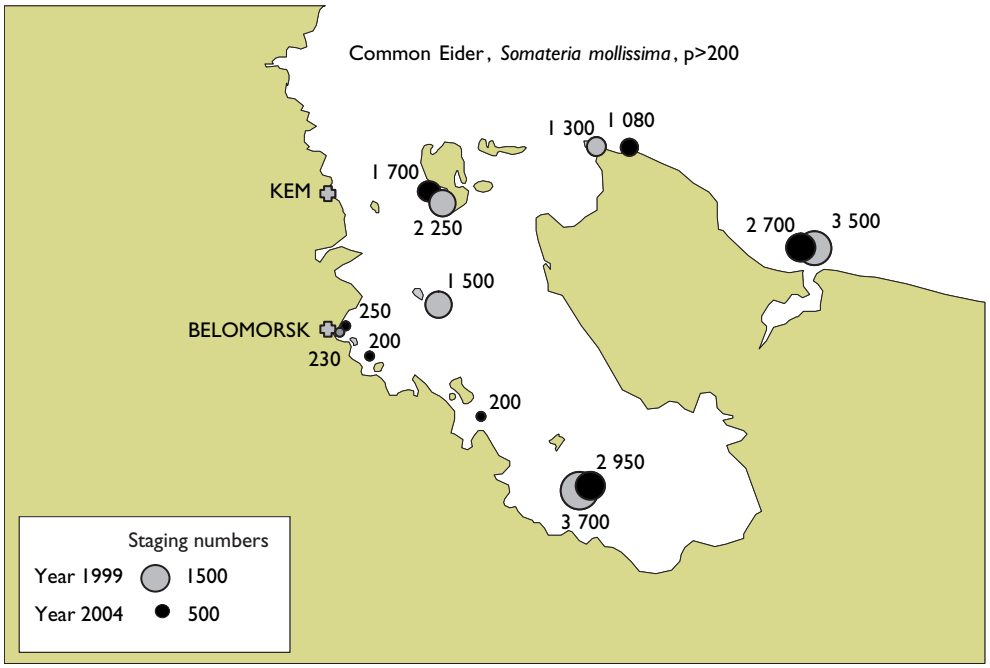


Figure 34. Positions of staging numbers (> 200 ind.) of common eider during the White Sea expeditions 1999 and 2004.

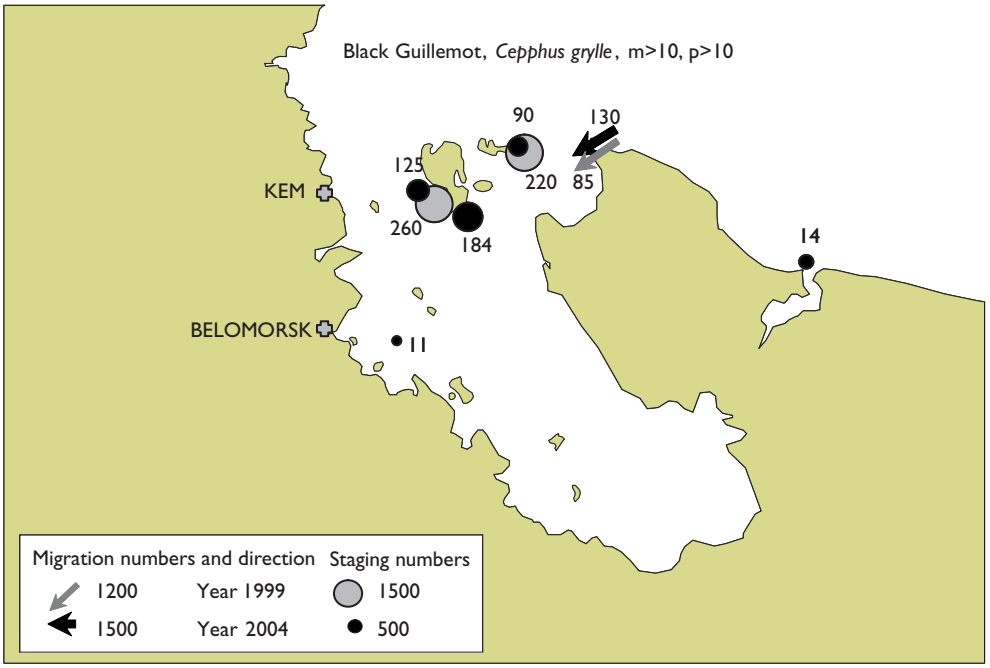


Figure 35. Positions of observed migration (> 10 ind.) and staging (> 10 ind.) numbers of black guillemot during the White Sea expeditions 1999 and 2004

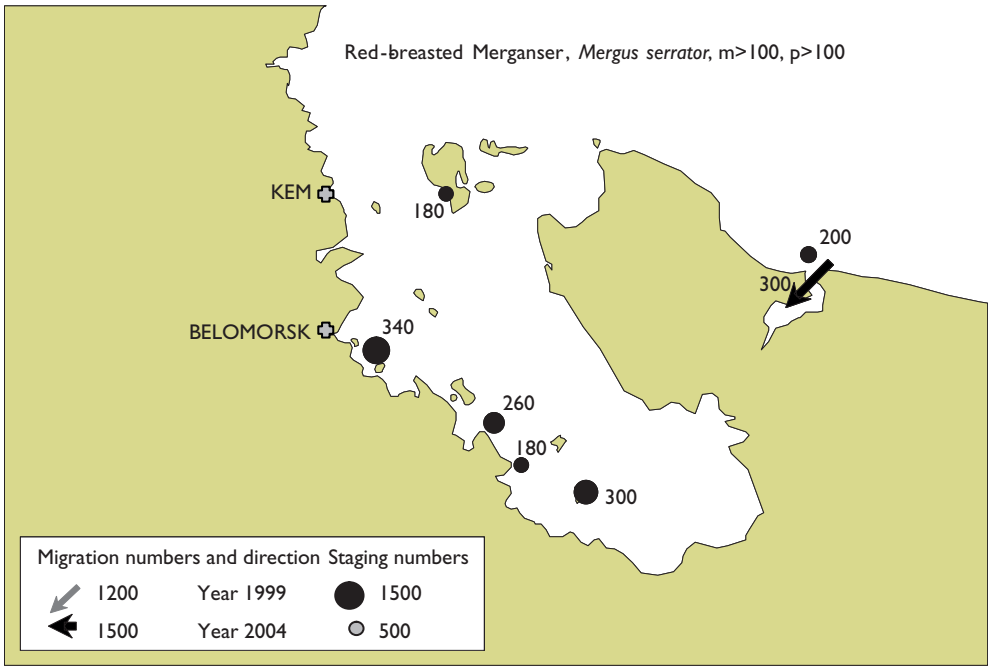


Figure 36. Positions of observed migration (> 100 ind.) and staging (> 100 ind.) numbers of red-breasted merganser during the White Sea expeditions 1999 and 2004.

3.5

Transect line counts

Figures 37 & 38 show where transect line counts were made. Transect line counts were made roughly in four areas: western Onega Bay, eastern Onega Bay, Solovetski and Anzerskij Islands area and southern Dvina Bay. Table 6 gives overall results of the transect line counts carried out during the expeditions and Table 7 gives results of average densities of each bird species reported in these four areas mentioned above.

Generally bird densities were higher in 2004 than in 1999, despite the fact that transect line counts were done nearly in same areas and where the sample size was nearly the same (Tables 6 & 7, Figs 37 & 38). However, during both expeditions the most abundant species in transect line counts was unsurprisingly the long-tailed duck: a total of 343 birds in 1999 and 1067 in 2004, giving an average densities of 3.90 and 10.9 birds/km^{2,} respectively. The second and third abundant bird species were different in 1999 and 2004. In 1999 the second abundant species was the common eider (1.35 birds/km^2) and the third abundant species was the black guillemot (1.28 birds/km^2). In 2004 comparable species were the common scoter (3.82 birds/km^2) and barnacle goose (1.13 birds/km^2, consisting of one flock of 110 birds).

The highest densities of birds in transect line counts were found in 2004 in western Onega Bay with average density of 53.7 birds/km^2. Densities of e.g. long-tailed duck, common scoter, common eider, black-throated diver and red-necked grebe *Podiceps grisegena* were the highest in this area. However densities of velvet scoter and red-throated divers were the highest in eastern Onega Bay and density of black guillemot was clearly the highest in the area around Solovetski and Anzerskij Islands. One flock of barnacle goose (110 ind.) was observed in transect line counts in Dvina Bay giving unrealistic high density value of 3.44 birds/km^2 to this area (Table 7).

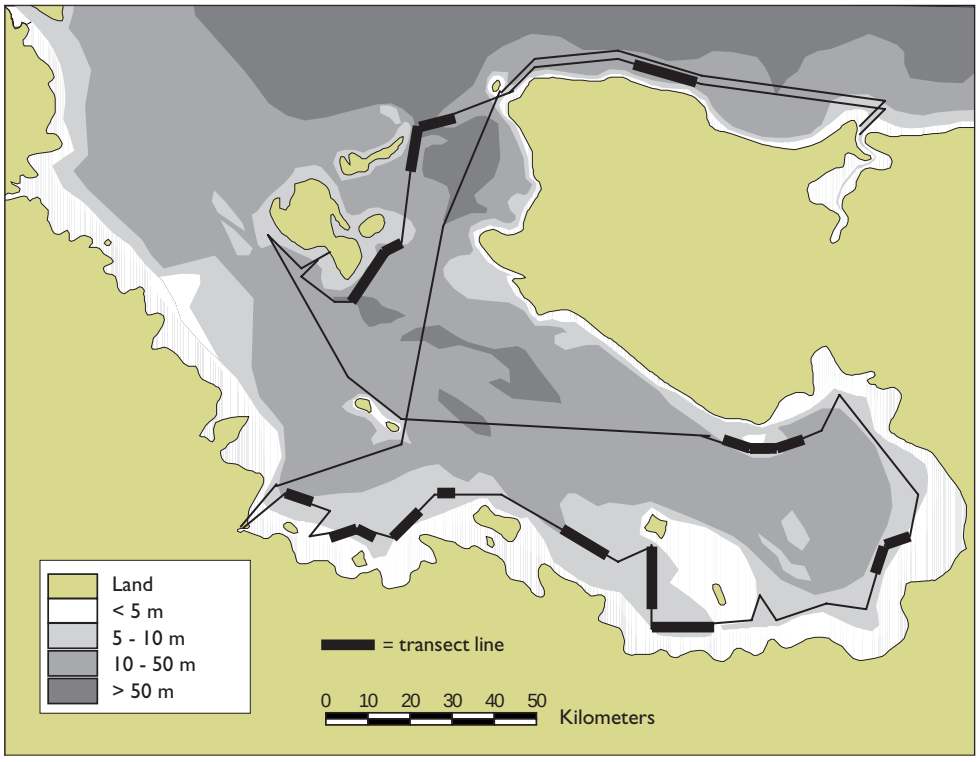


Figure 37. Positions of transect line counts carried on during the White Sea expedition 1999 and the depths of the sea area roughly represented.

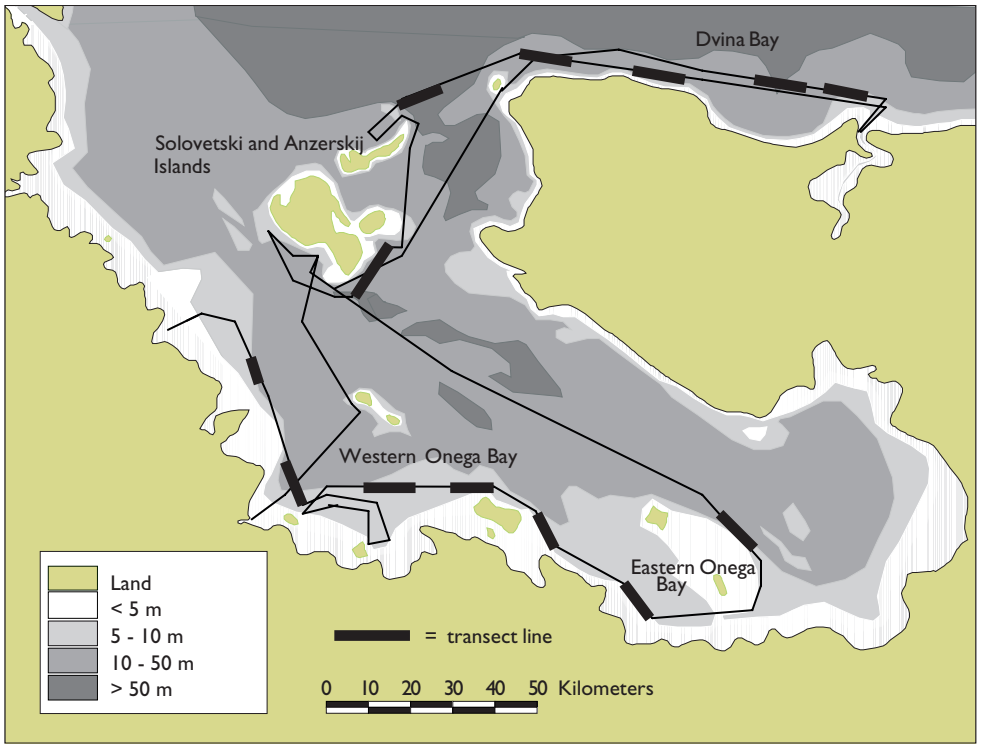


Figure 38. Positions of transect line counts carried on during the White Sea expedition 2004 and depths of the sea area roughly represented.

Table 6. The overview on the transect line counts during the White Sea expeditions 1999 and 2004.

	1999	2004
Total number of transect lines	57	50
Total area covered by transect line counts (km^2)	88	97.5
Total number of birds recorded in transect line counts	695	1788
Number of species recorded in transect line counts	12	11
Overall average density of birds recorded in transect line counts (birds/km^2)	7.9	18.4
Maximum number of birds recorded along a transect line	169	492
Minimum number of birds recorded along a transect line	0	0
Maximum density of birds recorded along a transect line (birds/km^2)	84.5	246
Minimum density of birds recorded along a transect line (birds/km^2)	0	0
Maximum density of birds of a single species recorded along a transect line (birds/km^2)	80	160

Table 7. Average bird and mammal densities based on transect line counts in Western and Eastern Onega Bay, Solovetski - Anzerskij Islands area and Southern Dvina Bay (see Fig. 38) during White Sea expedition 2004 and average densities of both expeditions. The highest sea-area values of each species are **bolded**. n.d. = no data.

Area	W. Onega	E. Onega	Sol.- An.	Dvina	Whole exp.	
Species	2004	2004	2004	2004	1999	2004
Barnacle Goose *Branta leucopsis*				**3.44**		1.13
Long-tailed Duck *Clangula hyemalis*	**38.75**	0.04	0.81	2.03	3.90	10.94
Common Scoter *Melanitta nigra*	**11.33**	1.00	-	1.84	0.50	3.82
Velvet Scoter *M. fusca*	0.20	**2.38**	-	-	0.10	0.64
Common Eider *Somateria mollissima*	**2.39**	1.25	-	-	1.35	0.93
King Eider *S. spectabilis*	-	-	-	-	0.03	-
Goldeneye *Bucephala clangula*	-	-	-	-	0.21	-
Red-breasted Merganser *Mergus serrator*	**0.04**	-	-	-	-	0.01
Red-throated Diver *Gavia stellata*	0.20	**0.79**	0.13	0.16	0.38	0.33
Black-throated Diver *G. arctica*	**0.24**	0.08	-	0.09	0.03	0.14
Red-necked Grebe *Podiceps grisegena*	**0.27**	-	-	-	0.04	0.07
Razorbill *Alca torda*	-	-	-	-	0.04	-
Black Guillemot *Cepphus grylle*	0.27	-	**1.81**	0.03	1.28	0.38
Puffin *Fratercula arctica*	-	-	-	0.03	0.04	0.01
Average bird density	**53.69**	5.54	2.75	7.72	7.90	18.40
Ringed Seal *Phoca hispida*	0.04	-	**1.00**	0.03	n.d.	0.18
Bearded Seal *Erignathus barbatus*	0.04	-	**0.06**	-	n.d.	0.02
Unidentified seal	0.04	-	**0.81**	0.03	n.d.	0.15
Beluga whale *Delphinapterus leucas*	-	-	**0.44**	0.03	n.d.	0.08
Average mammal density	0.12	0.00	2.31	0.09	n.d.	0.44
Counted area (km^2)	25.5	24.0	16.0	32.0	n.d.	97.5

4 Discussion

4.1

Number of birds and importance of the White Sea

The numbers of birds identified during observation of migration remained relatively high. As can be seen in Table 2, identification percentages varied considerably between the species groups, but the percentages were nearly the same in both expeditions. The problems with the identification of flying divers and geese are well known (e.g. Kapanen & Leivo 1995, Nikander 1993), and result in relatively low numbers of identified birds out of all the recorded birds in these species groups. In these groups only about one third of the birds could be identified. On the contrary, the most abundant ducks: long-tailed duck, eider, common scoter and wigeon, are quite easy to identify even in flight, resulting in high proportion of identified birds among these species (see Table 2).

When migration is observed only part of birds can be identified in level of species and huge amount of the birds can only be identified in level of family or class. However, when the intensity of the migration is described all the observed birds need to be included, otherwise, if only birds with identified in level of species are used, the migration intensity will be underestimated. With a help of proportions of the identified species (for example ratio of red-throated divers and black-throated divers) and

Scaup (*Aythya marila*) migration is heavy especially in the early morning. Photo: Aleksi Lehikoinen

Most of the barnacles probably use the White Sea in autumns only as a flyway.
Photo: Aleksi Lehikoinen

number widely identified birds (for example unidentified divers) the total volume of each migrating species can be estimated.

The abundance of different species observed during the expedition depended mainly on the total size of their population known to migrate via the White Sea, and stage of their migration at the time. The long dark period (about 12 hours) during the autumn migration decrease the potential observation time in the autumn comparing to short darkness in the spring time (less than six hours in southern Finland and Estonia in the end of May). This is important phenomenon, since fairly many arctic migratory birds are capable for, or prefer, nocturnal migration (e.g. Alerstam 1990, Pettay 1996). The longer migration periods of species in autumn than in spring are also important reasons for low observed numbers, since expeditions lasted only three weeks and arctic autumn migration occurs from the July to December. However, the peak of many arctic bird species occurs during the end of September and the first half of October (e.g. Lehikoinen & Vähätalo 2000, Pettay et al. 2004).

The long-tailed duck was overwhelmingly the most frequently observed species during the expeditions (see Table 1), for obvious reason: It has by the largest population of all the arctic species migrating via the White Sea, at least 4.6 million birds (Delany & Scott 2002), and its main migration period, the first three weeks of October (e.g. Lehikoinen & Vähätalo 2000, Pettay et al. 2004), coincided fairly well with the timing of the expeditions. However, the total percentage of the total flyway population recorded during the expedition was relatively low (see Table 1). This may have been because observation was carried out along its main migration route for just a few days, and no single true migration day occurred during this period (see Appendixes 1–2, 5–7). The migration period continues also after the expeditions. Long-tailed ducks seem to prefer nocturnal migration during autumn migration (see section 4.3. and Fig. 16, Leivo et al. 2001), which why huge numbers of birds could have passed observation points during more than 12 hours long dark nights.

The low numbers and the percentages of the whole flyway population recorded for common scoter are easy to explain, since adult males already migrate in July-August to the Baltic Sea region to moult (Cramp & Simmons 1977, Pettay et al. 2004), while the main migration of females and juveniles occurs in September and continues till the beginning of October (Pettay et al. 2004), so most of the birds had already left the White Sea before expeditions.

Nocturnal migration (see section 4.3. and Fig. 20) and long migration period (see section 4.2.), from early September to December (Margus Ellermaa, unpublished autumn data 2004 from Estonia) probably explains the low observed numbers of velvet scoters during both expeditions. However, the flyway population of this species is about 1.0 million birds (Delany & Scott 2002) and much higher numbers were expected. Migration patterns of velvet scoter are still mostly unknown and need more studies, as it is also in the case of scaup. The timing of the expeditions should theoretically have coincided well with the scaup's main migration period (from mid September to mid October, e.g. Pettay et al. 2004, Margus Ellermaa, unpublished autumn data 2004 from Estonia), but few birds were recorded (see Table 1). Scaup seems to prefer nocturnal migration (see section 4.3., Leivo et al. 1994, Pettay 1996), which may explain low observed numbers. Our best records of both velvet scoter and scaup are emphasized to eastern observation points, indicating that both species may use even more south-eastern migration routes, explaining these low observed numbers. In the Gulf of Finland, the Baltic Sea, the autumn numbers of both species are also higher in eastern and southern part of the bay (Pöyhönen 1995, Pettay et al. 2004), which also indicates southeastern migration route.

High percentages of the flyway population were recorded for divers (4.1–13.6 %) and especially the Branta geese (14.5–32.4 %) during the expeditions (see Table 1). The main migration period of these geese species (late September and mid-October, e.g. Lehikoinen & Vähätalo 2000, Pettay et. al. 2004) coincided with the timing of the expedition and these species seem to use the White Sea as a main migration route. In contrast, Anser geese, despite having the same main migration period in the end of September and the first half of October (Lehikoinen & Vähätalo 2000, Pettay et al. 2004), do not seem to follow the White Sea route as faithfully as Branta geese (see section 4.4. and Fig. 21–22). Consequently much lower percentages of the total flyway populations were observed.

The low numbers of swans and waders observed during the expedition (see Appendix 5) can mainly be explained by the timing of their migration period. Whooper swans were just beginning their migration (see section 4.2.), but bewick's swans are probably using more southeastern migration route, since only few birds were recorded (see Appendix 1). Migration of the waders was mainly over for the autumn (e.g. Lehikoinen & Vähätalo 2000, Pettay et al. 2004) and only young dunlins were recorded in larger numbers.

