

Annual Conference: Workshops

1. Coastal saltmarshes throughout the world: significance and mechanisms in life histories of waders

Saltmarshes are globally spread and more or less important breeding, staging or wintering habitats on several wader flyways. More than 280 Ramsar sites around the world include intertidal marshes (including freshwater and brackish marshes). However, comparatively little is known about the function of these highly dynamic and unpredictable habitats at different stages in the life histories of waders. The purpose of this workshop was therefore to afford an opportunity for an exchange of experience and knowledge integrating several aspects of wader ecology from saltmarsh sites worldwide. The aims were to emphasise the significance of saltmarsh habitats in wader life histories, to contribute to an improvement in understanding the function of saltmarshes in wader biology, to highlight open questions and to inspire co-operation and coordination in coastal wader research and conservation.

Stefan Thyen

Abstracts of talks

Changes in land use and their consequences for saltmarsh communities

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Saltmarshes along the Wadden Sea have been agriculturally exploited since their emergence about 2600 BP. Since 1000 AD, saltmarshes have been embanked and transformed into agriculturally exploited polders. Along the mainland coast, artificial saltmarshes have been established by sedimentation fields and artificial drainage systems, and subsequently embanked. Natural saltmarshes, i.e. including drainage by creeks and without livestock grazing exist on some back barrier marshes and are up to 60 years old. Saltmarshes experience flooding and inundation water brings sediment that includes nutrients. Saltmarsh succession is driven by nitrogen input. During succession the quantity of the biomass (dry weight, canopy height) increases, but the quality (leaf/stem ratio, crude protein) decreases. Related to the changes in biomass quantity and quality, an initial increase and subsequent decrease is observed in the numbers of natural herbivores such as winter- and spring staging geese and resident hares. Hares facilitate for geese, whereas livestock in its turn facilitates for hares and geese. Long-term (up to 20 years) experimentally grazed and ungrazed island and mainland saltmarshes often confirm the observations on natural saltmarshes. Cessation of livestock grazing seems positive for the numbers of waders, but long-term studies are lacking. The first results of the effects of de-embanking are considered.

Direct and indirect interactions between shorebirds, burrowing crabs, and marsh plants in south-western Atlantic estuaries

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Estuaries from south Brazil to north Patagonia (Argentina) are important stopover sites for shorebirds. These are characterized by the intertidal burrowing crab *Chasmagnathus granulatus*. This crab inhabits vegetated saltmarshes and bare sediments forming large crab beds with densities up to 60 crabs m⁻². Many direct and indirect interactions were found in these environments among shorebirds, crabs and saltmarshes. Marsh plants are the main source of energy supporting high crab densities. Crabs affect sediment and their assemblages alter the suitability of intertidal habitats used by shorebirds. While some species exploit these areas for foraging, even feeding close to burrows and maximizing intake rates, others avoid crab beds. Given that crab beds are also avoided by people for recreational activities, the human effect on shorebirds is different for species that avoid or prefer these areas. Crabs also affect the abundance and availability of prey for shorebirds. However, as the zonation patterns of the benthic fauna are also altered, the result is a larger intertidal foraging area available for shorebirds among crab beds. Crabs also occupy patches of *Sarcocornia perennis* accelerating erosion rates at the centre, forming ring-shape patches. When these patches join, bare flat areas are formed leading to changes in the species distribution of shorebirds in such environments.



**Predation risk on saltmarshes:
a case study from the Firth of Forth, Scotland**

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Saltmarshes can provide good feeding areas for waders but may also have high predation risk. Waders may therefore have to trade-off a decrease in the probability of starvation by feeding in a saltmarsh against an increased probability of being killed. We present an overview of a system where Redshanks achieve very high intake rates on a saltmarsh but also suffer a very high risk of predation from Sparrowhawks. Use of the saltmarsh is dependent on the rate of energy gain in safer habitats, daily energy expenditure and density dependent competition for safer feeding sites. When forced to use the saltmarsh as a feeding area, Redshanks use a number of effective anti-predation behaviours to minimise their risk of capture per Sparrowhawk attack. However, they still suffer very high mortality when they are forced to feed on the saltmarsh for long periods during winter.

**The Sivash, Ukraine: salinity, prey quality and
wind action determine staging opportunities for
waders in Europe's largest
non-tidal, lagoon system**

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The Sivash is situated in the western part of the Sea of Azov, Ukraine, and is the largest united lagoon system in Europe covering about 2,500 km² of non-tidal open water, mudflats, hypersaline, brackish and freshwater lagoons. Half a million waders regularly stopover during spring and autumn migration. Salinity determines species composition of potential prey species varying from brine shrimps in hypersaline lagoons to polychaetes and bivalves in the brackish lagoons. Wind action determines short-term water level dynamics and consequently prey availability in the brackish lagoons, because mudflats usually fall dry on the lee side of the lagoons and more so during strong winds. On the other hand, brine shrimp availability in the hypersaline lagoons may be reduced by wave action and resulting turbidity during strong winds. The large number of relatively small, interconnected lagoons creates a huge shoreline and a virtual constant supply of feeding habitat for most of the 37 wader species regularly staging in the area despite or even due to the daily variation in wind speed and direction, temperature and rainfall. The Sivash is of particular high importance for the nominate subspecies of Broad-billed Sandpiper, as over 30% of the European population stages here at its last stopover site before the breeding grounds. We show that the suitability of the Sivash lagoons for Broad-billed Sandpiper is related to the high, local abundance of macro-invertebrates and high availability of feeding sites. The lack of similar stopover sites

in Central Asia may explain the existence of only two major flyways, the nominate subspecies migrating along the eastern Mediterranean Flyway and *sibirica* migrating along the Austral-Asian Flyway, and the small population size on a global scale.

**Fitness consequences of habitat selection –
the importance of saltmarshes as feeding habitat
for Avocet chicks in the Wadden Sea**

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With more than 10,000 breeding pairs, the Wadden Sea coast of the Netherlands, Germany and Denmark holds a substantial part of the total European breeding population of Avocets *Recurvirostra avosetta*. In recent times, Avocets successfully colonized various secondary habitats and a considerable proportion is now breeding in reclaimed areas. However, in northern Germany, breeding success in reclaimed habitats was found to be consistently lower than in nearby saltmarsh habitats. This might be a reason to be concerned for the conservation of the north-western European Avocet population.

Several factors might explain the variation in breeding success of Avocets in saltmarshes and embanked habitats. The impact on hatching success of egg predation and flooding of breeding colonies seems to be of minor importance. However, weather-related chick mortality was identified as the main factor explaining annual variation in breeding success in both habitat types (Hötker & Segebad 2000, *Bird Study* 47). In periods of adverse weather conditions, chicks have to spend more time being brooded and this reduces the time the adults have available for foraging. We compared time budgets, habitat selection and foraging behaviour of Avocet chicks in saltmarshes and embanked habitats in order to investigate the effect of habitat selection on chick survival of Avocets in the Wadden Sea.

Saltworks as feeding grounds for shorebirds

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Coastal saltworks or salinas are functional wetlands supporting important numbers of waterbirds around the world. We assessed the role of saltworks as feeding grounds for several shorebird species by reviewing data about time spent foraging and net energy intake rates on intertidal natural areas and on saltworks. We concluded that saltworks are suitable foraging habitats for migrating shorebirds such as Little Stint, Curlew Sandpiper, Dunlin, Sanderling, Redshank or Black-tailed Godwit. We supported the idea that saltworks are valuable buffer wetlands that may supplement declining natural habitat for many long-distance migrating shorebirds, especially small-sized calidrid species.



Agricultural habitat provides an important dietary component for Dunlin wintering on the Fraser River delta: evidence from stable isotope analysis

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At the Fraser River delta, Canada's largest west coast estuary, native saltmarsh was converted to agricultural land over a century ago. The value of this farmland for foraging waders has not previously been quantified. We evaluated the proportional use of agricultural versus estuarine food sources using stable isotope analysis ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) of Dunlin *Calidris alpina pacifica* blood, testing for individual, age, sex, morphological, seasonal, and weather-related differences in farmland feeding. Based on single ($\delta^{13}\text{C}$) and dual isotope mixing models, farmland contributes approximately 38% of their diet, with wide variation among individuals in the extent of terrestrial feeding, ranging from an estimated 1 to 95% of diet. Dunlin field-use peaks in January. Younger birds had higher terrestrial isotopic values than adults, obtaining an average of 43.2% of their diet from fields, compared with 34.5% for adults. We observed a relationship with temperature and precipitation only for adult dunlin. The isotope data provide no evidence for sex or overall body size effects on proportion of diet from fields. The maintenance of suitable farmland habitat is an important component in conservation planning for this Dunlin population, and may prove significant on a wider geographic scale, particularly where native habitat such as saltmarsh has been removed or reduced.

Fitness consequences of habitat selection in the Eurasian Oystercatcher *Haematopus ostralegus*

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A population of Eurasian Oystercatchers has been followed on the Dutch Wadden Sea island of Schiermonnikoog for 22 years. Oystercatchers breed on the saltmarsh and feed on the intertidal mudflats. Some pairs have adjacent feeding and nesting territories, other pairs have separated feeding and nesting territories. This difference in spatial organization, at a scale of only a few hundred metres, has enormous consequences. We will discuss the importance of territory quality versus individual quality in determining reproductive output. Because of consistent differences in territory quality, young oystercatchers adjust their habitat selection strategy. Consequently, differential habitat selection affects population dynamics in this declining population.

The importance of the Wadden Sea saltmarshes for breeding waders

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Since 1991, the breeding birds in the Wadden Sea have been monitored under a programme that has provided essential data on the importance of this unique area.

The results of two total surveys confirm the outstanding value of the Wadden Sea, especially for colonial breeding species. Moreover habitats like saltmarshes, brackish meadows and permanent grassland in polders are also important breeding areas for several territorial species. Two groups of non-colonial wader species can be identified as showing opposite trends: species that use mudflats as feeding habitat, such as Redshank and Eurasian Oystercatcher are increasing, whereas most species dependant on terrestrial feeding in habitats affected by farming practises are declining.

So far, habitat protection in the Wadden Sea has focused on marine habitats and colonial breeding species. With the intensification of farming practises, many species have declined dramatically on inland meadows. At the same time, the importance of saltmarshes, brackish meadows and permanent grassland in polders has increased significantly for several territorial breeding species. There is a need for targeted nature management of these large areas of extensive farming to ensure their future as important breeding habitats for waders of the Wadden Sea and north-west Europe.

Distribution and abundance patterns of Redshank in the UK: How important is saltmarsh for breeding Redshanks?

