Shorebirds

Table of Contents

Shorebirds

Shorebirds 2016

Novcic, I. 2016. Niche dynamics of shorebirds in Delaware Bay: Foraging behavior, habitat choice and migration timing. *Acta Oecologica* **75**:68-76.

(Abstract)

Niche differentiation through resource partitioning is seen as one of the most important mechanisms of diversity maintenance contributing to stable coexistence of different species within communities. In this study, I examined whether four species of migrating shorebirds, dunlins (*Calidris alpina*), semipalmated sandpipers (*Calidris pusilla*), least sandpipers (*Calidris minutilla*) and short-billed dowitchers (*Limnodromus griseus*), segregate by time of passage, habitat use and foraging behavior at their major stopover in Delaware Bay during spring migration. I tested the prediction that most of the separation between morphologically similar species will be achieved by differential migration timing. Despite the high level of overlap along observed niche dimensions, this study demonstrates a certain level of ecological separation between migrating shorebirds. The results of analyses suggest that differential timing of spring migration might be the most important dimension along which shorebird species segregate while at stopover in Delaware Bay. Besides differences in time of passage, species exhibited differences in habitat use, particularly least sandpipers that foraged in vegetated areas of tidal marshes more frequently than other species, as well as short-billed dowitchers that foraged in deeper water more often than small sandpipers did. Partitioning along foraging techniques was less prominent than segregation along temporal or microhabitat dimensions. Such ranking of niche dimensions emphasizes significance of temporal segregation of migratory species e separation of species by time of passage may reduce the opportunity for interspecific aggressive encounters, which in turn can have positive effects on birds' time and energy budget during stopover period.

Ortiz de Elgea, A., and J. Arizaga. 2016. Fuel load, fuel deposition rate and stopover duration of the Common Sandpiper *Actitis hypoleucos* during the autumn migration. *Bird Study* **63**:262–267.

(Abstract)

Capsule: Common sandpipers stopping over in a tidal marsh in northern Iberia during the autumn migration period showed a moderate mean fuel load and low fuel deposition rate, but relatively long stopover periods, suggesting a 'hopping' strategy of migration.

Aims: The main objectives of this paper were to analyse the stopover ecology of migrant Common Sandpipers at Txingudi coastal marshes, northern Iberia, in autumn.

Methods: Common sandpipers were captured during the autumn migration of 2007–2013 at the Txingudi marshlands (province of Gipuzkoa, northern Iberia). Data were obtained from a constant effort ringing station working on a daily basis.

Results: We observed a moderate fuel load and fuel deposition rate and long stopovers.

Conclusion: Our results suggest overall a 'hopping' migration strategy. When moving along the coast of northern Iberia, Common Sandpipers may not use key wetlands to gain much fuel, as found in other waders or in some wetlands of inland Iberia, but all coastal marshes seem to be potentially used in the same way.

Tavera, E. A., D. B. Lank, and P. M. Gonzalez. 2016. Effects of migration distance on life history strategies of Western and Semipalmated sandpipers in Peru. *Journal of Field Ornithology* **87**:293–308.

(Abstract)

Migration distances of shorebird species correlate with life history strategies. To assess age-specific migratory preparation and adult wing-molt strategies, we studied Western Sandpipers (*Calidris mauri*) and Semipalmated Sandpipers (*C. pusilla*) with different migration routes at the Paracas National Reserve in Peru, one of the most austral non-breeding areas for these sandpipers, from 2012 to 2015. Western Sandpipers breed near the Bering Sea, ~11,000 km from Paracas. Semipalmated Sandpiper populations at Paracas are a mixture of short-billed birds from western Arctic breeding sites, plus long-billed birds from eastern sites, ~8000 km distant. Adults of both species arrive in October with primary feathers already partially renewed so wing molt starts at sites further north. Semipalmated Sandpipers with longer bills completed wing molt later than shorter billed birds. Adults of both species prepared for migration in February and March. No juvenile Western Sandpipers prepared for migration, confirming the "slow" over-summering life history strategy of more southerly non-breeding populations. Juvenile Semipalmated Sandpipers showed bimodality in strategies. Most showed no migratory preparation, but, during three non-breeding periods, from 27% to 31% fattened, molted, and partially replaced outer primaries during the pre-migratory period. Juveniles with longer culmens were heavier and tended to have more alternate plumage. Juveniles that were partially molting primaries had longer culmens and more alternate plumage. Juvenile Semipalmated Sandpipers from eastern-breeding populations thus have a higher propensity for a fast life history strategy, and western birds a slow one, at this non-breeding site in Peru. Western-breeding Semipalmated Sandpiper populations thus resemble Western Sandpipers, suggesting a common, possibly distance-related, effect on life history strategy.

Oudman, T., A. I. Bijleveld, M. M. Kavelaars, A. Dekinga, J. Cluderay, T. Piersma, and J. A.

van Gils. 2016. Diet preferences as the cause of individual differences rather than the consequence. *Journal of Animal Ecology* **85**:1378–1388.

(Abstract)

1. Behavioural variation within a species is usually explained as the consequence of individual variation in physiology. However, new evidence suggests that the arrow of causality may well be in the reverse direction: behaviours such as diet preferences cause the differences in physiological and morphological traits.

2. Recently, diet preferences were proposed to underlie consistent differences in digestive organ mass and movement patterns (patch residence times) in red knots (*Calidris canutus islandica*). Red knots are molluscivorous and migrant shorebirds for which the size of the muscular stomach (gizzard) is critical for the food processing rate.

3. In this study, red knots (*C. c. canutus*, n = 46) were caught at Banc d'Arguin, an intertidal flat ecosystem in Mauritania, and released with radio-tags after the measurement of gizzard mass. Using a novel tracking system (time-of-arrival), patch residence times were measured over a period of three weeks. Whether or not gizzard mass determined patch residence times was tested experimentally by offering 12 of the 46 tagged red knots soft diets prior to release; this reduced an individual's gizzard mass by 20–60%. To validate whether the observed range of patch residence times would be expected from individual diet preferences, we simulated patch residence times as a function of diet preferences via a simple departure rule.

4. Consistent with previous empirical studies, patch residence times in the field were positively correlated with gizzard mass. The slope of this correlation, as well as the observed range of patch residence times, was in accordance with the simulated values. The 12 birds with reduced gizzard masses did not decrease patch residence times in response to the reduction in gizzard mass.

5. These findings suggest that diet preferences can indeed cause the observed among-individual variation in gizzard mass and patch residence times. We discuss how early diet experiences can have cascading effects on the individual expression of both behavioural and physiomorphic traits. This emphasizes that to understand the ecological consequences of individual differences, knowledge of the environment during development is required.

Nareff, G. E., S. H. Schweitzer, E. P. Wiggers, and W. E. Mills. 2016. Time-activity Budgets of Yellowlegs in Managed Tidal Impoundments and Adjacent Tidal Marshes. *Journal of the Southeastern Association of Fish and Wildlife Agencies* **3**:220–224.

(Abstract)

Managed tidal impoundments are man-made wetlands constructed from natural tidal marshes and swamps with embankments and water control structures that manage water levels using tidal cycles. In South Carolina, 28,000 ha of managed tidal impoundments potentially provide important habitat for migrating and resident wildlife. The importance of traditionally-managed

tidal impoundments relative to natural tidal marsh to migratory birds is poorly understood. Examining how birds allocate their time on managed tidal impoundments and natural tidal marshes can provide insight into whether birds are using these resources similarly or for different biological needs. We examined diurnal activity of greater yellowlegs (*Tringa melanoleuca*) and lesser yellowlegs (*T. flavipes*) to determine how these focal species used managed tidal impoundments and tidal marshes along the coast of South Carolina. Overall, frequency of behaviors differed between managed tidal impoundments and natural tidal marshes ($F = 6.5$, $df = 5, 5$; $P = 0.031$). Proportion of time yellowlegs moved (locomotion) was greater on tidal marshes ($F = 19.6$, $df = 1, 69$; $P < 0.001$), while proportion of time spent loafing ($F = 5.7$, $df = 1, 69$; $P = 0.019$) was greater on managed tidal impoundments. The greater proportion of time spent loafing on managed tidal impoundments suggests these wetlands provide body-maintenance opportunities not available in tidal marshes. Our results reveal the importance of managed tidal impoundments to migratory shorebirds within the coastal landscape. These managed habitats provide protected roosting sites and abundant, available food resources because of the controlled hydrological cycle.

Lyons, J. E., J. A. Collazo, and G. Herring. 2016. Testing assumptions for conservation of migratory shorebirds and coastal managed wetlands. *Wetlands Ecol Manage* **24**:507–520.

(Abstract)

Managed wetlands provide critical foraging and roosting habitats for shorebirds during migration; therefore, ensuring their availability is a priority action in shorebird conservation plans. Contemporary shorebird conservation plans rely on a number of assumptions about shorebird prey resources and migratory behavior to determine stopover habitat requirements. For example, the US Shorebird Conservation Plan for the Southeast-Caribbean region assumes that average benthic invertebrate biomass in foraging habitats is 2.4 g dry mass m-2 and that the dominant prey item of shorebirds in the region is Chironomid larvae. For effective conservation and management, it is important to test working assumptions and update predictive models that are used to estimate habitat requirements. We surveyed migratory shorebirds and sampled the benthic invertebrate community in coastal managed wetlands of South Carolina. We sampled invertebrates at three points in time representing early, middle, and late stages of spring migration, and concurrently surveyed shorebird stopover populations at approximately 7-day intervals throughout migration. We used analysis of variance by ranks to test for temporal variation in invertebrate biomass and density, and we used a model based approach (linear mixed model and Monte Carlo simulation) to estimate mean biomass and density. There was little evidence of a temporal variation in biomass or density during the course of spring shorebird migration, suggesting that shorebirds did not deplete invertebrate prey resources at our site. Estimated biomass was 1.47 g dry mass m-2 (95 % credible interval 0.13–3.55), approximately 39 % lower than values used in the regional shorebird conservation plan. An additional 4728 ha (a 63 % increase) would be required if habitat objectives were derived from biomass levels observed in our study. Polychaetes, especially *Laeonereis culveri* (2569 individuals m-2), were the most abundant prey in foraging

habitats at our site. Polychaetes have lower caloric content than levels assumed in the regional plan; when lower caloric content and lower biomass levels are used to determine habitat objectives, an additional 6395 ha would be required (86 % increase). Shorebird conservation and management plans would benefit from considering the uncertainty in parameters used to derive habitat objectives, especially biomass and caloric content of prey resources. Iterative testing of models that are specific to the planning region will provide rapid advances for management and conservation of migratory shorebirds and coastal managed wetlands.

Karagicheva, J., E. N. Rakhimberdiev, A. Dekinga, M. Brugge, A. Koolhaas, J. ten Horn, and T. Piersma. 2016. Seasonal Time Keeping in a Long-Distance Migrating Shorebird. *Journal of Biological Rhythms* **31**:509–521.

(Abstract)

Because of the complications in achieving the necessary long-term observations and experiments, the nature and adaptive value of seasonal timekeeping mechanisms in long-lived organisms remain understudied. Here we present the results of a 20-year-long study of the repeated seasonal changes in body mass, plumage state, and primary molt of 45 captive red knots *Calidris canutus islandica*, a High Arctic breeding shorebird that spends the nonbreeding season in temperate coastal areas. Birds kept outdoors and experiencing the natural photoperiod of the nonbreeding area maintained sequences of life-cycle stages, roughly following the timing in nature. For 6 to 8 years, 14 of these birds were exposed to unvarying ambient temperature (12 °C) and photoperiodic conditions (12:12 LD). Under these conditions, for at least 5 years they expressed free-running circannual cycles of body mass, plumage state, and wing molt. The circannual cycles of the free-running traits gradually became longer than 12 months, but at different rates. The prebreeding events (onset and offset of prealternate molt and the onset of spring body mass increase) occurred at the same time of the year as in the wild population for 1 or several cycles. As a result, after 4 years in 12:12 LD, the circannual cycles of prealternate plumage state had drifted less than the cycles of prebasic plumage state and wing molt. As the onset of body mass gain drifted less than the offset, the period of high body mass became longer under unvarying conditions. We see these differences between the prebreeding and postbreeding life-cycle stages as evidence for adaptive seasonal time keeping in red knots: the life-cycle stages linked to the initiation of reproduction rely mostly on endogenous oscillators, whereas the later stages rather respond to environmental conditions. Postbreeding stages are also prone to carryover effects from the earlier stages.

Lilleyman, A., S. T. Garnett, D. I. Rogers, and M. J. Lawes. 2016. Trends in Relative Abundance of the Eastern Curlew (*Numenius madagascariensis*) in Darwin, Northern

Territory. *Stilt* **68**:25-30.

(Abstract)

The Eastern Curlew (*Numenius madagascariensis*) has recently been uplisted to Critically Endangered under Australian Government legislation due to an ongoing decline of the species population on its non-breeding grounds. Declines have been reported from nearly all monitored sites along the coastline of Australia and at some, local extinction is predicted within the next thirty years. In contrast, numbers recorded at two sites in the Darwin region appear to have increased in the same period. Since 1980 numbers at Lee Point have increased by 9 % per year (SE = 2%); at East Arm Wharf in Darwin Harbour, the annual population increase was 17 % per year (SE = 9%) for the period of 2009-2015. This local increase over time may reflect changes in bird roosting behaviour and an increase in suitable high tide roosting habitat. The consistent use of an artificial site at East Arm Wharf is promising for adaptive management of the species and other shorebirds that are threatened by the effects of habitat loss along coastlines.

van Gils, J. A., S. Lisovski, T. Lok, W. Meissner, A. Ożarowska, J. de Fouw, E. N. Rakhimberdiev, M. Y. Soloviev, T. Piersma, and M. Klaassen. 2016. Body shrinkage due to Arctic warming reduces red knot fitness in tropical wintering range. *Science* **352**:819-821.

(Abstract)

Reductions in body size are increasingly being identified as a response to climate warming. Here we present evidence for a case of such body shrinkage, potentially due to malnutrition in early life. We show that an avian long-distance migrant (red knot, *Calidris canutus canutus*), which is experiencing globally unrivaled warming rates at its high-Arctic breeding grounds, produces smaller offspring with shorter bills during summers with early snowmelt. This has consequences half a world away at their tropical wintering grounds, where shorter-billed individuals have reduced survival rates. This is associated with these molluscivores eating fewer deeply buried bivalve prey and more shallowly buried seagrass rhizomes. We suggest that seasonal migrants can experience reduced fitness at one end of their range as a result of a changing climate at the other end.