The abundance of eiders during the expeditions – with a total of 20 000 staging birds in 1999 and more than 12 000 birds in 2004 (see Appendix 5–7) – was notable. According to Koryakin et al. (2002) the total breeding population of the White Sea is about 10 000 pairs. Since more than 80 % of these birds were moulting adult males, either a lot of males must have come to the White Sea from somewhere else, or the estimate for the breeding population is far too low. The former conclusion is supported by information of Scott & Rose (1996), whose suggest that breeding birds from as far as Novaya Zemlya may come to the White Sea to winter. According to Bianki (1983) migration of eider males to their moulting areas in the White Sea occurs between the end of May and August. Eiders of different sex and age seem to also concentrate in completely different areas. Females and juveniles seem to prefer more shallow water areas, which are more difficult to survey by the vessel (see Appendix 1). Eiders winter

abundantly in the White Sea, mainly in the Onega Bay, in small areas which remain unfrozen all winter (Bianki et al. 1975, 1993).

4.2

Age and sex ratio

Age and sex ratios provide good information of the migration situation and breeding success. Male waterfowls tend to migrate earlier in the autumn than females and juveniles (Cramp & Simmons 1977) and migration phenology of different age classes can also be different. Clear male biased sex-ratios were observed throughout the expeditions for common eider, velvet scoter and goldeneye. This indicates that males of these species are moulting in the White Sea, before migration to wintering areas. This is supported by information in Bianki (1983), who presents that migration of common eiders, velvet scoters, goldeneyes, goosander and red-breasted merganser to their moulting areas in the White Sea occurs mainly between the end of May and August. Unlike these species in common scoter most of the observed birds were females or juveniles and only few adult males were recorded. Common scoter males are moulting in the Baltic Sea and they had already left in July and August before expeditions (Pettay et al. 2004, see also Appendix 5). In scaups the sex ratio changed during the expedition 2004 from male biased to female biased indicating that males migrate earlier in September and females and juveniles migrate mostly in October.

In wigeon proportion of males was fairly low 10–30 %. This indicates that adult males have mostly left already. The sex ratio of migrating long-tailed ducks was male biased indicating that migration was in the beginning since males are shown to migrate about one week earlier than birds in female-plumage (Leivo et al. 2001). In long-tailed ducks the proportion of males was higher in larger flocks. Thus, different size of migrating flocks is needed to be counted (not just small flocks, which are easier to count) to get reliable information about sex ratios of waterfowl.

Migration patterns of black- and red-throated divers seems to differ, since proportion of adult red-throated divers in breeding plumage decreased during expedition 2004 unlike in black-throated, whose proportion of adults in breeding plumage stayed same throughout the whole expedition. This indicates that in black-throated migration patterns of adults and young birds are similar unlike in red-throated, whose adults migrate before juveniles. However, a typical flock of red-throated divers included one juvenile and one adult, which was calling during the migration flight (Appendix 5). Leivo et al. (1995) have earlier described this phenomenon, which indicates that adults are leading juveniles in the beginning of autumn migration and teaching the suitable migration routes. Based on this, the early migrating adults in breeding plumage are probably failed in breeding, non-breeding birds or they are more "irresponsible" parents of the family, since red-throated divers have fairly often only one juvenile (average clutch size 1.7; Cramp & Simmons 1977). Proportion of adult red-throated divers in winter-plumage increased rapidly in October (Fig. 8), which indicates the beginning of moult of adults to winter-plumage. According to Jonsson & Tysse (1992) and Leivo (1995) red-throated divers moult rapidly, in a week or two, their body feathers from breeding plumage to winter plumage. Red-throated divers seem to start moulting into winter plumage earlier than black-throated, since black-throated divers did not show signs of body moulting.

Most of the observed whooper swans were adults, which indicate that migration was just in the beginning since non-breeding birds tend to migrate before family flocks of both parents and juveniles (Pöyhönen 1995). In 2004 altogether 18 broods of brent geese was counted with average brood size of 3.1 indicating fairly good breeding success (Cramp & Simmons 1977). Black guillemots and common gulls seem to have

excellent breeding success (31 % and 36 % of the observed birds were young birds, respectively) in 2004 comparing to arctic skua (Table 3, Appendix 5).

4.3

Diurnal patterns of migration

According to Alerstam (1990) ducks and geese are flexible in their migration times and migrate by day as well as by night. Thus, many species, having left a staging area, may continue to fly for more than a whole day without stopping. This is the case, for instance, with the geese that traditionally stage in areas quite distant from each other. This means that large flocks of birds may pass any observation point at very different times of the day, or during the night, depending on the distance from their last point of departure. Our results suggest that several species like wigeon, velvet scoter, scaup, long-tailed duck and barnacle goose tend to migrate in good numbers at the night. Especially, the ducks seem to prefer nocturnal migration showing late evening and early morning peaks (Figs 16–18, 20). Nevertheless, many diurnal birds tend to migrate in greatest numbers in the morning (Kontkanen 1995b, Leivo et al. 2001). The expeditions found this tendency to be clearest for divers (Figs 9–11).

By analyzing the diurnal rhythm of migration, some indications of possible points of departure of arctic birds may be obtained. Determining of distances to the departure areas is probably the most accurate concerning divers and on geese to some extent and the least certain on diving ducks, since they often prefer nocturnal migration (e.g. Pettay 1996).

In front Esko Gustafsson and back Nikolay V. Lapshin observing migration. Photo: Jorma Pessa

During the intensive diver migration days at Pertominsk intensive migration were observed during three periods. Assuming that divers (in case of Pertominsk mainly black-throated, see section 6.4. and Appendix 5) start their migration around dawn (in this case around 7:00 a.m.; Leivo et al. 2001) and with knowledge of average migration flight speed of divers, about 70 km/h + wind speed (Alerstam 1990), we may determine the average departure distances of these migration peaks. Clear early morning peak occurred in 7:30–8:00 (Figs 16 & 18) indicating that good numbers of divers have departed only maximally a few tens of kilometers off the Pertominsk coast. This area is probably stopping area for divers, who wait for better migration weather to cross the Onezhsky Peninsula. The second clear peak occurred just before noon (or around noon) at 10:00–12:00 (–13:30). These birds have probably departed from a distance of 250–450 (–550) km away from Pertominsk, which would be around the mouth of the White Sea Channel. The third (afternoon) peak was observed in 14:00–16:00 and these birds may have departed from as far as 600–850 km away from Pertominsk, from the Pechora Sea. The forenoon peak was clearly the strongest of these indicating that most of the migrants observed at Pertominsk would have departed around the mouth of the White Sea Channel. However, the fact that only one or two of three peaks occurred during one good migration day indicate that divers don't depart same areas every big migration day, but several important stop-over areas are used during migration from the Pechora Sea through the White Sea.

In case of red-throated diver, only two peaks were recorded: morning peak 8:30–10:30 and afternoon peak 12:30–15:30 (Fig. 13). Forenoon birds are suspected to have departed from the area of the White Sea Channel 150–400 km away from the main observation point Zhizhginski and afternoon birds have probably departed around the Kanin Peninsula and the Pechora Sea 450–800 km away from Zhizhginski.

In barnacle goose, migration showed only one clear peak during both expeditions. However, the timing of this peak differed in both expeditions (in 1999 at 11:00–14:00 and in 2004 at 13:00–17:00). This may be caused by two reasons: the barnacles have departed from different areas or the timing of departure has been different. The latter alternative seems more likely, since waterbirds seem to use mainly the same staging areas every year (e.g. Heath & Evans 2000). Geese are fairly flexible, being able to migrate during any time of the day (Alerstam 1990), thus migration of geese may start immediately when the wind conditions turn favourable in the departure areas, which would explain the difference in timing. However, late observation time of geese (especially Anser geese) during both expeditions indicates that these geese have departed far away outside the White Sea Channel. This is supported by Bianki et al. (1993) according to whose long-term studies white-fronted geese do not stage on the eastern shores of the White Sea at all, and bean geese only stage there in small numbers. In 2004, based on migration observations from Estonia and Sweden (www.vironlintuseura.fi, www.artportalen.se/birds) at least part of the barnacle geese migrated non-stop more than 2 500 km over the White Sea and the Baltic Sea (see Appendix 5).

4.4

Migration routes

Bianki et al. (1975) studied the volumes, routes and directions of migration in different species during extensive field studies carried out between 1956 and 1963 in various parts of the White Sea. These issues have also been fundamental to earlier Finnish ornithological expeditions to the area (Leivo 1993, Kontiokorpi 1996). These studies, together with the mass of data available from studies of eastern Finland and Estonia by Finnish ornithologists (Pöyhönen 1995, Pettay et al. 2004), give a relatively good

Dunlin (*Calidris alpina*) was the only wader species recorded in large numbers during the expedition. Photo: Aleksi Lehikoinen

picture of the migration route and directions used by different arctic species along the White Sea – Baltic Sea route.

The main direction of autumn migration for most of the species using the White Sea route is southwest, since they head to the Baltic Sea region to stop-over or winter. Some of the birds using the White Sea route may exceptionally migrate southwards to the Black Sea region – the black-throated diver being the best known example (Cramp & Simmons 1977). Another example seems to be arctic skua based on our data. During both expeditions heavy migration was observed to southeast direction at Pertominsk (Fig. 32). These birds were probably heading to the Black or Caspian Sea continuing on to their wintering areas Arabian waters (e.g. Olsen & Larsson 1997).

Some species, e.g. swans and Anser geese, migrate more or less directly southwest regardless of the coastline or peninsulas. Most of these birds leave the White Sea from Dvina Bay and the southern part of Onega Bay, and many use the Pertominsk route (Bianki et al. 1975). Contrastingly, some other species, such as red-throated diver, brent geese, long-tailed duck and common scoter to some extent, normally follow the coastlines up to the western coast of the White Sea before heading over the mainland (Leivo 1993, Leivo et al. 2001). These species are clearly more abundant in Zhizhginski and Belomorsk route than in Pertominsk route. The migration routes of common scoter have not ultimately clarified, since good numbers of staging common scoter were recorded in Pertominsk and Hedostrov areas, but any migration records confirming the crossing over the Onezhsky Peninsula at Pertominsk were not observed. By comparison fairly good migration numbers were observed at Zhizhginski. Common scoter may however cross the Onezhsky Peninsula west from Pertominsk, where no intensive observation was made (Fig. 28), which is supported by the findings of Kokhanov (1983). Because of this many of the migration routes coming into Zhizhginski Strait, as was observed during the expeditions.

The key areas for studying migration strategies in the White Sea are the Pertominsk coast and the Zhizhginski Strait, which are located along quite separate migration routes (Bianki et al. 1975). It has to be stressed that a comparison of these routes on the basis of expeditions' data is somewhat misleading, since observations were not simultaneous. The differences in the route selection detected during the expeditions may also be related to variations in the weather (especially the wind direction and speed), and the migration period of each species. For example the abundance of white-fronted geese recorded at Pertominsk was much higher in 1999 than in 2004, since heavy northwest wind in 2004 have probably pushed the migration route more to the east. However, our findings during both expeditions support each other and are

Observing took place from the second deck at the back of the vessel. From left Pekka Rusanen, Esko Gustafsson and Alexander V. Kondratyev. Photo: Jorma Pessa

strengthen by other data in the White Sea (Bianki et al. 1975, 1993, Kokhanov 1983), Finland (Pöyhönen 1995), Estonia (Pettay et al. 2004), and by map inspection.

According to the findings of this expedition, red-throated divers, clearly favor the northern route, past Zhizhginski. As can be seen in Figures 30–31, red-throated were much scarcer migrants at Pertominsk comparing to black-throated, which was abundant in both routes and perhaps even more abundant in Pertominsk.

Bianki et al. (1975) stated that the diver's main migration route was observed as going via Zhizhginski, and that only a minority of the divers migrated via Pertominsk, passing over the Onezhsky Peninsula. However, due to identification problems, their data could not distinguish between the two diver species, so no obvious differences in preferred migration routes could be revealed. Our observations at Pertominsk clearly demonstrates that tens of thousands divers are migrating over Onezhsky Peninsula and the Pertominsk route is really important flyway for black-throated divers (Fig. 31), in contradiction to the records of Bianki et al. (1975).

Another noticeable difference was that Anser geese were much abundant in Pertominsk than in Zhizhginski, which was preferred by brent geese. Barnacle geese were abundant along both routes. These findings are supported by many years of

observations in Finland (Pöyhönen 1995). Barnacles and especially brents, which leave the White Sea mainly from Belomorsk area, are abundant in Finland in most years. Anser geese, on the other hand, are normally much scarcer, and abundant occurrence is related to eastern winds, since their main migration route passes southeast of Finland (Pöyhönen 1995).

When discussing about the differences in preferences between these two separate routes long-tailed duck is the most extreme example (Fig. 27). Their numbers were remarkably bigger at Zhizhginski than at Pertominsk during both expeditions. Even the migrating long-tailed ducks observed at Pertominsk did not tend to cross the peninsula, but followed the coastline to west heading to Zhizhginski. This is well supported by the data of Bianki et al. (1975), according to whom only a small proportion of the long-tailed duck population use Pertominsk route, whereas huge numbers of long-tailed ducks fly around the Onezhsky Peninsula via Zhizhginski to Belomorsk region, from where they start their non-stop flight to the Baltic Sea.

4.5

Staging areas

Many important staging areas for arctic waterfowl were found during the expedition (Table 5, Fig. 33). Although concentrations more than 10 000 birds were counted in these areas, these numbers were relatively low compared to the total numbers of birds using the White Sea migration route (see Table 1) and to the numbers that have been recorded in many well-known wintering areas in the Baltic Sea region (see Durick et al. 1994). This can partly be explained by the fact that the daily numbers of birds in staging areas tend to be much lower than in wintering areas, because the turnover of birds in any staging area is high, with only a small fraction of the whole population staying in an area at any time. In autumn this is even more emphasized, because autumn migration period of many arctic migrants are much longer than spring migration period (e.g. Lehikoinen & Vähätalo 2000, Pettay et al. 2004). Unfortunately, no information on the rate of turnover among arctic birds on migration is available to our knowledge.

Bianki et al. (1993) reported surprisingly large maximum densities of over 10 000 birds/km^2 for long-tailed duck and more than 1 000 birds/km^2 for eider, common scoter and on Onega Bay, goldeneye. On the basis of our experiences, these must be figures calculated for the heaviest recorded concentrations, rather than averages for any larger areas in the White Sea. In either case, the older figures reinforce the evidence of the status of the White Sea as a very important staging area for migratory arctic birds.

The importance of the waters around sandy Hedostrov Island as a staging area is apparently a new discovery, as it is not mentioned in previous literature, such as Bianki et al. (1975). More importantly, this was the only location visited during the expeditions where the velvet scoters, the least known species of all the migratory arctic waterfowl species occurring in the White Sea region, was recorded in larger numbers. The large numbers of velvets scoters is probably related to food abundance and composition in the sandy waters around Hedostrov Island.

The food of velvet scoter is variable, and it depends on the habitats (e.g. Cramp & Simmons 1977). According to the data of Bianki et al. (1995), velvet scoter primary feeding habitats on the White sea are sandy-bottom substrates with infaunal clams, such as *Serripes groenlandicus*, *Tridonta borealis*, *Arctica islandica*, Ledidae, *Macoma baltica*, and also some crustatians, while blue mussels Mytilus edulis were taken in much less extent. This preference for selecting sandy bottoms as staging areas, probably affects the migration route of velvet scoters. For example in the northeastern Baltic Sea, the

Sandy bottoms where food availability (e.g. blue mussels) is good probably affects the selecting of migration route of velvet scoters.
Photo: Jorma Pessa

velvet scoters are staging much more bigger numbers in Estonian side (Gulf of Riga), which has sandy bottoms unlike in northern Finnish side of Gulf of Finland, which has mainly stony or rocky bottoms, where velvet scoter numbers are relatively low (e.g. Pöyhönen 1995, Pettay et al. 2004). In Lithuanian coast of the Baltic Sea this species also demonstrates a significant tendency to occupy marine areas with sandy bottom substrates at depths between 2 and 30 m. The diet of velvet scoters here was dominated by benthic organisms common in the soft bottom biotopes: namely the infaunal bivalves Mya arenaria and Macoma baltica, crustacean Mesidothea entomon and polychaete Nereis diversicolor (Zydelis 2000). In case of the White Sea velvet scoters prefer eastern parts of White Sea, which has sandy bottoms unlike western sides, which are rocky or stony (see Fig. 29) (Niemelä et al. 1993, Koistinen et al. 2001).

Relatively high numbers of black guillemots in the coastal waters of Solovetski and Anzerskij Islands (Fig. 35) were also noteworthy. The observed densities 3.9 birds/km^2 in 1999 and 1.25 birds/km^2 in 2004 based on staging areas (see Table 5) and 1.81 birds/km^2 based on transect line counts in 2004 (see Table 7), was as high as the densities in its most important wintering areas in the Baltic Sea (Durinck et al. 1994).

The huge concentration of 55 000 wigeon in Unskaya Bay in 2004 was one of the most important findings of the expeditions. Such big concentrations are rarely recorded even in the best wetland areas of Europe (e.g. Heath & Evans 2000, Pettay et al. 2004). The concentration represents about 4.6 % of the whole flyway population 1 200 000 (estimate from Hagemeijer & Blair 1997, Delany & Scott 2002). In particular the shallow north - north-western and north-eastern parts of the bay seems to be very important staging area for wigeons and the concentration carry out clearly the criteria of important bird areas (IBA) in Europe (Heath & Evans 2000).

Nearly all the concentrations in the most important areas (except eider, Table 5) as well as many other concentrations (Appendix 5) and densities of transect line counts (Table 7) were bigger in 2004 than in 1999. This could be caused by more unsuitable migration weathers in 2004 than in 1999 (see section 2.3.). Due to unfavorable migration weathers birds may have stopped migration more often than during better migration weather. By way of comparison, the heaviest migrations of each group of

arctic birds (geese, divers, ducks and skuas) were higher in 1999 than in 2004 (Appendixes 5–7), probably for the same reason. Migrations were more intensive due to more suitable migration weathers in 1999 than 2004, since birds prefer to migrate during the tail-wind (e.g. Alerstam 1990, see also section 3.3.2).

The coastal waters between the Suhoe and Sumskij Posad, southwestern Onega Bay, are known to be a very important staging area, especially for brent goose and wigeon (Bianki et al. 1975, Leivo 1993, Kontiokorpi 2002). Unfortunately, due to strong winds and heavy swell conditions the accurate exploration of this area was not possible. However, in 2004 the evening flight of geese and ducks was counted in the outer see, even though the species could not be exactly identified this count gave at least the minimum estimates of the geese and ducks in this area. 20 000 geese and 6 000 ducks recorded in 2004 suggested the high value of the area for waterfowl.

4.6

Transect line counts

The data from transect line counts (see Tables 6–7) revealed that the densities of staging birds in off-shore areas outside the important staging areas were low. However, during these expeditions transect lines were counted only while the research vessel was sailing directly from one study area to another and not along the previously planned zig-zagging route which should have given better coverage of the most promising coastal areas – a procedure which would be followed during a more thorough survey. Since the identification of the most important concentrations of birds and the related counts of numbers and densities of birds were carried out using another method (see sections 2.5. and 3.3.), transect line counts were mainly used merely to provide comparative density values for assessing the importance of staging areas. Nevertheless, transect line densities give impressions of the general abundance of species in different sea areas of the White Sea (Table 7). For example the density of velvet scoters was clearly the highest in eastern Onega Bay, indicating that this area is generally important for the species also outside the main staging area around Hedostrov Island. Thus, the information of transect line counts, despite fairly low densities, is useful to support the results of staging areas and main migration routes of species (see more accurately Appendix 5). Based on densities of transect line counts the most important sea area for staging birds were clearly the western part of Onega Bay (Table 7), which is supported by the observed concentrations outside the lines (Figs 27–28 & 30).

5 Marine mammals

White Whale, Beluga, (*Delphinapterus leucas*) is the only widely distributed marine mammal in the White Sea.
Photo: Aleksi Lehikoinen

Although marine mammals were not the primary target species of the expeditions, they were observed during the expedition almost as assiduously as birds. Every sighting of a marine mammal was also noted on the bird sighting forms. Detecting marine mammals at sea is more challenging than observing birds since even a moderate swell can easily conceal the shape of a seal or a whale between the waves. Seals on the shore are of course much easier to detect and identify.

Three species of marine mammals were recorded during both expeditions: ringed seal (*Phoca hispida*), bearded seal (*Erignathus barbatus*) and beluga whale (*Delphinapterus leucas*). These three species are the most widely distributed marine mammals in the White Sea (Jensen 1993).

The ringed seal was the most frequently observed marine mammal during the expeditions, with total records of about 272 animals (plus 49 unidentified seals) in 1999 and about 450 animals (plus 71 unidentified seals) in 2004. During both expeditions the highest daily totals were counted on the way from Solovetski Island to Pertominsk, with the largest numbers recorded in the vicinity of the Solovetski, Muksalma and Anzerskij Islands (1st Oct 1999 233 animals and 27th Sep 2004 163 animals plus 57 unidentified seals). The weather conditions during both days were cloudy with light or weak wind, which facilitated the seal counts. Another very good ringed seal area was coastal waters of Pertominsk. On 3rd Oct 2004 at least 123 animals was counted during the low tide resting on stones and beach near the coast line. The highest records of ringed seals during expeditions are shown in Figure 39.

The bearded seal was not observed so numerously as ringed seal, although few dozens were recorded during both expeditions. In 1999 about 70 animals were recorded, with the better part – a concentration of 50 animals – between Kondostrov Island and Nimenia Bay in the eastern part of Onega Bay. In 2004 about 37 animals was recorded, with better concentrations of eight individuals in eastern Onega Bay, 12 individuals around Solovetski and Anzerskij Islands and about 8 individuals off Pertominsk in Dvina Bay.

The total numbers of fascinating beluga whales were about 70 during expedition 1999 and about 170 in 2004. The highest numbers were observed during both expeditions between Solovetski Island and Pertominsk. In this area 37 animals were

recorded on 1st Oct 1999 and 114 animals were recorded on 27th Sep 2004, when the weather conditions were also advantageous to observe marine mammals. The highest concentrations recorded during the expeditions are shown in Figure 40. In addition to adults, one sub-adult and three young, greyish-coloured whales were recorded in 1999 and 130 adults and 8 immatures were identified in 2004.