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Animals are expected to distribute themselves in such a way as to maximise their reproductive output. Therefore breeding density is often regarded as a proxy measure for habitat quality. Redshank *Tringa totanus* are amongst the most ubiquitous of breeding waders in the UK. Important populations of breeding Redshank can be found on saltmarsh, grazing marsh and the uplands and coastal machair of Scotland. It has been estimated that 45% of the UK breeding population (Brindley *et al.* 1998) and 10% of the NW European population (Piersma 1986) currently nests on saltmarsh, making this a habitat of both national and European importance for breeding Redshank. In this presentation, we give an overview of the distribution and abundance of breeding Redshank across a range of habitats within the UK and make some predictions of habitat quality from patterns of breeding densities.



Sea level rise: Are breeding Redshank *Tringa totanus* caught between the sea wall and the deep blue sea?

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In the UK, the highest densities of breeding Redshanks are found on saltmarshes. This could be interpreted as evidence that saltmarsh is the highest quality breeding habitat for the species. However, breeding densities may not accurately reflect habitat quality, particularly in habitats that are undergoing environmental change. Sea level rise (SLR) is the most certain of climate change impacts, and for low-lying coastal areas the threats are particularly severe. The key implications of SLR are a loss or decline in the availability or suitability of saltmarsh and potential losses of other coastal habitats. Mitigation may not be possible in the coastal zone, and so inland habitat creation may become important. However, the relative quality of these different habitats for breeding wader species is not known, making effective mitigation strategies difficult to devise. East Anglia is both low-lying and has important breeding populations of Redshanks. Their habit of breeding on both coastal and inland habitats makes this an ideal species for a comparative study of habitat quality. Here, we present a comparison of Redshank breeding success on saltmarsh and coastal and inland grazing marshes and discuss these findings in relation to the production of high quality mitigation habitats to replace future losses of coastal habitats.

Wadden Sea saltmarshes, management and birdlife

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The Wadden Sea saltmarshes are a unique habitat along the coastlines of Denmark, Germany and the Netherlands. They

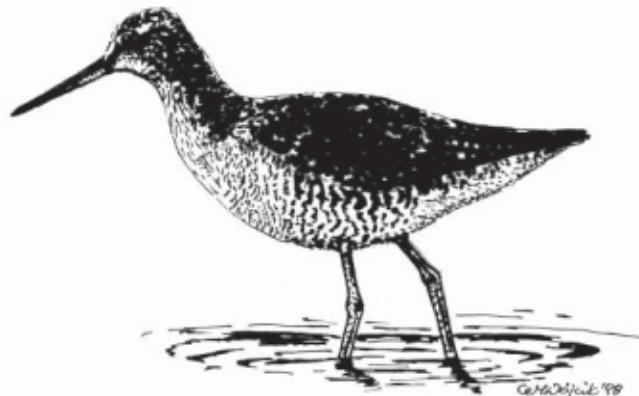
are protected by nature protection laws or are designated as national parks. This presentation gives an overview of the location, type and size of the marshes, presents data on spatial development and summarises the aims of the trilateral management arrangements as well as within the different countries. The main focus of the presentation will be a summary of the response of the birdlife to different saltmarsh management regimes in the Wadden Sea.

The importance of the Wadden Sea saltmarshes for reproduction of Redshanks *Tringa totanus*

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The majority of the European Redshank breeding populations are in decline, but population trends vary regionally. Whereas many inland populations and even the coastal population of Great Britain have declined dramatically during recent decades, the Wadden Sea breeding population is relatively stable at a high level. To contribute to an understanding of this phenomenon, Redshank reproduction was studied at different Wadden Sea breeding sites in Germany. At a mainland site in the western Jadebusen (since 2000) and on Wangerooge Island (2003), hatching success and potential influencing factors including, e.g., nest-site selection, behaviour and habitat use of adults, were investigated. At the mainland site, hatching success was extremely low (1–11% of clutches in 2000–2003) due to high predation, whereas it was comparatively high on the island (89%). Potential causes of these substantial differences are presented and discussed. We also try to assess possible consequences on demography and population dynamics on a broader spatial scale.



2. Monitoring Arctic-breeding shorebirds: in their breeding areas

This workshop focussed on improving and coordinating existing programs that monitor shorebirds in their Arctic habitats, including measuring population and demographic parameters of shorebirds, habitat use, prey and predator abundances, and environmental factors. Invited speakers described (1) geographic and logistical constraints faced by Arctic shorebird biologists around the world, (2) intensive demographic/ecological studies on Arctic shorebirds, and (3) less intensive checklist/density studies. The remainder of the day was spent on developing and finalizing protocols that can be implemented circumpolar-wide. Such protocols will be published in a future issue of the *Wader Study Group Bulletin*.

Rick Lanctot

Abstracts of talks

The slippery slopes of assessing the status of montane-nesting shorebirds: a protocol for Alaska

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Mountains are prominent features of all continents, but their associated avifaunas are generally poorly known. Such regions are usually remote, vast, and difficult to work in, with Alaska an exemplar of each. Beginning in the late 1990s, we designed a protocol to inventory primarily montane-nesting shorebirds and implemented it between 2001 and 2003 on some 81,000 km² of National Park lands in north-west Alaska. Building from the few small-scale studies done previously in this region, our objective was two-fold: 1) design a protocol that was efficient and repeatable under existing and near-future constraints of economics and logistics, and 2) obtain sufficient data on the occurrence, abundance, and habitat requisites of individual species to allow multi-scale (point, plot, and landscape) descriptions of habitat associations and populations (distribution, relative abundance, and density for abundant species).

From a stratified and randomized grid we selected 69, 10 × 10 km plots. Within each, we conducted 20–28 point counts during a 2-day period, with points spaced at least 500 m apart along transects and allocated in proportion to available topography and habitat. At each point, we conducted a 10-minute count of shorebirds and potential predators, followed by a 5-minute count for all other birds. These totaled 276 and 138 hours of survey time, respectively. We recorded 2,044 shorebirds and potential predators during the 10-minute counts and 5,330 birds during the 5-minute counts. A total of 115 bird species was detected on the plots, including 23 shorebird species and 14 potential predator species. Species richness was highest in areas closest to the coast (30 species/plot), with slightly fewer species recorded at more interior parks. The most commonly detected shorebirds and potential predators over the 3 years were *Pluvialis dominica* (0.19 birds per point), *Gallinago delicata* (0.17), *Numenius phaeopus* (0.15), *Stercorarius longicaudus* (0.25), and *Corvus corax* (0.10). Between 2004 and 2007 the protocol will be applied to 35,000 km² of National Park lands in south-west Alaska.

The use of double-sampling and habitat-based regression models for estimating shorebird distribution and abundance in North America

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The Arctic portion of the Program for Regional and International Shorebird Monitoring (PRISM) recommends periodic, comprehensive surveys of breeding shorebirds in the Arctic region of North America to estimate population size and trends, and to provide information on distribution, abundance, and habitat relationships. PRISM relies on a double sampling method that includes intensive and rapid surveys at a sample of plots selected randomly within a study area and stratified by habitat suitability. Species-specific detection rates are estimated by conducting intensive surveys on a small sample of plots that are also surveyed using the rapid method. After collecting data at a large number of locations, regression models are built that predict the number of birds that would be recorded on rapid surveys covering every plot distributed throughout the entire study area. These numbers are summed across all the plots and divided by the detection rate developed from the intensive plots. The current design aims to have at least two-thirds of the breeding range of each species surveyed, and at least an 80% power to detect a 50% decline occurring over 20 years with $\alpha = 0.15$, a two-tailed test, and a procedure that acknowledges effects of potential bias. Once implementation has begun, the entire Arctic portion of North America will be surveyed within a 5–7 year period, and given sufficient funds, repeated regularly. Data from migration and wintering areas will also be used to monitor shorebird population trends. To date, a lack of funds and the desire for a peer-review of Arctic PRISM has delayed full implementation of the program.



Shorebird monitoring at Zackenberg, high Arctic north-east Greenland

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Since 1995, monitoring of shorebirds in a 19 km² area has taken place at Zackenberg Research Station in central north-east Greenland (<http://biobasis.dmu.dk>). Monitored species are Great Ringed Plover *Charadrius hiaticula*, Red Knot *Calidris canutus*, Sanderling *C. alba*, Dunlin *C. alpina*, Ruddy Turnstone *Arenaria interpres* and Red-necked Phalarope *Phalaropus lobatus*. Numbers of potentially breeding pairs are recorded early in the season, followed by monitoring of breeding phenology, hatching and fledging success during the rest of the season. Methodologies are described in a manual (http://www2.dmu.dk/1_Viden/2_Miljoe-tilstand/3_natur/biobasis/biobasismanual.asp). Monitoring of populations and breeding success of Arctic shorebirds is notoriously difficult, and shortcomings will be discussed in the talk.

Intensive shorebird studies in Taimyr, Russian Arctic

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During 2000–2002, we conducted studies on breeding shorebirds from the Willem Barentz Biological station at Medusa Bay near Dikson, south-west Taimyr, Russia (73°N, 80°E). Our study area consisted of 4 km² of gently rolling typical tundra between 0 and 50 m above sea level. The basic research aim was to identify energetic bottlenecks in the breeding cycle and selective forces affecting the optimal phenology of breeding, and within that framework we carried out a variety of activities:

1. Daily recording of number of lemmings seen per hour in the field (index of lemming abundance)
2. Daily pitfall trapping and counting of surface-active arthropods in two lines of 10 traps in dry and wet tundra throughout the summer (daily and seasonal variation in insect availability as food for shorebirds)
3. Near-daily transects to count all waders and search for colour-marked birds (arrival date, transients)
4. Counts of visible bird migration in daily 1-hour watches and during clap-netting
5. Intensive nest-searching and trapping and colour-marking of breeding adults of nearly all shorebird species plus later searches for broods (nest densities, site tenacity, replacement clutches, condition of breeding adults)
6. Estimation of laying dates by egg-flotation or direct observations; regular revisits to nests to monitor success and ring chicks (laying dates, nest survival)
7. Intensive brood searches and recapturing of chicks (Little Stint) during the chick period (breeding density, chick growth rates, brood movements, (brood survival))
8. Clap-netting of waders during arrival period (arrival condition, arrival date)
9. Clap-netting of migrating waders during the departure period (departure condition)
10. Measuring nest attendance of uniparentally incubating

waders using temperature-loggers (time budgets during incubation)

11. Behavioural observations of Little Stint broods (time budgets of chicks and adults)
12. Doubly-labeled water experiments in Little Stint and Dunlin (energy expenditure during incubation and chick-rearing)

Besides the above, we monitored the following abiotic parameters:

- a. progress of snow melt – by walking near-daily transects
- b. weather parameters – a standard weather unit at the station plus operative temperature
- c. seasonal development of permafrost depth (1 year)

Activities 1–6(7) would be most likely included in an intensive monitoring program, and these activities would take *c.* 10 man-hours per day in the arrival period and 15–20 h/day thereafter for our 4 km² study area containing 160–200 wader nests.