Ponsero, A., A. Sturbois, N. Desroy, P. Le Mao, A. Jones, and J. Fournier. 2016. How do macrobenthic resources concentrate foraging waders in large megatidal sandflats? *Estuarine, Coastal and Shelf Science* **178**:120-128.

(Abstract)

The relationship between foraging shorebirds, macrobenthos and sedimentary parameters

has been widely studied across Western Europe. Megatidal areas have large zones uncovered when the water retreats. Consequently, in such cases, the tide also influences foraging activities. This paper examines the use of an intertidal space by waders to define how macrobenthic resource concentrates foraging activity of birds in a large megatidal sandflat. This approach combines accurate spatial distribution of waders (Oystercatcher, Eurasian Curlew, Bar-tailed Godwit and Red Knot) according to their activity with ecological/biological parameters. A differential exploitation of the flat is clearly shown, with macrobenthic biomass appearing as one of the main explanatory factor for the four species considered on the western part of the bay and altitude (shore elevation) in the eastern part. The novelty of this study relates to the large area, also presumed to be a functional unit, while considering at the same time the singularities of the different parts of the flat. This multi-scale approach identifies important factors influencing the differential distribution patterns observed. The different selected parameters present an important variability in their contribution, underlining the complexity of explaining the distribution of foraging birds. Consequently, the study of such complex phenomena needs to consider additional variables to improve the relevance of explanatory models.

Beauchamp, G. 2016. Function and structure of vigilance in a gregarious species exposed to threats from predators and conspecifics. *Animal Behaviour* **116**:195-201.

(Abstract)

Vigilance can be targeted at predators or competitors, but there has been little work on the factors that affect vigilance aimed at competitors, which is known as social vigilance, and how it should be structured to detect and avoid conspecific threats. Social vigilance might be expected to play an important role in foraging groups with frequent conflicts over resources. I examined social vigilance in skimming semipalmated sandpipers, Calidris pusilla, which exploit minute prey at the surface of the substrate using a head-down position that leaves them vulnerable to aggressive displacement by neighbours. Attacks over resources occurred frequently in skimming sandpipers. In these groups, vigilance increased when neighbours were closer, suggesting that close neighbours posed a threat and that vigilance has a non-negligible social component in skimming groups. The negative exponential distribution best fitted the empirical distribution of intervals between successive vigilance bouts during skimming. This type of distribution implies that a bout of vigilance is initiated at the same rate regardless of the time spent head down in the current skimming bout, a feature that would prevent would-be attackers from targeting sandpipers at times of predictable vulnerability. This study shows that the occurrence of threats from within the group can promote randomness in the temporal organization of vigilance.

Loonstra, A. H. J., T. Piersma, and J. Reneerkens. 2016. Staging Duration and Passage Population Size of Sanderlings in the Western Dutch Wadden Sea. *Ardea* **104**:49-61.

(Abstract)

The population of Sanderlings Calidris alba along the East Atlantic flyway has grown considerably during the last decades. Perhaps reflecting this augmented population size, increasing numbers of Sanderling have been reported to stage in the Wadden Sea during spring and autumn migration. Estimates of the numbers of Sanderlings in the Wadden Sea have previously been based on a limited number of counts that were not corrected for the turnover of individuals. In this study, we accounted for turnover using estimates of the probability that individually colour-ringed Sanderlings are still present two days after a sighting. In combination with daily counts during high tide, we estimated the total number of Sanderlings that used the island Griend and surrounding mudflats, in the western Dutch Wadden Sea, during southward passage in 2013 and 2014. We also estimated minimal staging durations of Sanderlings at Griend. Non-moulting birds were significantly heavier upon capture, which suggests that they were refuelling for long non-stop migratory flights. Winter sightings confirmed that the non-moulting Sanderlings winter in sub-Saharan Africa and that the moulting Sanderlings spent the winter in Europe or northern Africa. With an average minimal stay in the western Dutch Wadden Sea of 9 days in 2013 and 12 in 2014, non-moulting Sanderlings stayed for a much shorter time than moulting Sanderlings, which stayed for 32 days in 2013 and 36 days in 2014. Non-moulting individuals were less likely to be resighted between years. Estimates of minimal staging duration are likely underestimates of the true staging duration, and we propose that moulting Sanderlings probably complete their wing moult in the Wadden Sea. We estimated that the total number of Sanderlings using the western Dutch Wadden Sea before migration to European or African wintering areas were 27,546 (95% CI 22,739–41,449) in 2013 and 22,574 (95% CI 16,436–46,114) in 2014. This would amount to 11–14% of a total flyway population of 200,000 individuals, representing an amazing degree of concentration for what is regarded as a rather widely and thinly spread shorebird species.

Cunningham, J. A., D. C. Kesler, and R. B. Lanctot. 2016. Habitat and social factors influence nest-site selection in Arctic-breeding shorebirds. *Auk* **133**:364–377.

(Abstract)

Habitat selection theory suggests that shorebirds should choose nest sites that maximize survival and fitness. We investigated how habitat, and proximity to conspecific or heterospecific nesting birds, was related to nest-site selection in American Golden-Plovers (*Pluvialis dominica*), Dunlin (*Calidris alpina*), Long-billed Dowitchers (*Limnodromus scolopaceus),* Pectoral Sandpipers (*C. melanotos*), Red Phalaropes (Phalaropus fulicarius), and Semipalmated Sandpipers (*C. pusilla*) in Barrow, Alaska, USA, between 2005 and 2012. We used remote-sensing data to link habitat information to used and unused nest sites, and we measured distances from nests to other nearby nesting shorebird neighbors. Results from

an information-theoretic approach to identify best-approximating models indicated that all species selected nest sites on the basis of both habitat and social cues. Macroscale tundra moisture level within 50 m of the nest, which was closely associated with vegetation community, was an informative variable for Dunlin, Long-billed Dowitcher, and Red Phalarope, which all selected wetter habitat. Enhanced tundra microrelief increased the probability of nest-site selection for American Golden-Plover, Long-billed Dowitcher, Pectoral Sandpiper, and Semipalmated Sandpiper. American Golden-Plover, Dunlin, Pectoral Sandpiper, and Semipalmated Sandpiper selected sites farther from conspecific nests than predicted by chance. Our results indicate that shorebirds select nest sites on the basis of habitat features, and that some are also influenced by proximity to other nesting shorebirds. These findings indicate that shorebirds select nests that are likely to aid incubation abilities, reduce predator detection of nesting birds, enhance detection of predators, enhance foraging, and reduce competition from conspecifics. The variable needs of the different Arctic-breeding shorebirds indicate that climate change will have both beneficial and harmful consequences. Our habitat models may be useful for predicting areas of high shorebird importance throughout the Arctic Coastal Plain, allowing mitigation of proposed anthropogenic developments.

Verhoeven, M. A., J. van Eerbeek, C. Hassell, and T. Piersma. 2016. Fuelling and moult in Red Knots before northward departure: a visual evaluation of differences between ages, sexes and subspecific morphs. *Emu* **116**:158-167

(Abstract)

The departure of migratory birds from their non-breeding grounds is thought to be driven by the phenology of their breeding destination. In north-west Australia, two plumage morphs of Red Knot (*Calidris canutus*) prepare for a 5500-km journey to Yellow Sea staging areas. These morphs are recognised as the subspecies C. c. piersmai and C. c. rogersi, which breed at different latitudes and have different seasonalities. From February to May 2011, we observed the migratory preparation of individually marked birds of known age, sex and type. This enabled a comparison of fuelling rates and prealternate moult among these classes. First-year birds did not prepare for migration. Second-year birds accumulated smaller fuel stores and reached lower plumage scores than adults. Adults of both types reached their highest abdominal profile scores by the end of April when they were last observed in Roebuck Bay. This lack of difference between types in the timing of fuelling and departure is surprising. Based on the differences in staging and breeding phenology, C. c. rogersi is expected to leave north-west Australia 2–4 weeks before C. c. piersmai. Assuming that types and subspecies are equivalent, our findings in combination with other research on Red Knots in the East Asian–Australasian Flyway suggest that it takes more than breeding origin alone to explain annual cycles in migratory birds. Concurrent migratory schedules imply that, during northward staging in the Yellow Sea, there is strong variation in fuelling rates between and within subspecies depending on non-breeding origin. The ongoing loss of staging habitat may therefore have differential effects on Red Knots in the East Asian–Australasian Flyway.

Szabo, J. K., P. F. Battley, K. L. Buchanan, and D. I. Rogers. 2016. What does the future hold for shorebirds in the East Asian-Australasian Flyway? *Emu* **116**:95–99.

(No abstract available)

Szabo, J. K., C.-Y. Choi, R. S. Clemens, and B. D. Hansen. 2016. Conservation without borders – solutions to address migratory shorebird declines in the East Asian-Australasian Flyway. *Emu***116**:215–221.

(Abstract)

Globally, populations of migratory shorebirds are threatened and steeply declining. This is especially true for those using the East Asian-Australasian Flyway (EAAF). Loss of intertidal mudflats in crucial staging areas, especially around the Yellow Sea, is considered to be the primary driver of these declines. Migratory shorebird conservation faces considerable challenges, including competing demands on wetland habitats, compounded by differing economic priorities, jurisdictions and attitudes towards wildlife among countries along their migratory route. A key part of addressing these challenges is to improve shorebird habitat management, both in protected and unprotected areas. This ultimately requires stronger commitment from national governments, for instance by enforcing and strengthening multi-, and bilateral agreements. However, economic drivers for development have considerable consequences for shorebird conservation and erode the effectiveness of these policy tools. Here, we highlight socio-political approaches for implementing conservation actions: the success of these actions will hinge on stronger engagement of citizens and governments in habitat protection and shorebird monitoring. One part of this strategy is to increase awareness in communities and governments of shorebird issues through international collaboration, knowledge sharing, capacity-building and support for local action (of both citizens and government officials). Internationally-mediated economic solutions accompanied by political actions among flyway partners, for example bilateral agreements on intertidal mudflat reservation and co-funding to support this, are critical to halt shorebird population declines.

Moores, N., D. I. Rogers, K. G. Rogers, and P. M. Hansbro. 2016. Tidal-flat Reclamation and Shorebird Declines in Saemangeum and the Republic of Korea. *Emu* **116**:136–146.

(Abstract)

Saemangeum, in the Republic of Korea (ROK, commonly called South Korea) was one of the

most important shorebird staging sites in the Yellow Sea. It supported at least 330 000 shorebirds annually between 1997 and 2001, including ~30% of the world population of Great Knots (*Calidris tenuirostris*) during both northward and southward migration. Construction of a 33-km long sea-wall was completed in April 2006. We show that shorebird numbers at Saemangeum and two adjacent wetlands decreased by 130 000 during northward migration in the next two years and that all species have declined at Saemangeum since completion of the sea-wall. Great Knots were among the most rapidly affected species. Fewer than 5000 shorebirds were recorded at Saemangeum during northward migration in 2014. We found no evidence to suggest that most shorebirds of any species displaced from Saemangeum successfully relocated to other sites in the ROK. Instead, by 2011–13 nearly all species had declined substantially in the ROK since previous national surveys in 1998 and 2008, especially at more heavily reclaimed sites. It is likely that these declines were driven by increased mortality rather than movement to alternate staging sites given that other studies have shown concurrent declines in numbers and survival on the non-breeding grounds. This is the first study in the East Asian–Australasian Flyway to confirm declines of shorebirds at a range of geographical scales following a single reclamation project. The results indicate that if migratory shorebirds are displaced from major staging sites by reclamation they are probably unable to relocate successfully to alternate sites.

Melville, D. S., Y. Chen, and Z. Ma. 2016. Shorebirds along China's Yellow Sea coast face an uncertain future – a review of threats. *Emu* **116**:100–110.

(Abstract)

Coastal wetlands along China's Yellow Sea coast are in crisis with current annual land claim estimated at about 600 km2 per year. Most intertidal areas in the Bohai Sea will soon be lost with the exception of the Yellow River delta, while Jiangsu Province plans to reclaim 1,800 km2 by 2020, which will remove much of the remaining tidal flats. Even where tidal flats remain widespread aquaculture, including use of pesticides, is reducing prey availability, while exotic Spartina continues to expand to the detriment of both shellfishers and shorebirds. Roosting sites may become a limiting factor in future. Reduced survival rates and population declines of shorebirds which stage on China's Yellow Sea coast are a clear indication that worse is yet to come unless steps are taken urgently to safeguard key sites and reconsider future land claim plans.

Lisovski, S., K. Gosbell, M. Christie, B. J. Hoye, M. Klaassen, I. D. Stewart, A. J. Taysom, and C. D. T. Minton. 2016. Movement patterns of Sanderling (*Calidris alba*) in the East Asian–Australasian Flyway and a comparison of methods for identification of crucial areas for conservation. *Emu* **116**:168–177.

(Abstract)

Worldwide, most populations of migratory shorebirds are in jeopardy, none more so than those of the East Asian–Australasian Flyway (EAAF). In order to preserve these highly mobile species a detailed understanding of their use of feeding and resting sites along the flyway is required. In this study we used light-level geolocators and new analytical tools to reveal individual breeding locations and migration routes of 13 Sanderlings (*Calidris alba*) that spend their nonbreeding season in South Australia. We then used these individual migration routes to identify the timing and location of important stopping areas and compared this with assessments based on resightings of leg-flagged birds and count data. During both northward and southward migration, Sanderlings were found to make extensive use of five main areas of the Chinese coastline, the Yellow Sea and the northern end of the Sakhalin Peninsula. Insights gained from the individual migration routes highlight inherent biases in using only count and resighting data to identify important feeding and resting sites along the Flyway. These findings suggest that data on individual movements may be crucial to effective conservation planning of shorebirds in the EAAF and elsewhere in the world.

Lilleyman, A., D. C. Franklin, J. K. Szabo, and M. J. Lawes. 2016. Behavioural responses of migratory shorebirds to natural and anthropogenic disturbances at a high-tide roost. *Emu***116**:111–118.

(Abstract)

For many shorebirds, long-distance migration is a critical life stage that renders them vulnerable to disturbance during a stopover and on non-breeding grounds, where these disturbances may further reduce fat deposition and reduce the likelihood of survival of birds already exhausted by migratory flights. Beaches in northern Australia provide key departure and arrival points for non-stop flights of more than 5,000 km. At a beach near the city of Darwin, we measured the frequency of disturbance stimuli, and the response (flight-initiation distance, resettlement time) of roosting migratory shorebirds (knots Calidris spp. and sand plovers Charadrius spp.) to disturbances. The energy costs of disturbances were extrapolated from existing energy budget models. Flight was the most common individual response to disturbances (0.86 alarm flights per hour). The likelihood of an alarm flight response increased as (1) distance to the source of disturbance decreased, (2) flock size decreased, and (3) when birds were in a single-species flock. Energy budget models suggested that ten alarm flights per day increased daily energy expenditure by 4.5-4.7% for knots and 7.5-7.8% for sand plovers, which may reduce energy reserves to below levels that can be replenished by normal daily intake rates.