Based on transect line counts (Table 7) and other observations, the most important sea area for marine mammals were area around Solovetski, Muksalma and Anzerskij Islands.

Ringed Seals (*Phoca hispida*) resting on the stones during the low tide at the mouth of Unskaya Bay. Photo: Aleksi Lehikoinen

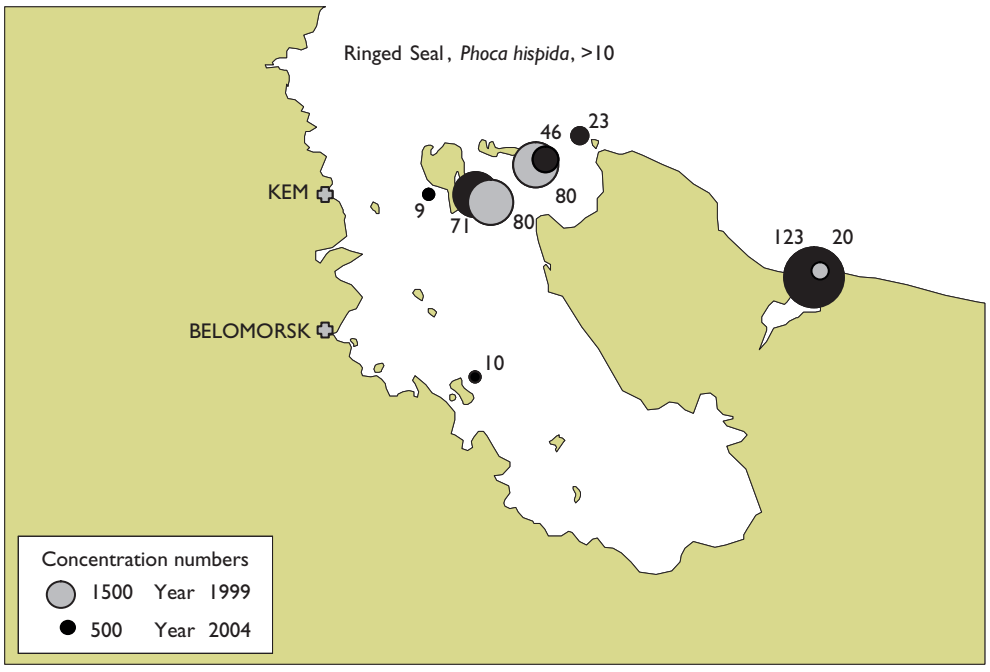


Figure 39. Positions of observed concentrations (> 10 ind.) of ringed seals during the White Sea expeditions 1999 and 2004.

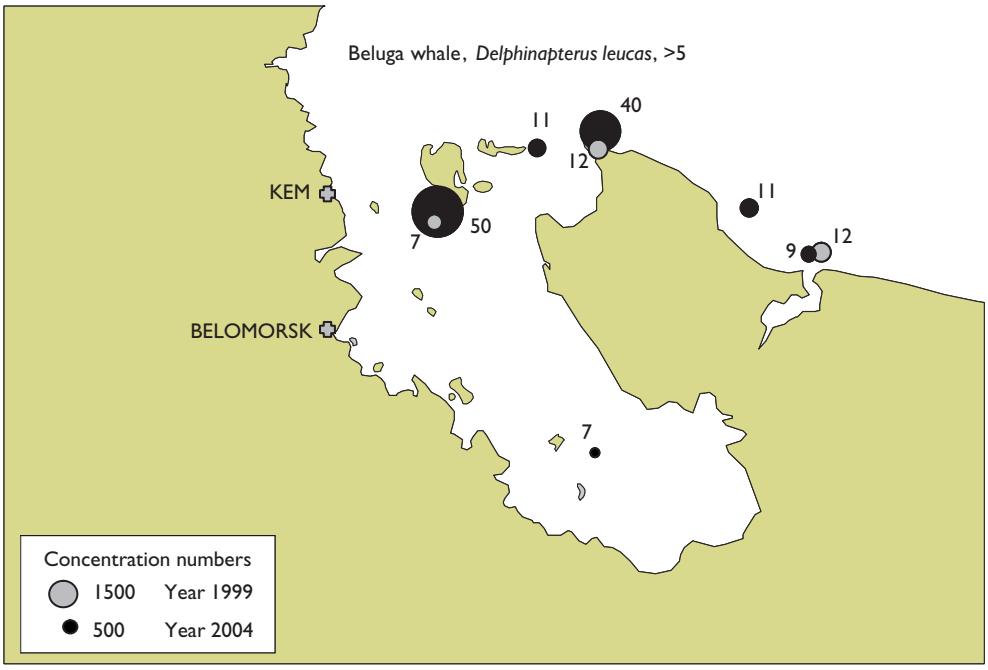


Figure 40. Positions of observed concentrations (> 5 ind.) of beluga whales during the White Sea expeditions 1999 and 2004.

6 Conclusions and proposals for action

The White Sea expeditions were successful. In general, the numbers of migrating birds recorded were much higher than those reported by Bianki et al. (1975) for several reasons. Firstly the populations of the migrating arctic birds of the White Sea flyway have changed from the study days of Bianki. Especially the populations of geese have increased significantly (e.g. Cramp & Simmons, Delany & Scott 2002). Secondly knowledge of bird identification have increased during end of the 1990s and the participants were highly experienced observers, which had the chance to choose ideal anchorages for the vessel with regard to the observation of migration and thirdly high-quality equipments (telescopes, binoculars etc.) nowadays make identification possible from further off than in 1950s or 60s.

The findings from this kind of expeditions do not necessarily give completely reliable information on the staging areas of arctic birds in the area discussed. The situation can change rapidly as migration progresses, and sites occupied only by few birds one day may crowd with large numbers of birds on another day. This was well documented by comparing the found concentrations of expeditions 1999 and 2004. The data can clearly reveal that certain areas are important, but cannot be relied upon to infer that other areas are not important, or to indicate the maximum numbers of birds that can be seen in any area during a whole migration period. Although many important staging areas may be revealed even during such brief surveys, other known and presumed staging areas should be surveyed using extensive counts during the whole migration period for at least one season, or preferably over two or three years, to get a more comprehensive idea of bird numbers and the dynamics of concentrations in different areas.

The expeditions revealed that vessel survey is not the only suitable way to study staging areas in expansive areas of sea. Other methods for monitoring, surveying and exploring staging areas and migration routes could be aerial count by aircraft, visual migration observation in a single place, satellite telemetry and radar transmission. Advantages, disadvantages and costs of all these five methods are summarized in Table 8.

Observing is conducted the whole daylight time near the village of Pertominsk. Observers from right Nikolay V. Lapshin, Olli Lamminsalo, Pekka Rusanen, also making notes, Timo Asanti, Esko Gustafsson and Aleksi Lehikoinen. Photo: Jorma Pessa

Table 8. Use of five different study methods of bird migration in the White Sea area. Their advantages, weaknesses, costs and use in practice.

Method	Advantages	Weaknesses	Costs and use in practice
Vessel survey (including opportunity to use small boat)	• Enables to stop and spend longer period in a suitable observation place	• The vessel can not enter the areas of shallow waters (depth < 5 meters)	• Costs are fairly low. Price of three week expedition around 10 000 euros. Several vessel surveys have been already carried out.
	• Enables to higher identification percent than in aerial counts, because of the longer observation period and thus makes possible to spot the uncommon species and separate different plumages of the birds	• Because of strong winds it is seldom possible to use small boat to enter the shallow waters	
		• Moving is fairly slow and only small part of the area can be surveyed during a single day	
	• Enables to do transect line counts in deeper waters (depth > 5 m)	• If using the vessel 'Ekolog', the survey need to be concluded before 15th October, when the Baltiskij - Belomorsk channel is closed for the winter	
	• Enables possibility to observe visual migration and study migration routes		
Aerial surveys	• Enables to survey most parts of the southern White Sea in a single day	• Difficult to detect scarce species and species, which do not aggregate in larger numbers (e.g. divers).	• Costs are fairly expensive. Optimally surveys could be done once or twice a week during the whole migration season. Cost of one-day-survey is more than 1000 euros.
	• In theory enables to choose optimal survey dates with good weather conditions	• Difficult to identify different plumages of the birds	
	• Enables to survey also the areas of shallow water	• Not possible to stop to survey of visual migration	
	• Enables to do transect line counts in all parts of the sea-area		
Visual migration observation in a single area	• Enables to study migration volumes and directions	• Not possible to survey staging areas outside the observation area or nocturnal migration	• Costs are low. Food and accommodation are cheap. Several short periods monitoring projects have been carried out in the Belomorsk area (e.g. Leivo 1993, Kontiokorpi 2002).
	• Enables to study diurnal rhythms, difference in timing of migration between different sexes or age-classes, or other details of migration dynamics	• Several study sites are needed to determinate the main migration routes	

Method	Advantages	Weaknesses	Costs and use in practice
Satellite telemetry	• Enables to study the migration individually including accurate staging sites, migration routes and timing of migration and staging periods.	• Only small numbers of birds can be deployed by transmitters.	• Expensive. One satellite transmitter cost around 4000 euros (http://microwave telemtry.com/Bird_PTTs/price.php) and Walker (2005) has proposed that at least 20 or more transmitters are needed to generalize the results to the larger population. Migration routes of the brent geese and bewick swans have been studied in the White Sea flyway previously (Nolet et al. 2001, Green et al. 2002a, 2002b, Klaassen et al. 2004).
	• Enables to find new undiscovered staging areas also outside the White Sea area	• Because of small sample size the results could be difficult to generalize to concern the whole population of the flyway.	
Radar transmission	• Enables to study migration volumes and migration routes	• Migrating species can not be identified directly from the radar screen, but species or taxon of the migrants can be suggested by the knowledge of phenology and visual migration observations.	• Expensive. However, if there are suitable weather radars in Arkhangel and Belomorsk, these could be used. To our knowledge radar has not been used before in the White Sea area, but there are some studies already in the Baltic Sea area (e.g. see Alerstam 1990).
	• Enables to study nocturnal migration		
		• Only part of the White Sea can be scanned from one spot.	

Due to data of expeditions the main migration routes of most of the arctic birds could be determined. The locations where the heaviest migration could be observed, known as migration channels, are the Zhizhginski Strait, the Pertominsk area and, to lesser extent, the coast around and south-east of Belomorsk. Such channels could play an important role in setting up a low-budget monitoring system to study populations' changes, breeding success and other respect of the ecology of arctic species, as well as providing basic data on diurnal rhythms, difference in timing of the migration between different sexes or age-classes, or other details of migration dynamics like it have been done in Finland and Estonia (e.g. Leivo et al. 1994, Pettay 1996, Kontkanen 1995b, 1996, Lehikoinen & Vähätalo 2000, Pettay et al. 2004). The monitoring of the populations of arctic bird species should be ideally conducted both at Zhizhginski and at Pertominsk at the same time, since their species compositions are quite distinct.

Findings related to the studies of the daily patterns of migration observed during the expeditions support the idea about the importance of the White Sea Channel and Pechora Sea regions as research areas, since they evidently contain important staging areas for many arctic species. Furthermore, from map inspection, it can be supposed that the White Sea Channel is also a significant migration channel for arctic birds.

Another possible shortcoming of expedition was that potential staging areas could only be surveyed along 5–10 km wide sectors along either side of the vessel's route during good weather conditions. As a result, large sea areas remained uncovered. However, most staging areas should have been evident, since arctic water birds normally stay in waters less than 20 meters deep to feed (Durick et al. 1994), and the vessel sailed in such waters for most of the voyages. Areas that remained undiscovered most probably include some stop-over areas in the open sea, and others in waters right along the coast which could not be reached by the vessel. Base on the results of the expeditions, especially brent geese and wigeons seem to prefer shallow tidal bays, which are impossible to reach by the vessel.

By vessel it is difficult to react to rapid changes in the numbers of staging birds during a migration period. A survey of the whole White Sea takes at least several weeks, during which time many migrating species would pass through the area and many large concentrations would remain undiscovered. If transect line counts were also widely conducted at the same time, the survey would last for at least another two weeks.

In conclusion, a survey of staging areas in an area the size of the White Sea cannot be comprehensively conducted by using a vessel alone. However, using a vessel survey to map staging areas has some benefits compared to aerial surveys, the other much used method for counting birds on the sea. These benefits included the long observation times for each recorded individual (resulting better identification percentages, better chances to discern the plumages of birds, and more accurate counts of numbers of birds), better chances to detect elusive and more sparsely distributed species like divers and auks, which can easily remain undetected during aerial counts (Komdeur et al. 1994), and lower costs (Table 8).

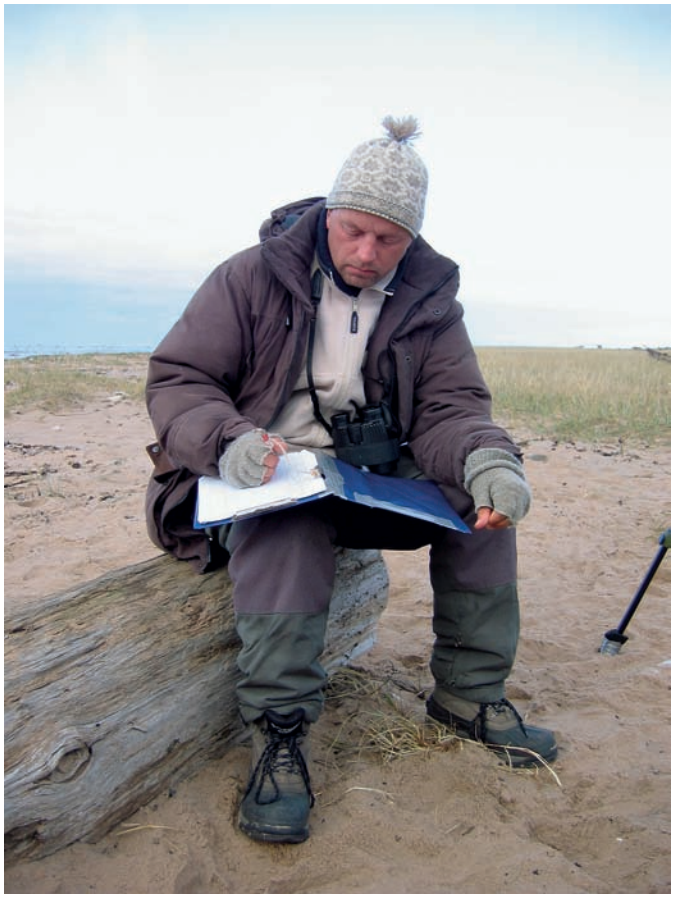
Organizing intensive aerial counts over the White Sea would be essential for research into important staging areas. In addition, to get a clear overall idea of the dynamics of concentrations of migratory arctic species, aerial surveys should be simultaneously carried out in adjacent parts of the migration route, i.e. over the White Sea, Lake Ladoga, the Gulf of Finland and perhaps Estonian waters. Since the timing of peak migration differs in many arctic species the surveys needed to be made several times during the migration period to get overall view of concentrations of most of the species. In addition to aerial counts, vessel surveys should also be organized in certain limited areas.

Research projects like this are necessary to give keys for the adequate protection of arctic migrants. The impact of conservation measures taken in these birds' relatively well-known and protected breeding and wintering areas in Western Europe is somewhat diminished if their staging areas along their migration routes remain unknown and unprotected. In general, staging areas are very sensitive to environmental risks during migration periods, since very large numbers of birds simultaneously concentrate in very limited areas.

Since migration routes of many arctic migrating birds are finally started to understand in the Baltic Sea and the White Sea, after studies of many decades, it start to be time to collect all the information of the Baltic Sea – White Sea flyway into one database. This database, would give information of migration routes of each species including all the known important staging areas and what time of the year areas are used in larger numbers. Such information would be irreplaceable when measuring possible effects of oil-spill to birds in different parts of the flyway. The database would be important when planning to establish new nature protection areas for the water areas. In case of the White Sea the most important areas for arctic birds are at least waters off Belomorsk including Suhoe and Virma archipelago, waters around Hedostrov Island and Solovetski, Muksalma and Anzerskij Islands (also the most important area for marine mammals) and Unskaya Bay (including the mouth of the bay). However, the migration of the arctic birds occur not only between the Baltic Sea and the White Sea, but the breeding areas of most of birds are situated in wide areas in Russian tundra, that is why the migration continues much further northeast from the White Sea. How the migration routes of arctic species continue through these northeastern areas and where the important staging areas are situated, are mostly unknown. In the future, more attention should be paid to solve how migration of arctic birds passes through e.g. in Kanin Peninsula and Pechora Sea area.

Based on the results of expeditions several proposals for action can be proposed:

- Gather all the information of the migration routes and important staging areas of arctic birds of the White Sea and the Baltic Sea flyway into one publication
- Work out protection plans of the most important staging areas of arctic birds and sea mammals in the White Sea
- Work out an operation plan in case of possible oil-spill in the White Sea
- Organize aerial survey(s) in the White Sea to explore the shallow water areas, which could not be studied from the vessel and thus remained less attention during the expeditions
- Organize new expeditions to study the migration routes and search important staging areas of arctic birds around the Dvina delta, Kanin Peninsula and the Pechora Sea
- Organize new expeditions to explore the migration routes and search important staging areas of arctic birds in the White Sea area during the spring migration



Everybody did also the secretary work. Observations were written down on a special form ac-cording to 30-minute periods. In the evening the daily data was computerized i.e. documented on an excel-program. Here Pekka Rusanen writes down on the form the observations that has been an-nounced. Photo: Jorma Pessa

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APPENDIXES

Appendix 1. The timetable and destinations of the expedition 1999.

21.9.	Arrival at Petrozavodsk, departure by vessel for the Belomorsko – Baltickij canal, overnight at Lake Onega.
22.9.	Entry to the Belomorsko – Baltiskij canal, all day passing through the locks of the canal, overnight at Lake Vygozero.
23.9.	All day passing through the canal, overnight near the city of Belomorsk.
24.9.	Arrival at Belomorsk in the morning, entering the White Sea in the evening, overnight near Osinka Island.
25.9.	Departure for the coast off Suhoe in the morning, departure for Razostrov Island in the afternoon, overnight of the island.
26.9.	Departure at noon for Kondostrov Island, overnight off the island.
27.9.	Late morning departure, anchoring near delta of the River Njuhtsa in the afternoon and exploring the delta with small boat, departure for Nimenia in the evening, overnight on the bay.
28.9.	Departure for Uhtalahti Bay in the afternoon, overnight on the bay.
29.9.	Departure for the Zhuzhmui Island in the late morning, landing and exploration by foot of Great Zhuzhmui Island in the evening, overnight off the island.
30.9.	Departure for Solovetski Island in the morning, exploration of the western coast of Solovetski, anchoring at noon, and overnight at the harbour of Solovetski Island, exploring the island by foot in the afternoon.
1.10.	Departure for Pertominsk in the morning, arrival in the evening and overnight at the village of Pertominsk.
2.10.	All day in Pertominsk area, in the morning anchoring off the coast, and landing on the mainland with a small boat for the day, moving to Unskaya Bay in the afternoon and exploring the northern part of the bay by boat and on foot, overnight at the Pertominsk harbour.
3.10.	All day in Pertominsk, anchored off the coast, returning to the harbour for the night.
4.10.	All day in Pertominsk area, the vessel moving to an anchorage 10 km off the coast, then back to the harbor for the night.
5.10.	Morning in the Pertominsk area, the vessel moving to an anchorage off the coast, departure for Zhizhginski in the afternoon, anchoring and overnight in the middle of the Zhizhginski Strait.
6.10.	All day in Zhizhginski Strait.
7.10.	All day in Zhizhginski Strait, sailing to the western side of the strait in the evening for the night.
8.10.	Out into the Zhizhginski Strait in the early morning, all day in the strait, departure for Belomorsk in the evening.
9.10.	Arrival on the Belomorsk coast during the night, observation of migration in the morning, entering the Belomorsko – Baltiskij canal through the first lock in the afternoon, overnight in a harbor of Belomorsk.
10.10.	Observation of migration in the morning, departure for Petrozavodsk at noon and the expedition ended.

Appendix 2. The timetable and destinations of the expedition 2004.

21.9.	Departure from Kajaani (Finland) at 9 a.m. by minibus and arrival at the city of Kem (Russia) 8 p.m.
22.9.	Whole day observation of migration in Kem harbor.
23.9.	Departure Kem at 7 a.m. and arrival to Suhoe Archipelago at 11:20 a.m. Departure to Suhoe Archipelago at 1 p.m. and arrival at outer archipelago of Suhoe 3 p.m. Observation of migration whole evening.
24.9.	Whole day in outer archipelago of Suhoe – Virma Bays. Afternoon and evening in Suhoe Archipelago counting the flying geese (present) above the coast (Suhoe and Belomorsk area).
25.9.	Departure from Suhoe Archipelago early in the morning. Exploring the southern coastal areas of Onega Bay (inc. Mjagostrov Island) till the Island of Hedostrov. Departure from Hedostrov at 3 p.m. along the outer archipelago of Kondostrov Island and arrival at Solovetski at 10 p.m.
26.9.	Whole day in the island of Solovetski. Observing in the village and surrounding areas; the Botanical garden, Boat station and Dolgaya (Long) Bay.
27.9.	Departure from Solovetski at 8:30 a.m. and exploring the southern and eastern waters of Solovetski Islands and eastern and northern waters of Antzerskij Island. Arrival at the village of Pertominsk in the evening at 9 p.m.
28.9.	Observing migration from the ship outside Pertominsk till 10 a.m. Exploring staging waterfowls around outer sea-area of Pertominsk from 10 a.m. till 1 p.m. Observing in Pertominsk village area rest of the day.
29.9.	Whole day in Pertominsk and exploring the Unskaya Bay (9:30 a.m. 3:30 p.m.) with little boat.
30.9.	Whole day in Pertominsk observing migration.
1.10.	Whole day in Pertominsk observing migration.
2.10.	Whole day in Pertominsk observing migration.
3.10.	Whole day in Pertominsk observing migration.
4.10.	Departure Pertominsk at 8:00 a.m. and arrival to Zhizhginski Strait at 1:30 p.m.
5.10.	Whole day in Zhizhginski Strait observing migration.
6.10.	Whole day in Zhizhginski Strait observing migration.
7.10.	Departure Zhizhginski strait at 1:00 p.m. and arrival to Solovetski 5:30 p.m.
8.10.	Departure Solovetski at 7:30 a.m. and arrival at Zhuzhmui 11:00 a.m. Departure Zhuzhmui 1:00 p.m. and arrival at Belomorsk 3:00 p.m.
9.10.	Observation whole day in the area of southern part of Belomorsko – Baltickij canal.
10.10.	Departure Belomorsk 7:00 a.m. and arrival at Kajaani 1:00 p.m. Expedition ended.