As (development of) breeding densities was not our main research question, we spent no time on census activities other than nest searches, but 1–2 additional researchers carried out territory mapping of waders in the study area in several years beginning in 1998, within a monitoring framework set up by WIWO. A point of concern for monitoring schemes is that intensive studies as described here do increase predation rates on nests at least in some years. In site-tenacious species (which form a minority at Medusa Bay), this may well affect population trends and intensive study sites are probably better separated from density monitoring areas.

Approaches to breeding shorebird monitoring in a circumpolar perspective

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The ability to detect change in populations of Arctic-breeding shorebirds and identify factors responsible for such change depends on multiple factors. In this paper, the principal factors affecting shorebird monitoring in different regions of the Arctic are reviewed, primarily using information accumulated in the Arctic Birds Breeding Conditions Survey database. The fact that a high proportion of the Arctic is very remote and difficult and costly to access is an important factor in any plan for Arctic monitoring. In particular, Arctic parts of Europe and Alaska are different from Siberia and high Arctic Canada with respect to logistical and financial constraints for research. Subjective factors explain inconsistencies in monitoring techniques arising, for example, from different research traditions and study goals in different countries. Natural factors reflect differences in biology between shorebird species and between populations of a single species in the various biogeographic zones. Differences between species in mating systems or anti-predator behaviour are a restraint from using identical survey techniques for population monitoring. Densities of shorebird populations differ between biogeographic zones, and this affects the choice of survey methods. Thus variability of shorebird monitoring techniques among the Arctic regions can be explained to a considerable extent by a wide variety of factors that make development of unified approaches challenging.



3. Monitoring Arctic-breeding shorebirds: in their non-breeding areas

This workshop was organised as an output from the Committee for Holarctic Shorebird Monitoring (see *Wader Study Group Bull.* 103: 2–5) to take forward the ideas that were discussed at the workshop in Denmark in December 2003. The workshop had the following aims:

1. To discuss possible methods for monitoring recruitment and survival of waders outside the breeding season.
2. To identify the constraints of the various methods.
3. To assess whether it is possible to obtain population-wide parameters for recruitment and survival.
4. To work towards the production of guidelines for undertaking demographic monitoring.

The workshop stimulated lively discussions and these have fed into draft guidelines that will be published in the April 2005 issue of the *Bulletin*.

The morning session focused on recruitment. It was extremely gratifying to see that counts of the proportion of juveniles in the field yielded similar results as those from catches and these in turn correlated well with counts of birds that remained in their austral winter quarters during their first breeding season. Work in Australia has shown that the timing of the assessment the adult: juvenile ratio in the field is critical. There were two periods when it was possible: (1) a two-week period when all birds had arrived but the juveniles were easy to distinguish and (2) a period just prior to the return migration when the adults were in breeding plumage but the juveniles were still in non-breeding plumage. This showed that there needed to be detailed studies to validate the methods used to assess recruitment in each area. There was considerable discussion about the need to monitor a population throughout its range in order to assess accurately the absolute level of recruitment (number of birds) rather than just an index of relative recruitment (per cent juvenile) from a few sites, or a part of the range. This is particularly important where a species has age-related wintering areas. In addition, it was felt that it was important to consider the effect of changes in the local environment when assessing long-term trends in recruitment.

The afternoon session focused on survival and population monitoring. Two methods of monitoring survival were discussed. Using individual colour marks that can be read in the field was shown to work well if there was a dedicated group of people to resight the birds. Reliance on casual observations was unlikely to be sufficient to monitor survival on its own. The second was the analysis of retraps from ringing operations. To be successful and produce survival estimates with reasonable confidence limits it was suggested that about 50 resightings or retraps a year would be a reasonable figure to aim for when designing studies. There was agreement that colour ringing studies had great potential in yielding much information with relatively few birds ringed, but that such schemes needed to be well co-ordinated and they could not fully replace re-trapping efforts.

There were several themes that ran through both the morning and afternoon discussions:

1. Substantial amounts of data have already been collected. The people who have collected these data need to be brought together with statisticians who can develop methods for appropriate analyses. Statisticians should be encouraged to produce user-friendly analysis packages. One way of ensuring that this happens is through focused workshops, where the data-providers spend time discussing their data with the statisticians.
2. We should ‘embrace heterogeneity’ in populations and data collection, despite statistical challenges, as this is likely to lead to the greatest insights into the factors driving populations.
3. Any monitoring should be carried out at a range of sites encompassing a range of sizes and ecological features.
4. Many of the long term datasets are collected by volunteers who need guidance and feedback to encourage them to continue to develop their work.
5. Long-term monitoring is vital for assessing the impacts of global warming on waders, particularly those which breed in the high Arctic that are especially vulnerable.
6. There is a need for wader ecologists to use political influence to ensure that the funds are available to deliver the data needed to monitor international agreements, such as the African Eurasian Migratory Waterbird Agreement and EU Directives. The volunteer collectors of the information are keen; they just need support and encouragement.

Nigel Clark and Rob Robinson

Abstracts of talks

Modelling populations by integrating recruitment and survival

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Recruitment and survival are the main drivers of population change. Thirty years of ringing and count data collected on

the Wash (UK) are used to investigate whether changes in survival and recruitment estimates obtained from ringing are sufficient to account for changes in the annual counts of Oystercatcher and Knot populations. The population dynamics were different between species – Oystercatchers showed very consistent survival, except for years in which food shortages caused large-scale mortality and variable recruitment, whereas Knot showed very variable survival and recruitment rates. In both populations, however, recruitment



drove the long-term population trend. The work shows the value of long term monitoring in identifying the causes of population change. The results are discussed in the light of the practical difficulties that occur with long term monitoring programmes and identify key issues to be borne in mind when designing monitoring studies.

Monitoring recruitment from the proportion of juveniles in catches: methodological considerations

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The proportion of juvenile waders in cannon net catches in the UK was used to investigate methodologies for producing estimates of juvenile recruitment with confidence intervals. An individual index using linear modelling is recommended. The potential biases involved in the use of catch data to measure recruitment are discussed. Some practical measures for minimizing such biases when setting up new projects to monitor recruitment through ringing studies are considered.

Monitoring recruitment on migration at Ottenby

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Data from regular trapping of waders in the autumns 1948–2002 at Ottenby, Sweden, are presented. Birds are trapped in walk-in traps in July–September. Numbers trapped can vary drastically both between and within years, depending on weather-dependent changes in trapping conditions. Since adults and juveniles normally pass Ottenby with a month's separation in time (adults first), the number of adults and juveniles trapped in a given year may vary independently, precluding a meaningful estimate of juvenile production (juveniles/adults). Instead, a more meaningful reproductive estimate may be the number of juveniles as such. It is shown that the number of juveniles trapped of species from the same breeding areas vary particularly well together. It is also known that for Red Knots and Curlew Sandpipers, the number of juveniles is highest in years with high densities of lemmings in the Arctic. A problem, however, is that years with low numbers trapped may still be good years in terms of reproduction, but trapping conditions have been poor at Ottenby.

Monitoring recruitment in the non-breeding season: does it work

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The proportion of juveniles in catches has been used to monitor the recruitment of a range of waders that spend the non-

breeding season in Australia. I present information on those species that do not migrate back to the Arctic in their first year and show that for some the counts of non-breeding birds in the austral winter are closely correlated with the proportion of juveniles caught in the previous austral summer. This validates the use of catches to monitor recruitment. The need to take the productivity of the previous year into account when assessing breeding productivity is discussed.

The importance of integrative data in demographic monitoring

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Integrating data collected across the flyway, throughout the annual cycle or across different disciplines can facilitate demographic monitoring of non-breeding shorebirds. Examples include the use of age-ratios as a measure of recruitment and the interpretation of apparent population declines.

Western Sandpipers *Calidris mauri* are small migratory shorebirds that mainly breed in Alaska and overwinter on the American Pacific coast between southern Canada and Peru. Combining data collected at 12 sites showed that adults and juveniles were not distributed evenly throughout the non-breeding range, but juveniles were overrepresented at the northern and the southern ends of the range. Such latitudinal trends in age-ratios need to be taken into consideration when age-ratios are used as an index of recruitment.

The observed distribution pattern interacted with a latitudinal life-history divide: northerly juvenile Western Sandpipers migrated north and attempt to breed in their first summer, while southerly juveniles overwintered at their nonbreeding sites. This suggests that two life-history strategies exist, provided that individuals of either strategy have similar life-time fitness. Survivorship estimates obtained on breeding and nonbreeding areas were comparable, but apparent juvenile survivorship was higher in Panama than in Mexico, as predicted from their life history differences.

The number of Western Sandpipers counted on southward migration at Sidney Island, a small stop-over site in British Columbia, Canada, has declined dramatically over the last 10 years. Average length-of-stay as well as body mass also decreased significantly, while birds using larger intertidal areas in nearby Boundary Bay maintained a consistent body mass. Food conditions, as inferred from blood parameters indicating fattening rates, were, however, better at Sidney Island than at Boundary Bay. Higher body mass renders individuals vulnerable to depredation, and numbers of Peregrines *Falco peregrinus* in the area have increased during the past decade. Site choice is thought to be a trade-off between food availability and safety, and larger, more open sites are generally considered safer. An individual leaves the more dangerous but more profitable site when reaching a certain 'departure-mass threshold'. The increased predation pressure at Sidney Island has lowered this threshold, which in turn lead to a shortening of length-of-stay. As a consequence, fewer birds were counted, even though population modeling with mark-recapture techniques showed that the total number of individuals using Sidney Island had not changed significantly. Instead, the lower counts were caused



by a behavioural shift in habitat use. Raptor population recovery is taking place on a continental scale, and it is thus possible that such shifts are taking place elsewhere. Protocols to monitor populations of migrants should take this possibility into account.

Dunlin survival estimates from a long-term wintering study in southern England

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Since November 1978, Dunlin have been caught at a site in Poole Harbour, southern England. The site, beside a well-illuminated main road, is mainly used at night and only during the winter (early November to mid-March) by up to 1000 birds. Full-height mist-nets are used, set just below the high tide mark, beginning c.15 m from the road.

From 498 catches, 4,372 individuals have been caught (1,384 as juveniles). Thirty-two per cent were caught in later winters, often many times. The juvenile numbers varied between 7 and 179 per winter, corresponding to 4.5 and 81 per 100 adults (average 25/100 adults), and normally showed a 3 or 4 year cycle. The recapture rate in later winters was the same for both age-classes, but varied significantly between the months of ringing, being highest for Nov./Dec. Fifty-five per cent of Dunlin recaptured from previous winters were caught again in a later winter. This suggests that 60% of the birds initially caught are regular at the site with the remainder transient. In recent years most of the adults caught are already ringed.