Conklin, J. R., T. Lok, D. S. Melville, A. C. Riegen, R. Schuckard, T. Piersma, and P. F. Battley.

2016. Declining adult survival of New Zealand Bar-tailed Godwits during 2005–2012 despite apparent population stability. *Emu* **116**:147–157.

(Abstract)

Like many migratory shorebird populations using the East Asian-Australasian Flyway, Bar-tailed Godwits Limosa lapponica baueri in New Zealand have significantly declined since the mid-1990s, but census data indicate a relatively stable population since 2004. The demographic drivers of both the decline and stabilisation remain unknown. We estimated annual survival from mark-recapture data of 30 adult godwits in New Zealand during 2005–2014. Adult survival declined over the study period from 0.89–0.96 in 2005–2010 to 0.83–0.84 in 2011–2012. The simultaneous decline in annual survival found in a separate study of Bar-tailed Godwits L. l. menzbieri in northwest Australia suggests a common effect of their high dependence on threatened migratory staging sites in the Yellow Sea; the more extreme decline in L. l. menzbieri may reflect ecological differences between the populations, such as timing and extent of use of these sites. At current apparent recruitment rates, persistent adult survival of ca. 0.84 would lead to a population decline of 5–6% per year in L. l. baueri. Our study implies that the demographic precursors to a population decline developed during a period of apparent population stability; this suggests that monitoring a single index of population stability is insufficient for predicting future trends.

Clemens, R. S., D. I. Rogers, B. D. Hansen, K. Gosbell, C. D. T. Minton, P. Straw, M. Bamford, E. J. Woehler, D. A. Milton, M. A. Weston, B. Venables, D. Weller, C. Hassell, W. Rutherford, K. Onton, A. Herrod, C. E. Studds, C.-Y. Choi, K. L. Dhanjal-Adams, G. A. Skilleter, and R. A. Fuller. 2016. Continental-scale decreases in shorebird populations in Australia. *Emu* **116**:119–135.

(Abstract)

Shorebird population decreases are increasingly evident worldwide, especially in the East Asian-Australasian Flyway (EAAF). To arrest these declines, it is important to understand the scale of both the problem and the solution. We analysed an expansive Australian citizen science data set spanning the years from 1973 to 2014 to explore factors related to differences in trends among shorebird populations in wetlands throughout Australia. Of seven resident Australian shorebird species, the four inland species exhibited continental decreases, while the three coastal species did not. Decreases in inland resident shorebirds were related to changes in water availability at non-tidal wetlands, suggesting that degradation of wetlands in Australia's interior is playing a role in these declines. The analyses also revealed continental decreases in abundance in 12 of 19 migratory shorebird species, and decreases in 17 of 19 migratory species in the southern half of Australia over the past 15 years. Many trends were most strongly associated with continental gradients in latitude or longitude, suggesting some large-scale patterns in the decreases with steeper declines often evident in the south of Australia. After accounting for this effect, local variables did not explain variation in migratory shorebird trends between sites. Our results are consistent with other studies indicating that

migratory shorebird population decreases in the EAAF are most likely being driven primarily by factors outside Australia. This reinforces the need for urgent overseas conservation actions. However, substantially heterogeneous trends within Australia, combined with inland resident shorebird declines indicate effective management of Australian shorebird habitat remains important.

Choi, C.-Y., K. G. Rogers, X. Gan, R. S. Clemens, Q.-Q. Bai, A. Lilleyman, A. Lindsey, D. A. Milton, P. Straw, Y.-t. Yu, P. F. Battley, R. A. Fuller, and D. I. Rogers. 2016. Phenology of southward migration of shorebirds in the East Asian-Australasian Flyway and inferences about stopover strategies. *Emu* **116**:178–189.

(Abstract)

The southward migration strategies of shorebirds remain poorly understood in the East Asian–Australasian Flyway, yet understanding such strategies is critical to shorebird conservation. We estimate passage dates of 28 species of shorebird from count data at 15 sites to infer their migration strategies, using Thompson's modelling approach. Our estimates of passage dates were consistent with available tracking data, giving us confidence that the modelled estimates were accurate. For large-bodied shorebirds, modelled departure dates from the northern Yellow Sea were similar to arrival dates throughout Australia, and their arrival dates in different regions in Australia were also similar, suggesting they flew directly from Asian staging areas to Australian non-breeding areas, or stopped only very briefly on the way. In contrast, small-bodied species apparently made multiple stops, especially in northern Australia, during their migration to their final non-breeding destinations. These differing patterns suggest that larger species in this Flyway depend on a small number of staging sites, whereas smaller species migrate in shorter steps and require additional staging sites between the northern Yellow Sea and Australasia. It is likely that some of these sites have not as yet been discovered, and that conservation of small shorebird species requires a more complete accounting of unknown and understudied staging sites.

Aharon-Rotman, Y., S. Bauer, and M. Klaassen. 2016. A chain is as strong as its weakest link: assessing the consequences of habitat loss and degradation in a long-distance migratory shorebird. *Emu* **116**:199–207.

(Abstract)

The conservation of migratory species represents a major challenge, as they use multiple sites, all contributing in varying degrees in sustaining high survival and reproductive success. There is particular concern for shorebirds of the East Asian–Australasian Flyway (EAAF), where declining numbers of migratory species have mostly been attributed to habitat loss along the

East Asian coast. Using a stochastic dynamic programming migration model, we assessed the effect of habitat degradation scenarios along the EAAF on migration behaviour, survival and reproductive success of a long-distance migrating shorebird, the Ruddy Turnstone (*Arenaria interpres*). Following manipulation of habitat quality through changes in intake rate, we found that changes on the wintering (major non-breeding) ground in South Australia had the highest negative effect on reproductive success and survival. We also identified Taiwan and the Yellow Sea as sites with high importance for reproductive success. Although habitats along the East Asian coastline are currently most threatened from a range of global change processes, we highlight the importance of conserving high-quality shorebird wintering habitat in Australia. This may be of notable importance to trans-equatorial migratory shorebirds, which often make a long non-stop flight from their wintering grounds in order to skip low-latitude sites that typically provide little food.

Pérez-Vargas, A. D., M. Bernal, C. S. Delgadillo, E. F. González-Navarro, and M. F. Landaeta. 2016. Benthic food distribution as a predictor of the spatial distribution for shorebirds in a wetland of central Chile. *Revista de Biología Marina y Oceanografía* **51**:147-159.

(Abstract)

Coastal landscapes of central Chile are important places for species of resident and migratory shorebirds. Estuarine environments are critical habitats that provide resting places and food resources for large concentrations of shorebirds to replenish their energy during their migration. We hypothesized that shorebirds choose particular habitats based on food availability in a tidal wetland of Aconcagua River, central Chile. We evaluated composition and abundance of benthic ensemble in foraging areas, and its local spatial distributions in these foraging areas. The main prediction was that selected trophic items may reflect the main distribution of shorebirds. The total benthic invertebrates registered were 11,514 individuals, corresponding to 25 taxa, being crustaceans, polychaetes, oligochaetes, and insects the major taxonomic groups. The total and foraging shorebirds registered were 2,105 and 1,136 individuals, respectively; corresponding to 18 species belonged to 4 Families: Charadriidae, Haematopodidae, Recurvirostridae and Scolopacidae. Tidal flats around the study site exhibit non-random spatial distributions of feeding shorebirds, responding to food availability within the Aconcagua river wetland. Our integrated analysis showed significant differences between tidal flat areas based on abundance and composition of benthic trophic items (mediated by sediment characteristics), and some relationships between foraging shorebirds and trophic items in particular tidal flat areas. These results have implications for shorebird conservation and future wetland management, mainly in relation to environmental changes and other causes of habitat loss and destruction linked with worldwide decline in many shorebird populations.

Philippe, A. S., D. Pinaud, M.-L. Cayatte, C. Goulevant, N. Lachaussee, P. Pineau, M. Karpytchev, and P. Bocher. 2016. Influence of environmental gradients on the distribution of benthic resources available for shorebirds on intertidal mudflats of Yves Bay, France. *Estuarine, Coastal and Shelf Science* **174**:71-81.

(Abstract)

The case study of Yves Bay (Pertuis Charentais, France) highlighted links between environmental gradients (i.e. sediment characteristics and emersion time) and prey distribution and availability for the two most numerous shorebird species overwintering in Yves Bay: the red knot *Calidris canutus* and the dunlin *Calidris alpine*. Two hundred and fifty-two stations were sampled on a predetermined 250 m regular grid covering the intertidal mudflats of this major wintering site in France for east-Atlantic migratory shorebirds. The distribution of principal benthic species abundance and biomass was modelled along two environmental gradients: sediment structure (particularly pronounced northesouth sand-mud gradient) and emersion time. The effect of emersion time combined with sedimentary structure strongly explained abundances and biomasses of the main prey for *C. canutus* and *C. alpine* in the bay (*Cerastoderma edule*, *Hydrobia ulvae*, *Macoma balthica*, *Scrobicularia plana*, and *Nephtys hombergii*). This study highlighted prey species-specific spatial segregation/overlapping as well as spatial interferences in the trophic niche of the two shorebirds.

Lyons, J. E., W. L. Kendall, J. A. Royle, S. J. Converse, B. A. Andres, and J. B. Buchanan. 2016. Population Size and Stopover Duration Estimation Using Mark–Resight Data and Bayesian Analysis of a Superpopulation Model. *Biometrics* **72**:262–271.

(Abstract)

We present a novel formulation of a mark–recapture–resight model that allows estimation of population size, stopover duration, and arrival and departure schedules at migration areas. Estimation is based on encounter histories of uniquely marked individuals and relative counts of marked and unmarked animals. We use a Bayesian analysis of a state–space formulation of the Jolly–Seber mark–recapture model, integrated with a binomial model for counts of unmarked animals, to derive estimates of population size and arrival and departure probabilities. We also provide a novel estimator for stopover duration that is derived from the latent state variable representing the interim between arrival and departure in the state–space model. We conduct a simulation study of field sampling protocols to understand the impact of superpopulation size, proportion marked, and number of animals sampled on bias and precision of estimates. Simulation results indicate that relative bias of estimates of the proportion of the population with marks was low for all sampling scenarios and never exceeded 2%. Our approach does not require enumeration of all unmarked animals detected or direct knowledge of the number of marked animals in the population at the time of the study. This provides flexibility and potential application in a variety of sampling situations (e.g., migratory birds, breeding seabirds, sea turtles, fish, pinnipeds, etc.). Application of the methods is

demonstrated with data from a study of migratory sandpipers.

Churchwell, R. T., S. J. Kendall, A. L. Blanchard, K. H. Dunton, and A. N. Powell. 2016. Natural Disturbance Shapes Benthic Intertidal Macroinvertebrate Communities of High Latitude River Deltas. *Estuaries and Coasts* **39**:798–814.

(Abstract)

Unlike lower latitude coastlines, the estuarine nearshore zones of the Alaskan Beaufort Sea are icebound and frozen up to 9 months annually. This annual freezing event represents a dramatic physical disturbance to fauna living within intertidal sediments. The main objectives of this study were to describe the benthic communities of Beaufort Sea deltas, including temporal changes and trophic structure. Understanding benthic invertebrate communities provided a baseline for concurrent research on shorebird foraging ecology at these sites. We found that despite continuous year-to year episodes of annual freezing, these estuarine deltas are populated by a range of invertebrates that represent both marine and freshwater assemblages. Freshwater organisms like Diptera and Oligochaeta not only survive this extreme event, but a marine invasion of infaunal organisms such as Amphipoda and Polychaeta rapidly recolonizes the delta mudflats following ice ablation. These delta sediments of sand, silt, and clay are fine in structure compared to sediments of other Beaufort Sea coastal intertidal habitats. The relatively depauperate invertebrate community that ultimately develops is composed of marine and freshwater benthic invertebrates. The composition of the infauna also reflects two strategies that make life on Beaufort Sea deltas possible: a migration of marine organisms from deeper lagoons to the intertidal and freshwater biota that survive the 9-month ice-covered period in frozen sediments. Stable isotopic analyses reveal that both infaunal assemblages assimilate marine and terrestrial sources of organic carbon. These results provide some of the first quantitative information on the infaunal food resources of shallow arctic estuarine systems and the long-term persistence of these invertebrate assemblages. Our data help explain the presence of large numbers of shorebirds in these habitats during the brief summer open-water period and their trophic importance to migrating waterfowl and nearshore populations of estuarine fishes that are the basis of subsistence lifestyles by native inhabitants of the Beaufort Sea coast.

Bijleveld, A. I., R. B. MacCurdy, Y.-C. Chan, E. Penning, R. M. Gabrielson, J. Cluderay, E. L. Spaulding, A. Dekinga, S. Holthuijsen, J. ten Horn, M. Brugge, J. A. van Gils, D. W. Winkler, and T. Piersma. 2016. Understanding spatial distributions: negative density-dependence in prey causes predators to trade-off prey quantity with quality. *Proceedings of the Royal Society B: Biological Sciences* **283**:20151557.

(Abstract)

Negative density-dependence is generally studied within a single trophic level, thereby neglecting its effect on higher trophic levels. The 'functional response' couples a predator's intake rate to prey density. Most widespread is a type II functional response, where intake rate increases asymptotically with prey density; this predicts the highest predator densities at the highest prey densities. In one of the most stringent tests of this generality to date, we measured density and quality of bivalve prey (edible cockles *Cerastoderma edule*) across 50 km2 of mudflat, and simultaneously, with a novel time-of-arrival methodology, tracked their avian predators (red knots *Calidris canutus*). Because of negative density-dependence in the individual quality of cockles, the predicted energy intake rates of red knots declined at high prey densities (a type IV, rather than a type II functional response). Resource-selection modelling revealed that red knots indeed selected areas of intermediate cockle densities where energy intake rates were maximized given their phenotype-specific digestive constraints (as indicated by gizzard mass). Because negative density-dependence is common, we question the current consensus and suggest that predators commonly maximize their energy intake rates at intermediate prey densities. Prey density alone may thus poorly predict intake rates, carrying capacity and spatial distributions of predators.