Appendix 3. Weather conditions during the White Sea expedition 1999.

Date	Temp. (°C)	Wind speed (m/s) and direction	Cloudiness	Visibility	Other information
21.9.	+13	W 5	2=>6/8	10–20 km	
22.9.	+10	WNW 3	4/8	10–20 km (200 m)	occasionally foggy
23.9.	+6/+13	NW 1/S–SW 2	1-2/8	>20 km	
24.9.	+6/+10	SE 5/N 8	6=>8/8	10–20 km	light rain in the evening
25.9.	+8/+10	N 8/N 12/N 9	8=>6/8	10–20 km	
26.9.	+8	N 5/E 3	8/8	10–20 km	
27.9.	+8	E 2–3	8/8	2–4 km	rain till 14:00
28.9.	+8	NW–W 6/SW 4	8=>6/8	2–4 km/10–20 km	rain forenoon, showers aftern.
29.9.	+6/+8	SE 4/SE 12	6=>8/8	>20 km/2–4 km	rain forenoon
30.9.	+6	S 4/SW 6	5=>3/8	>20 km	
1.10.	+10	E 2/E 4	7=>3=>8/8	>20 km (1–2 km)	occasionally foggy
2.10.	+9	SW 10	8=>6/8	10–20 km(1–2 km)	showers in the evening
3.10.	+6/+12	WNW 8/ S 2/E 4	6-8/8	10–20km/4–10 km	occasionally light rain
4.10.	+8/+12	S 4/S 6	7/8	10–20 km	
5.10.	+8/+10	SW 4/S 6	6=>4/8	2–4 km/>20 km	rain till 8:00
6.10.	+6	S 1–3	0-8/8	4–10 km (<200 m)	whole day foggy
7.10.	+6	NE 4/NE 8/NE 10	3=>8/8	>20 km/4–10 km	rain from 16:30
8.10.	+6/+10	SW 3/SW 14	3=>6/8	>20 km	afternoon showers
9.10.	+8/+10	SE-E 3–5	7-8/8	10–20 km/4-10 km	occasionally rain
10.10.	+6	NE 4	8/8	1–2 km	light rain

Appendix 4. Weather conditions during the White Sea expedition 2004.

Date	Temp. (°C)	Wind speed (m/s) and direction	Cloudiness	Visibility	Other information
22.9.	+9/+15	ESE 12/SE 10/SE 14	8/8	4–10 km	showers from 16:30
23.9.	+10	SE 12/SE7/0/SW 3/SW 7	8/8	2-20 km/>20 km	rain till 15:30
24.9.	+10/+13	SE 7/SE 4/ S 6	5–7/8	>20 km	one shower 8:15–9:15
25.9.	+9/+12	SE 7/SSW 4	7/8	>20 km	few showers
26.9.	+8/+12	E 2/ S 2	4/8	> 20 km	whole day very still
27.9.	+8/+10	SSE 2/ SE 6	8/8	100-200 m/>20 km	foggy morning, rain 13–19
28.9.	+10	SE 4/SE 12/SE 6	8/8	10-20 km/>20 km	weak rain till 17:00
29.9.	+6/+11	SSE 6/WSW 3	6–8/8	>20 km	weak showers till 16:00
30.9.	+8/+9	NNW 10/8/12	8=>6/8	2-20km/>20 km	rain till 13:30 (heavy 12–13)
1.10.	+6/+8	WNW 3/NW 5/NW 12	5–8/8	>20 km	one weak midday shower
2.10.	+6/+8	NW 5/NNW 10/NNW 5	5–8/8	mainly >20 km	several short showers
3.10.	+5/+8	SW 0–2	5–8/8	mainly 10-20 km	two afternoon showers
4.10.	+7/+9	WSW 4/W 10/W 6	8=>4=>8/8	>20 km	no rain!
5.10.	+6/+8	SW 4/SSW 12/SSW 7	2–8/8	>20 km	rain in the evening 21:30=>
6.10.	+8	S 12/SW 12	8/8	2-10km/>20 km	rain 8:50–10:00
7.10.	+8/+7	W 8/WNW 12-14/W 7	5–8/8	>20 km	
8.10.	+5/+3	N 7/E 14	8/8	2-10km/10-20 km	rain till 12:00
9.10.	+0/+3	WNW 2/NW5/NNW 4	1–7/8	>20 km	
10.10.	-2	N–NW 3–5	1–2/8	>20 km	occasionally weak snowing

Appendix 5. Annotated list of the bird species recorded during the White Sea expeditions 1999 and 2004.

The figures after the name of each species indicate the total number of individual birds of the species identified during the expeditions at the White Sea area. Expeditions are separated with diagonal 1999/2004. For some species these figures are lower than the corresponding figures in Table 1, which also include some unidentified birds allocated to each species according to their respective proportions amongst the birds of their species group identified. For many species largest numbers recorded on any single occasions or day are also noted.

Abbreviations: ind. = individual, m = migrating, ad = adult, subad = subadult, imm = immature, cy = calendar year (e.g. 3cy is a bird of the third calendar-year, +3cy is older than 3cy), the cardinal points are shown using first letters e.g. SW = southwest.

The following 142 species were observed during the expeditions.

Mute swan *Cygnus olor* 0/4
One flock of four ind. (+1cy) were swimming in the outer archipelago of Suhoe on 24-25th Oct 04, which is probably the first record of the species in the White Sea area. The nearest breeding areas are situated in eastern Gulf of Finland in the Baltic Sea (Hagemeijer & Blair 1997).

Bewick's swan *C. columbianus bewickii* 9/2
Surprisingly few sightings were made. Much heavier migration was expected in the Pertominsk area since it was known that the species uses the south-eastern route on the way to wintering areas in north-western Europe and based on observations from Finland the main migration period from the White Sea to the Baltic Sea should have been during the expeditions: end of September and the first two weeks of October (Pöyhönen 1995). According to Bianki et al. (1993) the bewick's swan is more abundant on Dvina Bay than the whooper swan.

Whooper swan *Cygnus cygnus* 33/140
Although whooper swan was clearly the most abundant swan species during the expedition, quite small numbers were observed. Unlike bewick's swans, whooper swans are known to concentrate to some extent in the White Sea (Bianki et al. 1975), but probably due to the late migration of the species (Pöyhönen 1995) no staging migratory birds were observed during these expeditions. In 1999 39 and in 2004 153 unidentified swans were also observed migrating. The greatest observed migrations were recorded at Pertominsk: 30th Sep 04 27 + 35 unidentified swans and 1st Oct 04 7 + 96 unidentified swans. Nearly all the observed whooper swans were adults or subadults (+1cy) (less than 2% were juveniles), which indicates also that migration was just at the beginning. Swans are known to migrate in family flocks (including both parents and juveniles) to their wintering areas and non-breeding birds are known to migrate before these family flocks (Pöyhönen 1995). In the southern Kola Peninsula thousands of moulting subadult whooper swans are known to concentrate (Bianki et al. 1975, Scott & Rose 1996).

Bean goose *Anser fabalis* 1 343/1 667
Although recorded in fairly large numbers, bean goose was the least abundant of the four most numerous arctic goose recorded during the expedition. All the birds were observed on migration. One heavy migration was recorded during both expeditions at Pertominsk: on 3rd Oct 99 1 292 ind. and on 30th Sep 04 1 172 ind. (with the relevant proportion of unidentified birds added to this sum, the numbers of birds on those days

were actually much higher). In 1999 bean geese occurred mainly in the same flocks with white-fronted geese which indicates that they may use same staging areas, and they are both strongly associated with Pertominsk route (see Fig. 21). However in 2004 bean goose migration occurred bit earlier than white-fronted goose migration. During the heavy migration on 30th Sep only one white-fronted goose was identified and larger mixed flocks of bean and white-fronted was not recorded until on 2nd Oct. This indicates that at least some of the staging areas are different.

Most of the birds recorded were probably so called tundra bean geese, subspecies *rossicus*, since all the individuals, which were observed good enough to determine the subspecies, were identified as rossicus (n = 124). The timing of migration indicates also rossicus, because birds of nominate subspecies (so called taiga bean goose) migrate usually earlier in September (Pöyhönen 1995, Pessa et al. 2004). *Rossicus* is known to breed in tundra area east from Kola Peninsula and fabalis subspecies in taiga zone from Scandinavia to West Siberia (Pessa et al. 2004). Especially birds of northern Russia (most of *rossicus*, according to Delany and Scott 2002 population 600 000 ind., and eastern birds of *fabalis*, total population 100 000 ind.) probably use a more south-eastern route to their wintering areas in Central and NW Europe. The yearly numbers of bean geese observed during autumn migration at Finland have been quite stable and there is not so big year variation depending on weather, especially wind, conditions during the migration period as in white-fronts (Pöyhönen 1995).

White-fronted goose *A. albifrons* 5 642/428
Recorded abundantly in 1999, but in 2004 only few hundreds of birds were recorded despite several good migrations of geese were recorded. Number of white-fronted geese recorded from Finland in autumns vary a lot depending on wind conditions during the migration period (Pöyhönen 1995) and probably north-western winds during all the good goose migrations in Pertominsk in 2004 have pushed the main migration route to southeast. Only one heavy migration was recorded in 1999: on 3rd Oct Pertominsk 4 401 ind. (with the relevant proportion of unidentified birds added to this sum, the numbers of birds on that day was actually much higher). Majority of population, that migrates through NW Russia (1 000 000 ind., Delany & Scott 2002), seems to use more south-eastern routes over the mainland of NW Russia to their wintering areas in Europe. The proportion of young birds was fairly low in 2004 (24 %, n = 70) indicating quite poor breeding success.

Grey-lag goose *A. anser* 0/1
One was migrating in flock of 110 White-fronts. Small numbers of grey-lag geese is known to breed in western Kanin Peninsula (Bianki et al. 1993) and according to Follestad & Golovkin (2000) grey-lag goose may occasionally breed in the eastern White Sea.

Barnacle goose *Branta leucopsis* 34 490/46 138
Barnacle goose was the most abundant goose species during the both expeditions. The White Sea is well situated along the migration route of barnacles from their breeding areas in northern Russia (Novaya Zemlya and adjacent areas) to their wintering areas in NW Europe. Staging and feeding birds were only on meadows of the White Sea islands (e.g. Zhizhginski Island c.1000 ind. in 1999). According to local ornithologist (Alexander Cherenkov discussion 26th Sep 04) small numbers of barnacle goose (up to a few thousands) have been recorded staging on eastern coastal area of Solovetski Island during autumns. However these birds may have stopped their migration, because of unsuitable weather. Kontiokorpi et al. (2002) have recorded up to 5 000 staging birds outside Virma-village in south-western White Sea. Barnacles feed on grasses and they need large open meadows or fields to their stop-over areas (Cramp &

Simmons 1977). Such areas are scarce in the White Sea area and most of the barnacles probably use the White Sea in autumns only as a flyway to their wintering areas.

Heavy migration occurred on many days: 3rd Oct 99 Pertominsk 6 148 identified birds, 6th Oct 99 Zhizhginski 6 871 ind., 7th Oct 99 Zhizhginski 17 666 ind. and 30th Sep 04 Pertominsk 2 274 ind., 1st Oct 04 Pertominsk 31 786 ind. and 2nd Oct 04 Pertominsk 6 332 ind. In Figs 10 and 14 can be observed that barnacle migration was the most intensive around noon (1999) and afternoon (2004). Assuming that majority of the birds had started their migration early in the morning and average flying speed is about 70 km/h (+ tailwind) (Alerstam 1990) the large majority of birds had probably departed from areas around Kanin Peninsula about 500-800 km from southern coast of Dvina Bay. The majority of barnacles were recorded in monospecific flocks, with only a minority of birds in mixed flocks, mainly with white-fronted and brents. These mixed flocks have probably formed during migration flight, because e.g. brent and barnacle geese use different foraging habitats (see also brent goose below). Based on observations of many bird stations and other observation places in 2005 the heavy barnacle migration recorded at Pertominsk on the 1st Oct continued till Estonia (2nd Oct) and Sweden (e.g. Öland on 2nd - 3rd Oct), where good numbers of barnacle migration were observed (internet pages of Estonian birding society and common observation report system of Sweden, Svalan). Some thousand were reported in Southern Sweden, which indicates that at least some barnacles migrated strait till Northern Sea (observation from Svalan-webpages).

Barnacles used both the Pertominsk and the Zhizhginski routes in large numbers (see Fig. 23). This is probably exceptional among geese, since Anser geese seem to clearly prefer the south-eastern route (Pertominsk), and brents northern route (Zhizhginski). A frequently debated detail of barnacle migration is its tendency to follow coastlines. On the contrary to earlier statements, according to Leivo et al. 2001, barnacles do follow coastlines whenever does not result in too much of a detour away from their main migration direction. This was well proved at the Zhizhginski Strait in 1999 where thousands of barnacles came from different eastern direction (some strait NE, some even from ESE) and were clearly following the coastline westwards. However, in 2004 when heavy migration occurred in Pertominsk all the flocks were migrating strait to SW, over the mainland at the wide front from both sides of Unskaya Bay.

Brent goose *B. b. bernicla* 16 980/7 500

The second abundant goose species during both expeditions, although if proportions of unidentified geese were included to sums white-fronts would have been more numerous in 1999. Brent geese showed clearly prefer western Zhizhginski-Belomorsk route, since they are commonly known to follow coastlines instead of minimizing the flight distance during spring migration. This behaviour (also in barnacles to some extent) facilitates feeding, drinking and resting on route (Green et al. 2002a). Brent geese have reported to have quite complex migratory system with several stopover places used in different ways by different individuals. However, same individuals have noted to use quite often same staging areas during both spring and autumn migration (Green et al. 2002b).

Very important concentration area is known to exist off the villages of Suhoe and Virma near Belomorsk, where a flock of 70 000 brents was recorded in autumn 1992 (Leivo 1993, Kontiokorpi 2002). Unfortunately due to heavy swell these areas could not be explored with care during expeditions. Nevertheless, in 2004 flocks of flying geese in the evening were counted further out sea above the areas and recorded 20 000 geese (unidentified) give estimate of the minimum numbers of birds and the importance of the area. Heavy migration was recorded at Zhizhginski on 6-8th Oct 99, 3 328 ind., 9 551 ind. and 3 459 ind., respectively, and at Kem on 22th Sep 04 1 963 ind. One individual of subspecies hrota which are normally breeding in Greenland

and Svalbard (Delany & Scott 2002) was recorded on 6th Oct 99. A few birds of hrota are recorded every year during the spring migration of brent geese in the Gulf of Finland (e.g. Pöyhönen 1995).

Wigeon *Anas penelope* 17 700/89 837
Wigeon is an abundant subarctic migrant in the White Sea, where it concentrates in large numbers on many bays (Bianki et al. 1975). During the expeditions three large concentrations were recorded: 55 000 ind. in Unskaya Bay (2004), 10 000 ind. in southern part of Uhtalahti Bay (1999) and 6 000 ind. (unidentified Anas-ducks, probably wigeons) in coastal waters off Suhoe and Virma. The last mentioned place, was already known as an important staging area for wigeon, where Finnish ornithologists have recorded up to 25 000 birds in autumn (Kontiokorpi 2002). Due to heavy swell, this area could not be explored intensively during expeditions. However, distant flying flocks were counted in the evening of 24th Sep 04, giving minimum estimates of the staging birds. In 1999 in both Uhtalahti and Unskaya Bays white-tailed eagles (*Haliaeetus albicilla*) and hunters (*Homo sapiens*) were disturbing and preying the staging wigeons. The huge staging numbers in Unskaya Bay is notable, since 55 000 birds comprehends about 4.6 % of total populations of the flyway (estimate from Hagemeijer & Blair 1997, Delany & Scott 2002).

Several large migrations were recorded. 7th Oct 99 Zhizhginski 1 037 ind., 8th Oct 99 Zhizhginski 2 782 ind., 22nd Sep 04 Kem 3 801 ind., 28th Sep 04 Pertominsk 2 922 ind., 30th Sep 04 Pertominsk 13 018 ind. 1st Oct 04 Pertominsk 3 530 ind., 2nd Oct 04 Pertominsk 6 418 ind. and 3rd Oct 04 1 555 ind. Wigeon migration was heavy especially early in the morning and late in the evening at Pertominsk in 2004 and migration was poor around noon. This indicates that large numbers of wigeons pass the observation point during the night time when they can not be observed.

Teal *A. crecca* 175/271
The biggest migrations: 8th Oct 99 Zhizhginski 77 ind., 22nd Sep 04 Kem 42 ind. and 1st Oct 04 Pertominsk 48 ind. The only bigger concentration was recorded on southern coast of Solovetski Island 42 ind. on 27th Sep 04.

Mallard *A. platyrhynchos* 420/232
Clearly the biggest staging numbers were observed in Belomorsk: 9th Oct 99 295 ind. and 9th Oct 04 105 ind. The greatest migration was recorded at Zhizhginski on 8th Oct 99 42 ind.

Pintail *A. acuta* 439/3 843
Few heavier migrations were recorded: 8th Oct 99 Zhizhginski 281 ind., 22nd Sep 04 Kem 400 ind., Pertominsk 1st Oct 04 413 ind., 2nd Oct 04 1784 ind. and 3rd Oct 04 785 ind. According to Bianki et al. (1993) pintail's staging areas and migration patterns greatly resample those of wigeon. However, very few staging birds were observed during expeditions unlike wigeon.

Garganey *A. querquedula* 0/1
One bird was migrating on 22nd Sep 04 with great migration day of Anas-ducks.

Shoveler *A. clypeata* 14/98
Scarce in 1999, but in 2004 few heavier migration were recorded: 22nd Sep 04 Kem 20 ind., 27th Sep 04 Off Solovetski 14 ind. and Pertominsk 1st Oct 04 14 ind., 2nd Oct 04 14 ind. and 3rd Oct 04 16 ind.

Tufted duck *Aythya fuligula* 51/535
Scarce in 1999, with the greatest record of 19 migrating birds at Zhizhginski on 8th Oct. In 2004 one moderate migration recorded on 22nd Sep at Kem 262 ind. + 70 Aythya sp. The second highest migration was only 32 ind. at Pertominsk on 29th Sep 04.

Scaup *A. marila* 1 229/4 360
Scaup was less abundant than expected. No large concentrations were recorded. This may partly be due to a strict preference to stage and feed in shallow waters (Leivo et al. 2001, see also Durick et al. 1994) that remained insufficiently explored during this expedition. Normally scaups concentrate clearly on the Pertominsk route, i.e. in the south-eastern parts of the White Sea, where they also concentrate in large numbers, up to 100–1 000 birds/km^2 (Bianki et al. 1975, 1993). In 2004 clearly the largest migration numbers were recorded at Pertominsk area, but in 1999 only a few migrating birds were observed regardless of very active observation on all four days in Pertominsk. The greatest recorded migration numbers during expeditions were: 8th Oct 99 Zhizhginski 345 ind., 24th Sep 04 Archipelago of Virma 494 ind., 2nd-4th Oct 04 Pertominsk 1568 ind., 571 ind. and 361 ind, respectively. Interestingly birds observed on 24th Sep 04 were migrating to southeast (instead of southwest like in other cases) along the southern coast of Onega Bay, which may indicate that better staging area could be situated somewhere in the eastern part of the Onega Bay. The migration numbers were also fairly low comparing for example to numbers recorded in the Baltic Sea in spring time (Pettay et al. 2004). However, the migration season is fairly long in autumn starting in early September and continues till November (Pettay et al. 2004), which why the concentrations and migrations are smaller than in the spring time when the main migration from the Baltic Sea to Russia occur within two or three weeks (Pettay 1996). Also the preference of the species to migrate mainly at the night time complicates the observation. Based on data of expeditions scaup migration is heavy especially in the early morning (see Fig. 18), indicating that night migrating birds continue their migration during a few light hours. The sex-ratio changed clearly during expedition 2004 from male biased in the beginning to female-plumage biased in the end of the expedition. This indicates that most of the adult males are migrating in September and in the beginning of October and females and juveniles start their migration in the end of September.

Eider *Somateria mollissima* 20 000/12 514
Practically all the birds recorded were staging, and no real migration was proved. Several large concentrations were recorded e.g. off Hedostrov Island (3700 ind. in 1999 and 2950 ind in 2004), east coast of Zhuzhmui Islands (1500 ind. in 1999, not visited in 2004), southwest and south side of Solovetski Island (2250 ind. in 1999 and 1880 ind. in 2004), northwest tip of Onezhsky Peninsula (1300 ind. in Zhizhginski in 1999 and 1510 ind. in 2004) and off Pertominsk (3500 ind. in 1999 and 2700 ind. in 2004) (see also Fig. 33–34 and Table 5). Bianki et al. (1993) classified the eider as a scarce staging species in Dvina Bay, especially in autumn. Perhaps the staging area along the Pertominsk coast was unknown to Russian ornithologists. According to Koryakin et al. (2002) the population of the White Sea is around 10 000 pairs divided half to the Onega Bay and half to the Kandalaksha Bay.