Estimates of annual survival made using the later winter retraps, had values between 0.65 and 0.96 ($\sigma \approx 0.02$) with an average of 0.81. Estimates from the survival of individual cohorts gave the values around 0.8. A stable population with an annual survival of 0.80 would need an annual productivity of 25 young per 100 adults.

Although 10% of retrapped birds occurred 10 years after ringing, none were caught later than 16 years. A plot of log (% caught N years later) against N was linear for the first 11 years (juveniles), and 9 years (adults), corresponding to $S = 0.81$, but then S dropped to about 0.6, suggesting increasing mortality, as there was no evidence of ring loss.

Monitoring wader survival through metal ringing studies

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An understanding of annual survival patterns is important in helping to diagnose causes of changes in numbers. Survival is most easily measured through catching and ringing birds and analysing the pattern of subsequent recaptures and recov-

eries (found dead or sighted in the field) of individuals. We compare and contrast the results obtained from a number of studies and consider their strengths and weaknesses. From this we outline some of the practicalities that need to be considered in setting up projects to monitor the survival of both immature and adult birds in wader populations.

Measuring productivity from numbers at flyway termini

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The southern termini of the flyways are likely to be particularly sensitive to changes in numbers of waders using them. In an era of global climate change it is those birds that migrate the longest distances that are most likely to mis-time their northward migration so that their arrival on the breeding grounds is later than optimal, resulting in reduced breeding success, and smaller numbers of individuals migrating south along the flyway. These smaller numbers of birds are likely to be accommodated at sites nearer to the breeding ground, so that the southern termini are likely to demonstrate exaggerated declines. For many long-distance migrant waders, one-year old birds do not return to the breeding grounds, but remain at their first non-breeding site through the breeding season (the austral winter). This provides a final opportunity to measure the breeding productivity in the Arctic one year previously. Thirty years of data from Langebaan Lagoon, Western Cape, South Africa, is used to illustrate this approach to estimate breeding productivity.

Colour-marking studies to monitor survival

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Long-term monitoring is the only reliable way in which population parameters, such as survival and mortality rates, can be estimated with any accuracy. It is therefore very important in identifying trends and in guiding conservation. Long-term colour-marking studies ought to be ideal for survival analysis of shorebirds in the non-breeding season. However, problems that stem from both the methodology used (e.g. variability in resighting effort and probability) and lack of information about the status of individuals (e.g. territoriality and variability in the level of site fidelity) need to be carefully considered before embarking on such a study. In this presentation, some of the practical problems that are likely to be encountered are discussed with particular reference to a database that holds 25 years information on the wintering shorebird populations of the Tees Estuary in north-east England. Recommendations as to how to approach the collection of data that is more appropriate for survival analyses from colour-marking studies will be suggested.



4. Turnover issues at migration stopover sites – how many individual birds use a site, when do they arrive and how long do they stay?

The term 'turnover' is a broad concept but essentially is an understanding of the number of individuals coming into and leaving a population of birds at a specific site and thus being able to establish the length of stay (LOS) and the total numbers of birds passing through the area. For many years, there has been an appreciation of turnover in populations of birds but, in practice, this has rarely been measured. It is an important concept as counts of birds have long been used as a basis for designating sites as important for nature conservation and it can also provide interesting biological insights into the study of the migration strategies of individual animals.

One of the major barriers to measuring turnover in wader populations has been a poor understanding among shorebird biologists of both the field and statistical methodologies necessary, and the constraints and potential biases that can occur when estimating LOS and total numbers. This workshop was designed to bring together both statisticians and field biologists to further our understanding and develop easily applicable methods and guidelines for fieldworkers. These will appear in a future issue of the *WSG Bulletin*.

Phil Atkinson

Abstracts of talks

Ecological correlates of turnover – are there interesting questions to be answered?

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At staging sites, the arrival time, length of stay of individuals and total number of birds that pass through are often of interest, but 'turnover' in its widest sense can often tell us more than just the numbers of birds passing through staging sites. It can inform on migration strategies of individuals, whether different populations pass through and use sites in different ways, ecological conditions on staging areas and life history decisions made by birds. This talk will give examples of where turnover can be used to answer some interesting questions about shorebird ecology and life history.

Estimating turnover and volume in staging wader populations: methodological and practical aspects

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At wader staging sites, estimating the total number of birds

passing through during a migration season (volume) is necessary to determine the importance of the site and thus the amount of conservation effort that should be dedicated to it. Estimating volume is closely related to estimating turnover or stopover duration, but also includes estimating how many birds are present at any one time. Here I will present one possible approach to estimating volume, along with some ideas for how this could be integrated with the more established methods for estimating stopover duration. Next, I will deal with some of the practical issues faced by wader biologists, and how these could affect the validity of volume or turnover estimates. Among the most dangerous problems is heterogeneity, where two or more populations use the same staging site simultaneously. In extreme cases, this can lead to highly biased estimates of volume.

Turnover in Red Knot *Calidris canutus* spring staging in Delaware Bay, USA

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Each spring Delaware Bay (eastern USA) supports large numbers of staging Red Knots before the final leg of their spring migration to the Arctic. Recent declines in winter numbers and spring peak numbers have prompted concerns over the demography of this population. Using peak numbers as a measure of population size is problematic since arrivals and departures may be staggered through May, and stable isotope analysis of flight feathers indicates that different wintering populations may be involved. Understanding turnover is therefore of paramount importance to understanding both the ecology of Red Knots within the Delaware Bay system, and determining more accurately their population trends. Here we present the first two years of results from banding and resighting of Red Knot using inscribed coloured flags. These results highlight the staggered arrival into Delaware Bay and how stopover duration may vary annually.

**Using predictive GIS modelling
 in order to investigate
 large-scale shorebird migration, turn-over rates
 and populations in the Sea of Okhotsk,
 Russian far east**

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Predictive spatial modeling allows us to present the relative probability of occurrence for species of interest at specific localities. This new approach can be particularly useful for large areas which are unknown or poorly studied. The Sea of Okhotsk in the Russian Far East consists of a huge coastline along the East Asian-Australasian Flyway. Detailed shorebird survey data, turn-over and population estimates are usually missing for this region, and therefore we use 'presence only' information and confirmed absence from our own six years of field work and from a Russian Literature Review in order to help in predicting the occurrence of shorebirds (Great Knot, Red Knot and Bar-tailed Godwit) during autumn and spring migration. For habitat predictors, we use tidal range, river type and size, surrounding substrate type and mudflat size obtained from Remote Sensing layers, software tools, hardcopy maps and others. A progressive modeling approach is presented using GIS and statistical linear and non-linear modeling algorithms such as GLMs, CART and MARS. It is shown how turn-over estimates from our fieldwork and from scenarios can be used in this new spatial modelling context in order to match and to evaluate relevant estimates of the overall population along the flyway.

**Difficulties in estimating the number
 of birds using a staging site:
 a methodologist's point of view**

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Counts of birds present on different dates at a staging site do not by themselves allow us to estimate how many birds have passed through that site. It is necessary to know whether those present on different dates are the same or different birds. Individual recognition of a representative proportion of the birds is the key. This said, the quality of the results will depend on both the quality of the data and that of the models used for analysis. I believe that good coverage of the season is desirable. Also, I argue that local marking has advantages over the observation of birds marked elsewhere. As for the models, it seems unavoidable to incorporate some kind of heterogeneity of the probability of encounter.

**Turnover rates and population estimates of
 spring migrating Ruffs *Philomachus pugnax* in
 south-west Fryslân, the Netherlands**

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South-west Fryslân (the Netherlands) is an important stopover site of Ruff during northward migration, and to a lesser extent during southward migration. For a few years, bi-weekly counts have been made by local birdwatchers to assess the number of Ruffs using the area, but this yielded only conservative estimates of the numbers of Ruff passing through the area. To measure turnover rates, between 15 March and 15 May 2004, in close collaboration with the local 'wilsternetters', 1,089 Ruffs were captured, measured and individually colour-banded. Over the same period we checked staging flocks for the presence of individually marked birds, and also received a good number of resightings from the general public. Here we will present a data analysis carried out with MARK software to give estimates of stopover time and turnover. Furthermore, individual arrival, length of stay and departure will be related to biometrics and sex. This will allow us to test the suggestion that more than one population passes through the area. We will also elaborate on our hope that a colour-banding project like this will allow us not only to get a better insight in the timing of migration but in the long run will provide us with survival rates of birds with a known life history. Moreover, it might give us a first glance at population structuring. The latter will be investigated using molecular techniques.



Annual Conference – Abstracts of talks

The use of low tide foraging areas by waders in the western Scheldt (south-western Netherlands), a habitat suitability analysis

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In the Western Scheldt (south-western Netherlands), the low tide distribution of a number of wader species and shelducks was assessed from September 2003 until October 2004. In total, 8 counts were performed. Abiotic data for the counting sites were available. The distribution pattern was analysed following an adapted GLM-modelling technique. It was found that suitable foraging sites may or may not be used, while unsuitable sites will not be used for foraging. The method will be outlined, and results presented.

The WSG Colour-marking Register

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Colour-marking is fundamental to many wader research projects. To maintain the validity of these projects The Wader Study Group coordinates a central register for colour-marking schemes for waders. This central database is designed to avoid conflicting schemes running concurrently, provide guidance on colour-marking and to act as a central contact between ringers/banders and observers.

The database can only function with the whole-hearted cooperation of colour markers and good communication between them, the Register and observers. An overview of the Register will be presented along with new developments in colour-marking and the Register.

Oystercatchers *Haematopus ostralegus*, Cockles *Cerastoderma edule* and cockle fishery in the Dutch Wadden Sea

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Suction dredging for cockles in the Dutch Wadden Sea, an internationally renowned nature area, has been at the heart of a heated controversy between nature conservationists and fishermen since about 1990. To investigate the various opposing claims on the effects of both the cockle fishery and the mussel fishery in the Wadden Sea and Oosterschelde, and to evaluate the shellfish fishery policy that was adopted in 1993, the Dutch government established an extensive research program, which was recently completed (Ens *et al.* 2004). The report can be downloaded from:

www.alterra.wur.nl.

The talk presented at the conference confined itself to the effect of shellfish fishery on a major predator of shellfish in Dutch coastal waters, the Oystercatcher *Haematopus ostralegus*. The aim of the policy of food reservation is to prevent extra mortality among birds due to extraction of shellfish by fishermen in years when shellfish are scarce. To investigate if the calculations underlying this policy were sound, we developed a model describing the amount of food stress Oystercatchers experienced for a given food supply (Rappoldt *et al.* 2004). We applied this model to the Oosterschelde (Rappoldt *et al.* 2003b) and to the Wadden Sea (Rappoldt *et al.* 2003a). It was very clear that the amount of food reserved for the birds was too low, because the reservation was based on the physiological food requirement, i.e. the amount of food the birds actually consume in the course of the winter to stay healthy, instead of the ecological food requirement, which we defined as the amount of food that has to be present in the ecosystem at the start of winter, so that the birds can meet their physiological food requirement. We found the ecological food requirement to be three times higher than the physiological food requirement, in line with results for estuaries in Great Britain and France (Goss-Custard *et al.* 2004).