Lehikoinen, A., S. Fraixedas, D. Burgas, H. Eriksson, H. Henttonen, H. Laakkonen, P. Lehikoinen, J. Lehtomäki, J. Leppänen, S. Mäkeläinen, J. Niemimaa, M. Pihlajaniemi, J. Santaharju, and K. Välimäki. 2016. The impact of weather and the phase of the rodent cycle on breeding populations of waterbirds in Finnish Lapland. *Ornis Fennica* **93**:31–46.

(Abstract)

Climate change may affect bird populations both directly by changing the weather conditions, and indirectly through changes in the food chain. While both theoretical and empirical studies have shown climate change having drastic impacts on polar areas, its consequences on Arctic bird species are still poorly known. Here we investigated how weather and changes in predator–prey interactions affected the annual growth rates of sub-Arctic birds by monitoring the breeding numbers of three duck and seven wader species in the alpine tundra of Finnish Lapland during 2005–2015 (except for 2006). We hypothesized that growth rates of waterbirds would be positively associated with warm and dry weather due to improved reproductive success. Furthermore, we tested the hypothesis that waterbirds have a higher reproductive success during the cyclic rodent peaks, when predators mainly prey on rodents, than during the decline and low phases of the cycle, when predation pressure towards waterbirds increases. Results showed that population growth rates of breeding ducks were negatively associated with the sum of rainfall in the previous year. In waders, growth rates were positively associated with the phase of the rodent cycle in the same year. Our results emphasize the importance of monitoring Arctic bird populations on their breeding areas to explore what the consequences of climate change might be for breeding waterbirds by linking the effects of both weather and rodent abundance.

Pandiyan, J., and S. Asokan. 2016. Habitat use pattern of tidal mud and sand flats by shorebirds (Charadriiformes) wintering in southern India. *Journal of Coastal Conservation* **20**:1–11.

(Abstract)

Habitat use pattern and status of shorebirds in southern India were investigated in six tidal flats comprising three mudflats and three sand flats on the east coast of southern India. Totally, 7757 shorebirds belonging to 21 species were recorded during September 2000–March 2002. The birds preferred mudflats over sand flats. Density, diversity and richness of shorebirds were relatively higher in tidal flats, especially in mudflats. The shorebirds preferred mudflats over sand flats as stopover sites and sites for refueling the required energy during migration. Rhythmic changes in tidal pattern also influenced the allochthonous nutrients and prey species, which also attracted the migratory shorebirds. However, the abundance of shorebirds with reference to tidal flats *season*tide and habitats*seasons * tide had strong variations ($P < 0.001$). During migratory season, bird density, diversity and species richness were observed higher than in other seasons.

Catry, T., P. M. Lourenço, R. J. Lopes, C. Carneiro, J. A. Alves, J. Costa, H. Rguibi-Idrissi, S. Bearhop, T. Piersma, and J. P. Granadeiro. 2016. Structure and functioning of intertidal food webs along an avian flyway: a comparative approach using stable isotopes. *Functional Ecology* **30**:468–478.

(Abstract)

1. Food webs and trophic dynamics of coastal systems have been the focus of intense research throughout the world, as they prove to be critical in understanding ecosystem processes and functions. However, very few studies have undertaken a quantitative comparison of entire food webs from a key consumer perspective across a broad geographical area, limiting relevant comparisons among systems with distinct biotic and abiotic components.

2. We investigate the structure and functioning of food webs in four tidal ecosystems of international importance for migratory shorebirds along the East Atlantic Flyway: Tejo estuary in Portugal, Sidi Moussa in Morocco, Banc d'Arguin in Mauritania and Bijagos archipelago in Guinea-Bissau. Basal food sources, shorebirds and their prey (benthic invertebrates) were sampled in all areas, and Bayesian stable isotope mixing models and community-wide metrics were used in a comparative analysis among areas.

3. Significant differences among study areas were found in the structure of food webs, as well as in the relative importance of basal resource pools supporting each food web. Overall, the food web of Banc d'Arguin was characterized by lower trophic diversity and higher functional

redundancy than the other sites. This result might be explained by the low number of trophic pathways of organic matter transfer in this seagrass-dominated system which, as a fossil estuary, lacks inputs from both freshwater and nutrient-rich offshore oceanic waters.

4. Structure of shorebird communities was consistent with the main organizational patterns found for each food web, highlighting the less diverse character of the community of Banc d'Arguin. At Banc d'Arguin and Bijagos archipelago, which displayed the smallest and largest isotopic niche widths in bird assemblage, respectively, mean niche overlap among species was low, suggesting high interspecific partitioning in resource use. Tropical systems typically offer comparatively lower harvestable prey biomass for shorebirds and might thus strengthen interspecific competition, leading to low niche overlap among species.

5. Our study reveals relevant differences in the structure of food webs and shorebird communities in coastal areas along an avian flyway. While differences in trophic redundancy of food webs point to distinct levels of ecosystem resilience, contrasts in the organization of shorebird communities highlight the plasticity in the foraging behaviour of species inhabiting areas with distinct environmental conditions.

Koloski, L., S. Coulson, and E. Nol. 2016. Sex Determination in Breeding Dunlin (*Calidris alpina hudsonia*). *Waterbirds* **39**:27-33.

(Abstract)

Male and female Dunlin (*Calidris alpine*) exhibit slight plumage and structural differences. Discriminant function analysis based on morphological characteristics can effectively differentiate between sexes in several subspecies of Dunlin. We assessed the level of sexual size dimorphism in a subspecies that breeds in sub-Arctic Canada (*C. a. hudsonia*), and used discriminant function analysis to create equations to classify individuals to sex using five body measurements (body mass, head length, culmen length, tarsus length, and flattened wing chord). Females were significantly larger than males for all body measurements. Discriminant function analysis using tarsus length, head length, and body mass correctly classified 87.1% of molecularly sexed females (n = 31) and 92.6% of males (n = 27). The classification of an independent sample (n = 12) resulted in 100.0% correct assignment of sex with 33.3% of individuals falling within the undetermined range. A discriminant function analysis equation is provided for use with non-breeding populations using only structural characteristics with classification accuracies of 83.9% for females and 81.5% for males. The resulting equations from this study have classification accuracies comparable to those equations developed for other Dunlin subspecies and can be used to reliably differentiate sexes of *C. a. hudsonia* using body measurements collected in the field. Received 3 February 2015, accepted 12 March 2015.

Ryan, L. J., J. A. Green, and S. G. Dodd. 2016. Weather conditions and conspecific density influence survival of overwintering Dunlin *Calidris alpine* in North Wales. *Bird Study* **63**:1–9.

(Abstract)

Capsule: Inter-annual survival rates of juvenile Dunlin *Calidris alpine* increased with wet weather conditions but decreased with the density of conspecifics in winter, ranging from 0.34 to 0.62 in the best model. Adult inter-annual survival remained high and constant at 0.72.

Aims: To estimate inter-annual survival rates of both adult and juvenile Dunlin in North Wales. To quantify the effects on survival rates of weather conditions and conspecific density.

Methods: Cormack–Jolly–Seber models in Program MARK were used to analyse 21 years of ringing data (1990–2011) from Traeth Lafan, North Wales. Models were constructed using a two age-class structure. The influence of a range of weather conditions and WeBS census data on survival were examined.

Results: Adult survival was best modelled at a constant rate of 0.72 (se 0.008) across the 21 years. Juvenile survival rates were found to vary most strongly with total rainfall (mm) during the season and the number of conspecifics present. Survival rates varied from 0.34 (se 0.06) to 0.62 (se 0.09), with higher survival in years with high rainfall and low numbers of birds.

Conclusion: Survival rates of juvenile Dunlin are affected by both weather and density of conspecifics. These results have implications for the future of Dunlin in the UK when considering both climate change and habitat loss.

Gutiérrez, J. S., and T. Piersma. 2016. Ecological context determines the choice between prey of different salinities. *Behavioral Ecology* **27**:530–537.

(Abstract)

Food choice has profound implications for the relative intakes of water and salts, and thus for an animal's physiological state. Discrimination behaviors with respect salt intake have been documented in a number of vertebrate species, but few studies have considered the ecological context in which they occur. Here, we report on the results of a 2-choice experiment designed to examine the influence of dietary salt content and freshwater availability in food discrimination behaviors in red knots *Calidris canutus* (Aves: Scolopacidae) that feed on mud snails *Peringia ulvae* (Gastropoda: Hydrobiidae) whose body fluids have either relatively low (25‰) or high (42‰) salinity. Birds ate more and spent longer time foraging on low-salinity mud snails when their salt gland sizes—an indicator of excretory capacity—were relatively small and when they were deprived of freshwater. However, as they enlarged salt glands—following a prolonged exposure to salty diet without access to freshwater—and regained access to freshwater, their preference for low-salinity prey disappeared. Such a change of preference illustrates the context dependency of discrimination. As the birds were able to maintain salt–water balance—inferred from plasma sodium concentration—under all

conditions, changes in salinity preferences may occur without measurable physiological signs of osmotic stress. Our results highlight the importance of ecological context for understanding foraging responses. We argue that areas with high salinities could act as refuges for euryhaline invertebrates and fish from top vertebrate predators.

Catry, T., P. M. Lourenço, R. J. Lopes, P. Bocher, C. Carneiro, J. A. Alves, P. Delaporte, S. Bearhop, T. Piersma, and J. P. Granadeiro. 2016. Use of stable isotope fingerprints to assign wintering origin and trace shorebird movements along the East Atlantic Flyway. *Basic and Applied Ecology* **17**:177–187.

(Abstract)

Migratory connectivity can be defined as the flux of individuals or populations among areas between stages of an animal's lifecycle. Many shorebird species perform long-distance migrations and while moving between breeding and wintering grounds, they depend on a network of intermediate wetlands (stopover sites) where populations of different origins extensively overlap. The difficulty to discriminate such populations represents a serious obstacle to the identification of the links between breeding or wintering areas and stopover sites, and also precludes the estimation of demographic parameters for each population. In this study, we test if linear discriminant models based on stable carbon and nitrogen isotope ratios in toenails can be used to identify populations of several shorebird species of different wintering origins overlapping at two stopover sites of the East Atlantic Flyway. In addition, we evaluate the ability of this approach to infer migratory phenological patterns of shorebirds. Linear discriminant analyses performed overall well in distinguishing the isotopic signals of birds from wintering areas (in France, Portugal, Morocco, Mauritania and Guinea-Bissau) in most species, correctly classifying over 80% (n = 542) of all wintering individuals sampled at these areas. Assignment rates of shorebirds captured during spring migration were also high (96%, n = 323) at the Tejo estuary, Portugal, but lower (40%, n = 185) at Marennes-Oléron Bay in France, and also differed among species. A large proportion of spring migrants captured in Portugal and France were assigned to Banc d'Arguin in Mauritania, the most important wintering area in the flyway. Phenological patterns derived for dunlins (*Calidris alpine*), common ringed plovers (*Charadrius hiaticula*) and grey plovers (*Pluvialis squatarola*) suggest that the first northward migrants started arriving at the Tejo estuary during the second half of March, with peaking numbers occurring during April or May.

Piersma T, Lok T, Chen Y, Hassell CJ, Yang H-Y, Boyle A, Slaymaker M, Chan Y-C, Melville DS, Zhang Z-W, Ma Z. 2016. Simultaneous declines in summer survival of three shorebird species signals a flyway at risk. *Journal of Applied Ecology* **53**:479–490.

(Abstract)

1. There is increasing concern about the world's animal migrations. With many landuse and climatological changes occurring simultaneously, pinning down the causes of large-scale conservation problems requires sophisticated and data-intensive approaches.

2. Declining shorebird numbers along the East Asian–Australasian Flyway, in combination with data on habitat loss along the Yellow Sea (where these birds refuel during long-distance migrations), indicate a flyway under threat.

3. If habitat loss at staging areas indeed leads to flyway-wide bird losses, we would predict that: (i) decreases in survival only occur during the season that birds use the Yellow Sea, and (ii) decreases in survival occur in migrants that share a reliance on the vanishing intertidal flats along the Yellow Sea, even if ecologically distinct and using different breeding grounds.

4. Monitored from 2006–2013, we analysed seasonal apparent survival patterns of three shorebird species with non-overlapping Arctic breeding areas and considerable differences in foraging ecology, but a shared use of both north-west Australian nonbreeding grounds and the Yellow Sea coasts to refuel during northward and southward migrations (red knot *Calidris canutus piersmai*, great knot *Calidris tenuirostris*, bar-tailed godwit *Limosa lapponica menzbieri*). Distinguishing two three-month non-breeding periods and a six-month migration and breeding period, and analysing survival of the three species and the three seasons in a single model, we statistically evaluated differences at both the species and season levels.

5. Whereas apparent survival remained high in north-west Australia, during the time away from the non-breeding grounds survival in all three species began to decline in 2011, having lost 20 percentage points by 2012. By 2012 annual apparent survival had become as low as 0.71 in bar-tailed godwits, 0.68 in great knots and 0.67 in red knots. In a separate analysis for red knots, no mortality occurred during the migration from Australia to China. In the summers of low summer survival, weather conditions were benign in the Arctic breeding areas.
6. We argue that rapid seashore habitat loss in the Yellow Sea is the most likely explanation of reduced summer survival, with dire (but uncertain) forecasts for the future of these flyway populations. This interpretation is consistent with recent findings of declining shorebird numbers at seemingly intact southern non-breeding sites.

7. Policy implications. Due to established economic interests, governments are usually reluctant to act for conservation, unless unambiguous evidence for particular cause–effect chains is apparent. This study adds to an increasing body of evidence that habitat loss along the Yellow Sea shores explains the widespread declines in shorebird numbers along the East Asian–Australasian Flyway and threatens the long-term prospects of several long-distance migrating species. To halt further losses, the clearance of coastal intertidal habitat must stop now.

Martins RC, Catry T, Rebelo R, Pardal S, Palmeirim JM, Granadeiro JP. 2016. Contrasting estuary-scale distribution of wintering and migrating waders: the potential role of fear. *Hydrobiologia* **768**:211–222.

(Abstract)

In estuaries hosting both wintering and migrating populations of waders of the same species, the distinct ecological constraints on birds in different seasons may result in different criteria being used for selection of suitable foraging habitat. We analysed the distribution patterns of dunlins *Calidris alpine* in the Tagus estuary, Portugal, during the non-breeding season and investigated the roles of prey availability and predation risk to explain those patterns. The southern estuary provided higher prey availability but their narrower flats may induce greater fear of predation in waders than the open northern flats. However, our data suggest that the real risk was similar. Migrating birds avoided the southern estuary, favouring areas perceived as safer over better feeding opportunities. In contrast, wintering dunlins favoured the southern flats, despite their proximity to cover. Presumably, wintering waders have a better knowledge of the estuary, including its real predation risks, taking advantage of the best foraging areas. Without such knowledge, waders in short stopovers have to select their foraging areas based on indirect indicators of predation risk, such as distance to cover. This study illustrates the importance of incorporating specificities of habitat preferences by wintering and migrating wader populations in conservation planning for large estuaries.