Remarkably, 98 % in 1999 and 82 % in 2004 of the eiders were moulting males indicating that juveniles and females use different foraging areas. Proportion of female plumage birds were higher in very shallow waters near the coast (e.g. on 26th Sep 04 only 30 adult males and 230 female-plumage birds were observed at harbour of Solovetski), which may partly explain observed biased sex-ratio, because shallow areas are more difficult to survey by the ship. Some of the eider drakes have probably bred further northeast and migrated from there to moult in the White Sea, which is

supported by information in Scott & Rose (1996) and Bianki (1983). However, the eider population may also be naturally male biased like it has been recorded in the Gulf of Finland, the Baltic Sea (Kilpi et al. 2003), but perhaps not so heavily as observed during the expeditions. Eiders winter in large numbers in the White Sea (Bianki et al. 1975, 1993). No migration occurs from the White Sea to the Gulf of Finland via eastern Finland (various bulletin of local ornithological societies in Finland). Few autumn records of eider are known in recent decades despite intensive observation. This contrast with king eider (several sightings each autumn in eastern Finland), and especially steller's eider, which migrates partly through eastern Finland to wintering sites in the Baltic Sea (Pöyhönen 1995 and Pettay et al. 2004).

King eider *S. spectabilis* 100/36
King eider was much rarer than common eider. During both expeditions the greatest numbers were observed in Dvina Bay: off Pertominsk (50 ind. in 1999 and 30 ind. in 2004) and at Zhizhginski Strait (18 ind. in 1999). Unlike common eider, nearly all the birds were in female-plumage. In 1999 over half of the birds were juveniles and only a few moulting adult males were recorded and in 2004 all the birds observed better (29) were juveniles. This species is highly arctic and is known to move westwards from breeding areas in northernmost Russia in late autumn (Scott & Rose 1996). The main breeding sites are on the mainland tundra from Cape Kanin (west coast) eastwards (Cramp & Simmons 1977). However, there are a few breeding records in the White Sea (Kandalaksha Bay) (Kokhanov 1999). Bianki et al. (1993) classify king eider as a regular visitor both during migration periods and in winter in the White Sea.

Steller's eider *Polysticta stelleri* 2/0
Two individuals during two expeditions was much less than expected, since the size of winter population of the Baltic Sea is c. 7 000 birds (Scott & Rose 1996) and the species obviously migrates there via the White Sea route (see Pettay et al. 2004). According to Bianki et al. (1975), steller's eiders moult regularly in the White Sea channel each autumn, but only a minority of these birds winter irregularly in the White Sea (Bianki et al. 1993). The low numbers of expeditions could be explained by the very late migration period of the species, since the majority of the population do not arrive to the Baltic Sea before the beginning of December (see Pettay et al. 2004).

Long-tailed duck *Clangula hyemalis* 270 000/192 000
Long-tailed duck was clearly the most abundant arctic migrant in the White Sea (Bianki et al. 1993). The size of the Northern Russia population is about 4.6 million birds (Delany & Scott 2002) most of which migrate via the White Sea to the Baltic Sea to winter (Cramp & Simmons 1977). Although it was clearly the most abundant species recorded during the expedition, numbers of birds and magnitude of migration were lower than expected, possible partly due to unsuitable weather conditions. In 2004 all four days in Zhizhginski, good migration place of long-tailed ducks, the wind was head-wind, S-W, for migrating birds (Fig. 16). The numbers of birds recorded during expeditions were only 5.0–6.8 % of the whole population, while this percentage was much higher for Branta-geese (14–32 %) for example (see Table 1 and section 4.1.).

Only three concentrations of moderate numbers of birds were found: 10 000 ind. near Osinka Island, 8 400 ind. between Zhizhginski and Letniv Navolok and 1 000 ind. off Pertominsk (Fig. 27, Table 5). Waters between Belomorsk and Mjagostrov Island and between Zhizhginski and Pertominsk seems to be important stop-over areas for long-tailed ducks especially when weather conditions are unfavourable for migration. Importance of the last one of the areas is supported by observations of Bianki et al. (1975), who have also recorded regularly large numbers of long-tailed ducks on this part of the Dvina Bay. In transect line counts long-tailed duck was by far the most

abundant species. The average density of long-tailed ducks were in 1999 and 2004 3.90 birds/km^2 and 10.94 birds/km^2, respectively. The highest densities were found in western Onega Bay (38.8 birds/km^2) and the maximum density along a single line was 160 birds/km^2.

The main migration route was clearly western resembling route of brent geese and flocks often following the southern coast of Dvina Bay concentrating in Zhizhginski Strait (Fig. 27). Heavy migration was recorded on three days at Zhizhginski: 6th Oct 99 92 000 ind., 7th Oct 99 103 860 ind. and 4th Oct 04 54 000 ind. These migrations were dominated by adult males (more than 50 % of birds) and based on long-term studies of Leivo et al. (2001) adult males migrate a week or so before females and juveniles in autumn. This indicate that majority of long-tailed ducks had not migrated through the White Sea. The sex-ratio of long-tailed ducks change due to flock size in the way that proportion of adult males are higher in bigger flocks (>50 birds in a flock).

Diurnal rhythm of migration included several peaks (see Figs 12 & 16 and section 3.2.2.), which indicates that departure areas are widely dispersed around the White Sea and long-tailed ducks seem not to concentrate as much in certain staging areas as many other species. However, according to Leivo et al. (2001) masses of long-tailed ducks departure usually in autumn in the evening, which is supported by data of 4th Oct 04. During that evening clear late evening peak recorded and migration continued strong on next morning (5th Oct 04) indicating that heavy migration occurred during the whole night. Long-tailed duck is clear nocturnal migrant during spring migration (Pettay 1996). Long-tailed ducks winter regularly in moderate numbers in the White Sea (Cramp & Simmons 1977, Bianki et al. 1993).

Common scoter *Melanitta nigra* 15 000/42 427

Common scoter was abundant arctic migrant in the White Sea (Bianki et al. 1993). The whole flyway population is 1.6 million birds (Delany & Scott 2002). Four good staging (4 000–10 000 birds in each) areas were found during the expeditions (Fig. 28, Table 5). Common scoters evidently use the Pertominsk area and outer archipelago of Suhoe as a staging area for a longer period, since a similar number of active feeding birds was observable there on several days. In the transect line counts common scoter was the second numerous species in 2004 (3.8 birds/km^2), but scarce in 1999 (0.39 birds/km^2). The highest densities were found in the western Onega Bay (11.3 birds/km^2). Autumn migration period of Northern Europe common scoters is really long. Most of the drakes migrate already in July and August to their moulting areas and females and juveniles start their migration in September (Pettay et al. 2004). Therefore it was not big surprise that nearly all the common scoters were females or juveniles (see section 3.2.1.) and because the migration is divided for several months any heavy migration was not recorded.

All the intensive migrations were recorded at Zhizhginski indicating that common scoter use same kind of migration route as long-tailed duck: 6-8th Oct 99 2 692 ind., 2 452 ind. and 3 660 ind. and 4th Oct 04 1 159 ind. However, good concentrations of common scoters were also observed along the eastern route at Pertominsk and at Hedostrov indicating that common scoters either circle the Onezhsky Peninsula via Zhizhginski or fly over the peninsula (Fig. 28). Good migration numbers at Zhizhginski and poor at Pertominsk despite the suitable weather conditions indicate that at least some common scoters circle the peninsula on their way to southern Onega Bay. However, according to Kokhanov (1983) adult common scoters males cross the Onezhsky Peninsula west from Pertominsk.

Velvet scoter *M. fusca* 3 769/12 618

The migration period of velvet scoter is fairly long. Based on intensive daily migration observations from northwest coast of Estonia during autumn 2004 (3rd Jul–12th

Dec) good migration numbers (up to 1 000 birds/day) were recorded already in July and August and fairly good migrations were observed as late as in the beginning of December. One third (17 800 ind.) of the total migration sum of autumn had been observed till 19th Sep (Margus Ellermaa, Estonian birding society literary inf.), which indicates that huge proportion of the White Sea – Baltic Sea -flyway population had already migrated before the expedition 2004 was started. Comparing to the total population of the flyway (1.0 million birds, Delany & Scott 2002), only low numbers were recorded during the expeditions. However, a probably previously unknown staging area was found in shallow sandy waters off the Hedostrov Island in Onega Bay (1 700 ind. in 1999 and 4 200 ind in 2004). In addition to this, staging birds were recorded only on the Pertominsk coast (up to 370 ind.).

The highest densities based on transect line counts were found in eastern Onega Bay (2.38 birds/km^2) and only a few or none birds were found in other sea areas. The biggest migrations of the expeditions were observed at Pertominsk: 30th Sep–2nd Oct 04, 2 728 ind., 1 292 ind. and 1 812 ind., respectively. Only small numbers were observed at Zhizhginski during both expeditions (Fig. 29). Bianki et al. (1975, 1993) found also the highest numbers of velvet scoters at Dvina Bay. Observations indicate that velvet scoters use eastern migration route and fly over the Onezhsky Peninsula. This is supported by the fact that velvet scoters have noted to bend straight during the migration over land areas more often unlike common scoters, which usually tend to follow coastline. For example during spring migration velvet scoters migrate normally over the northwest mainland of Estonia, when typically common scoters are following the coast line.

Our results support the hypothesis that velvet scoters seem to prefer staging areas with sandy bottom (like both Hedostrov and Pertominsk area). Sandy areas probably offer food more surely than rocky areas. This preference of sandy bottoms probably affects to the selection of migration route of velvet scoters. The Finnish side of Gulf of Finland and the west part of the White Sea are rocky or stony instead of sandy areas of Estonian side of the Gulf of Finland, the Gulf of Riga and eastern part of the White Sea e.g. Hedostrov (Niemelä et al. 1993, Koistinen et al. 2001). According to our data and Pöyhönen (1995) and Pettay et al. (2004) velvet scoters are uncommon in the first two areas, but common or abundant in latter two areas. In 1999 at least half and in 2004 72 % (n = 295) of migrants were adult males indicating that migration of females and juveniles was in the beginning, since drakes are migrating at first (Cramp & Simmons 1977). Diurnal rhythm of migration showed two long peaks at Pertominsk: one in forenoon and one in evening peak with less intensive migration around noon and afternoon (Fig. 20). This supports the idea that velvet scoters are nocturnal migrants during both autumn and spring migration (Pettay 1996).

Goldeneye *Bucephala clangula* 2 056/1 723

Although goldeneyes migrate in large numbers via the White Sea to the Baltic Sea to winter, relatively low numbers were recorded during the expeditions. The only areas where larger flocks of staging birds were recorded was Uhtalahti Bay (100 ind. in 1999), Pertominsk (200 ind. in 1999 and 110 in 2004) and off Belomorsk (120 ind. in 2004). The maximum density recorded by Bianki et al. (1993), 1000 birds/km^2, is much higher than recorded during our expeditions. Moderate migrations was recorded at Zhizhginski 7–8th Oct 99, 430 ind. and 750 ind., at Pertominsk 2nd Oct 04, 210 ind. and at Belomorsk 9th Oct 04, 202 ind. In 1999 about 3/4 and in 2004 83 % (n = 148) of the goldeneyes were adult males indicating that migration was in the beginning. In the Gulf of Finland the main autumn migration period is situated in October and in the beginning of November (Lehikoinen & Vähätalo 2000, Pettay et al. 2004).

Smew *Mergus albellus* 9/11
Surprisingly low numbers were recorded during the expedition, considering that the size of the flyway population migrating from North Russia to wintering areas in the Baltic Sea is over 20 000 birds (estimate from Scott & Rose 1996).

Red-breasted merganser *M. serrator* 440/2 062
Red-breasted mergansers were recorded widely during the expeditions in moderate numbers. However, the largest numbers of staging birds were recorded in 2004 in southern coast of Onega Bay including four staging areas over one hundred birds (the biggest ones 340 ind. in Virma archipelago on 24th Sep 04 and 300 ind. off Hedostrov Island on 25th Sep 04, see Fig. 36). Other concentration numbers were observed at southwest coast of Solovetski Island (80 ind. in 1999 and 120 in 2004) and on coastal waters of Pertominsk (70 ind. in 1999 and 200 in 2004). The only greater migrations were recorded at Pertominsk: 73 ind. on 30th Sep 04 and 133 ind. on 2nd Oct 04. The species breeds fairly late and young birds of the brood observed at Solovetski on 26th Sep 04, where still growing their flying feathers.

Goosander *M. merganser* 309/287
Goosanders were rarer than previous species, but not uncommon. The biggest numbers of staging birds were observed on southwest coast of Solovetski (89 ind. in 1999 and 80 ind. in 2004) and on the coastal waters of Pertominsk (50 ind. in 1999 and 42 ind. in 2004). No clear migration recorded possible, because the migration period starts later in the end of October and November (Lehikoinen & Vähätalo 2000, Pettay et al. 2004). However, according to Bianki et al. (1993), the goosander is not very abundant in the White Sea.

Hazel grouse *Bonasa bonasia* 1/4
One ind. was seen at Pertominsk on 2nd Oct 99 and four ind. on Solovetski Island on 26th Sep 04.

Black grouse *Tetrao tetrix* 4/9
In 2004, all birds were observed around Pertominsk, where one female flew westwards over the Unskaya Bay on 3rd Oct 04.

Red-throated diver *Gavia stellata* 4 956/4 092
Small concentrations were recorded in western Onega Bay (Fig. 30): on 24-25th Sep 04 outer archipelago of Suhoe and Virma 200 ind. and outside Belomorsk 8th Oct 04 500 ind. This area seems to be clear stop-over place for red-throated diver, before they start to migrate to the Baltic Sea. This is supported by the information that migration in this area (on 24–25th Sep 04) was intensive early in the morning and forenoon, indicating that departure areas are not far away. According to Bianki (1983) densities of 25–40 divers/km^2 have been reported in the shallow waters off Belomorsk (e.g. the same area where our highest concentrations were observed). However, due to identification problem of divers Bianki (1983) could not specify the species, but based on our data these have probably been red-throated. In transect line counts the average density was low, only 0.3 birds/km^2 during both expeditions. Heavy migration recorded on 7–8th Oct 99, 1 583 ind. and 1 537 ind., respectively and on 24th Sep 04, 649 ind. Red-throated divers preferred clearly Zhizhginski – Belomorsk route (see Fig. 30, section 3.2.3.) and were minority at Pertominsk.

Proportion of adult birds in breeding plumage decreased during expedition 2004 (Fig. 7), which indicate that adults migrate before juveniles. However, typical flock of red-throated diver included one juvenile and one adult in breeding plumage, which was calling during the migration flight. According to Leivo et al. (1995) adults are

leading juveniles in the beginning of autumn migration and teaching the suitable migration routes. Based on this, the early migrating adults in breeding plumage have probably failed in breeding or they are more "irresponsible" parents of the family, since red-throated divers have fairly often only one juvenile (Cramp & Simmons 1977). Heavy migration recorded both in the morning and in the afternoon (Fig. 13). A hypothesis was formed that the birds passing during the forenoon peaks had probably departed from the White Sea Channel and afternoon birds had departed much further around the Kanin Peninsula or the Pechora Sea.

Black-throated diver *G. arctica* 8 961/14 150
No important staging areas were found and clearly less staging birds were observed than red-throated divers. In transect line counts the average density was also smaller than red-throated divers only 0.02 birds/km^2 in 1999 and 0.14 birds/km^2 in 2004. However, heavy migration was recorded on many days: 3rd Oct 99 Pertominsk 2 317 ind., 7th Oct 99 Zhizhginski 2 831 ind. and Pertominsk 30th Sep-2nd Oct 04, 3 294 ind., 2 971 ind. and 3 164 ind., respectively. Given figures are identified black-throated divers, even though total number of migrating divers was much higher, since identification proportion of divers is fairly low (about 35 %, Table 2). More than 10 000 divers in one day was recorded two times, all at Pertominsk and most of these divers were black-throated: 3rd Oct 99 11 920 ind. (93.4 % of the identified divers were black-throated), 2nd Oct 04 11 718 (91.5 %). Black-throated divers were abundant in both the Zhizhginski and the Pertominsk route, however the heaviest migrations were observed at Pertominsk, indicating that migration may be bit emphasized to eastern route. Migration included several peaks during fore- and afternoon indicating that birds have departed from several areas (see Fig. 9, section 3.2.2.). The proportion of adults in breeding plumage did not decrease, like it did in red-throated, indicating that there is no difference in migration phenology between adults and juveniles. The proportion of adult in breeding plumage was very high 94.1 %, indicating low breeding success. Unlike on red-throated, we did not observe any cases were adult black-throated diver would have lead juvenile (and called) in migration flight.

Great Northern diver *G. immer* 9/2
All sightings: in 1999: 2nd Oct 3 ind. m, and 3rd Oct 1 ind. m at Pertominsk, 6th Oct 4 ind. m, and 7th Oct 1 ind. m at Zhizhginski. All non-breeding plumages: one 2cy and other 1-2cy. In 2004: 1cy and adult in eclipse plumage present on 4th Oct the way from Pertominsk to Zhizhginski. Great northern diver is a rare vagrant in Finland in autumn and most of the records are from late autumn from October and November (accepted record of Finnish rarity committee, www.birdlife.fi/), and some of these migrants comes definitely from the White Sea.

White-billed diver *G. adamsii* 5/0
All sightings in 1999: 3rd Oct 1 ind. m at Pertominsk, 7th Oct 3 ind. m, and 8th Oct 1 ind. at Zhizhginski. Plumages: four adult summer-plumage and one 1cy. White-billed diver is scarce, but regular passage of migration in Finland in autumn, from October to January (e.g. Rissanen et al. 2002, 2003, 2004), which probably winters in small numbers in the Baltic Sea (Lehikoinen et al. 2003) and some of these migrants definitely comes from the White Sea.

Red-necked grebe *Podiceps grisegena* 36/109
Fairly common in the outer archipelago of Suhoe and Virma, where about 50 staging birds were observed 23rd-25th Sep 04. The transect line counts gave density of 0.27 birds/km^2 in western Onega Bay. The best migrating numbers were at Zhizhginski 11 migrating on 7th Oct 99 and at Pertominsk on 1st Oct 04, where a flock of nine birds

was observed starting their migration at 19:30, when it was nearly dark. Red-necked grebes are typically nocturnal migrants (Pöyhönen 1995).

Northern gannet *Morus bassana* 0/2
Two single 1cy birds were observed in 2004: present bird off Pertominsk on 30th Sep and migrating bird to SW between Zhuzhmui Island and Belomorsk on 8th Oct. Gannets are known to breed in Kola Peninsula, in Kharlov island, (northeast Murman) since 1996. In 1998 ca. 35 nest and sites were occupied (Barret & Krasnov 2000). Northern gannet is very rare vagrant to the Baltic Sea in autumn. For example there are altogether 35 records from Finland till 2003 (accepted records of Finnish rarity committee, www.birdlife.fi/rk).

Great shearwater *Puffinus gravis* 1/0
One migrating bird was identified on 24th Sep 1999 near Osinka Island. The species was not previously recorded in Russia. A detailed note on this observation is published in the Russian Journal of Ornithology (Leivo et al. 2000).

Great cormorant *Phalacrocorax carbo* 38/159
Most of the birds were observed in the western part of Onega Bay and none was recorded in Pertominsk area. Clearly the biggest numbers were observed in outer archipelago of Suhoe and Virma 70 ind. on 24th Sep 04. Other concentrations more than 10 birds were observed at Belomorsk on 9th Oct 99 (15 ind.) and at S coast of Solovetski Island on 27th Sep 04 (18 ind.). Cormorants have bred in the White Sea in Kandalaksha Bay in small numbers since 1962 with increasing numbers (Bianki et al. 1997). Small colony was established in Onega Bay in 1980s in the Island of Malaya Sennukha (Lapshin 2002). In the end of 1990s the total population of the White Sea was more than 580 pairs including eight colonies in Onega and Kandalaksha Bays (Koryakin et al. 2002). Breeding birds of the White Sea belong to subspecies carbo, unlike breeding birds in the Baltic Sea, which belong to subspecies sinensis (Cramp & Simmons 1977). According to Bianki et al. (1997) breeding cormorants of the White Sea are known to winter along the coast of Denmark and south-east Sweden, where they migrate through the Baltic Sea.

White-tailed eagle *Haliaeetus albicilla* 34/57
White-tailed Eagles were recorded widely and fairly good numbers during the expeditions. Only clear migration record was on 9th Oct 04 at Belomorsk 8 ind. migrating to S or SW over the mainland. Others were regarded as present birds. Concentrations of at least four birds during one day were recorded in Kem (6 birds on 22nd Sep 04), in outer archipelago of Suhoe and Virma (5 birds on 24th Sep 04), Uhtalahti (4), Pertominsk (4), Unskaya Bay (4) and Zhizhginski (6 birds on 6th Oct 04). One third in 1999 and more than half in 2004 of the eagles, which age was identified, were immatures indicating fairly good breeding success in the area. Plumages in 1999: 22ad, 1 5cy, 1 3cy, 1 1cy, 6 imm and in 2004: 16ad, 2 subad, 1 2–3cy, 2 2cy, 2 1cy, 10 imm.

Hen harrier *Circus cyaneus* 2/4
All sightings: 2 female-plumage m 3rd Oct 99 Pertominsk, 1cy m on 22nd Sep 04 Kem, 1 female-plumage present on 27th Sep 04 on Island S from Solovetski and two female-plumage m on 30th Sep 04 at Pertominsk.

Goshawk *Accipiter gentilis* 3/4
All sightings: 1cy p on 2nd Oct 99 Pertominsk, 1 m on 6th Oct 99 Zhizhginski, 1m 8th Oct 99 Zhizhginski, 1cy male m on 1st Oct 04 at Pertominsk, 3 males (1ad, 2 1cy) m on 9th Oct 04 at Belomorsk.

Sparrowhawk *A. nisus* 4/21
The biggest migrations: 4 m both on 30th Sep 04 and on 1st Oct 04 at Pertominsk and 4 m on 9th Oct 04 at Belomorsk.

Rough-legged buzzard *Buteo lagopus* 33/98
Fairly good migration was recorded at Pertominsk on 30th Sep 04, when 63 birds migrated to SE. During next day 19 birds more were migrating same directions. These birds must have been migrated over the sea from Kola Peninsula by using good tailwind during both days.