According to our model calculations, the carrying capacity of the Dutch Wadden Sea for Oystercatchers was decreased by about 15,000 birds. However, the wintering population of Oystercatchers declined from 260,000 in the 1980s to a stable level of 170,000 at the end of the 1990s. According to our calculations, most of this decline is due to the disappearance of the intertidal mussel beds in 1990, followed by a slow recovery. There is no doubt that intensive mussel seed fishery played an important role in this decline, but the relative importance of other factors like failing recruitment and heavy storms is still a matter of debate.

Several scientific puzzles remain. We did not find that Oystercatchers decreased more in areas that were open to the fishery compared to areas that were closed. However, we did find that birds in areas closed to fishery were in better condition (Verhulst *et al.* 2004). An even bigger puzzle is that during the first years of the study, recruitment of cockles was higher in the areas closed to fishery, in line with the reports of Piersma *et al.* (2001) that suction dredging has long-lasting negative impacts on the suitability of sediment for shellfish recruitment. However, since 2000, recruitment is slightly higher in the areas open to fishery. According to Ens *et al.* (2004) this may be due to the negative effects on recruitment of the much higher cockle stocks in the areas closed to shellfish fishery.

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The utilisation of the modern agricultural landscape by Golden Plovers *Pluvialis apricaria* during autumn stopover in southern Sweden

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The negative effects of farming practices on birds that breed or winter in the modern agricultural landscape have received much attention, but much less notice has been taken of birds that use this habitat during migration. The Golden Plover uses agricultural land for several months when stopping over on migration and is therefore a suitable species to study in this aspect. Are agricultural landscapes harmful to the plovers or are they possibly beneficial? In autumn 2003, I censused a largely arable landscape in south-west Scania, and determined the number and distribution of Golden Plovers as well as their habitat selection. Most flocks were found on arable land, only 2% on grassland. The plovers preferred large fields with a vegetation height <10 cm. Above all, they selected fields with winter cereals. Most Golden Plovers were recorded around Barsebäck. This appears to be a high quality daytime roosting area due to its many large arable fields and proximity to the sea. The modern agricultural landscape seems to be beneficial to migrating Golden Plovers since they preferred one of the most large-scale and exploited areas of arable land available. Moreover, they avoided small-scale farmland and grassland. However, we do not know how this utilisation affects plovers in the long term.

Primary moult and biometry of Wood Sandpipers wintering in southern Africa

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The progression of moult in Wood Sandpipers was analysed

based on data on 1,070 birds wintering in southern Africa, collected during 1963–2000. Based on field records of moult (according to Ashmole 1962), primary scores (PS) were calculated and compared between regions and age classes (1st winter, 2nd winter and adults – adults comprising birds in their 2nd or later winter).

Moult progression did not differ among regions for any age class (Mann-Whitney U-test, in all cases $P > 0.05$), suggesting that the same population winters over the whole of Southern Africa. Adults completed their moult (PS = 50), when 1st winter birds had a maximum PS of 30 (i.e. they had moulted up to 6 outer primaries, but usually 4). Adult Wood Sandpipers were more advanced in moult in subsequent periods of the winter season than both 1st winter and 2nd winter birds (U-test, for all comparisons $P < 0.05$). At the beginning of the wintering period, some 2nd winter birds were more advanced in moult than adults, suggesting that they had stayed in the wintering grounds over their first breeding season. The differences in primary scores arose from differing moult strategies. The percentage of adults showing normal (continuous) moult renewing all primaries was 98.3; 97.1% of 1st winter birds showed supplemental moult (i.e. renewing the outer 4–6 primaries), 2nd winter birds showed mostly (71.4%) normal moult. Suspended moult was found in two adults. Wing length differed neither among regions (U-test: for all age classes $P > 0.05$) nor age classes (Kruskal-Wallis test: $P > 0.05$). The moult speed calculated based on retrap data did not differ between 1st winter birds and adults (U-test: $P > 0.05$). No relationship was found between the speed of moult and body mass (Spearman Rank for adults and 1st winter: $P > 0.05$).

Juvenile shorebirds on the Banc d'Arguin, Mauritania, feed on dangerous places, but why?

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We report on a study in progress which tries to explain age-related predation costs by assessing age-dependent foraging strategies.

In the Banc d'Arguin, Mauritania, juveniles of Red Knot (and several other shorebird species) were more often depredated by large falcons than adults (observations based on prey remains). Furthermore, juvenile birds appeared to segregate from the adults, choosing more dangerous patches to forage. Although these peculiarities in juvenile behaviour are a well-known phenomenon, mechanisms are often unclear. So, why do juvenile Red Knots in the Banc d'Arguin take these risks?

Three possible mechanisms explaining age-related patch choice are hypothesised:

1. an energy–predation trade-off
2. age-dependent competitive abilities
3. age-dependent foraging abilities



Small male Ruffs *Philomachus pugnax* with feminine plumages: evidence for a third reproductive strategy, the faeder?

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The Ruff is a sexually dimorphic wader, with the bigger males having very variable breeding plumage. Two male strategies have been described. The colourful 'independent' males occupy territories on leks (or attend leks as marginal males). In contrast, the white-ruffed 'satellite' males are tolerated by the independent males, but 'steal' copulations. Wing length does not overlap between the sexes, but sometimes intermediate birds with female plumage occur. Fifteen of these birds have been collected in the Netherlands and in Belarus and had normal testes. Moreover molecular sexing of the Dutch birds confirm them to be males. The feminine breeding plumage of the intermediate sized birds contained the 'striped' feathers typical of the prenuptial plumage. We suggest that these males represent the original stage of maleness in Ruffs and propose to name them 'faeders', the Old English for arch-father. We will present data on the frequency of faeders at two stopover sites. In addition, we report on a preliminary study of faeders held in outdoor aviaries with normal males and females. Conditions resembled a natural lek, with displaying males. Behavioural observations indicate that the males treated faeders as if they were females. In addition to male-male and male-faeder (semi-) copulations, eight male-female copulations were observed, and once a faeder was seen to copulate with a female.

The Bragantinian intertidal, north-eastern Brazil – a low quality wintering habitat for North American shorebirds?

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The northern coast of South America is known as a major wintering site for North American migrating shorebirds. In 2001/2002 I had the opportunity to investigate a part of this coast: the intertidal areas of the Bragantinian peninsula. During winter, shorebirds reach high densities in this area. However, investigation of the benthic community showed that the food supply for the shorebirds is small. Moreover, only a tiny fraction is harvestable by the birds. Therefore: is the intertidal area we investigated a low quality wintering habitat?

We estimated the monthly consumption of all birds present in the study area and found that it exceeded the food supply several times over. Even high reproductive and growth rates, as often shown by tropical benthic organisms, could not compensate for this. In contrast to this finding, an enclosure experiment detected hardly any influence of avian predation on the benthic community. Consequently, most of the birds must have had other, more profitable foraging areas elsewhere.

Comparison of feeding techniques of Wood Sandpiper *Tringa glareola* and Ruff *Philomachus pugnax* during spring migration in north-eastern Poland

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This study on the foraging ecology of two wader species – Ruff and Wood Sandpiper – that are not specialised in terms of their feeding techniques was conducted in 2002 on a lake in the Sajna River valley, north-eastern Poland. It appeared that while foraging on a stopover site during spring migration Ruffs used a different ecological niche than Wood Sandpipers. Ruffs foraged significantly more in medium and deep water and also made more medium and deep probes, indicating a strategy of touch-location of prey by random probing. Consistent with this was a high intensity of probing and proportionally low rate of success. In contrast, Wood Sandpipers foraged less intensively but more effectively. This, together with frequent changes of feeding location in terms of water level indicates that Wood Sandpipers use visual detection of prey to a greater extent than Ruffs.

How many shorebird nests do we miss?

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In the Arctic regions of North America, the Program for Regional and International Shorebird Monitoring (PRISM) uses double-sampling to estimate population sizes and trends of tundra-breeding shorebirds. This approach assumes that most nests are located on a sample of intensively surveyed plots. We tested this assumption at the Kanaryarmiut Field Station (KFS) in the Yukon Delta National Wildlife Refuge and at the Barrow Environmental Observatory (BEO) near Barrow, Alaska. At each site, four 16-ha survey plots were established. Two surveyors independently visited each plot 6–11 times over 3–4 weeks and spent 48–70 hours per plot searching for nests. A third independent rope-dragging crew visited each plot 3–4 times over 2–3 weeks and spent about 16–18 hours per plot per team searching for nests. A total of 62 and 39 shorebird nests were located at KFS and BEO, respectively, with the dominant species being Western Sandpiper, Dunlin, and Red-necked and Red Phalaropes. Across all plots, the percentage of discovered nests found by the four individual surveyors ranged from 70–89% at KFS and 43–75% at BEO. Rope-draggers found 61% and 65% of the nests present at KFS and BEO, respectively. We explore how search effort at the two sites may explain differences in nest detection and use a Lincoln-Peterson estimator to approximate the true number of nests on the plots.



Spacing behaviour of wintering Red Knots *Calidris canutus* on the Banc d'Arguin, Mauritania

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Spacing behaviour in non-breeding shorebirds represents predictable responses by individuals to ecological and evolutionary processes. Its behavioural characteristics enable individuals to deal with spatial and temporal variability in resources in order to maximize survival. In December 2003, we studied the spacing behaviour of 20 radio-tagged Red Knots *Calidris canutus* on Banc d'Arguin, Mauritania. Strengthening earlier implications we found that birds are very site faithful to their roost and that the daily foraging range is as small as 10 km² of intertidal area over months. We found no differences between their movements by day and by night. This pattern differs from space use by Red Knots wintering the Wadden Sea where they continuously change roost sites, and cover an area as large as 800 km² in a couple of tides, but do not show differences between day and night either. Further on, we compared our findings with the space use of Red Knots wintering in Patagonia and north-western Australia which have comparable home ranges to those found in Mauritania but do differ in spacing behaviour between night and day.

The importance of drainage channels for waders foraging on tidal flats

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Small scale features of tidal flats can influence the carrying capacity of estuarine wetlands. In this study, we evaluated the influence of drainage channels, one of the most obvious of these features, on the quality of feeding habitat for waders in the Tagus estuary, Portugal. We measured wader abundances in five distance classes from the channels (<1 m, 1–2 m, 2–5 m, 5–10 m and >10 m). In addition, we measured the density of macroinvertebrate prey and the sediment physical–chemical characteristics at different distances from the channels. All seven studied wader species had substantially higher densities near the channels, usually several times higher than away from them. In the study area, 44% of the birds were feeding on just 12% of the available surface (i.e. less than 5 m from a drainage channel). There was no evidence that sediment characteristics had a significant influence on the densities of birds near channels. However, prey abundance corresponded closely to that of the birds, suggesting that this factor strongly influenced the small scale distribution of waders on the tidal flats. We concluded that the areas around drainage channels are particularly important

feeding sites for waders, so channel networks should be preserved to maintain the foraging value of tidal flats.