Gerwing TG, Kim J-H, Hamilton DJ, Barbeau MA, Addison JA. 2016. Diet reconstruction using next-generation sequencing increases the known ecosystem usage by a shorebird. *The Auk* **133**(2):168-177.

(Abstract)

Molecular scatology and next-generation sequencing identified previously unknown linkages among ecosystems in the diet of Semipalmated Sandpipers (*Calidris pusilla*) in the Bay of Fundy, Canada. During their annual migratory stopover, the birds consumed a wider range of prey items than previously reported, which suggests that they are not selecting for the amphipod *Corophium volutator* and are acting as generalist foragers. Our analysis identified several novel prey items—arachnids, crabs, bivalves, several terrestrial and freshwater insect species, ctenophores, cnidarians, and fish (likely eggs or juveniles)—indicating that Semipalmated Sandpipers consume prey from marine, freshwater, and terrestrial ecosystems. Connections between Semipalmated Sandpipers and freshwater and terrestrial ecosystems were previously unknown in the Bay of Fundy. Current conservation efforts for this species are focused on beach and intertidal habitats; however, we may also need to consider the surrounding freshwater and terrestrial habitat.

Conklin, J. R., J. Reneerkens, Y. I. Verkuil, P. S. Tomkovich, P. J. Palsbøll, and T. Piersma. 2016. Low genetic differentiation between Greenlandic and Siberian Sanderling populations implies a different phylogeographic history than found in Red Knots. *Journal of*

Ornithology **157**:325–332.

(Abstract)

The Greenlandic and west-central Siberian breeding populations of Sanderlings *Calidris alba*are separated by ca. 2000 km during the breeding season, but mix in Europe to some extent during migration. However, the number of Siberian Sanderlings that spend the nonbreeding season along the East Atlantic Flyway (extending from western Europe to South Africa), if any, is unknown. Although both populations are considered part of the nominate subspecies *C. a. alba* based on morphology, population structure in Sanderlings has yet to be described with molecular methods. We examined genetic differentiation at the mtDNA control region (CR) and seven microsatellite loci between Greenland- and Siberia-breeding Sanderlings in order to: (1) develop a diagnostic tool for assessing the breeding origin of Sanderlings along the East Atlantic Flyway, and (2) provide a comparison with the co-distributed and ecologically similar Red Knot, in which CR differentiation of geographically analogous populations (*C. canutus islandica* and *C. c. canutus*) has indicated isolation of lineages near the time of the last glacial maximum. By contrast, we found only weak differentiation between the Sanderling breeding populations at the CR, and no differentiation at microsatellite loci. These results suggest that the assignment of breeding origin of Sanderlings on Afro-European flyways will not be possible with simple and inexpensive genetic methods, and imply that Sanderlings and Red Knots have very different post-glacial phylogeographic histories.

Chan, Y.-C., M. Brugge, T. L. Tibbitts, A. Dekinga, R. R. Porter, R. H. G. Klaassen, and T. Piersma. 2016. Testing an attachment method for solar-powered tracking devices on a long-distance migrating shorebird. *Journal of Ornithology* **157**:277–287.

(Abstract)

Small solar-powered satellite transmitters and GPS data loggers enable continuous, multi-year, and global tracking of birds. What is lacking, however, are reliable methods to attach these tracking devices to small migratory birds so that (1) flight performance is not impacted and (2) tags are retained during periods of substantial mass change associated with long-distance migration. We developed a full-body harness to attach tags to Red Knots (*Calidris canutus*), a medium-sized shorebird (average mass 124 g) that undertakes long-distance migrations. First, we deployed dummy tags on captive birds and monitored them over a complete migratory fattening cycle (February–July 2013) during which time they gained and lost 31–110 g and underwent a pre-alternate moult of body feathers. Using each individual's previous year fattening and moult data in captivity as controls, we compared individual mass and moult differences between years between the tagged and reference groups, and concluded that the attachment did not impact mass and moult cycles. However, some birds shed feathers under the tags and under the polyester harness line commonly used in avian harnesses. Feather shedding was alleviated by switching to smoothed-bottom tags and monofilament harness lines. To field-trial this design, we deployed 5-g satellite transmitters on

ten Red Knots released on 3 October 2013 in the Dutch Wadden Sea. Bird movements and tag performance appeared normal. However, nine tags stopped transmitting 11–170 days post-release which was earlier than expected. We attribute this to bird mortality rather than failure of the attachments or transmitters and suggest that the extra weight and drag caused by the tag and its feather-blocking shield increased the chance of depredation by the locally common Peregrine Falcons (*Falco peregrinus*). Our results demonstrate that species- and place-specific contexts can strongly determine tagging success. While captive trials are an important first step in developing an attachment method, field trials are essential to fully assess attachment designs.

Yang, H.-Y., B. Chen, T. Piersma, Z. Zhang, and C. Ding. 2016. Molluscs of an intertidal soft-sediment area in China: Does overfishing explain a high density but low diversity community that benefits staging shorebirds? *Journal of Sea Research* **109**:20–28.

(Abstract)

The Yellow Sea is a key staging ground for shorebirds that migrate from Australasia to the Arctic each spring. A lot of attention has been paid to the impact of habitat loss due to land reclamation on shorebird survival, but any effects of overfishing of coastal resources are unclear. In this study, the abundance of molluscs in the intertidal mudflats of northern Bohai Bay on the Chinese Yellow Sea was investigated in 2008–2014 from the perspective of their importance as food for northward migrating shorebirds, especially Red Knots *Calidris canutus*. Numerically contributing 96% to the numbers of 17 species found in spring 2008, the bivalve *Potamocorbula laevis* (the staple food of Red Knots and other shorebirds) dominated the intertidal mollusc community. In the spring of 2008–2014, the densities of *P. laevis* were surprisingly high, varying between 3900 and 41,000 individuals/m2 at distinctly small sizes (average shell lengths of 1.1 to 4.8mm), and thus reaching some of the highest densities of marine bivalves recorded worldwide and providing good food for shorebirds. The distribution of *P. laevis* was associated with relatively soft sediments in close proximity to the recently built seawalls. A monthly sampling programme showed steep seasonal changes in abundance and size. *P. laevis* were nearly absent in winter, each year settling on the intertidal mudflats anew. Peak densities were reached in spring, when 0-age *P. laevis*were 1–3 mm long. The findings point to a highly unusual demographic structure of the species, suggesting that some interfering factors are at play. We hypothesise that the current dominance of young *P. laevis* in Bohai Bay reflects the combined pressures of a nearly complete active removal of adult populations from mid-summer to autumn for shrimp farming (this clearing of adults may offer space for recruitment during the next spring) and low numbers of epibenthic predators of bivalves, such as shrimps and crabs, due to persistent overfishing in recent decades (allowing freshly settled juveniles to reach high densities). To the best of our knowledge, the idea that overfishing of competing marine mesopredators benefits staging shorebirds, at least in the short term, is novel; it now needs further experimental and comparative scrutiny. The long-termeffects of overfishing on benthic communities of the mudflats need further investigation.

Kim, W. Y., E. H. Lim, D.-P. Lee, and H.-C. Sung. 2015. Behavior of Migrant Kentish Plovers (*Charadrius alexandrines*) in the Ramsar Wetland of Yubu Island. *The Korean Journal of Ornithology* **22**:55-65.

(Abstract)

The research in this study has been conducted on a daily basis from March 14 to April 2, 2013 in order to investigate, according to their habitats, the behaviors of Kentish Plovers (*Charadrius alexandrines*), which breed and stop over in the Ramsar Wetland of Yubu Island in Janghang-eup, Seocheon-gun, Chungcheongnam-do. The sex of each individual bird was determined and the frequency of behaviors in the observed site was investigated. As a result, the size of the male population was about 2 times that of the female population and the number of the male population was also significantly dominant. The daily maximum number of individual birds were 174 on March 16th. The biggest difference between the male and female population sizes appeared on March 15th, having many male birds. The next day, March 16th, the largest number of female birds during the research period arrived. In terms of behaviors of male birds in salt farms and sand dunes, the stop behavior accounts for over 50 percent and feeding accounts for less 10 percent of their behaviors while, in mud flats, the stop behavior accounts for less 40 percent and feeding accounts for about 30 percent of their behaviors. The female birds also had a similar pattern of behaviors with male birds, but the frequency of their flight was significantly low compared to that of male birds. In terms of diurnal behaviors, birds fed in the morning and took the stop behavior in the evening. After migration, the frequency of the stop behavior declined while the frequency of walking and feeding significantly increased. In this way, Kentish Plovers dominantly took the stop and feeding behaviors at the stopover site, Yubu Island, and this is believed to result from the fact that they replenish the energy sources that consumed during their migrations. Further continuous research will contribute to the providing fundamental data to protect and manage the birds and their habitats located in the major wetlands in South Korea.

Meissner, W. 2015. Male-Biased Sex-Ratio of Dunlins *Calidris alpine* in the Gulf Of Gdańsk (Southern Baltic) During Autumn Migration. *Ardeola* **62**:335-342.

(Abstract)

This long-term study (10 years) aimed to check if the sex-ratio of dunlins *Calidris alpine* at a stopover site in the southern Baltic region was biased. Two age classes among non-juvenile dunlins were recognised: immatures (2nd calendar year) and adults (> 2nd calendar year). There was a significant male bias in the sample of 4,406 non-juvenile dunlins captured during

their southward migration. Overall, 60.3% of immatures and 59.4% of adults were males. Particularly among adults, the proportion of males increased significantly after the start of autumn migration. The annual sex-ratios were consistently male biased, but varied somewhat and fluctuated in parallel for adults and immatures. One plausible explanation for the male bias is that males and females differ in migration strategy. Females may make longer flights and avoid stopover sites with unpredictable feeding conditions, such as the southern Baltic coasts, which provide low quality habitat. Assuming a balanced non-juvenile population sex ratio, the 'missing' females could stopover elsewhere in the Baltic or fly directly to the tidal areas of the Wadden Sea. The sex ratio in the study area may depend on wind conditions during the early phase of autumn migration. In some years, adverse weather may force more females than usual to stopover in the study area.

Murray, N. J., and R. A. Fuller. 2015. Protecting stopover habitat for migratory shorebirds in East Asia. *Journal of Ornithology* **156**:217-225.

(Abstract)

Many migratory species depend on staging sites at which they refuel while on migration, and effective protection of such habitats is crucial to their conservation. Here we investigate the extent to which protected areas cover and ameliorate loss of tidal flats in East Asia, the key staging habitat for threatened and declining shorebirds migrating through the East Asian–Australasian Flyway. We discover rapid losses of the tidal flat ecosystem both inside (-0.42% year-1) and outside (-0.89% year-1) protected areas. In China, tidal flats are well represented within protected areas (22.9 % of current tidal flats occur within protected areas), but habitat loss continued despite protection (-0.55 % year-1 inside, -0.97 % year-1 outside). By contrast, in South Korea, where 12.1% of remaining tidal flat is in protected areas, the rate of habitat loss outside protected areas was the highest in our study region (-1.83% year-1), yet inside protected areas there was tidal flat aggradation (+1.13% year-1), indicating either that protected area placement is biased away from vulnerable habitats, or protected areas are highly effective in South Korea. Tidal flats across our study area were lost most rapidly in internationally important sites for migratory shorebirds (-1.66% year-1), suggesting that transformative land use change of coastal areas is occurring disproportionately in regions that are important for migratory birds. We urge (1) improved management of existing protected areas in East Asia, particularly in China, (2) targeted designation of new protected areas in sites crucial for supporting migratory birds and (3) integrated decision-making that simultaneously plans for coastal development and coastal conservation.

Pakanen, V.-M., N. Rönkä, R. L. Thomson, and K. Koivula. 2015. No strong effects of leg-flagged geolocators on return rates or reproduction of a small long-distance migratory

shorebird. *Ornis Fennica* **92**:101–111.

(Abstract)

Small light-level geolocators have revolutionized research on avian migration and breeding ecology. However, proper evaluations of their impact on the life history of individuals compared to control individuals that experience the same conditions are still rare. Geolocator effects may be species specific and depend on the type of mounting, sex and size of individuals. While geolocators have been used extensively and without negative effects on large shorebirds, relatively little is known about their effects on small shorebirds, especially of those attached on leg-flags. We mounted 30 leg-flagged geolocators (15 on each sex) on Southern Dunlins (*Calidris alpina schinzii*) – a small, long distance migratory shorebird (40–52 grams) – and examined the effects of geolocators on return rates and reproduction through comparisons to a control group. The whole attachment weighed 1.5–2% of an individual's body mass. We found no evidence of lowered return rates. Out of 30 birds, 22 (73%) returned from both groups. Returning birds had similar breeding probability, timing of breeding, clutch size and nesting success. The proportion of unhatched eggs was higher in the geolocator group, but this difference was not significant. Inspection of unhatched eggs from the treatment group suggested no clear damage to eggs caused by geolocators. Our results suggest that at least one small wader species can withstand the extra weight imposed by appropriately sized geolocators. However, our study lasted only for one year, and long term evaluations that capture the full suite of environmental conditions and assess impact on brood care are needed.

Putra, C. A., D. Hikmatullah, D. M. Prawiradilaga, and J. B. C. Harris. 2015. Surveys at Bagan Percut, Sumatra, reveal its international importance to migratory shorebirds and breeding herons. *Kukila* **18**:46-59.

(Abstract)

The Bagan Percut region of north-eastern Sumatra, Indonesia, is becoming well known for its large concentrations of migratory shorebirds. From January to June 2011 we made monthly counts of shorebirds and waterbirds at four mudflats and one heron rookery. Fifty-one species were recorded, including 35 migratory species, and eight breeding species in the rookery. We counted 20,114 migratory shorebirds (mudflats) and 45,648 breeding waterbirds (rookery) over six months of surveys. We observed >1% of the East Asian-Australasian flyway population of five species of migratory shorebirds: Nordmann's Greenshank *Tringa guttifer* (globally Endangered), Lesser Sand Plover *Charadrius mongolus*, Pacific Golden Plover *Pluvialis fulva*, Eurasian Curlew *Numenius arquata*, and Ruddy Turnstone *Arenaria interpres*. Our results support the work of others that indicate that Bagan Percut is an important habitat for wintering, migrating, and summering shorebirds. We recommend that Bagan Percut be added to the East Asian-Australasian Flyway Partnership list of internationally important wetlands because the area meets all three criteria for inclusion.