Golden eagle *Aquila chrysaetos* 1/0
1 imm was heading S on 3rd Oct 99 at Pertominsk.

Osprey *Pandion haliaetus* 4/1
1 was heading S on 22nd Sep 04 at Kem.

Kestrel *Falco tinnunculus* 0/1
1 female-plumage bird was recorded migrating on 25th Sep 04 near Mjagostrov Island.

Merlin *F. columbarius* 10/8
In three occasions more than one bird observed on one day: two birds were chasing hen harrier on 27th Sep 04 on Island S from Solovetski, 1 migrating and 1 present bird was observed on 30th Sep 04 at Pertominsk and 2 m on 7th Oct 04 Zhizhginski.

Peregrine *F. peregrinus* 6/29
Most of the birds were observed on migration. Most of the birds, whose age was identified were juveniles (in 1999 2ad 2 1cy and in 2004 6ad 14 juveniles) indicating good breeding success. However, adult peregrines migrate earlier than juveniles (Kjellen 1992, Ekroos et al. 2004), which is why most of the adults may have already migrated. In addition to these birds, three unidentified (2 in 1999, 1 in 2004) large falcons observed were probably peregrines, as gyrfalcon (Falco rusticolus) is very rare in the White Sea (Bianki et al. 1993).

Common crane *Grus grus* 0/1
Voice of crane was heard on 26th Sep 04 at Solovetski Island.

Oystercatcher *Haematopus ostralegus* 20/97
The biggest numbers were observed at Pertominsk during both expeditions: 2nd Oct 99 12 ind., 30th Sep 04 68 ind. m and 2nd Oct 04 11 ind.

Ringed plover *Charadrius hiaticula* 27/27
Clearly the largest sightings at Pertominsk: on 2nd Oct 99 27 ind. and on 29th Sep 04 19 ind.

Golden plover *Pluvialis apricaria* 53/112
The biggest day counts: 3rd Oct 99 Pertominsk 28 ind. m, 24th Sep 04 archipelago of Suhoe and Virma 24 ind. m and 30th Sep 04 Pertominsk 68 ind. m. All the birds, which age was identified (59) were 1cy.

Grey plover *P. squatarola* 67/76
The biggest day counts: 22nd Sep 04 Kem 24 ind. m and 29th Sep 04 Pertominsk 14 ind. m and 3 p. All the birds, which age was identified (63) were 1cy.

Knot *Calidris canutus* 0/32
All sighting in 2004: 22nd Sep Kem 2 1cy m, 24th Sep Virma Archipelago a flock of 9 p, 28th Sep Pertominsk a flock of 20 p and 3rd Oct Pertominsk 1 m.

Sanderling *C. alba* 2/43
All sightings: 1st Oct 99 Pertominsk 2 ind., 27th Sep 04 between Zhizhginski and Lopsenga 9 1cy m, 28th Sep 04 Pertominsk 28 m, 29–30th Sep 04 Pertominsk 1cy p and 3rd Oct 04 Pertominsk 5 1cy m.

Little stint *C. minuta* 0/17
All sightings in 2004: 22nd Sep Kem 2 m and 28-30th Sep Pertominsk 5-9juv p.

Purple sandpiper *C. maritima* 66/86
All the purple sandpipers, except three records, were observed at Dvina Bay (Anzerskij - Zhizhginski - Pertominsk). The highest day counts: 3rd Oct 99 Pertominsk 39 ind. m in 15 flocks, 27th Sep 04 between Anzerskij and Lopsenga 17 m in four flocks and 5th Oct 04 Zhizhginski 18 m in four flocks. Normally, purple sandpipers are observed feeding on stony shores, and little data has been published about their migration in northern Europe. The purple sandpiper is a regular autumn visitor to the White Sea, and winters in large numbers on northern of Kola Peninsula (Bianki et al. 1993). Birds recorded in the White Sea probably continue their migration to the Baltic Sea, where purple sandpipers are wintering every year (e.g. Cramp & Simmons 1983).

Dunlin *C. alpina* 1 749/369
The only wader species recorded in large numbers during the expeditions. Three staging areas were recorded: 700 ind. on the coast at Belomorsk, 270 ind. (including 100 unidentified small waders) at Unskaya Bay and 400 ind. (all unidentified small waders) along western shallow waters off Pertominsk. Several moderate migrations were recorded (unidentified small waders are included in sums): 563 ind. 24th Sep 99, 390 ind. 25th Sep 99, 440 ind. 28th Sep 99, 792 ind. 3rd Oct 99, 374 ind. 2nd Oct 04 and 340 ind 3rd Oct 04. About 99 % in 1999 and 97 % in 2004 of all the dunlins were juveniles. The main migration period for adults is July-August (e.g. Lehikoinen & Vähätalo 2000). According to Bianki et al. (1993), the dunlin is by far the most abundant wader in the White Sea.

Ruff *Philomelachus pugnax* 0/1
1 ind. was migrating on 24th Sep 04 at Virma Archipelago.

Common snipe *Gallinago gallinago* 1/10
All sightings: 1 ind. 24th Sep 99 Belomorsk, 1 ind. p 26th Sep 04 Solovetski, 4 ind. p 29th Sep 04 airport of Pertominsk, 2 ind. p 7th Oct 04 Solovetski and 2 ind. p and 1 ind. m Belomorsk on 9th Oct 04.

Bar-tailed godwit *Limosa lapponica* 2/0
All sightings: 29th Sep 99 1 ind. and 3rd Oct 99 Pertominsk 1 ind.

Spotted redshank *Tringa erythropus* 0/2
2 ind. were migrating on 22nd Sep 04 at Kem.

Ruddy turnstone *Arenaria interpres* 0/1
1 ind. was migrating on 24th Sep 04 at Virma Archipelago.

Red phalarope *Phalaropus fulicarius* 0/1
1 ind. was swimming 8th Oct 04 close to the vessel outside Belomorsk. The nearest breeding areas are situated in Novaya Zemlya and Svalbard (Cramp & Simmons 1983). Red phalarope is a rare vagrant in the Baltic Sea area, with only 55 accepted records of rarity committee from Finland (www.birdlife.fi).

Pomarine skua *Stercorarius pomarinus* 107/5
Large numbers of pomarine skuas were recorded during expedition 1999, but species was rare in 2004. The species' autumn migration along the White Sea – Baltic Sea route has not been well documented, and autumn observations in Finland are scarce (Pöyhönen 1998b). However, in some years hundreds of birds have been observed on eastern coast of Sweden, the Baltic Sea (Wirdheim 2000). Also Bianki et al. (1993) know very few sightings of pomarine skuas in the White Sea, whereas they classify it as a very abundant species during migration on the northern coast of the Kola Peninsula. However, in autumn 1999 hundreds of pomarine skuas (especially young birds) were recorded all around southern Finland (e.g. Lehikoinen 2000, Lehikoinen et al. 2003) and along the east coast of Sweden (Wirdheim 2000). This indicate very good numbers of lemmings and high breeding success in the high arctic, since pomarine skuas are specialized to hunt lemmings during the breeding season (Olsen & Larsson 1997). In Sweden the invasion in autumn 1999 was heavier than ever reported since 1903 (Wirdheim 2000). In Sweden the numbers of yearly observed pomarine and long-tailed skuas have clearly fluctuated synchronously within a three-year cycle based on the cycle of lemmings in the Russian tundra (Wirdheim 2000). In 1999 the invasion of pomarine skuas in the White Sea and the Baltic Sea may have also been influenced by weather conditions: cold eastern and northeastern winds in Russian tundra and low pressure in Svalbard area, which may have pushed skuas from their normal migration route along the northern coast of Norway (Wirdheim 2000).

During expedition 1999 pomarines were observed almost every day. Juveniles were also recorded even at the Lake Onega and the Lake Vygozero, and large numbers were observed at the Onega Bay in the White Sea. However, juveniles did not seem to be ready to migrate, rather they were flying in various directions, with no attempt to migrate over the mainland. In contrast, adults were recorded only at Dvina Bay, migrating purposefully southwards (like three of the five individuals in 2004). According to Olsen & Larsson (1997) migration peak in south Scandinavia is 3–4 weeks after arctic skua and adult pomarines are migrating before juveniles. A total of 38 ad (37 pale morphs, 1 dark morph), 5 ad/subad, 1 subad and 67 juveniles (mostly normal, i.e. intermediate morph) were identified. Unlike in arctic skuas, pale morph in adult pomarines is predominant over whole breeding range (Olsen & Larsson 1997). The greatest daily sums were in 1999: 28th Sep 21 ind., 3rd Oct 29 ind. and 4th Oct 15 ind. All sightings in 2004 concerned adult birds of pale morph indicating a very poor breeding year: 1st Oct Pertominsk 1+1 heading to S, 2nd Oct Pertominsk 1 S and 8th Oct between Solovetski and Belomorsk 1 + 1 m.

Arctic skua *S. parasiticus* 181/241
Fairly large numbers were observed and occurrence was clearly concentrated in Dvina Bay. Two heavy migrations were recorded at Pertominsk: 3rd Oct 99, 99 identified + 249 unidentified skuas and 30th Sep 04, 154 identified and 208 unidentified skuas (including huge flock of 96 birds!). In 1999 most of skuas were migrating to southeast along the coast line, but in 2004 more than half of the (arctic) skuas migrated southwards along the Unskaya Bay. A question arose whether these southeast migrating

birds were heading for the Black Sea region or the Baltic Sea. The former alternative seems more likely. This hypothesis is supported by data reported by Cramp & Simmons (1983), according to whom there are many migration records of arctic skuas in the Black and Caspian Sea and at the Lake Aral, from where they are supposed to continue to the Arabian waters to winter. According to Olsen & Larsson (1997) arctic skua is a regular, but scarce autumn migrant in Israel. Small numbers of arctic skuas observed at Onega Bay were also noted migrating to southeast direction. However, according to extensive research (e.g. Pöyhönen 1998a, Olsen & Larsson 1997, Margus Ellermaa, literary inf.) the arctic skua is a regular and abundant migrant over eastern Finland and in the Gulf of Finland in autumn (hundreds of birds every autumn), and these birds must have departed from the White Sea. Migration routes of these skuas in White Sea are still uncertain (Fig. 32).

In 1999 total of 138 ad, 1 subad and 39 juveniles and in 2004 total of 235 ad and 9 juveniles were identified, indicating fairly poor breeding success in 2004. The breeding success of arctic skua is not related to rodent densities like in pomarine skua, because the diet of arctic skuas consists of small invertebrate, fish and plants (Olsen & Larsson 1997). Nearly all the adults were pale morph (in 1999 134 pales and 4 dark, in 2004 234 pales and 1 dark morph) indicating the migrants were predictably Siberian origin, where more than 90 % are pale morph comparing to breeding birds in Varanger, northern Norway, where about half are dark morphs (Olsen & Larsson 1997).

Great skua *Catharacta skua* 3/2
All sightings: 1cy 3rd Oct 99 and 1 ind. 5th Oct 99 Pertominsk, 1 ind. 7th Oct 99 Zhizhginski, 1 ind. both 23rd Sep 04 and 24th Sep 04 in outer archipelago of Suhoe and Virma. The nearest breeding areas are situated in northern Norway (Hagemeijer & Blair 1997).

Little gull *Larus minutus* 12/19
Most of the records were made in Onega Bay. The biggest sightings: 11 ind. 28th Sep 99 Nimenia Bay and 6 ind. 25th Sep 04 eastern waters of Kondostrov Island. All the birds were 1cy.

Black-headed gull *L. ridibundus* 21/71
All sightings in 2004 were made in Pertominsk, where at least 27ind. were migrating and 44 ind. were present 28th Sep - 3rd Oct.

Common gull *L. canus* 840/2 129
The species was common all around the southern White Sea. None bigger concentrations were recorded. However, a few moderate migrations were observed: 196 ind. on 30th Sep 04 Pertominsk, 239 ind. and 268 ind. on 6th and 7th Oct 04 Zhizhginski. In 2004 about 36 % of the birds (n = 1 539, see section 5.2.1.) were juveniles indicating fairly good breeding success. The total population of the White Sea is around 7 000 pairs (Koryakin et al. 2002).

Lesser Black-backed gull *L. fuscus* 170/316
Two distinctive subspecies were observed: the nominate subspecies *L.f.fuscus* (69 ind. in 1999 and 81 in 2004) and eastern subspecies (known as the eastern black-backed gull) *L.f.heuglini* (56 ind. in 1999 and 95 ind. in 2004). In additions, about 200 birds (including all 1cy birds, 140 ind. in 2004) could not be identified as to their subspecies. Among these were a few intermediate (adult) birds in which the colour of the back was between the almost black *L.f.fuscus* and the slaty-grey of *L.f.heuglini*. *L.f.fuscus* was clearly dominant at Onega Bay (98 ind. in 1999 and 68 ind. in 2004 against 13 ind. in 1999 and 31 ind. in 2004 of *L.f.heuglini*), whereas *L.f.heuglini* was much more abundant

in Dvina bay (45 ind. in 1999 and 64 ind. in 2004 against 10 ind. in 1999 and 12 ind. in 2004 of *L.f.fuscus*) (see also Fig. 41). In 1999 the majority of lesser black-backed gulls were adults, while in 2004 nearly half (44%) of the birds were 1cy. In the identification of subspecies, Rauste (1999) was followed. According to Koryakin et al. (2002) nearly 2000 pairs breed in the White Sea area.

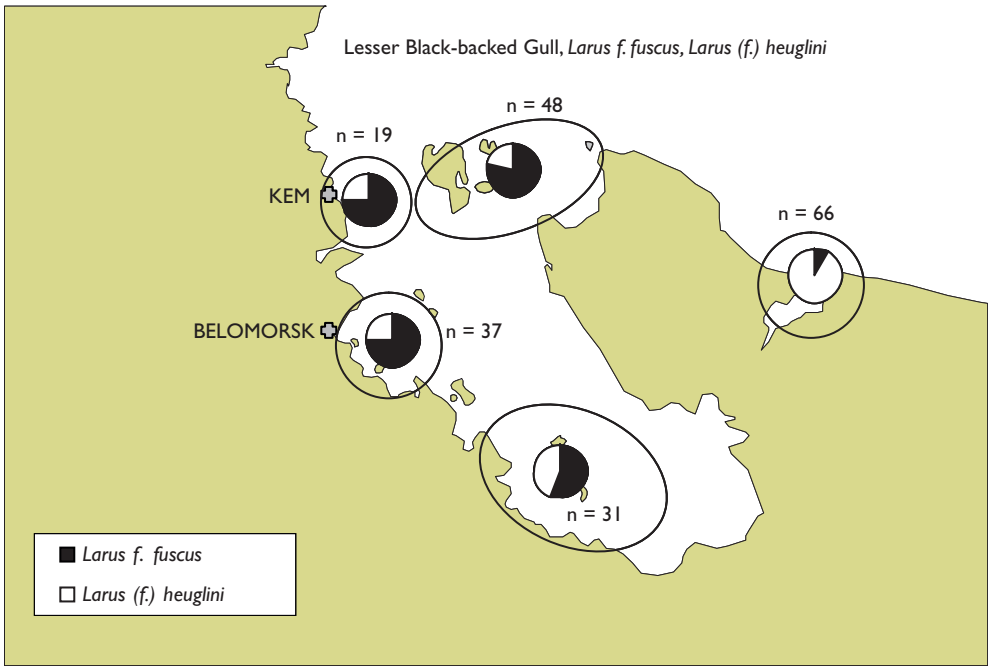

Figure 41. Occurence and proportions of nominative subspecies of lesser black-backed gull *Larus f. fuscus* and eastern (sub)species *L. (f.) heuglini* in different parts of the White Sea during the expeditions 1999 & 2004.

Herring gull *L. argentatus* 600/720
Herring gull was common all around southern White Sea. Clearly the biggest concentration was observed in Zhizhginski Strait on 7th Oct 04 170 ind. whereas only a few moderate migration were recorded: 54 ind. on 2nd Oct 04 Pertominsk and 67 ind. on 6th Oct 04 Zhizhginski. Different age classes were identified in 2004 in the following way: 240 ad 5 3cy, 6 2cy, 3 subad and 167 1cy, indicating good breeding success in past summer. According to Koryakin et al. (2002) the population of the White Sea is nearly 10 000 pairs.

Glaucous gull *L. hyperboreus* 0/6
All sightings in 2004: 2cy m W on 30th Sep Pertominsk, 1cy p on 1st Oct Pertominsk, 1ad p on 2nd Oct Pertominsk, 2cy p on 5th Oct Zhizhginski and 2ad m SW on 6th Oct Zhizhginski. All adults were moulting their primaries (about 3-4 outer primaries were unmoulted). The closest breeding areas are situated in the northern part of the White Sea Channel (Koryakin et al. 2002).

Great black-backed gull *L. marinus* 60/56
The species was noted to be uncommon everywhere during the expeditions. All the bigger concentrations were observed around city of Belomorsk: 20 ind. on 24th Sep 99 and 17 ind. on 8th Oct 04, or near smaller villages: 6 ind. on 22nd Sep 04 Kem harbor and

6 ind. 29th Sep 04 Pertominsk. Different age classes were identified in 2004 in the following way: 40ad, 1 3cy, 1 2cy, 14 1cy, which indicate fairly good breeding success.

Kittiwake *Rissa tridactyla* 8/5
All sightings: 1 ind. on 25th Sep 99 Osinka Island, 2 ind. on 28th Sep 99 Nimenia Bay, 1 ind. on 4th Oct 99 Pertominsk, 4 ind. on 7th Oct 99 Zhizhginski, 2 ind. m NW on 22nd Sep 04 Kem, 1 ind. on both 1st Oct and 4th Oct 04 Pertominsk and 1 ind. m on 8th Oct 04 outside Belomorsk. All birds were 1cy. Up to 42 pairs of kittiwakes bred in the Kandalaksha Bay during 1987–1991 (Koryakin et al. 2002). Small numbers of kittiwakes migrate from the White Sea to the Baltic Sea every autumn, mainly in October and November, although there is a big variation in yearly numbers. In better years few dozen kittiwakes are recorded around southern Finland, while in some years there are only a few records (e.g. Ekroos et al. 2004).

Arctic tern *Sterna paradisaea* 1/1
All sightings: 1cy on 28th Sep 99 at Nimenia Bay and 1cy m SW on 7th Oct 04 Zhizhginski. Arctic tern is the most abundant breeding bird in the White Sea (Koryakin et al. 2002) and the breeding populations estimates are several tens of thousands (Cramp 1985). According to local ornithologist of Solovetski huge colonies are situated in islands of Zhizhginski (20 000 pairs), Anzerskij (3 000 pairs), Muksalma (8 000 pairs) and islands near southern coast of Solovetski (3 000 pairs) (Alexander Cherenkov local ornithology of Solovetski, discussion 26.9.2004). However, the main migration period of arctic terns is situated in July and August (Lehikoinen & Vähätalo 2000, Pettay et al. 2004), which why only a few terns were observed during expeditions.

Common/Arctic tern *S. hirundo/paradisaea* 5/0
All 1cy.

White-winged tern *Chlidonias leucopterus* 1/0
1cy bird was observed on 9th Oct 99 at Belomorsk. A surprising sighting of this fairly southern species, which closest breeding sites are near the city of Kargopol about 400 km from Belomorsk (Pekka Rusanen, unpublished). According to Bianki et al. (1993) there are no previous records of the species in the White Sea.

Razorbill *Alca torda* 68/85
Razorbills were recorded in low numbers during the expedition all over the White Sea without any bigger concentrations. Weak migration was recorded in Zhizhginski, where 46 ind. migrating SW or W on 4-7th Oct 04. However, this may be just linked to feeding flying of the species. According to Koryakin et al. (2002) the breeding population of the White Sea is more than 3000 pairs and it is as abundant as the black guillemot. However, about only one tenth of numbers of black guillemot were observed during expeditions, indicating that most of the razorbills probably migrate through White Sea Channel to winter coastal waters of Norway. According to Cramp (1985) there are only a few winter off Murmansk and northern Norway, since most of the birds of all-age-groups move further southwest. There are only a very few records in inland Finland of razorbill during recent decades, indicating that razorbills rarely migrate from the White Sea to the Baltic Sea. All six birds, which were observed good enough to identify the age, were age class of 1cy, indicating that adults have already migrated.

Black guillemot *Cepphus grylle* 1 118/674
Recorded in large numbers during the expedition (cf. razorbill). Most of the birds were recorded around Solovetski and Anzerskij Islands. The largest concentrations were

on the SW–S coastal waters of Solovetski Island (260 ind. in 1999 and 310 ind. in 2004) and off the SE–E coastal waters of Anzerskij Island (220 ind. in 1999 and 90 ind. in 2004) (see also Table 5, Figs. 33 & 35). In other parts of the White Sea the species was much scarcer (see also Fig. 35). Moderate migration was also recorded in Zizgiski Strait, where 135 ind. migrating mainly to SW–W on 4–7th Oct 04 (the highest day of 59 ind. on 5th Oct). Was this migration just linked to feeding flying of the species or were birds truly migrating to their wintering areas in the middle parts of the White Sea, remains unconfirmed. The breeding population of the White Sea is around 3 000 pairs (Koryakin et al. 2002) and the species is wintering in good numbers in the White Sea (Cramp 1985). In 1999, black guillemot was, surprisingly, the third abundant (and sixth abundant in 2004) species in transect line counts. The average density in 1999 and 2004 was 1.28 birds/km^2 and 0.38 birds/km^2, respectively (see also Table 7). In 2004 about 30 % of birds (n = 456, see section 5.2.1.) were juveniles indicating good breeding success during past summer.

Puffin *Fratercula arctica* 14/8
All sightings around Solovetski Island or at Dvina Bay: 5 ind. on 1st Oct 99 around Solovetski Island, 2 ind. and 7 ind on 6th Oct and 7th Oct 99 at Zhizhginski, 3 ind. on 27th Sep 04 around Solovetski Island, 1 ind. on 27th Sep 04 near Anzerskij Island, 3 ind. on 4th Oct 04 between Pertominsk and Zhizhginski and 1 ind. on 6th Oct 04 at Zhizhginski. A small colony of puffins (2–3 pairs) is known to exist in Onega Bay, small rocky island called Sennukha between Zhuzhmui and Solovetski Islands (Cherenkov & Semashko 1994, Koryakin et al. 2002). However, based on observations of expeditions the total breeding population of the White Sea must be higher or some birds migrate from north to winter in the White Sea.