Western Sandpipers change foraging behaviour with abiotic factors: Implications for their hemispheric distribution

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Migratory shorebirds need to replenish their energy reserves by foraging at stop-over sites en route. Adjusting their foraging behaviour to accommodate variation in local prey availability would therefore be advantageous. We test whether Western Sandpipers *Calidris mauri*, a sexually dimorphic shorebird, adjust their foraging behaviour in response to local changes in prey availability, as inferred by changes in diurnal time and sediment temperature. Both males and females showed quantitative changes to foraging mode in relation to each of these variables. Probing, for example, which is used to exploit infaunal prey, was significantly more common at higher temperatures. Our results are consistent with the notion that Western Sandpipers can adjust their foraging behaviour in response to variation in prey availability. Further, we speculate that temperature-induced changes to prey location may contribute to the striking sexual segregation observed for this species during the migratory season.

Seasonal and tidal variation in activity patterns of the African Black Oystercatcher *Haematopus moquini* at Koeberg Nuclear Power Station

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Observations were carried out from June 2003 until May 2004 at two sites at Koeberg Nuclear Power Station (33°40'S, 18°25'E), Western Cape, South Africa. One site was on a sheltered rocky shore, created by the construction of a harbour at the power station, and the other on an open sandy beach. Observations were recorded as the number of African Black Oystercatchers birds performing each of 12 activities in a 20-minute period during daytime. Four activities, foraging, standing, sleeping, lying down and preening accounted for over 90% of all activities observed at both study sites. A suite of explanatory variables, meteorological and tidal, were available for each observation period. Each of the activities was modelled using a generalized linear model, with a binomial distribution. On the rocky shore, the influence of tide height on feeding (with knock-on effects to most other activities) dominated all other explanatory variables; on sandy shores, temperature and wind had a large influence. On rocky shores feeding activity peaked at low tide, whereas on sandy shores it peaked on the outgoing tide.



Sex differences in biometrics and migration phenology of Wood Sandpipers *Tringa glareola* on spring passage in north-east Poland

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In this study, differences in biometrics, as well as in timing of migration, between male and female Wood Sandpipers were found on spring migration in Poland. Wood Sandpipers were ringed in Kwieciewo (53°50'N, 20°20'E, north-east Poland) during the period 27 April to 14 May 2003, by the WRG KULING. A standard set of measurements was taken from each bird and a drop of blood was taken for laboratory analyses from most individuals. Due to a lack of a distinct sexual dimorphism, the birds were sexed by DNA analysis, based on amplification of the CHD gene with PCR technique (according to Griffiths *et al.* 1998). In total, 29 females and 31 males were identified. Females were on average larger than males – differences in total head, tarsus plus toe, wing length and body mass were significant (*t*-test: $P < 0.05$ in each case). However, for each measurement the range of values for males and females overlapped greatly, thus it would not be possible to distinguish sexes in the field by any single parameter. With a larger dataset, a discriminant function could be established to “calculate” the sex of a given individual from a complex of its body measurements. The median date of migration of males through the ringing site (8 May) was 3 days earlier than of females (11 May) (Mann-Whitney U test: $Z = 2.97$, $P < 0.05$). This corresponds with earlier occupation of breeding territories by the males, before the arrival of the females.

Functional aspects of shifts in preen wax composition in shorebirds

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Birds possess a preen (or uropygial) gland on their rump that secretes substances which are preened into the plumage, and which are probably essential for plumage maintenance. Secretions of the uropygial gland predominantly consist of complex mixtures of many different wax esters. We have found that shorebirds show pronounced seasonal changes in the composition of their preen waxes. At departure to and arrival on the breeding grounds, the usual monoester wax drastically changes to a more complex diester-based wax, which is maintained throughout the breeding season by incubating individuals only. The diesters have high molecular weights and probably different physical properties than monoesters, and the secretion and use of diesters rather than monoesters may entail specific costs and benefits. We will present results of comparative and experimental research into

the functioning of different preen wax mixtures in resistance against feather abrasion, plumage colouration, olfactory conspicuousness, and growth-inhibition of feather-degrading bacteria.

Does the presence of water over the sediment during low-tide increase wader prey activity?

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In some estuaries large areas of intertidal flats remain covered by a film of water during most or all the low-tide period. It has been argued that benthic invertebrates are more active when the sediment is covered by water, and that this may influence the availability of prey for waders. We studied the surface activity of *Scrobicularia plana* siphons and *Hediste diversicolor*. Our objectives were (i) to measure invertebrate activity throughout the tidal cycle and (ii) to quantify the influence of surface water thereon. We filmed invertebrate activity in plots of 500 cm² of intertidal sediment during the entire tidal cycle (exposure period about 7 hours). After a control period, the water level in the plots was manipulated so that some were allowed to dry during low-tide, while others were kept covered with 0.5 cm or 2 cm of water. There were more siphons of *S. plana* at sediment surface after emersion and in the middle of the cycle, and generally the activity was more regular with more water. The number of siphon ‘sweeps’ was highest with more water, probably because food particles in such conditions are more dispersed. *H. diversicolor* were more active at the end of the cycle, and less active in the presence of water.

Fitness components in Black-tailed Godwits *Limosa limosa*

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Life-history patterns in shorebirds are fascinating and can give some insight to the evolution of their migration systems. It has been proposed that those species that breed in the high Arctic are specialized in that they are long distance migrants using extreme, but relatively pathogen-free, Arctic breeding areas and marine wintering grounds. This might lead to relatively low immunocompetence. Species breeding further south are less specialized, invest more in their immune system and so can afford to use pathogen-rich fresh water habitats as wintering grounds. The amount of available habitat enforces populations wintering in marine habitats to be smaller. As a result, they have a greater likelihood of population bottlenecks which may lead to lower immunocompetence. Shorebird species wintering inland have larger populations, a higher genetic variability and thus can invest more in the immune system. This hypothesis was the stimu-



lus for the project we present on Black-tailed Godwits. The objective is to obtain an overview of variation in quality and current condition defining traits in individual Black-tailed Godwits concerning timing, plumage intensity and reproductive success. We established an individually colour-ringed breeding population of Black-tailed Godwits. Here, we like to present the first results of this study, with a focus on relations between different fitness components.

The breeding social system of eastern Broad-billed Sandpipers: does it differ from that of the western subspecies?

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Current knowledge of the social system of breeding Broad-billed Sandpipers *Limicola falcinellus* is rather superficial and based largely on information accumulated for the western subspecies *L. f. falcinellus* in Scandinavia (Cramp & Simmons 1983, Rae *et al.* 1998). For the eastern race, *L. f. sibirica*, which breeds in north-eastern Siberia, only Flint (1973) offers substantial information on social biology. The available data for these taxa suggest that there are differences in their territorial and parental behaviours. Specifically, males in Scandinavia defend territories, but those in east Siberia are "very peaceful" and perform communal display flights. Further, in Scandinavia both parents incubate, while in east Siberia only males are reported to carry out this duty. Such seemingly marked differences would normally lead to questions about the conspecificity of the two races. However, more study is clearly warranted, particularly of the eastern race, before taxonomic and other issues can be properly assessed. To this end, an isolated population of Broad-billed Sandpipers was studied in south-east Taimyr, north-central Siberia, in 2003. Nesting birds were individually colour-marked and the locations of displaying males mapped. The results suggest that the differences between the eastern and western populations are less than expected.

The analysis of growth

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A statistical problem that arises quite frequently is finding an equation that describes the growth of chicks from hatching to fledging. Fieldwork consists of weighing and measuring a sample of chicks on the day of hatching, refinding these chicks at intervals of a few days, and redoing the measurements, until such time as the chicks fledge, or cannot be found. The paper describes some of the pitfalls that arise with the usual statistical approaches used. It also develops a method that can be used when the chicks are measured for the first time at an unknown age.

Conservation genetics of Golden Plovers in Germany: A breeding population close to extinction?

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The German breeding population of Golden Plovers *Pluvialis apricaria* is small and highly endangered, the number of breeding pairs as well as fledging success having declined dramatically in recent years. In 2003, only 4 breeding pairs (12 territorial pairs) were recorded. Earlier investigations indicate that the German breeding population has been isolated from other European populations. There is an ongoing debate whether the German population is unique and should be protected as a separate conservation unit, or whether it is similar to breeding populations in other countries and therefore of less interest for conservation from a biodiversity perspective.

In a pilot study of the genetic variation and phylogeographic structure of Golden Plovers, we analysed DNA samples from the German breeding population, as well as a set of samples from populations throughout the species breeding range. Both field collections and museum material were included in the study. We applied three molecular genetic methods in the study of Golden Plovers: mtDNA sequencing, nuclear DNA sequencing, and microsatellite analysis.

The results show a low genetic variability in the species, but some unique haplotypes are found in the German population. We discuss the implications of these results for conservation and management of the German breeding population of Golden Plovers.

This work is supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Ministry for the Environment of Lower Saxony.

The Red Knots of northern Norway revisited

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Knots migrating through north Norway in May have hitherto been proved, through biometrics, banding recoveries, departure direction and departure timing, to be *C.c. islandica* breeding in Greenland and north-east Canada. In May 2004, there was evidence that *islandica* and *C.c. canutus* from breeding grounds in Siberia were present in Porsangerfjord in north-east Norway at the same time. This evidence is based on sightings of 22 individually colour-marked Knots from Holland, Germany and Mauritania in the period 19–26 May. Up to 23 May, all Knot sightings were probably *islandica*. On 23 May, a flock of 22,000 birds were found at one site. These had not been present a day earlier. Three of these birds had been marked in Mauritania, the wintering



grounds of *canutus*, and one had been seen in an earlier year on 23 May in Germany at a date too late for migrating *islandica*. No birds in this flock could be proved from sightings to belong to *islandica*. This is the first evidence that *canutus* migrates through northern Norway – at least in some years – in spring. Plans are outlined for future research in Porsangerfjord.