Novcic, I., D. S. Mizrahi, R. R. Veit, and W. O. C. Symondson. 2015. Molecular analysis of the value of Horseshoe Crab eggs to migrating shorebirds. *Avian Biology Research* **8**:210–220.

(Abstract)

Detection of prey DNA from faecal samples is a non-invasive method being successfully applied to the dietary analysis of birds as well as other vertebrates and invertebrates. We have employed this technique to examine the significance of Horseshoe Crab eggs (*Limulus polyphemus*) for Dunlins (*Calidris alpina*), Semipalmated Sandpipers (*Calidris pusilla*), Least Sandpipers (*Calidris minutilla*) and Short-billed Dowitchers (*Limnodromus griseus*) during northbound migration at their major stopover area in Delaware Bay. This was accomplished through polymerase chain reaction amplification of *Limulus* DNA from faecal samples using new Horseshoe Crab-specific primers. We detected the consumption of crab eggs in all study species, although results suggest that eggs may be a less important food source for Least Sandpipers than for the other species. Consumption of eggs increases as the migration season progresses, implying a strong preference of birds for this resource at the end of May, when eggs are readily accessible. The results confirm the value of Horseshoe Crab eggs for migrating shorebirds in this crucial stopover area. The *Limulus*-specific primers we designed can be effectively used for detection of semidigested *Limulus* DNA from faecal samples and thus they can be employed in the dietary analysis of other predators that seasonally capitalise on Horseshoe Crabs or their eggs.

Loktionov, E. Y., P. S. Tomkovich, and R. R. Porter. 2015. Study of incubation, chick rearing and breeding phenology of Red Knots *Calidris canutus rogersi* in sub-Arctic Far Eastern Russia aided by geolocators. *Wader Study* **122**:142-152.

(Abstract)

This is the first study of the breeding biology of Red Knots of the subspecies *Calidris canutus rogersi* in the Chukotka region, Far Eastern Russia. Direct behavioral observations and geolocator data of two Red Knots were compared to study the breeding phenology, incubation period and incubation bouts in sub-Arctic Chukotka, a region with twilight around midnight. The incubation period was 23 days after the second or third egg was laid, including about half a day in the nest with the hatched chicks. This corresponds with 21–21.5 days of incubation estimated by the traditional way (interval for the last egg of a clutch from laying to hatching). We suggest that males incubate longer than females. Geolocator data of brooding males after their chicks left the nest differed from those of females that do not attend chicks. Geolocator data might thus indicate the sex of Red Knots. For both males, the lengths of their respective incubation bouts and offduty periods did not significantly differ. Both bout lengths increased in the second half of the incubation period. Brooding time of chicks seems to gradually decrease during the summer, but it was not possible to determine when brooding ceased or when the

chicks became independent. Birds started their southward migration 28–28.5 days after families left their nests. This is longer than estimated by direct local field observations and by another geolocator study of Red Knots.

Gerwing, T. G., A. M. A. Gerwing, D. Drolet, M. A. Barbeau, and D. J. Hamilton. 2015. Spatiotemporal Variation in Biotic and Abiotic Features of Eight Intertidal Mudflats in the Upper Bay of Fundy, Canada. *Northeastern Naturalist* **22**:1-44.

(Abstract)

We examined biotic and abiotic variables on the expansive intertidal mudflats of the upper Bay of Fundy, Canada, at 8 geographically separate sites over 2 years (2009–2011). Invertebrate density, surface density of primary producers (mainly diatoms, measured as chlorophyll-a concentration), shorebird- and fish-foraging activity, and sediment properties varied considerably through time and space. Dissimilarity in the invertebrate community between consecutive sampling rounds was lower during peaks in density and richness (June–August) than during periods of low density and richness (December–March). All but one site located within Chignecto Bay (one arm of the upper Bay of Fundy) had similar invertebrate communities; sites within the Minas Basin (the other arm of the upper Bay) had more distinct communities compared to Chignecto Bay mudflats. The amphipod *Corophium volutator*, *Copepoda*, *Ostracoda*, and the polychaetes *Phyllodocidae* and *Spionidae* were usually main contributors to observed community differences over space and time. Although our sites are all silt-dominated mudflats, mean particle size, sediment penetrability, and depth to the apparent redox discontinuity potential (aRDP, a measure of sediment-oxygen content) were usually main contributors to site differences in sediment conditions. However, when we pooled samples over sites and sampling rounds, percent water content and percent organic-matter content accounted for the majority of the variation in sediment properties, likely reflecting within-site patchiness. Such quantification of spatiotemporal patterns in biotic and abiotic variables is an essential first step in the development of predictive models or the design of manipulative experiments to investigate ecological relationships.

Green, J. A., S. Sripanomyom, X. Giam, and D. S. Wilcove. 2015. The ecology and economics of shorebird conservation in a tropical human-modified landscape. *Journal of Applied Ecology* **52**:1483–1491.

(Abstract)

1. Rapid and extensive land-use change in intertidal foraging habitat and coastal roosting habitat is thought to be driving major population declines of shorebirds migrating through the East Asian–Australasian Flyway. Along the Inner Gulf of Thailand, a critical stopover and

wintering ground for these birds, artificial wetlands (salt pans and aquaculture ponds) have replaced much of the natural coastal ecosystem.

2. We conducted a two-part study to (i) assess the importance of salt pans and semi-traditional aquaculture ponds to shorebirds and (ii) understand the economic forces that drive land-use change in this region by interviewing salt pan and aquaculture operators.

3. Salt pans provide important roost habitat, particularly for shorter-legged birds, which are less able to utilize aquaculture ponds due to their greater depth. Moreover, three focal shorebird species foraged extensively in salt pans and semi-traditional aquaculture ponds, even when intertidal mudflats were exposed, suggesting that artificial wetlands could buffer against the impacts of degraded intertidal foraging areas for some shorebird species.

4. Economic profits from salt production and semi-traditional aquaculture are similar. Risks to investment and per capita profitability are key factors in determining whether to convert land from one use (e.g. salt pan) to the other (aquaculture).

5. Synthesis and applications. Salt pans provide an important resource to migrating shorebirds. As development pressures increase, operators may need financial incentives if salt pans are to be maintained over large areas. Although semi-traditional aquaculture is used less by shorebirds, drained ponds provide opportunities to roost and forage. Semi-traditional aquaculture operators should drain their ponds regularly to provide supplementary habitat for shorebirds. Use of nets and pond liners should be discouraged in both systems. Optimizing aquaculture pond and salt pan management for shorebirds could provide a more pragmatic, cost-effective and geographically extensive solution to conserving these birds than protected areas alone.

Carlier, A., L. Chauvaud, M. van der Geest, F. Le Loc'h, M. Le Duff, M. Vernet, J. Raffray, D. Diakhate, P. Labrosse, A. Wague, C. Le Goff, F. Gohin, B. Chapron, and J. Clavier. 2015. Trophic connectivity between offshore upwelling and the inshore food web of Banc d'Arguin (Mauritania): New insights from isotopic analysis. *Estuarine, Coastal and Shelf Science* **165**:149-158.

(Abstract)

Banc d'Arguin (BA), Mauritania, is a nationally protected shallow gulf > 10,000 km^2 between the Sahara desert and the upwelling system off the Mauritanian coast. In the southeast, BA consists of a 500 km2 tidal flat, the most important wintering site for shorebirds using the East Atlantic Flyway. The Mauritanian upwelling-driven phytoplankton production supports the most productive fisheries worldwide, but little is known about its trophic role in the functioning of the inshore BA food web. Using stable isotopes as trophic tracers to distinguish between upwelling-driven phytoplankton, open ocean phytoplankton, and benthic primary producers, we assessed the spatial extent to which the inshore BA food web is fuelled by upwelling-driven phytoplankton production. The d13C and d15N signals were characterized in dominant primary producers, benthic invertebrate taxa, and various fish species along an offshore-

inshore (northwest-southeast) gradient. We also monitored the spatial and temporal extent of upwelling entering BA during 2008 with remote sensing of sea surface temperature and chlorophyll a data. The results suggest that benthic invertebrates and fishes living in the northwestern part of BA depend on the nearby upwelling phytoplankton production, but this food source does not support the intertidal benthic community in southeast BA. Furthermore, the isotopic signatures of fishes suggest weak trophic connectivity between the northern subtidal and southeastern intertidal BA. Our results support the hypothesis that the southeastern tidal flat region functions as a distinct ecosystem with a food web supported mainly by local benthic primary production, which is crucial knowledge for effective management of the pristine BA national park.

Henkel, J. R., and C. M. Taylor. 2015. Migration strategy predicts stopover ecology in shorebirds on the northern Gulf of Mexico. *Animal Migration* **2**:63–75.

(Abstract)

Twenty-eight species of migratory shorebirds rely on the coastlines of the northern Gulf of Mexico (NGOM) to fuel migrations to near-arctic breeding grounds. Shorebird species vary in their migration ecology: some species use a “jump” strategy, migrating long distances without stopping, while others use “skip” and “hop” strategies, stopping to refuel at shorter intervals along their journey. We compared stopover duration, body condition (fat scores and size-adjusted mass), and refueling rates (plasma metabolite concentrations), in three Calidrid sandpiper species (*Calidris pusilla*, *C. mauri*, and *C. alpina*) that differ in migration strategy after leaving the NGOM during spring. Results indicate that, while birds refueled at similar rates, *C. alpina*, an intermediate distance jump migrant, reached higher fuel stores before departing on migration than the hop and skip migrants, *C. pusilla* and *C. mauri*. *C. alpina* also spent more time on the NGOM than the other two species. Results suggest that NGOM habitats may be particularly important for migration success in *C. alpina*. This knowledge will help us predict the potential population level consequences of habitat loss due to global change on NGOM shorebird populations and develop conservation plans to mitigate these impacts.

McCallum, H. M., K. J. Park, M. G. O’Brien, A. Gimona, L. Poggio, and J. D. Wilson. 2015. Soil pH and organic matter content add explanatory power to Northern Lapwing *Vanellus vanellus*distribution models and suggest soil amendment as a conservation measure on upland farmland. *Ibis* **157**:677-687.

(Abstract)

Habitat associations of farmland birds are well studied, yet few have considered relationships

between species distribution and soil properties. Charadriiform waders (shorebirds) depend upon penetrable soils, rich in invertebrate prey. Many species, such as the Northern Lapwing *Vanellus vanellus*, have undergone severe declines across Europe, despite being targeted by agri-environment measures. This study assessed whether there were additive effects of soil variables (depth, pH and organic matter content) in explaining Lapwing distribution, after controlling for known habitat relationships, at 89 farmland sites across Scotland. The addition of these soil variables and their association with elevation improved model fit by 55%, in comparison with models containing only previously established habitat relationships. Lapwing density was greatest at sites at higher elevation, but only those with less peaty and less acidic soil. Lapwing distribution is being constrained between intensively managed lowland farmland with favourable soil conditions and upland sites where lower management intensity favours Lapwings but edaphic conditions limit their distribution. Trials of soil amendments such as liming are needed on higher elevation grassland sites to test whether they could contribute to conservation management for breeding Lapwings and other species of conservation concern that depend upon soil-dwelling invertebrates in grassland soils, such as Eurasian Curlew *Numenius arquata*, Common Starling *Sturnus vulgaris* and Ring Ouzel T*urdus torquatus*. Results from such trials could support improvement and targeting of agri-environment schemes and other conservation measures in upland grassland systems.

Lourenço, P. M., J. A. Alves, T. Catry, and J. P. Granadeiro. 2015. Foraging ecology of sanderlings *Calidris alba* wintering in estuarine and non-estuarine intertidal areas. *Journal of Sea Research* **104**:33–40.

(Abstract)

Outside the breeding season, most shorebirds use either estuarine or non-estuarine intertidal areas as foraging grounds. The sanderling *Calidris alba* is mostly associated with coastal sandy beaches, a habitat which is currently at risk worldwide due to increasing coastal erosion, but may also use estuarine sites as alternative foraging areas. We aimed to compare the trophic conditions for sanderlings wintering in estuarine and non-estuarine sites within and around the Tejo estuary, Portugal, where these two alternative wintering options are available within a relatively small spatial scale. To achieve this, we analysed sanderling diet, prey availability, foraging behaviour, and time and energy budgets in the different substrates available in estuarine and non-estuarine sites. In terms of biomass, the most important sanderling prey in the estuarine sites were siphons of the bivalve *Scrobicularia plana*, polychaetes, staphylinids and the gastropod *Hydrobia ulvae*. In non-estuarine sites the main prey were polychaetes, the bivalve *Donax trunculus* and chironomid larvae. Both food availability and energetic intake rates were higher on estuarine sites, and sanderlings spent a higher proportion of time foraging on nonestuarine sites. In the estuary, sanderlings foraged in muddy-sand substrate whenever it was available, achieving higher intake rates than in sandy substrates. In the non-estuarine sites they used both sandy and rocky substrates throughout the tidal cycle but had higher intakes rates in sandy substrate. Estuarine sites seem

to offer better foraging conditions for wintering sanderlings than non-estuarine sites. However, sanderlings only use muddy-sand and sandy substrates, which represent a small proportion of the intertidal area of the estuary. The extent of these substrates and the current sanderling density in the estuary suggest it is unlikely that the estuary could provide alternative wintering habitat for sanderlings if they face habitat loss and degradation in coastal sites.

Laidlaw, R. A., J. Smart, M. A. Smart, and J. A. Gill. 2015. The influence of landscape features on nest predation rates of grassland-breeding waders. *Ibis* **157**:700-712.

(Abstract)

In Europe, lowland wet grasslands have become increasingly fragmented, and populations of waders in these fragments are subject to unsustainably high levels of nest predation. Patches of taller vegetation in these landscapes can support small mammals, which are the main source of prey for many predators. Providing such patches of habitat could potentially reduce levels of nest predation if predators preferentially target small mammals. However, predator attraction to patches of taller vegetation for foraging, shelter, perching and/or nesting could also result in local increases in predation rates, as a consequence of increased predator densities or spill-over foraging into the surrounding area. Here we assess the influence of taller vegetation on wader nest predation rates, and the feasibility of managing vegetation structure to alter predator impacts. Between 2005 and 2011, the nest distribution and hatching success of Northern Lapwings *Vanellus vanellus*, which nest in the open, and Common Redshanks *Tringa totanus*, which conceal their nests in vegetation, were measured on a 487-ha area of wet grassland in eastern England that is primarily managed for breeding waders. Predation rates of Lapwing nests increased significantly with distance from patches of taller vegetation, and decreased with increasing area of taller vegetation within 1 km of the nest, whereas neither variable influenced Redshank nest predation probability. These findings suggest that the distribution and activity of nest predators in lowland wet grassland landscapes may be influenced by the presence and distribution of areas of taller vegetation. For Lapwings at least, there may therefore be scope for landscape-scale management of vegetation structure to influence levels of predation in these habitats.