Feral pigeon *Columba livia* 2/9
Only records: 2 ind. on 24th Sep 99 in Belomorsk area, 1 ind. on 26th Sep Solovetski and 8 ind. on 9th Oct Belomorsk.

Common wood pigeon *Columba palumbus* 0/4
All sightings in 2004: 2 ind. p on 26th Sep Solovetski, and single migrating birds at Pertominsk on 29th and 30th Sep.

Short-eared owl *Asio flammeus* 1/6
All sightings: 1 ind. m 6th Oct 99 Zhizhginski (where another unidentified Asio-owl was observed the same day), 1+1 ind. m on 27th Sep 04 around Solovetski and Zhizhginski Islands and migrating birds at Pertominsk: 1 ind. 29th Sep 04, 1 ind. 30th Sep 04 and 2 ind. 1st Oct 04.

Black woodpecker *Dryocopus martinus* 0/4
All sightings in 2004: 1 ind. on 26th Sep in Solovetski Island, 2 ind. on 29th Sep at Pertominsk and 1 ind. on 9th Oct Belomorsk.

Great spotted woodpecker *Dendrocopos major* 19/58
Very abundant in Solovetski Island in 2004, were about 50 ind. were observed on 26th Sep. Several observations of clearly smaller numbers were recorded at Pertominsk, Zhizhginski and Belomorsk.

Lesser spotted woodpecker *D. minor* 0/4
All sightings in 2004: 1 ind. (calling male) on 26th Sep Solovetski, 1 ind. on 29th Sep Pertominsk, 1 ind. m SE on 3rd Oct Pertominsk and 1 ind. on 9th Oct Belomorsk.

Three-toed woodpecker *Picoides tridactylus* 1/3
All sightings: 1 ind. on 2nd Oct 99 Pertominsk, 1 male on 29th Sep 04 Pertominsk, 1 ind. on 2nd–3rd Oct 04 Pertominsk and 1 ind. m S on 9th Oct 04 Belomorsk.

Skylark *Alauda arvensis* 1/2
1 ind. migrating on 2nd Oct 99 at Pertominsk and two birds present on the beach of Pertominsk 28–30th Sep 04 and one till 1st Oct.

Shore lark *Eremophila alpestris* 11/18
All sightings: 5 ind. on 2nd Oct 99 Pertominsk, 6 ind. on 9th Oct 99 Belomorsk, 2 ind. p on 1st Oct 04 Pertominsk, a flock of 12 ind. m SW on 2nd Oct 04 Pertominsk and a flock of 4 ind. m on 8th Oct 04 Zhuzhmui. Even though passerines were not the primary target species of the expeditions a fairly good numbers of shore larks were recorded. Figures are clearly higher than nowadays in southern Finland, where the numbers declined during in 1950–1970s (e.g. Väisänen et al. 1998, Lehikoinen et al 2003). The species is still a fairly numerous breeding bird in northeastern Norway and Kola Peninsula, but have disappeared from Finnish Lapland (Hagemeijer & Blair 1997, Väisänen et al. 1998). Most of this population seems to migrate southeastern route east from Finland, since good numbers (e.g. a flock of more than a hundred birds) have been reported from Russian side during recent years unlike in southern Finland (e.g. Loippo 2002).

Barn swallow *Hirundo rustica* 0/15
All sightings: 10 ind. (mostly juveniles) on 26th Sep 04 around monastery of Solovetski and 4 ind. m and 1 ind. p on 9th Oct 04 Belomorsk.

House martin *Delichon urbicum* 0/2
All sightings: 1 ind. m and 1 ind. p on 9th Oct 04 Belomorsk.

Meadow pipit *Anthus pratensis* 83/140
The biggest records: 50 ind. on 24th Sep 99 in Belomorsk area, 15 ind. m and 50 ind. p on 26th Sep 04 Solovetski and 37 ind. p on 29th Sep 04 Pertominsk (mainly around the airport).

Red-throated pipit *A. cervinus* 0/5
A flock of 5 ind. migrated on 26th Sep 04 at Solovetski.

Rock pipit *A. petrosus* 0/1
1 ind. was present on 1st Oct 04 at Pertominsk. The nearest breeding areas are situated in northern - north-eastern coast of Kola Peninsula (Cramp 1988).

White wagtail *Motacilla alba* 50/45
Fairly large numbers of 30 ind. on 24th Sep 99 in Belomorsk area and 25 ind. on 28–29th Sep 04 in Pertominsk, where numbers declined rapidly down to 2–5 ind. on 30th Sep–1st Oct 04, when wind turned to northern direction and weather got colder.

Bohemian wagwing *Bombycilla garrulus* 170/1890
Clearly the greatest record in 1999 was 120 ind. on 2nd Oct 99 at Pertominsk. Good numbers around Belomorks in 2004 due to good year of rowan berries on 8–9th Oct: 730 ind. m and about 800 ind. p. Small numbers were also observed in Solovetski (120 ind. on 26th Sep 04) and in Pertominsk (max 50 ind./day).

Wren *Troglodytes troglodytes* 0/1
1 ind. was on 26th Sep 04 in Solovetski.

Dunnock *Prunella modularis* 0/6
All birds were recorded in Solovetski on 26th Sep 04.

Robin *Erithacus rubecula* 6/21
All sightings: 1 ind. on 24th Sep 99 in Belomorsk area, 5 ind. on 2nd Oct 99 in Pertominsk, 10 ind. on 26th Sep 04 in Solovetski and 12 ind. on 28-30th Sep 04 in Pertominsk.

Black redstart *Phoenicurus ochruros* 0/2
1 ind. was recorded on 29–30th Sep 04 at Pertominsk and 2 ind. at the same place on 3rd Oct 04. Both individuals were in female-plumage and spent their time around abandoned buildings at the northern edge of village. Surprising records of this fairly southern species, which nearest regular breeding areas are situated in Estonia (Pettay et al. 2004, Hagemeijer & Blair 1997). However, the numbers of vagrants in southern Finland have been increasing since the 1960s (e.g. Lehikoinen 2003, Lehikoinen et al. 2003).

Redstart *P. phoenicurus* 0/2
Singles were recorded in Pertominsk on 28th and 29th Sep 04.

Eastern stonechat *Saxicola torguata maurus* 0/1
1cy male was observed on 26th Sep 04 in Solovetski. The White Sea area is situated to the western edge of the distribution of eastern stonechat. However, according to local ornithology, stonechat is not a regular breeder in Solovetski (Alexander Cherenkov, discussion 26.9.2004). Nevertheless there are several breeding records around White Sea area and even eastern Finland during recent years (Jännes & Nikander 1993, Hagemeijer & Blair 1997, Lindroos 1998, Kontiokorpi 2002).

Northern wheatear *Oenanthe oenanthe* 0/6
1 ind. m on 25th Sep 04, 3 ind. on 26th Sep 04 in Solovetski and 2 ind. on 29th Sep 04 in Pertominsk.

Fieldfare *Turdus pilaris* 1711/2755
Fieldfare was abundant during both years. The biggest sightings: c. 500 ind. m mainly SW on 24th Sep 99 in Belomorks area, 500 ind. on 1st Oct Anzerskij Island, c. 1000 ind. on 26th Sep 04 at Solovetski, 365 ind. m on 3rd Oct 04 at Pertominsk and 350 ind. m and 300 ind. p on 9th Oct 04 at Belomorks.

Song thrush *T. philomelos* 11/11
All sightings: 10 ind. on 24th Sep 99 in Belomorsk area, 1 ind. on 2nd Oct 99 in Pertominsk, 1 ind. p and 7 ind. night migrating during 3*5 minutes (22:00–24:00) on 21st Sep at Kem and 3 ind. p on 26th Sep 04 in Solovetski.

Redwing *T. iliacus* 113/325
Fairly good night migration of redwings was recorded in the evening of 21st Sep 04 at Kem. During periods of 3*5 minutes (between 22:00–24:00) 208 calls were heart. Only a few migrating birds were heart during other evenings. About 50 ind. were observed on 24th Sep 99 at Belomorsk area and 26th Sep 04 at Solovetski.

Mistle thrush *T. viscivorus* 2/2
2 ind. on 24th Sep 99 in Belomorsk area and two single sightings of migrating birds at Pertominsk on 29th Sep and 3rd Oct 04.

Chiffchaff *Phylloscopus collybita* 5/6
All sighting: 4 ind. on 2nd Oct 99 and about five ind. on 30th Sep–3rd Oct 04 in Pertominsk and 1 ind. on 9th Oct 04 Belomorks. Interestingly, in 1999 1 ind. on 24th Sep in Belomorks was identified by it's "tsi-vy" call as a southern race. Others identified birds had "normal" "hyi" calls.

Willow warbler *P. trochilus* 0/4
All 4 ind. were recorded on 29th Sep 04 at Pertominsk before cold winds from north.

Goldcrest *Regulus regulus* 19/19
The largest sightings: 15 ind. in 29th Sep 99 in Great Zhuzhmui Island, 8 ind. on 26th Sep 04 at Solovetski Island and 7 ind. on 30th Sep at Pertominsk.

Long-tailed tit *Aegithalos caudatus* 2/165
2 ind. were recorded on 30th Sep 99 at Solovetski. All bigger sightings in 2004: 44 ind. m and 49 ind. p in several flocks on 29th Sep Pertominsk area, 36 ind. m on 1st Oct Pertominsk and 25 ind. on 9th Oct 04 Belomorks. Autumn 2004 was good invasion year for long-tailed tits in southern Finland (Nikkinen 2005).

Willow tit *Parus montanus* 12/295
Clearly the biggest numbers were recorded on 29th Sep 04 when 229 ind. started to cross the Unskaya bay heading to S-SW. Small numbers elsewhere, including one lonely bird on the top of the ship, when the ship was anchored in the middle of Zhizhginski Strait on 4th Oct 04. The northern willow tits seem to cross larger water areas easier then southern ones. In southern Finland willow tits have very low tendency to cross larger water areas (Aalto 2004).

Siberian tit *P. cinctus* 2/3
2 ind. were recorded on 2nd Oct 99 at Pertominsk and 3 ind. on 26th Sep 04 in the village of Solovetski.

Coal tit *P. ater* 0/27
All sightings: 7 ind. on 26th Sep 04 on Solovetski Island and both 8 ind. and 12 ind. m on 29th Sep and 3rd Oct 04 at Pertominsk area.

Blue tit *P. caeruleus* 0/2
Singles were recorded in Solovetski and Belomorsk in 2004.

Great tit *P. major* 55/60
The species was fairly common in Solovetski, Pertominsk and Belomorsk in 2004. The biggest day counts were 20 ind. on 2nd Oct 99 at Pertominsk and on 9th Oct 04 at Belomorsk.

Treecreeper *Certhia familiaris* 0/3
1 ind. was observed on 26th Sep 04 at Solovetski Island and 2 ind. on 29th Sep 04 in Pertominsk area.

Great grey shrike *Lanius excubitor* 1/4
All sightings: 1 ind. on 8th Oct 99 at Zhizhginski, 1 ind. on islet in the archipelago of Suhoe and Virma on 24th Sep 04, 2 ind. on 26th Sep 04 in Solovetski and 1 ind. on 8th Oct 04 on Great Zhuzhmui Island.

Jay *Garrulus glandarius* 3/10
All sightings: 2 ind. on 24th Sep 99 at Belomorsk area, 1 ind. on 2nd Oct 99 at Pertominsk, 6 ind. on 26th Sep 04 on Solovetski Island and 1-2 ind. in Pertominsk on 29th Sep - 3rd Oct 04.

Magpie *Pica pica* 20/64
Magpie was fairly common in Solovetski, Pertominsk and Belomorsk, where up to 20 ind. were recorded in 2004.

Jackdaw *Corvus monedula* 20/27
All sightings at Belomorsk area: 20 ind. on 24th Sep 99 and 7 ind. m and 20 ind. p on 9th Oct 04. According to Kontiokorpi (2002), small numbers of jackdawns winter in Belomorsk regularly.

Rook *C. frugilegus* 0/4
1cy bird was recorded on 26th Sep 04 at Solovetski and 1 ind. m and 2 ind. p on 9th Oct 04 at Belomorsk.

Hooded crow *C. corone cornix* 423/940
Common all around the White Sea, especially around settlements, but some numbers were recorded in the archipelago too. The biggest observed numbers: 150 ind on 7th Oct 99 at Zhizhginski, 81 ind. on 29th Sep 04 Pertominsk, 125 ind. on 5th Oct 04 at Zhizhginski and 282 ind. m and 100 ind. p on 9th Oct at Belomorsk.

Raven *C. corax* 99/140
Raven was fairly common during both expeditions. The biggest day counts were 25 ind. on 24th Sep 99 at Belomorks area and 27 ind. on 29th Sep 04 at Pertominsk. Some individuals were quite bold towards humans and were searching for food in the villages (Solovetski, Pertominsk) with hooded crows unlike in Finland, where raven is a fairly shy bird.

Starling *Sturnus vulgaris* 50/45
All sightings: 10 ind. on 24th Sep 99 Belomorsk area, 40 ind. on 9th Oct 99 Belomorsk, 2 ind. p on 22nd Sep 04 Kem, 46 ind. p on 26th Sep 04 in Solovetski and 1 ind. in the same place on 7th Oct 04.

House sparrow *Passer domesticus* 56/156
House sparrows were fairly common in around settlements. The biggest numbers in Solovetski, where about 100 ind. on 26th Sep 04.

Tree sparrow *P. montanus* 2/8
All sightings: 2 ind. on 2nd Oct 99 Pertominsk and 8 ind. on 9th Oct 04 Belomorks.

Chaffinch *Fringilla coelebs* +/177
Chaffinch was fairly common in 2004 in Pertominsk and Solovetski, where up to 80 birds (on 26th Sep 04) were recorded. Smaller numbers were recorded elsewhere.

Brambling *F. montifringilla* +/650
The species was common in 2004. Clearly the biggest day count about 400 ind. was recorded on 28th Sep 04 in the village of Pertominsk, where flocks of tens of birds were feeding between the houses. Higher numbers were also recorded in Solovetski, where 100 ind. on 26th Sep 04.

Greenfinch *C. chloris* 2/5
Only sightings: 2 ind. on 24th Sep 99 in Belomorsk area and 5 ind. on 22nd Sep 04 in Kem.

Siskin *C. spinus* 25/70
In 1999 only record on 28th Sep 25 ind. migrating at Nimenia. Clearly the biggest day count 65 ind. on 26th Sep 04 on Solovetski Island. Only singles elsewhere in 2004.

Twite *C. flavirostris* 0/1
1 ind. was migrating along the ship for several hundreds of meters on 7th Oct 04 between Zhizhginski and Solovetski.

Redpoll *C. flammea* 402/614
Redpoll was abundant during both years. The greatest day count in 1999 was recorded in Belomorsk area on 24th Sep 255 ind. migrating E-SE. The biggest day counts recorded in 2004: 139 ind. m on 25th Sep and 220 ind. on 26th Sep on Solovetski Island. One nearly albino ind. (redpoll or arctic redpoll) was recorded in Solovetski on 26th Sep 04, with whole white remiges, tail feathers and underparts. Only the back and crown was buffish, small faint red spot on forehead and faint dark area in throat.

Arctic redpoll *C. hornemanni* 0/2
Singles were recorded in mixed flocks with redpolls on 26th Sep 04 in Solovetski and on 3rd Oct 04 in Pertominsk.

Two-barred crossbill *L. leucoptera* 2/3
2 ind. were recorded on 2nd Oct 99 at Pertominsk and 3 ind. (one male) on 26th Sep 04 in the botanical garden of Solovetski.

Common crossbill *L. curvirostra* 31/638 (including unidentified crossbills)
In 1999 clearly the greatest record was 24th Sep 28 ind. in Belomorsk area. The species was more numerous in 2004, especially in Pertominsk area. The biggest day counts were in 2004 (including unidentified crossbills) at Pertominsk 304 ind. m on 1st Oct and 113 ind. on 3rd Oct. Heavy invasion of common crossbills were recorded in southern Finland in summer 2004 (Nikkinen 2005).

Bullfinch *Pyrrhula pyrrhula* 77/186
Bullfinch was fairly common in Pertominsk and Belomorsk and abundant in Solovetski on 26th Sep 04, when about 100 birds were recorded.

Snow bunting *Plectrophenax nivalis* 9/23
All sightings: 5 ind. on 2nd Oct 99 Pertominsk, 3 ind. on 3rd Oct 99 Pertominsk, 1 ind. on 6th Oct 99 Zizgiski, 1 ind. m on 1st Oct 04 Pertominsk, 1 ind. m and 2 ind. p on 3rd Oct 04 Pertominsk, 18 ind. m on 5th Oct 04 Zhizhginski and 1 ind. m on 7th Oct 04 Zhizhginski.

Yellowhammer *Emberiza citrinella* 2/26
Yellowhammer was fairly common in Pertominsk, where up to 23 ind. were recorded in 2004, but uncommon elsewhere.

Rustic bunting *Emberiza rustica* (2)/1
1 ind. was recorded on 26th Sep 04 in Solovetski and 2 rustic/little buntings were observed on 24th Sep 99 around Belomorsk.

Reed bunting *Emberiza schoeniclus* 35/39
The species was fairly common in Belomorks, Pertominsk and Solovetski, where up to 19 ind. where recorded.

Appendix 6. Daily totals of the waterfowls, divers and skuas recorded during the White Sea expeditions 1999.

Species	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Cygnus bewickii				8											1		9
Cygnus cygnus										23			7		3		33
Cygnus sp.										24	7		6		2		39
Anser fabalis	1					14				1292	5			19	12		1343
Anser albifrons				339		5				4401	87			48	762		5642
Anser sp.		30		94	55	1				8913	217			55	855		10220
Branta leucopsis			97	83	60	17		13		6148	59	3	8371	17666	2142	1390	34490
Branta bernicla		5	165	41	1	11			40	13		188	3328	9551	3459	178	16980
Anser/Branta	73	3510	255	785	389	40		30		91836	338	1675	1140	9164	2570	1938	113743
Anser+Branta Total	74	3545	517	1342	505	88	0	43	40	112603	706	1866	12839	36503	9800	3506	183977
Anas penelope	42	152	37	128	10000	5000		1	3011	16	7	72	46	1037	2782	349	17700
Anas crecca		1		8				15		32		9	3	36	77	4	175
Anas platyrhynchos	200		1			14	10	25	10			1		6	42	311	430
Anas acuta	3				2	2			5	1	1	3	2	114	281	25	439
Anas clypeata				2										6	5	1	14
Anas sp.		60												10	847		917
Aythya fuligula				5								2	7	13	19	5	51
Aythya marila	3			105	16				35	31	78	211	47	278	345	80	1229
Aythya fuligula/ marila					52					2	50	5	5	17	19	27	177
Somateria mollissima	140	99	400	5000	100	3550	800	8000	2000	2000	1500	2600	1150	1000	1000	230	20000
Somateria spectabilis		2	2	2	1		2	9	12	52	34	19	7	10	4		100
Polysticta stelleri										1						1	2
Clangula hyemalis	130	11770	150	720	130	1500	2250	1422	1000	1250	526	10226	90009	95072	21908	37376	275439
Melanita nigra		185	300	1891	121	19	6	500	2500	1740	1568	2370	2692	2452	3661	351	20356
Melanita fusca		245	80	2130	37	16		3	3	400	18	31	237	441	123	5	3769
Melanita sp.		57															57
Bucephala clagula	6	30	50	65	20	100	40	40	200	150	40	67	40	429	750	128	2056
Mergus albellus								1						1	7		9
Mergus serrator		2	20	9	42	44	80	110	50	70	8	70	10	54	50	15	440
Mergus merganser	40		6	1			25	89	5	30		70	1	7	12	23	309
Unidentified waterfowl	3000	13260		2000	5000	100	40	2000		50		330	220	5620	7230	9635	48485
Waterfowl Total	3564	25863	1046	12066	15521	10345	3253	12215	8831	5825	3830	16086	94476	106603	39162	48566	407252
Bonasa bonasia									1								1
Tetrao tetrix									4								4
Gavia stellata	10	83	100	161	184	50	39	276	38	163	24	73	1583	1537	531	104	4956
Gavia arctica	1	3	30	88	438	60	2	193	12	2317	795	1034	821	2831	291	45	8961
Gavia immer									3	1			4	1			9
Gavia adamsii										1				3	1		5
Gavia sp.	35	134	184	98	361	414	39	474	23	9440	2501	3754	758	3560	1750	884	24409
Gavia Total	46	220	314	347	983	524	80	943	76	11922	3320	4861	3166	7932	2573	1033	38340
Podiceps grisegena		4	4	2		1		2		1		2	7	11	2		36
Puffinus gravis		1															1