The habitat requirements and breeding success of Malaysian Plovers in the Gulf of Thailand

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The Malaysian Plover breeds on coastal beaches and wetlands in the Gulf of Thailand. Although these habitats are being altered by tourism development and the encroachment of shrimp ponds and pastureland, there has been virtually no

research conducted on this near-threatened species. We monitored 60 pairs of Malaysian Plovers in Prachuap Khiri Khan and Petchburi provinces to determine the key micro- and meso-site characteristics influencing habitat selection and breeding success. At the micro-site scale, Malaysian Plovers selected nest sites with a low distance to vegetation, and a high percentage of ground debris, located near the centre of the width of the beach. At the meso-site scale, plovers selected wide beaches with low human disturbance far from trees. Mortality was roughly equal at the egg and chick stages and the mean number of chicks fledged per nest was 0.71 ± 0.11 . Fledgling success was greater in sites with a higher percentage of 0.5–4.0 m tall vegetation cover. During 77 hours of diurnal behavioural observations, we observed no predation events. However plovers were frequently disturbed by neighbouring conspecifics attacking chicks or people walking or motorcycling along the beach. Our study indicated that human disturbance and the reduction of beach width due to the planting of *Casuarina* trees and beach erosion may reduce nest habitat quality.

Annual Conference – Abstracts of posters

During the conference, Petra de Goeij organised the usual poster competition and participants voted for the one they preferred. The results were:

- 🌸 **1st prize: Fitness components in Black-tailed Godwits** by Julia Schroeder, Arjen Landmann, Freek Mandema & Fardo Witsenburg
- 🌸 **2nd prize: Measuring recruitment of shorebirds with telescopes: a pilot study of age ratios on Australian non-breeding grounds** by Danny I. Rogers, Ken G. Rogers & Mark A. Barter
- 🌸 **3rd prize: Functional aspects of shifts in preen wax composition in shorebirds** by Jeroen Reneerkens, Theunis Piersma & Jaap Sinninghe Damste

Variation in immunocompetence in migrating Red Knots *Calidris canutus*

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Long distance migration systems like those seen in shorebirds have inspired much research, but in many ways their evolution and maintenance remains a biological mystery. One hypothesis suggests that disease resistance may play an important role in these systems. Shorebirds with the most demanding migratory routes in terms of overall migration distance and the distance between staging sites, tend to be habitat specialists with small population sizes, restricted to small areas of high Arctic breeding habitat and small fringes of marine non-breeding habitat. These species tend to have low levels of genetic variability and may have genetically restricted or physiologically down regulated immune systems. We ask the following questions: Does immunocompetence vary between different staging and wintering sites along migratory routes? Does immunocompetence vary within a single migratory route between seasons? And can

this variation tell us anything about possible trade-offs between investment in immune defence and investment in optimal migration? We investigate these questions in the Red Knot a habitat specialist possessing recognized subspecies, each with migratory routes of varying distance and staging and wintering sites ranging from north temperate to tropical, to sub-Antarctic. This presentation discusses the project and preliminary results.

Saltmarshes on Wadden Sea islands: Population sources of breeding Redshanks *Tringa totanus*?

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In recent decades, the breeding population of Redshanks has declined dramatically in most north-western and central European breeding areas. In contrast, the Wadden Sea population has remained relatively stable. In studies designed to reach an understanding of these apparently inconsistent long-term population trends, it was found that in the mainland saltmarshes there was a very high rate of clutch predation



suggesting that breeding success would be too low to maintain the current population. In view of this finding, we investigated whether Wadden Sea Redshanks have significantly better hatching and, thus, breeding success. We studied Redshank nest-site selection and its effects on hatching success on Wangerooge Island, Lower Saxony, Germany, in 2003. We found very high hatching success (89%, $n = 15$ clutches) with a low predation rate (6.7%). We discuss possible causes of these results and their likely consequences for the population in the context of recent studies at mainland sites as well as previous studies on Wangerooge Island.

From hatching to fledging – an energetic perspective of Little Stint *Calidris minuta* chicks on the Taimyr Peninsula, Siberia

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The breeding areas of migratory shorebirds are where new generations of birds are born to replace those birds that died on migration or during winter. The Arctic summer is short and breeding birds and their chicks are also energetically stressed due to the high costs of thermoregulation. After incubation and the first few days of chick-rearing the energetic burden of collecting food is shifted to the chick. Shorebird chicks are precocial, therefore they require energy for locomotion and thermoregulation in addition to growth and development.

This study explores the ecological consequences of the precocial developmental mode for the Little Stint *Calidris minuta* at Medusa Bay on the Taimyr Peninsula, Siberian Russia. The Little Stint is the smallest wader that regularly migrates from southern Africa to the Palearctic to breed. The environment of the high Arctic is extreme with low temperatures, high wind velocities and low precipitation. The environment is particularly demanding on breeding Little Stints whose chicks are among the smallest warm-blooded animals in the tundra, weighing 4.2 g on hatching. Fieldwork was completed during the summer months, June to August 2002, and included the determination of chick energetics (daily energy expenditure, DEE) using doubly labelled water (DLW) methods, time budgets and growth rates in the field.

Does parental behaviour and timing of breeding season impact on chick growth and energetics?

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In the altricial-precocial spectrum of chick development, wader chicks exhibit the precocial mode of development, meaning they leave the nest soon after hatching. In self-

feeding precocial chicks, the burden of collecting food results in greater energetic demands from greater activity and the requirement for thermoregulation. As a possible result, self-feeding precocial chicks may grow slower than parent-fed precocials. Subtropical breeding waders have longer reproductive time spans and, as a result, exhibit slower growth and longer fledging periods than Arctic or temperate zone relatives. In addition, subtropical wader chicks experience warmer ambient temperatures. We investigated the impact of adult behaviour and timing of breeding on chick growth and energetics of the Blacksmith Plover *Vanellus armatus* and the Crowned Plover *Vanellus coronatus*. In South Africa, Blacksmith Plovers breed in winter, May to September, and only defend their chicks from potential predators whereas the Crowned Plover breeds in summer, September to April, and shows its chicks where food is. As a result of these differences in parental behaviour, we expected chick growth to be faster in Crowned Plovers and the energy expenditure of Blacksmith Plovers to be greater. Using the doubly labelled water (DLW) technique and respirometry, an energy budget could be determined for each species thus determining the impact of parental behaviour and timing of breeding on chick growth and energetics.

Spring migration of Whimbrel along the Frisian Wadden Sea coast

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The spring migration of Whimbrels *Numenius phaeopus* has been monitored over the past 10 years. Volunteers stationed along a 15-km dyke have counted the birds as they fly to their night roosts. Numbers have decreased from about 10,000 in the mid-1990s to 2,000 at present. Nowadays, no other major spring roost is known to occur in the Netherlands.

An autumn survey of Golden Plovers in Britain: results and implications for future surveys

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In October 2003, records of Golden Plovers in Britain were sought as part of a NW European survey. In addition to monthly waterbird surveys at major wetlands, casual records of Golden Plover flocks on terrestrial sites were requested through the birdwatching community. Results are presented and discussed in relation to population estimation, distribution and coverage issues. Implications for the design and implementation of future surveys are discussed.



The potential of farmyard manure and lime applications in increasing invertebrate availability to breeding waders on lowland wet grassland

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Surveys suggest a marked decline in the populations of many breeding waders in Britain, with formerly widespread species becoming concentrated in fewer areas, particularly those with directed management, such as nature reserves and areas targeted by agri-environment schemes. Reduced breeding success is believed to be the underlying cause of the population declines in some species. Low chick survival rates have been observed in many studies and one hypothesis for this is the reduction of food availability, particularly earthworms. Anecdotal evidence suggests that the maintenance of wet conditions on RSPB reserves may have led to soil acidification and a decrease in invertebrate food sources. This project aims to investigate the potential to increase the availability and abundance of invertebrates, particularly earthworms to breeding waders through the application of lime and farmyard manure to lowland wet grassland sites. Study plots for experimental applications have been set up at four RSPB reserves, with sampling carried out on soil properties, earthworm biomass and epigeal invertebrate abundance. Work on chick foraging responses and trials studying the effect of application rates are planned.

**Dynamics of sex and age-ratio in Ruffs
Philomachus pugnax during spring migration in southern Belarus**

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The Ruff *Philomachus pugnax* is one of most common and abundant wader species during spring migration in Belarus. We present data on age and sex-ratios in Ruffs during the spring migration seasons of 2001–2004 in the Pripyat floodplain.

In total, 970 adult males, 136 second-year males, 707 adult females and 45 second-year females were ringed, measured and weighed from mid-March to mid-May. For the purposes of analysis, all data were grouped in standard 5-day periods.

The mean proportion of females was 40%, ranging from 27 to 53%. A particularly low number of females were caught in 2001 and this was attributed to an early end to the catching period (8 May). The mean proportion of second-year birds was 9%. For 3 years of the study period it was practically constant (8–9%); only in 2001 was the proportion different (15%). The reason for this is unclear. However, larger numbers of second-year birds during spring 2001 may have resulted from favourable conditions and high breeding success the previous summer. Young females were recorded

less frequently, than young males, varying from 25% of young birds to 50% (in 2003). Our findings are similar to data from Italy (Serra *et al.* 1990), except that the number of second-year birds (especially females) was greater at Italian stop-over sites.

The phenology of spring passage is characterised by one migration peak. This occurs around the end of April – beginning of May when 51–64% (mean: 62%) Ruffs migrate.

On average, the first females arrive on the Pripyat floodplain a month later than the first males, but their peak passage is only 5 days later. Second-year males migrate later than adult males, passing through at about the same time as the adult females. The number of second-year females trapped was insufficient for an analysis but most were caught at the end of migration period.

It seems that males and females exhibit different migration strategies during spring passage through the Pripyat floodplain. The males use the area as a major refueling stop-over area and stay for a relatively long time (about a month). In contrast, the females arrive with a rather large body mass, sufficient for further long-distance flight. Therefore they do not need to stay in the area for very long. The data on body mass dynamics lends support to this hypothesis as do within-season retraps. For males, we have recorded 6 retraps with 3–17 day intervals between first and second captures, but only one retrap of a female (5 day interval).

Studies of wader migration in southern Belarus

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Wader migration studies were carried out on the floodplain meadows of the River Pripyat near the village of Turov (Gomel Region, 52.04°N 27.44°E). The study area is a small island, about 1 km², used as pasture throughout the growing season.

Regular catches of migrating waders started in the autumn of 1999 (small numbers of adult waders were also caught at the nest during 1997–1999 in connection with behavioural studies). The most efficient catching method was found to be walk-in traps, which were checked every three hours from dawn to dusk.

During nine years, 7,990 waders of 25 species were ringed. Three were dominant: Ruff *Philomachus pugnax*, Redshank *Tringa totanus* and Northern Lapwing *Vanellus vanellus*.

During 1998–2004, 26 long-distance recoveries from nine countries were obtained. Most related to Common Snipe *Gallinago gallinago* and Northern Lapwing. These species are game birds in France and Italy, where they have their wintering grounds, which resulted in large numbers of recoveries from birds shot in these countries. The longest distances between ringing and recovery sites were about 6,000 km – for a Great Snipe *Gallinago media* in Gabon and a Ruff in Mali – and 5,188 km for a Ruff in Yakutia, Russia.