Tan, L. X. L., K. L. Buchanan, G. S. Maguire, and M. A. Weston. 2015. Cover, not caging, influences chronic physiological stress in a ground-nesting bird. *Journal of Avian Biology* **46**:482-488.

(Abstract)

Predator exclosures (‘nest cages’) around nests are increasingly used to enhance hatching success of declining ground-nesting birds. However, such exclosures are contentious and

have been suggested to have detrimental effects on the species which they aim to protect. This study examines whether exclosures increase physiological stress of incubating birds, a hitherto unrecognised and untested potential drawback of exclosures. Red-capped plover *Charadrius ruficapillus* hatching success was radically altered and significantly higher for nests with exclosures (96.2%) compared with those without (6.8%). Chronic physiological stress in parents (as measured by the heterophil/lymphocyte [H/L] ratio in blood) did not vary between nests with and without exclosures, or between the sexes. However the absence of vegetative cover at the nest site was associated with a 62.7% elevation in H/L ratio, indicating that incubating birds which place their nests in the open are subject to increased levels of chronic stress. The results from this study demonstrate the fundamental importance of predation for the nesting success of this species and confirm that chronic stress levels are not a detrimental side effect of exclosure use.

McGowan, C. P. 2015. Comparing models of Red Knot population dynamics. *Condor* **117**:494-502.

(Abstract)

Predictive population modeling contributes to our basic scientific understanding of population dynamics, but can also inform management decisions by evaluating alternative actions in virtual environments. Quantitative models mathematically reflect scientific hypotheses about how a system functions. In Delaware Bay, mid-Atlantic Coast, USA, to more effectively manage horseshoe crab (*Limulus polyphemus*) harvests and protect Red Knot (*Calidris canutus rufa*) populations, models are used to compare harvest actions and predict the impacts on crab and knot populations. Management has been chiefly driven by the core hypothesis that horseshoe crab egg abundance governs the survival and reproduction of migrating Red Knots that stopover in the Bay during spring migration. However, recently, hypotheses proposing that knot dynamics are governed by cyclical lemming dynamics garnered some support in data analyses. In this paper, I present alternative models of Red Knot population dynamics to reflect alternative hypotheses. Using 2 models with different lemming population cycle lengths and 2 models with different horseshoe crab effects, I project the knot population into the future under environmental stochasticity and parametric uncertainty with each model. I then compare each model's predictions to 10 yr of population monitoring from Delaware Bay. Using Bayes' theorem and model weight updating, models can accrue weight or support for one or another hypothesis of population dynamics. With 4 models of Red Knot population dynamics and only 10 yr of data, no hypothesis clearly predicted population count data better than another. The collapsed lemming cycle model performed best, accruing ~35% of the model weight, followed closely by the horseshoe crab egg abundance model, which accrued ~30% of the weight. The models that predicted no decline or stable populations (i.e. the 4-yr lemming cycle model and the weak horseshoe crab effect model) were the most weakly supported.

Senner, N. R., M. A. Verhoeven, J. M. Abad-Gómez, J. S. Gutiérrez, J. C. E. W. Hooijmeijer, R. Kentie, J. A. Masero, T. L. Tibbitts, and T. Piersma. 2015. When Siberia came to the Netherlands: the response of continental black-tailed godwits to a rare spring weather event. *Journal of Animal Ecology* **84**:1164–1176.

(Abstract)

1. Extreme weather events have the potential to alter both short- and long-term population dynamics as well as community- and ecosystem-level function. Such events are rare and stochastic, making it difficult to fully document how organisms respond to them and predict the repercussions of similar events in the future.

2. To improve our understanding of the mechanisms by which short-term events can incur long-term consequences, we documented the behavioural responses and fitness consequences for a long-distance migratory bird, the continental black-tailed godwit *Limosa limosa limosa*, resulting from a spring snowstorm and three-week period of record low temperatures.

3. The event caused measurable responses at three spatial scales – continental, regional and local – including migratory delays (+19 days), reverse migrations (>90 km), elevated metabolic costs (+88% maintenance metabolic rate) and increased foraging rates (+37%).

4. There were few long-term fitness consequences, however, and subsequent breeding seasons instead witnessed high levels of reproductive success and little evidence of carry-over effects.

5. This suggests that populations with continued access to food, behavioural flexibility and time to dissipate the costs of the event can likely withstand the consequences of an extreme weather event. For populations constrained in one of these respects, though, extreme events may entail extreme ecological consequences.

Hughes, A. L. 2015. Coevolution of Body Form and Reproductive Effort in Shorebirds (Aves: Charadriiformes). *Evolutionary Biology* **42**:272–282.

(Abstract)

In order to test for co-evolution of reproductive life history with body form, cluster analysis applied to nine skeletal measurements was used to identify three distinctive body types within the avian order Charadriiformes: a ‘‘sandpiper’’ type, a ‘‘gull/plover’’ type, and an ‘‘auk’’ type. Both in conventional analyses and in phylogenetically independent contrasts, the sandpiper

body type was associated with increased values of a mass-adjusted measure of clutch volume and with decreased adult survival. A hypothesis that would explain the results is that increased reproductive effort characterizes charadriiform species with morphological features such as long bills and legs that render them vulnerable to predation, consistent with the hypothesis that reproductive effort represents a trade-off between current and future reproductive opportunities.

Dekker, D., and M. C. Drever. 2015. Kleptoparasitism by Bald Eagles (*Haliaeetus leucocephalus*) as a factor in reducing Peregrine Falcon (*Falco peregrinus*) predation on Dunlin (*Calidris alpina*) wintering in British Columbia. *Canadian Field Naturalist* **129**:159-164.

(Abstract)

Kleptoparasitism, or food piracy, is common in a wide range of taxa, particularly among predators, with the larger species forcing smaller species to surrender their catch. The Bald Eagle (*Haliaeetus leucocephalus*) is known to rob Peregrine Falcons (*Falco peregrinus*) of just-caught prey. We present time series of kleptoparasitic interactions between eagles and peregrines hunting Dunlin (*Calidris alpina*) that were wintering at Boundary Bay in the Fraser River valley, British Columbia. In 1108 hours of observation during January, intermittently between 1994 and 2014, we recorded 667 sightings of Peregrine Falcons, including 817 attacks on Dunlin resulting in 120 captures. The population of wintering Bald Eagles in the study area increased from about 200 in 1994 to 1800 in 2014, while the rate of kleptoparasitism at the expense of peregrines increased from 0.05 to 0.20. The increase in the number of Bald Eagles coincided with a decline in January sightings of Peregrine Falcons, which suggests that some falcons may have left the study area because of interference from eagles. The decrease in Peregrine Falcon numbers can be expected to have led to reduced predation risk for Dunlins. Christmas Bird Counts conducted in the Fraser River Valley have underscored the fluctuation in eagle and peregrine numbers reported here.

Scarton, F., and M. Montanari. 2015. Use of artificial intertidal sites by birds in a Mediterranean lagoon and their importance for wintering and migrating waders. *Journal of Coastal Conservation* **19**:321-334.

(Abstract)

Man-made habitats provide suitable nesting, resting and feeding habitats for many birds at coastal sites. Despite intensive study outside Europe, very few data are available to date on the bird communities that exploit artificial intertidal sites along the European coasts. Between July 2009 and December 2010, 32 ornithological surveys were performed at six artificial intertidal sites in the lagoon of Venice (Italy). Overall, 101 species (with 23,399 birds) were

observed, about a third of those occurring in the lagoon of Venice; 58 of these species were of conservation concern. Ten species comprised about 80 % of the total; bird abundance was the highest during the post-breeding migration and wintering period. Multivariate analysis identified similarity among sites, seasons and observed behaviours. Dredge islands were mostly used by waders as foraging sites, when surrounding tidal flats were still flooded. In winter the six dredged islands supported about 2 % of the dunlins *Calidris alpina* occurring in the whole lagoon of Venice and about 10% of the grey plovers *Pluvialis squatarola*. Since the study sites comprised just the 6%of the total dredge island area available in 2009–2010, the results indicate as large fractions of these shorebird populations might exploit the dredge island habitats for foraging. Among the newly created habitats, intertidal ponds and inner tidal flats were the most heavily used by birds, followed by dykes and mounds with ruderal vegetation. Maintenance of the habitat mosaic is a need for a conservation- based management of the dredge islands.

Rakhimberdiev, E. N., P. J. van den Hout, M. Brugge, B. Spaans, and T. Piersma. 2015. Seasonal mortality and sequential density dependence in a migratory bird. *Journal of Avian Biology* **46**:332–341.

(Abstract)

Migratory bird populations may be limited during one or more seasons, and thus at one or more places, but there is a dearth of empirical examples of this possibility. We analyse seasonal survival in a migratory shellfish-eating shorebird (red knot *Calidris canutus islandica*) during a series of years of intense food limitation on the nonbreeding grounds (due to overfishing of shellfish stocks), followed by a relaxation period when destructive harvesting had stopped and food stocks for red knots recovered. For the estimation of seasonal survival from the 15 yr-long near-continuous capture–resight dataset, we introduce a 'rolling window' approach for data exploration, followed by selection of the best season definition. The average annual apparent survival over all the years was 0.81 yr/1. During the limitation period, survival probability of adult red knots was low in winter (0.78 yr/1), but this was compensated by high survival in summer (0.91 yr/1). During the relaxation period survival rate levelled out with a winter value of 0.81 yr/1 and a summer survival of 0.82 yr/1. The fact that during the cockle-dredging period the dip in survival in winter was completely compensated by higher survival later in the annual cycle suggests sequential density dependence. We conclude that seasonal compensation in local survival (in concert with movements to areas apparently below carrying capacity) allowed the *islandica* population as a whole to cope, in 1998–2003, with the loss of half of the suitable feeding habitat in part of the nonbreeding range, the western Dutch Wadden Sea. As a more general point, we see no reason why inter-seasonal density dependence should not be ubiquitous in wildlife populations, though its limits and magnitude will depend on the specific ecological contexts. We elaborate the possibility that with time, and in stable environments, seasonal mortality evolves so that differences in mortality rates between seasons would become erased.

Lislevand, T., and S. Hahn. 2015. Skipping-type migration in a small Arctic wader, the Temminck ’s stint *Calidris temminckii*. *Journal of Avian Biology* **46**:419–424.

(Abstract)

By using morphometric data and geolocator tracking we investigated fuel loads and spatio-temporal patterns of migration and non-breeding in Temminck’s stints *Calidris temminckii*. Body masses in stints captured at autumn stopover sites from Scandinavia to northern Africa were generally not much higher than during breeding and did not vary geographically. Thus, we expected migrating stints to make several stopovers and either circumventing the Sahara desert with low fuel loads or fuelling at north African stopover sites before desert crossing. Geolocation revealed that birds (n=6) departed their Norwegian breeding site in the last part of July and all but one migrated south-west over continental western Europe. A single bird headed south-east to the Balkan Peninsula where the geolocator died. As predicted, southbound migration proceeded in a typical skipping manner with 1 – 4 relatively short stopovers (median 4 d) during 10 – 27 d of migration before reaching north-west Africa. Here birds spent 11 – 20 d before crossing the Sahara. The non-breeding sites were located at or near the Niger River in Mali and were occupied continuously for more than 215 d with no indications of itinerancy. Spring migration commenced in late April/early May when birds crossed the desert and used stopover sites in the western Mediterranean basin in a similar manner as during autumn. The lowest body masses were recorded in spring at islands in the central Mediterranean basin, indicating that crossing the Sahara and Mediterranean barriers is exhausting to these birds. Hence, the skipping-type pattern of migration revealed by geolocators is likely to be natural in this species and not an effect of instrumentation.

Gutiérrez, J. S., A. Soriano-Redondo, A. Dekinga, A. Villegas, J. A. Masero, and T. Piersma. 2015. How salinity and temperature combine to affect physiological state and performance in red knots with contrasting non-breeding environments. *Oecologia* **178**:1077–1091.

(Abstract)

Migratory shorebirds inhabit environments that may yield contrasting salinity-temperature regimes—with widely varying osmoregulatory demands, even within a given species—and the question is: by which physiological means and at which organisational level do they show adjustments with respect to these demands? Red knots *Calidris canutus* winter in coastal areas over a range of latitudes. The nominal subspecies winters in salty areas in the tropics, whereas the subspecies *Calidris canutus islandica* winters in north-temperate regions of comparatively lower salinities and temperatures. In this study, both subspecies of red knot were acclimated to different salinity (28/40 ‰)–temperature (5/35 °C) combinations for 2-week periods. We then measured food/salt intakes, basal metabolic rate (BMR), body mass and temperature, fat and salt gland scores, gizzard mass, heat-shock proteins,

heterophils/lymphocytes (H/L) ratio and plasma Na+ to assess the responses of each taxon to osmoregulatory challenges. High salinity (HS)-warm-acclimated birds reduced food/salt intake, BMR, body mass, fat score and gizzard mass, showing that salt/heat loads constrained energy acquisition rates. Higher salt gland scores in saltier treatments indicated that its size was adjusted to higher osmoregulatory demands. Elevated plasma Na+ and H/L ratio in high salinity-warm-acclimated birds indicated that salt/heat loads might have a direct effect on the water-salt balance and stress responses of red knots. Subspecies had little or no effect on most measured parameters, suggesting that most adjustments reflect phenotypic flexibility rather than subspecific adaptations. Our results demonstrate how salinity and temperature affect various phenotypic traits in a migrant shorebird, highlighting the importance of considering these factors jointly when evaluating the environmental tolerances of air-breathing marine taxa.

Aharon-Rotman, Y., M. Y. Soloviev, C. D. T. Minton, P. S. Tomkovich, C. Hassell, and M. Klaassen. 2015. Loss of periodicity in breeding success of waders links to changes in lemming cycles in Arctic ecosystems. *Oikos* **124**:861–870.