Species	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Phalacrocorax carbo	3	7	4		2	10	1	1						1	1	15	45
Haliaeetus albicilla	1	4	2	3	2	4		3	4	1		3	5	4	3		39
Circus cyaneus										2							2
Accipiter gentilis									1				1		1		3
Accipiter nisus	2													1	1		4
Buteo lagopus	18			1						7				3		4	33
Aquila chrysaetos										1							1
Pandion haliaetus					1					3							4
Falco columbarius			1			2		3		4							10
Falco peregrinus	1	1	1			1				1				1			6
Large Falco		1			1												2
Haematopus ostralegus								2	12	7		11		4			20
Charadrius hiaticula									27								27
Pluvialis apricaria	2			12						28		2		5	4		53
Pluvialis squatarola	14	1				3			12	12		10	2	3	10		67
Pluvialis sp.									10								10
Calidris alba								2									2
Calidris maritima						1			1	39	3	7	3	11	1		66
Calidris alpina	1080			18		1			234	373	6	34		1	2		1749
Gallinago gallinago	1																1
Limosa lapponica						1				1							2
Unidentified small wader	123	390		25			1		119	419	33	25	118	30	4		1287
Unidentified large wader	3										2	1					6
Unidentified wader											20				2		22
Wader Total	1223	391	0	55	0	6	1	4	415	879	64	90	123	54	23	0	3328
Stercorarius pomarinus	2	6	1	9	21	3				29	15	5	7	8	1	3	107
Stercorarius parasiticus	6				7			3	19	99	17	21	3	3	1	2	181
Catharacta skua												1		1			2
Stercorarius sp.	1	9		10	13	2	2	1		249	13	12	1	12	2	7	334
Skua Total	9	15	1	19	41	5	2	4	19	377	45	39	11	24	4	12	624
Larus minutus		1			11												12
Larus ridibundus	1								10	5			1	2	1	1	21
Larus canus	60	1	20	20	20	40	150	150	100	30	10	30	65	235	200	30	820
Larus (f.) heuglini		1	4		1			4	15	15	10	3	2	3	2		60
Larus fuscus fuscus		2	1		14			18	3	1	1	1	1	2			44
Larus (f.) heuglini/ fuscus					20	2	28	3			3	2		1	1		60
Larus argentatus	100	20	50	15	15	20	20	20	50	50	10	50	174	231	30	50	905
Larus marinus	20	1	1		5	3	1		10	2	3	7	2	6	2	10	73
Unidentified large *Larus*				20									100				120
Rissa tridactyla		1			2						1			4			8
Sterna paradisaea				1													1
Sterna paradisaea/ hirundo		1			4												5

Species	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Chlidonias leucopterus																1	1
Alca torda		4	1	6	10	10	1	11		4	1	4	7	6	2	1	68
Cepphus grylle			2	13		10	91	910		2	2	2	35	30	20	1	1118
Fratercula arctica								5					2	7			14
Alca/Uria		3			1	5	2	4		3		1	3	1	5		28
Alca/Uria/ Fratercula												2					2
Columba livia	2																2
Asio flammeus													1				1
Asio sp.													1				1
Dendrocopos major	1					5			7		4				1	1	19
Picoides tridactylus									1								1
Dendrocopos/ Picoides	1																1
Alauda arvensis									1								1
Eremophila alpestris									5							6	11
Anthus prantensis	50				1	4	1	20		5	1				1		83
Motacilla alba	30						7	10			3						50
Bombycilla garrulus	40								120							10	170
Erithacus rubecula	1								5								6
Turdus pilaris	600					200	70	600	30		1	1		200	9		1711
Turdus philomelos	10								1								11
Turdus iliacus	50			4	2	20	2	10	15		3	1	2	1	3		113
Turdus viscivorus	2																2
Unidentified small *Turdus*																8	8
Unidentified large *Turdus*			40	100						30		1	5		300		476
Phylloscopus collybita	1								4								5
Regulus regulus	3					15			1								19
Aegithalos caudatus							2										2
Parus montanus	2					7			3								12
Parus cinctus									2								2
Parus major	10						15	3	20		5					2	55
Lanius excubitor															1		1
Garrulus glandarius	2								1								3
Pica pica	10								1	2	5					2	20
Corvus monedula	20																20
Corvus corone cornix	100	1	1	5		10	50	50	4	10	40	2		150		50	423
Corvus corax	25	2	3	4		6	10	6	15	2		6		5		15	99
Sturnus vulgaris	10															40	50
Passer domesticus	15						20	5			15					1	56
Passer montanus											2						2
Fringilla coelebs	+						4										+
Fringilla montifringilla	+						2	4	1								+
Carduelis chloris	2																2

Species	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Carduelis spinus					25												25
Carduelis flammea	255				37			5		12		49		2		42	402
Loxia leucoptera									2								2
Loxia curvirostra									1								1
Loxia sp.	28							2									30
Pyrrhula pyrrhula	2					12		3	20		30				10		77
Plectrophenax nivalis									5	3			1				9
Emberiza citrinella	2																2
Emberiza rustica/ pusilla/aureola	2																2
Emberiza schoeniclus	20					3		10	1		1						35
Unidentified small passerine					227					30		12				3	272
MAMMALS																	
Ursus arctos									FS								0
Mustela erminea											1						1
Phoca hispida			3	3		1		233		4	17	10			1		272
Erignathus barbatus			10	50			1	5	2	1		1	5	1			76
Unidentified seal	1		1					2					30	15			49
Delphinapterus leucas					1			37	19	3	7	8	12	3			90

Appendix 7. Daily totals of the waterfowls, divers and skuas recorded during the White Sea expeditions 2004.

Species	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Cygnus olor			4	4																4
Cygnus bewickii					1								1							2
Cygnus cygnus		18			8	2	7			27	6	33	22		6		3	3	5	140
Cygnus sp.				3						35	96	9	10							153
Anser fabalis		18			18					1172	144	275	4			35	1			1667
Anser albifrons					45		1			1	172	81	95					330		725
Anser anser											1									1
Anser sp.				10	56			60		1006	358	593	51		20		1	332		2487
Branta leucopsis		1695		537	117	3	588	38	43	2274	31876	6332	1187	255	15	24		1154		46138
Branta bernicla		1964	376	169			27		469	166	103	836	345	1893	594		239	236	83	7500
Anser/Branta		64		21555	1172		150	127		5751	51463	11323	1696	529	89			4430	122	98471
Anser+Branta Total		3741	376	22271	1408	3	766	225	512	10370	84117	19440	3378	2677	718	59	241	6482	205	156989
Anas penelope	9	3801	207	1144	68	6	145	3282	55540	16018	4730	6418	1805	172	91	4	31	75	491	89837
Anas crecca		42	2	6		7	69	7	2	5	51	32	11	1		3	1	15	17	271
Anas platyrhynchos		1				8	28	1	21		2		2	8	8		21	35	105	232
Anas acuta		400	2	12	2		14	32	2	110	413	1784	785	10	46		3	4	224	3843
Anas querquedula		1																		1
Anas clypeata		22					14	4	3	11	14	14	16							98
Anas sp.		15	70					380	30	100		374		19	9			32		1029
Aythya fuligula		262	26	13		13	5	26	43	1	1		16	27	15	9		68	10	535
Aythya marila		28	10	537	78		3	75	133	261	213	1568	601	373	238	61	5	87	89	4360
Aythya fuligula/ marila		70	20	5			1			206		50		122						474
Somateria mollissima		6	220	207	3631	400	3933	2659	300	200	400	300	200	2310	203	98	787	280		12514
Somateria spectabilis								30						16		1				36
Somateria sp.			11												1	1				13
Clangula hyemalis		327	2727	3877	3692	5	4288	741	50	51	185	3063	11524	75530	30433	3434	27921	24849	57	191684
Melanita nigra		76	3886	3571	21748	1	162	7418	3500	2947	1028	1029	1444	3591	839	125	40	156	15	42427
Melanita fusca		31	66	15	4946		44	378	40	2738	1442	1814	355	38	36	323	27	112	223	12618
Melanita sp.			130																	130
Bucephala clagula		109	84	57	133	40	123	111	191	60	22	211	108	16	66	15	76	138	213	1723
Mergus albellus						4	4		1				1				1			11
Mergus serrator		56	36	280	860	125	89	212	21	113	46	133	41	3	12		57	17	1	2062
Mergus merganser		51	1	9	5	1	84	43	42	5	1	2	14	8				12	14	287
Mergus merganser/ serrator				80	10			1						15						106
Unidentified waterfowl		102	493	6425		340	370			2025	260	1301	11020	547	100	7	15	29321	25	52351
Waterfowl Total	9	5400	7991	16238	35173	950	9376	15400	59919	24851	8808	18093	27943	82806	32097	4081	28985	55201	1484	416642
Bonasa bonasia						4														4
Tetrao tetrix									4				5							9

Species	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Gavia stellata		32	119	784	526	2	115	39	38	200	338	296	146	212	203	132	180	712	18	4092
Gavia arctica	1	84	18	136	111	5	47	41	33	3294	2971	3164	1441	794	84	3	691	1231	1	14150
Gavia immer														2						2
Gavia sp.		81	119	1637	2107	15	138	54	87	5293	6043	8261	1557	1658	261	44	296	7468	137	35256
Gavia Total	1	197	256	2557	2744	22	300	134	158	8787	9352	11721	3144	2666	548	179	1167	9411	156	53500
Podiceps grisegena			39	5	19		4	6	1		14		4	3	6	3	3	2		109
Morus bassanus										1								1		2
Phalacrocorax carbo		5	14	88	53		18										4	7	6	195
Haliaeetus albicilla		6	6	5	4	3	7	4	4	2		1		4	4	6	6	3	9	64
Circus cyaneus		1					1			2										4
Accipiter gentilis											1								3	4
Accipiter nisus		2	1		1			2	2	4	5								4	21
Buteo lagopus						1				63	19							1	14	98
Pandion haliaetus		1																		1
Falco tinnunculus					1															1
Falco columbarius					1		2			2	1						2			8
Falco peregrinus		1	3	1	1	1	3		3	3	4	2	5		1	1				29
Small Falco				1																1
Large Falco			1																	1
Grus grus						1														1
Haematopus ostralegus		7	1				4	5		68		11	1							97
Charadrius hiaticula		5		1				7	19	8	1	1								34
Pluvialis apricaria		2	15	23						68	3				1					112
Pluvialis squatarola	1	24	5	12				4	17	5	2	1	3					2		76
Pluvialis sp.						13			15	3	2									33
Calidris canutus		2	9					20					1							32
Calidris alba							9	28	1	1			5							43
Calidris minuta		2						6	9	5										17
Calidris maritima							17		1			2	12	15	18	10	8	3		86
Calidris alpina		36	3				28	1	1	4		14	282	1						369
Philomachus pugnax				1																1
Gallinago gallinago						1			4								2		3	10
Tringa erythropus		2																		2
Arenaria interpres				1																1
Phalaropus fulicarius																		1		1
Unidentified small wader		1		6			114	18	1	47	300	360	60	400	50	2				1359
Unidentified large wader			12	15	1		2	13			44		6	1						94
Unidentified wader		1																		1
Wader Total	1	82	45	59	1	14	174	102	68	209	352	389	370	417	69	12	10	6	3	2368
Stercorarius pomarinus											2	1						2		5

Species	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Stercorarius parasiticus		11	1	23	12		1	7	2	154	21	3		1				5		241
Catharacta skua			1	1																2
Stercorarius sp.			2	9						208								1		220
Skua Total	0	11	4	33	12	0	1	7	2	362	23	4	0	1	0	0	0	8	0	468
Larus minutus		4	1	2	7		2	1				1						1		19
Larus ridibundus								25	44	24	27	21	10							106
Larus canus		181	21	90	47	10	88	11	48	206	197	169	97	156	234	249	318	59	50	2156
Larus (f.) heuglini		3	3	10	15		1	11	28	22	7	3	3			1				95
Larus fuscus fuscus		9	12	16	28	3	10								1	1		1		81
Larus (f.) heuglini/ fuscus		7		28	36	4	14	8	8	20	11	13	3	1	3	1	1	84		224
Larus argentatus		25	31	70	26	65	40	16	7	25	8	54	1	34	133	92	190		31	720
Larus hyperboreus										1	1	1			1	2				6
Larus marinus		6				2		2	10	4	9	4	3	6	5	5	4	17	7	74
Unidentified large *Larus*										5		22								27
Rissa tridactyla		2									1			1				1		5
Sterna paradisaea																	1			1
Alca torda				6	15		2							22	16	10	6	8		85
Cepphus grylle			2	1	21	2	410	4						36	64	26	102	6		674
Fratercula arctica							4							3		1				8
Alca/Uria															1					1
Alca/Uria/ Fratercula														1						1
Columba livia						1													8	9
Columba palumbus						2			1	1										4
Asio flammeus							2		1	1	2									6
Dryocopus martius						1			2										1	4
Dendrocopos major						50			1		2	1	2				1		1	58
Dendrocopos minor						1			1				1						1	4
Picoides tridactylus									1			1	1						1	3
Dendrocopos/ Picoides				1																1
Alauda arvensis								2	2	2	1									4
Eremophila alpestris											2	12						4		18
Hirundo rustica						10													5	15
Delichon urbicum						5													2	7
Anthus prantensis		7		3	3	65	1	15	37	5	5	2	2				4	1		140
Anthus cervinus						5														5
Anthus petrosus											1									1
Motacilla alba		3		1		5		25	24	5	2		1							59
Bombycilla garrulus						120		50	44	43	4	9	3	50			5	779	782	1889
Troglodytes troglodytes						1														1
Prunella modularis						6														6

Species	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Erithacus rubecula						10		4	7	1										21
Phoenicurus ochropus								1	1	1			2							2
Phoenicurus phoenicurus								1	1											2
Saxicola torquata						1														1
Oenanthe oenanthe					1	3			2											6
Turdus pilaris	60	278	6	28		1030		2	63	39	41	128	365		4		35	22	654	2755
Turdus philomelos	8					3														11
Turdus iliacus	208	20		8	6	45			7	2		1	7		5	1	2	2	11	325
Turdus viscivorus									1				1							2
Unidentified small *Turdus*		1									5	1	2				26	1		36
Unidentified large *Turdus*				10	5								50				30	35		130
Phylloscopus collybita										1	2	1	1						1	6
Phylloscopus trochilus										4										4
Regulus regulus						8			7	4										19
Aegithalos caudatus						6			93		36	1	4						25	165
Parus montanus						25		3	239		6	1	9	1					11	295
Parus cinctus						3														3
Parus ater						7			8				12							27
Parus caeruleus						1													1	2
Parus major						15		5	14		4	2	2				1		21	60
Certhia familiaris						1			2											3
Lanius excubitor				1		2												1		4
Garrulus glandarius						6			1		2		1							10
Pica pica		10						10	9	5	20	10	7					5	20	64
Corvus monedula																			27	27
Corvus frugilegus						1													3	4
Corvus corone cornix		40	20	10	4	40	42	40	81	30	30	50	30	79	137	13	25	81	382	C. 940
Corvus corax		10		6	1	15	3	5	27	4	7	5	10	2	1	3	20	32	20	C. 140
Sturnus vulgaris		2				43											1			45
Passer domesticus		12				100		10	2								11	2	30	156
Passer montanus																			8	8
Fringilla coelebs		6				80		50	20	1	10	5	5						1	177
Fringilla montifringilla						10		400	180	32	20	30	10							650
Carduelis chloris		5																		5
Carduelis spinus						65		1	1	1		1				1				70
Carduelis flavirostris																	1			1
Carduelis flammea					139	220		20	44	15	6	4	89	9	11	7	1	13	51	614
Carduelis hornemanni						1							1							2
Loxia leucoptera						3														3
Loxia curvirostra						35			7		289	95	112						25	563

Species	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	SUM
Loxia sp.						8			26		15	25	1							75
Pyrrhula pyrrhula						102		5	22	2	3	3	24				8		19	186
Plectrophenax nivalis											1		3		18		1			23
Emberiza citrinella								10	21	15	23	5	15						2	56
Emberiza rustica						1														1
Emberiza schoeniclus		1				29			7								1		1	39
Unidentified small passerine			8	36	90		9		3	9	54	5	57	9	36		251	29	45	641
MAMMALS																				
Lepus timidus								M												0
Ondatha zibethica						1														1
Microtus sp.													1							1
Ursus arctos								M	M											0
Mustela vison/ lutreola													M							0
Phoca hispida		1			18	6	163	50	82	X	X	X	123	50	7	3	5			C. 450
Erignathus barbatus			4		9		12	5			1		4	3						37
Unidentified seal					5		57	2						6			1			71
Rangifer tarandus							4													4
Delphinapterus leucas					25		114	3	6		3		2	13	2	3	2			173
Unidentified whale							1													1

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Abstract	Finnish Environment Institute organized two ornithological expeditions to the White Sea, between 21st September and 10th October1999, and between 21st September and 10th October 2004. The main aim of these expeditions was to map the most important staging areas for the migrating arctic birds at the White Sea. Several internationally important staging areas were found at the White Sea. Transect line counts at sea showed that the densities of birds outside these areas were smaller. During the expeditions a lot of data collected about the migration, daily rhythm, directions and routes of the migration, intensity, timing and the age and sex of the birds. Clear differences between species were noticed in the dynamics, directions of routes and intensity. Some of the species migrate on a wide front and others follow the coastal lines. The expedition was carried out by vessel. Compared to aerial surveys, which are also used for mapping of staging areas, vessel is cheaper. Vessel surveys allow more time for observing for instance birds which are sensitive or few in numbers. On the other hand a vessel is slow and shallow areas, which are important staging areas for waterfowl, are inaccessible. Aerial surveys make it possible to cover large areas and to find the most important staging areas for arctic waterfowl.			
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Julkaisun teema	Luonto			
Julkaisun osat/ muut saman projektin tuottamat julkaisut	Julkaisu on saatavana myös internetissä: www.environment.fi/publications			
Tiivistelmä	Suomen ympäristökeskus järjesti kaksi ornitologista tutkimusmatkaa Vienanmerelle 21.9.–10.10.1999 ja 21.9.–10.10.2004, joiden tarkoituksena oli kartoittaa Vienanmeren tärkeimpiä muuttavien arktisten vesilintujen kerääntymisalueita. Tutkimusryhmät löysivät Vienanmereltä useita kansainvälisesti tärkeitä kerääntymisalueita. Linjalaskennat merellä osoittivat, että lintutiheydet näiden kerääntymäalueiden ulkopuolella olivat pieniä. Matkojen aikana kerättiin runsaasti tutkimusaineistoa lintujen muutosta; päivärytmiikasta, muuttosuunnista ja -reiteistä, muuton voimakkuudesta ja ajoittumisesta, lintujen ikä- ja sukupuolijakaumista jne. Yleisesti muuton dynamiikassa, muuttoreiteissä ja voimakkuudessa havaittiin selkeitä eroja lajien välillä. Osa lajeista muuttaa laajalla rintamalla, kun taas toiset seuraavat rantalinjoja. Tutkimusmatka tehtiin laivalla. Verrattuna lentokoneeseen, jota myös käytetään vesilintujen kerääntymisalueiden kartoituksissa, laiva on kustannuksiltaan halvempi, se sallii lintujen pitemmän tarkkailuajan ja siitä on helpompi havaita arkoja tai harvalukuisia lajeja. Toisaalta laiva on hidas eikä sillä päästä matalikoille, jotka ovat monille vesilinnuille tärkeitä levähdysalueita. Kattavat lentolaskennat olisivatkin välttämättömyys arktisten vesilintujen kerääntymisalueiden kartoituksissa laajoilla merialueilla.			
Asiasanat	linnut, muuttolinnut, vesilinnut, kahlaajat, hanhet, kuikat, kihut, lokit, seuranta, kartoitus, lintulaskennat, kansainvälinen yhteistyö, muutto, arktinen alue, luonto, Vienanmeri, Venäjä			
Rahoittaja/ toimeksiantaja				
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Painopaikka ja -aika	Edita Prima Oy, Helsinki 2006			

PRESENTATIONSBLAD

Utgivare	Finlands miljöcentral		*Datum* Augusti 2006	
Författare	Aleksi Lehikoinen, Alexander V. Kondratyev, Timo Asanti, Esko Gustafsson, Olli Lamminsalo, Nikolay V. Lapshin, Jorma Pessa och Pekka Rusanen			
Publikations titel	**Survey of arctic bird migration and staging areas at the White Sea, in the autumns of 1999 and 2004** (Undersökning av arktiska fåglarnas flyttningsbeteende och samlingsområden vid Vita havet hösten 1999 och 2004)			
Publikationsserie och nummer	Miljön i Finland 25/2006			
Publikationens tema	Natur			
Publikationens delar/ andra publikationer inom samma projekt	Publikationen finns tillgänglig på internet: www.environment.fi/publications			
Sammandrag	Finlands miljöcentral anordnade två ornitologiska expeditioner till Vita havet 21.9.-10.1.1999 och 21.9.-10.10.2004. Ändamålet var att kartlägga de viktigaste samlingsområdena för arktiska flyttfåglar vid Vita havet. Forskningsgrupperna fann många internationellt viktiga samlingsområden vid Vita havet. Linjeinventeringarna visade att populationstätheten utanför dessa samlingsområden var liten. Under resorna insamlades rikligt med forskningsmaterial om fåglarnas flyttning i allmänhet; deras dyngsrytm, flyttningsrutter, intensitet samt uppgifter om fåglarnas ålder och könsfördelning osv. Generellt kan man säga att det finns tydliga skillnader i flyttdynamkien, rutterna och intensiteten mellan olika arter. Somliga arter flyttar i en bred front över havet medan andra använder kustlinjen. Expeditionerna gjordes med båt. Jämfört med flygplan, som också används vid kartläggning av samlingsområden, är båt billigare. Den möjliggor även längre observationstider och det är lättare att observera skygga och sällsynta fåglar. Å andra sidan är båten långsam och man når inte grunda vattenområden som är viktiga rastomården för många vattenfåglar. För att erhålla en heltäckande kartering av de arktiska fåglarnas samlingsområden på vidsträckta havsområden behövs kompletterande flygkarteringar.			
Nyckelord	fåglar, flyttfåglar, sjöfåglar, vadare, gäss, lommar, labbar, måsar, uppföljning, kartläggning, fågelräkning, internationellt samarbete, arktiska områden, natur, Vita havet, Ryssland			
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The White Sea is situated along the main migration route of millions of arctic waterbirds that breed in northern Russia and winter in the Baltic Sea and Atlantic regions. Two ornithological expeditions were organized to research the migration routes, directions, daily rhythms and staging areas during the autumns 1999 and 2004. In this report results of both expeditions are represented and discussed. In many species remarkable percentages of the whole White Sea - Baltic Sea flyway populations were recorded and many internationally important staging areas were found. The expedition 2004 was carried out in co-operation with Finnish and Russian ornithologists. The report also discuss surveys and monitoring of arctic bird populations, and emphasizes the significance of conservation of important staging areas of arctic birds along their migratory routes.

SYKE

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