Eight waders ringed in other countries were caught. Five were Dunlins *Calidris alpina* of which four were caught from one migrating flock during two days, 13–14 May 2002.



**Density, activity and breeding habitats of
Common sandpiper *Actitis hypoleucos* and
Little ringed plover *Charadrius dubius*
breeding on the Brenta river, north-east Italy**

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North-east Italy has few natural areas along its rivers. The presence of particular birds is indicative of a river's condition. The aim of this study on the Brenta river was to determine the density, activity and the habitat selection of two breeding waders: Common Sandpiper and Little Ringed Plover. Methods included mapping territories by repeatedly walking a stretch of the river between 1 March and 10 July 2003. The results were compared, where possible, with those of 2002, when the species were less intensively studied.

**Functional aspects of shifts in preen wax
composition in shorebirds**

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Birds possess a preen (or uropygial) gland on their rump that secretes substances which are preened into the plumage, and which are probably essential for plumage maintenance. Secretions of the uropygial gland predominantly consist of complex mixtures of many different wax esters. We have found that shorebirds show pronounced seasonal changes in the composition of their preen waxes. At departure to and arrival on the breeding grounds, the usual monoester wax drastically changes to a more complex diester-based wax, which is maintained throughout the breeding season by incubating individuals only. The diesters have higher molecular weights and probably different physical properties than monoesters, and the secretion and use of diesters rather than monoesters may entail specific costs and benefits. We will present results of comparative and experimental research into the functioning of different preen wax mixtures in resistance against feather abrasion, plumage colouration, olfactory conspicuousness, and growth-inhibition of feather-degrading bacteria.

**Measuring recruitment of shorebirds with
telescopes: a pilot study of age ratios on
Australian non-breeding grounds**

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The breeding success of migratory shorebirds differs from year to year; it is affected by factors such as lemming cycles and the time of snow-melt on the breeding grounds. Fluctua-

tions in breeding success can be detected in Australia because they affect age-ratios in the non-breeding flocks of shorebirds that we observe there. Documenting these age-ratios can provide valuable information; it can help to interpret population trends revealed by shorebird counts; it improves our understanding of why breeding success varies from year to year, and as breeding success varies geographically, it may provide insights about where our shorebirds breed. In the future it may play a large role in understanding the effects of global warming on shorebird populations. Australian shorebird banders, especially in Victoria, put a great deal of effort into catching and ageing large numbers of shorebirds in the austral summer so that age-ratios can be estimated. Some nice results are coming out of this work. However, huge efforts and large banding teams are required to collect these data, so few sites can be tackled.

In the right circumstances, many species of shorebird can be aged objectively in the field with a telescope. Age-ratio data obtained in this manner are presented from a pilot study at the Western Treatment Plant, near Melbourne, during the austral springs and summers of 2001–2003. The ageing methods used are described for Red-necked Stint, Curlew Sandpiper and Sharp-tailed Sandpiper. We found that the great majority of juveniles had arrived before post-juvenile moult became too advanced for telescope ageing. Local distribution of immatures was not homogenous; they tended to cluster in small groups and spent more time foraging at high tide than did adults. Implications of these findings for assessment of age-ratios by cannon-netting are discussed (in particular the sample sizes required for representative data), and we compare our overall age-ratios with those obtained through cannon-netting at the same site in the same years. We conclude that both cannon-netting and telescope observations can provide solid data on age-ratios.

Although we are confident that age-ratios can be estimated adequately at non-breeding sites, the approach does not give a direct measure of recruitment rates. Age-ratios can vary geographically, both on small and large scales. If we are to develop realistic estimates of recruitment rates it would therefore be desirable to measure age-ratios at many sites. This may be the greatest advantage of telescope observations, as they can be made by a single observer. They may also be valuable as a measure of age-ratios at sites where cannon-netting is not practical, or on species that are difficult to catch.

**Nocturnal feeding by the Grey Plover *Pluvialis
squatarola* in the Tagus estuary, Portugal**

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Most wader species that winter in estuaries feed in intertidal areas both during day and night. Although night feeding is a common behaviour, little is known about its importance to fulfil the energetic requirements of waders, particularly of visual predators such as the Grey Plover. We compared day and night feeding behaviour in this species on a mudflat area in the Tagus estuary, Portugal. We also evaluated the prey



availability in the area. The results demonstrated significant day/night differences both in the foraging behaviour of the waders and in the prey taken. Frequency of probes and pace-rate are lower at night, and the number of items of its preferred prey (the rag worm *Nereis diversicolor*) is lower in droppings collected at night. Grey Plovers tend to prey upon the most frequent size class (middle size) individuals of this species but have a tendency to take larger individuals during the night. This can be explained by the fact that at night larger prey are more easily detected by visual predators.

Using satellite imagery and GIS to study habitat selection by waders on sediment flats

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We evaluated the use of satellite imagery and GIS to study large-scale habitat selection by waders in the sediment flats of the Tagus estuary, Portugal. Low tide bird surveys were conducted from the coastline and from a network of transects. Virtually all the estuary was surveyed during two consecutive winters (2001/2002 and 2002/2003).

A Landsat image was classified to map sediment features. Sediment samples and on-site measurements (e.g. % cover of algae and shells) were collected from over 250 points located throughout the estuary. This point information was extrapolated to the estuary as a whole using the Landsat image. Landscape variables believed to influence habitat selection by feeding waders, such as the distance to urban areas and roost proximity, were obtained using GIS. A multivariate analysis was used to relate bird abundance to environmental variables obtained both from the classified Landsat image and GIS.

Feeding Dunlins, Grey Plovers, Redshanks, and Bar-tailed Godwits were associated with dry mud sediments characterized by high heterogeneity (e.g., presence of channels/creeks, shells and debris). Avocets and Black-tailed Godwits occurred mainly in the upper estuary, while Greenshank and Turnstone preferred low-lying areas, mainly oyster beds.

These results identify general foraging habitat preferences for waders at a large-scale and provide the basis for building satellite imagery/GIS predictive models for application to other estuaries.

Relationships between Redshank *Tringa totanus* breeding density and morphological characteristics of salt marshes in the Venice lagoon (Italy)

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The lagoon of Venice is the largest around the Mediterranean and includes about 3,700 ha of saltmarshes that are regularly flooded during high tide. These host the largest Mediterranean concentration of nesting Redshanks; estimated in 1993

at 1,000 pairs. In the lagoon, Redshanks often aggregate in colonies of up to 200 pairs each, sharing the same sites with terns and gulls. In 2001, a new survey resulted in a much higher estimate of 1,600 pairs. The whole saltmarsh area was divided in 16 smaller units and using GIS we evaluated possible correlations among several morphological characteristics of those sample areas and the number of breeding pairs. The density of Redshanks ranged from 0 to 123 pairs/100 ha, with the highest values in the southern lagoon basin. The mean density for the whole lagoon was 36.7 pairs/100 ha. The density of Redshanks did not correlate either with saltmarsh surface or with tidal-flat area. However, considering only the northern basin of the lagoon, the latter correlation was almost significant. On the other hand, significant correlations were observed between the coverage of salt marsh species such as *Sarcocornia fruticosa*, *Limonium narbonense*, *Puccinellia palustris* and breeding pairs. Other factors (such as aggregation with gulls and terns) play a dominant role in regulating distribution of Redshanks in the saltmarshes of the Venice lagoon.

Fitness components in Black-tailed Godwits

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During recent decades many bird species have advanced their laying date, probably as a consequence of higher spring temperatures. This link, however, is almost certainly indirect and for some species may not even exist. Therefore there is a need to track the underlying ecosystem and determine the causal factors that determine the fitness consequences of variation in laying-date. Black-tailed Godwits *Limosa l. limosa* have advanced their laying date in the Netherlands, which is hypothesised as either a result of (a) changed agricultural practices, such as progressively earlier hay-cutting that kills late broods, thus selecting for earlier breeding or (b) a better and earlier food supply due to climatic warming that enables the birds to start egg laying earlier.

We investigated which reproductive parameters are correlated with an earlier laying date in the Black-tailed Godwit in the Netherlands.

Heavy female Black-tailed Godwits laid earlier and early-laid eggs were bigger. Throughout the season, reproductive success declined, which may be an effect of female condition or egg quality or ecological factors that change throughout the season. Thus, even in an area where mowing does not affect the broods, early birds had a higher chance of a better reproductive outcome.

Food of Wood Sandpipers *Tringa glareola* during spring and autumn migration in north-eastern Poland

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This research was conducted in 2002, on a lake in the Sajna



River valley, north-east Poland. Wood Sandpipers were caught and the food they had swallowed was collected by stomach flushing. The remnants of prey organisms were classified to orders (insects) or other taxa.

In total, 126 stomach-content samples were collected during spring migration and 99 during autumn migration. 99% of samples contained different groups of insects, represented by all life stages: eggs, larvae, pupae and imagines. Most frequently represented orders were: flies Diptera, beetles Coleoptera, mayflies Ephemeroptera, bugs Heteroptera and dragonflies Odonata. Other taxa, found exceptionally in stomachs, included fish, reptiles, spiders, crustaceans, snails and leeches.

In autumn a significantly wider diversity of taxa was found (19 compared with 14 in spring, $\chi^2 = 136.6$, $P < 0.001$).

The breeding ecology of the Malaysian Plover

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Breeding behaviour such as incubation, parental care and successive nesting are influenced by many environmental

parameters. Although these parameters vary substantially between temperate and tropical environments, very few breeding wader studies have focused on tropical species. Here we examined the breeding ecology of the Malaysian Plover, a sedentary ringed plover that breeds throughout coastal south-east Asia. We monitored 56 pairs and 83 nests in Thailand. We then compared the breeding behaviour to temperate ringed plovers to investigate how the different environments could shape breeding strategies. Malaysian Plovers mates shared incubation and parental care duties equally. The lack of clear parental role division contrasts to the results of many temperate plover studies and could be attributed to heat stress as well as diel variation in prey abundance. At our study site Malaysian Plovers were monogamous within the season and all successive breeding attempts were with the same mate, at the same territory. This could be due to the relatively long duration of the breeding season, nocturnal predation risk as well as the difficulties of securing a breeding territory in the middle of the breeding season. The ability to re-nest within a single breeding season may be a significant factor influencing lifetime reproductive success because fledging success rate increases later in the season and a high proportion of birds managed to re-nest compared to temperate species. Sixty-one per cent of pairs that had failed on first breeding attempts re-nested and 17% of pairs that succeeded in their first breeding attempt re-nested.



Conference organisers Gregor Scheiffarth,
Christiane Ketzenberg and Jutta Leyrer
enjoy a well-deserved respite . . .
while volunteer barman
Gundolf Reichert
finds it thirsty work!