(Abstract)

Lemming population cycles in the Arctic have an important impact on the Arctic food web, indirectly also affecting breeding success in Arctic-nesting birds through shared predators. Over the last two decades lemming cycles have changed in amplitude and even disappeared in parts of the Arctic. To examine the large scale effect of these recent changes we re-analysed published data from the East Atlantic Flyway (EAF), where a relationship between lemming cycles and wader breeding success was earlier found, and new data on breeding success of waders in the East Asian–Australasian Flyway (EAAF). We found that 1) any long-term periodicities in wader breeding success existed only until the year 2000 in the EAAF and until the 1980s in the EAF; 2) studying these patterns at a smaller spatial scale, where the Siberian–Alaskan breeding grounds were divided into five geographical units largely based on landscape features, breeding success of waders from the EAAF was not correlated to an index of predation pressure, but positively correlated to Arctic summer temperatures in some species. We argue that fading out of lemming cycles in some parts of the Arctic is responsible for faltering periodicity in wader breeding success along both flyways. These changed conditions have not yet resulted in any marked changing trends in breeding success across years, and declining numbers of waders along the EAAF are therefore more likely a result of changing conditions at stop-over and wintering.

Minias, P., W. Meissner, R. Włodarczyk, A. Ozarowska, A. Piasecka, K. Kaczmarek, and T. Janiszewski. 2015. Wing shape and migration in shorebirds: a comparative

study. *Ibis* **157**:528–535.

(Abstract)

Migration is an energetically expensive and hazardous stage of the annual cycle of nonresident avian species, and requires certain morphological adaptations. Wing shape is one of the morphological traits that is expected to be evolutionarily shaped by migration. Aerodynamic theory predicts that long-distance migrants should have more pointed wings with distal primaries relatively longer than proximal primaries, an arrangement that minimizes induced drag and wing inertia, but this prediction has mostly been tested in passerine species. We applied the comparative method of phylogenetically independent contrasts to assess convergent evolution between wing shape and migration within shorebirds. We confirmed the assumption that long-distance migrants have less rounded wings than species migrating shorter distances. Furthermore, wing roundedness negatively correlates with fat load and mean distance of migratory flights, the basic components of migration strategies. After controlling for interspecific differences in body size, we found no support for a link between wing length and migration, indicating that wing shape is a more important predictor of shorebird migratory behaviour than wing length. The results suggest that total migration distance and migratory strategy may simultaneously act on the evolution of wing shape in shorebirds, and possibly in other avian species.

Johnson, O. W., R. R. Porter, L. Fielding, M. F. Weber, R. S. Gold, R. H. Goodwill, P. M. Johnson, A. E. Bruner, P. A. Brusseau, N. H. Brusseau, K. Hurwitz, and J. W. Fox. 2015. Tracking Pacific Golden-Plovers *Pluvialis fulva*: transoceanic migrations between non-breeding grounds in Kwajalein, Japan and Hawaii and breeding grounds in Alaska and Chukotka. *Wader Study* **122**:13–20.

(Abstract)

To learn more about transoceanic migrations of Pacific Golden-Plovers *Pluvialis fulva*, we tracked geolocator-equipped birds from non-breeding grounds at Kwajalein, Marshall Islands, and Hilo, Hawaiian Islands, and breeding grounds at Nome, Alaska. The annual travels of these plovers followed two pathways: 1) the Hilo birds made direct flights between Hawaii and Alaska in both spring and fall, and 2) the Kwajalein and Nome birds, with their non-breeding grounds in Oceania (far south of Hawaii's latitude), traversed a much longer circular route to and from Alaska. This route included lengthy spring stopovers in Japan and return flights through the mid-Pacific in fall. The plovers on these two pathways did not disperse evenly across the nesting range in Alaska. Rather, birds traveling the direct route from Hawaii arrived earlier and nested farther south than birds arriving via the circular route from islands beyond Hawaii. Latitudinal separation between the two groups appears to occur at approximately 61°N on the Yukon-Kuskokwim Delta. Three of nine Kwajalein birds migrated to nesting grounds in Chukotka, thus confirming connectivity between the two regions. All of the transoceanic flights in this study were nonstop and typically wind-assisted at an average minimum migration speed of 49 kph over periods ranging from three to eight days. The stopovers recorded in Japan

(average 23 days) likely indicate vital refueling for birds traveling northward from the Central and South Pacific. Most stopovers were on Honshu Island, and studies are needed there to better understand this component of the migratory cycle.

Lourenço, P. M., and T. Piersma. 2015. Migration distance and breeding latitude correlate with the scheduling of pre-alternate body moult: a comparison among migratory waders. *Journal of Ornithology* **156**:657–665.

(Abstract)

Moult is an important maintenance activity that should be carefully timed within the annual cycle. Many birds perform a pre-alternate moult of body feathers some time prior to the breeding season. In migrants, the timing of the pre-alternate moult coincides with the migration from wintering to breeding areas. In this study, we used visual plumage scores collected on the Continental Black-tailed Godwit *Limosa limosa limosa* in Portugal and The Netherlands to establish that the pre-alternate body moult of these birds during the northward migration between West Africa and The Netherlands takes place only in staging areas in the Iberian peninsula from late January to late February. A comparison of the moult strategy of these godwits with that of 20 other migratory wader populations (13 species) revealed that the former had a rather uncommon moult schedule which was more characteristic of populations with rather short migrations that breed at lower latitudes. We argue that this unusual moult schedule can be explained by a combination of ecological opportunity and proximate and ultimate trade-offs (hormonal incompatibly and maximization of plumage quality vs. time spent on migration, respectively).

Kentie, R., C. Both, J. C. E. W. Hooijmeijer, and T. Piersma. 2015. Management of modern agricultural landscapes increases nest predation rates in Black-tailed Godwits *Limosa limosa*. *Ibis* **157**:614–625.

(Abstract)

Effective conservation of endangered species requires a solid understanding of the demographic causes of population change. Bird populations breeding on agricultural grasslands have declined because their preferred habitat of herb-rich meadows has been replaced by grassland monocultures. The timing of agricultural activities in these monocultural grasslands is critical, as they often coincide with the nesting phase of breeding birds. Here, we aim to identify the effect of habitat management and targeted nest protection on nest survival of Black-tailed Godwits *Limosa limosa* in the Netherlands, a population that has shown a 70% reduction in breeding population size since the 1970s. To protect nests in monocultures from destruction, farmers are paid to either delay mowing or to leave a patch of

unmown grass around the nest, a patch which in practice varied in size. In herb-rich meadows, which are typically managed for bird conservation purposes, mowing occurs after hatching. Nest survival declined as the season advanced, more steeply on monocultures than on meadows. Targeted nest protection was only partially successful, as nest predation was considerably higher on mown grassland monocultures with small unmown patches around the nest than in mown monocultures with large unmown patches and in unmown fields. Increased predator densities over the years have been suggested as an important cause of the trend towards lower nest survival, but here we show that nest survival was higher on herb-rich meadows than on monocultures, and similar to the 1980s. It thus seems that increased predator densities are an increased threat during the egg stage only if habitat quality is low. High quality habitat in the form of herb-rich meadows therefore provides a degree of protection against predators.

Senner, N. R., M. A. Verhoeven, J. C. E. W. Hooijmeijer, and T. Piersma. 2015. Just when you thought you knew it all: new evidence for flexible breeding patterns in Continental Black-tailed Godwits. *Wader Study* **122**:21–27.

(Abstract)

Global climate change is rapidly altering the phenology and behaviour of species, leading to the occurrence of new and extreme trait values, especially among long-distance migratory birds. While infrequently published, the documentation and regular revision of the known spectrum of these trait values can be valuable for identifying the selective pressures acting on a population and influencing best management and conservation practices. Here we argue that the previously documented spectrum of reproductive behaviours in the rapidly declining Continental Black-tailed Godwit *Limosa limosa limosa* is in need of revision. Our data show that new extreme values for a number of reproductive traits occurred during the 2014 breeding season and that by almost every metric, 2014 had the longest laying period on record for the population. These findings suggest that godwit reproductive biology may be more flexible than previously thought and that this flexibility should be reflected by changes in European meadowbird policies.

Lindström, Å., M. Green, M. Husby, J. A. Kålås, and A. Lehikoinen. 2015. Large-scale monitoring of waders on their boreal and arctic breeding grounds in northern Europe. *Ardea* **103**:3-15.

(Abstract)

Large-scale and population-wide monitoring of waders on their boreal and arctic breeding grounds has hitherto been lacking, mainly because logistics are truly challenging in regions

with few ornithologists, vast areas and few roads. In Norway, Sweden and Finland (here 'Fennoscandia') there are now national monitoring schemes in place, aimed at tracking all bird species, which allows trends to be estimated for northern wader populations. We present joint Fennoscandian population trends for 24 wader species, covering the period 2002–2013 (in some cases somewhat shorter time periods). The data stem from 1263 routes in Norway, Finland, and the northern two thirds of Sweden, all situated north of 58°N. This area of one million km2 largely coincides with the boreal and arctic parts of Fennoscandia. The trends found are rather evenly distributed between strong increases and strong declines. Trends do not differ between short- and long-distance migrants, nor do they vary in relation to breeding latitude. Ringed Plover *Charadrius hiaticula*, Wood Sandpiper *Tringa glareola*, Green Sandpiper *T. ochropus* and Common Redshank *T. totanus* had significant positive trends, whereas Common Snipe *Gallinago gallinago*, Ruff *Philomachus pugnax* and Spotted Redshank *Tringa erythropus* were declining significantly in numbers. Trends could be calculated even for relatively uncommon breeding birds such as Temminck's Stint*Calidris temminckii*, Eurasian Dotterel *Charadrius morinellus*, Broad-billed Sandpiper*Limicola falcinellus*, Jack Snipe *Lymnocryptes minimus* and Red-necked Phalarope *Phalaropus lobatus*, although these trends build on few routes and individuals, and thus have low precision. The monitoring schemes in Norway and Finland are expected to increase in coverage in the coming years, with up to a total of 1555 northern routes being tracked when the schemes are fully developed. This should enable still more robust trend estimates for northern waders on their Fennoscandian breeding grounds to be calculated in the future.

Jukema, J., J. G. van Rhijn, and T. Piersma. 2015. Geographic variation in morphometrics, molt, and migration suggests ongoing subspeciation in Pacific Golden-Plovers (*Pluvialis fulva*). *The Auk* **132**:647-656.

(Abstract)

Breeding Pacific Golden-Plovers (*Pluvialis fulva*) cover 140 longitudinal degrees of Arctic tundra. Having examined 557 museum skins from across this huge distributional range, we conclude that Pacific Golden-Plovers breeding in Alaska are structurally larger than those breeding in Siberia, especially in wing length. Birds from Alaska also have more pointed wings and almost always postpone the initiation of primary molt until they reach their winter quarters, whereas many Siberian birds start primary molt in the breeding areas. These differences could have been favored by the longer transoceanic flights followed by the Alaskan populations to nonbreeding destinations in the Pacific Islands. We propose that the Alaskan and Siberian breeding birds be distinguished as distinct flyway populations to be used in conservation assessments by the international conservation community.

Simmons, R. E., H. Kolberg, R. Braby, and B. Erni. 2015. Declines in migrant shorebird populations from a winter-quarter perspective. *Conservation Biology* **29**:877–887.

(Abstract)

Many long-distance migrating shorebird (i.e., sandpipers, plovers, flamingos, oystercatchers) populations are declining. Although regular shorebird monitoring programs exist worldwide, most estimates of shorebird population trends and sizes are poor or nonexistent. We built a state-space model to estimate shorebird population trends. Compared with more commonly used methods of trend estimation, state-space models are more mechanistic, allow for the separation of observation and state process, and can easily accommodate multivariate time series and nonlinear trends. We fitted the model to count data collected from 1990 to 2013 on 18 common shorebirds at the 2 largest coastal wetlands in southern Africa, Sandwich Harbour (a relatively pristine bay) and Walvis Bay (an international harbor), Namibia. Four of the 12 long-distance migrant species declined since 1990: Ruddy Turnstone (*Arenaria interpres*), Little Stint (*Calidris minuta*), Common Ringed Plover (*Charadrius hiaticula*), and Red Knot (*Calidris canutus*). Populations of resident species and short-distance migrants increased or were stable. Similar patterns at a key South African wetland suggest that shorebird populations migrating to southern Africa are declining in line with the global decline, but local conditions in southern Africa's largest wetlands are not contributing to these declines. State-space models provide estimates of population levels and trends and could be used widely to improve the current state of water bird estimates.

Jardine, C. B., A. L. Bond, P. J. A. Davidson, R. W. Butler, and T. Kuwae. 2015. Biofilm Consumption and Variable Diet Composition of Western Sandpipers (*Calidris mauri*) during Migratory Stopover. *PLoS ONE* **10**:e0124164.

(Abstract)

Many shorebird species undertake long-distance migrations punctuated by brief stays at food-rich, estuarine stopover locations. Understanding use of these food resources helps guide conservation and responsible development decisions. We determined the extent and degree to which Western Sandpiper (*Calidris mauri*) utilized biofilm as a food resource across a large and variable stopover location during northward (spring) migration. We investigated the spatial heterogeneity in diet composition, to determine whether shorebirds were consistently feeding on biofilm or whether diet varied between naturally and anthropogenically delineated sites. We used stable isotope analysis to estimate that biofilm conservatively comprised 22% to 53% of Western Sandpiper droppings across all sampling sites and that prey composition differed significantly between areas within the stopover location. Widespread biofilm consumption demonstrates the importance of biofilm as a dietary component. Variable diet composition suggests that habitat heterogeneity may be an important component of high quality stopover locations in the context of "state-dependant trade-offs" of Western Sandpiper population sub-groups. Future management decisions must consider and address potential impacts on the biofilm community throughout a stopover location, as single site studies of diet composition

may not be adequate to develop effective management strategies for entire stopover sites.

Miller, M. P., S. M. Haig, T. D. Mullins, L. Ruan, B. Casler, A. Dondua, H. R. Gates, J. M. Johnson, S. Kendall, P. S. Tomkovich, D. M. Tracy, O. P. Valchuk, and R. B. Lanctot. 2015. Intercontinental genetic structure and gene flow in Dunlin (*Calidris alpina*), a potential vector of avian influenza. *Evolutionary Applications* **8**:149–171.

(Abstract)

Waterfowl (Anseriformes) and shorebirds (Charadriiformes) are the most common wild vectors of influenza A viruses. Due to their migratory behavior, some may transmit disease over long distances. Migratory connectivity studies can link breeding and nonbreeding grounds while illustrating potential interactions among populations that may spread diseases. We investigated Dunlin (*Calidris alpina*), a shorebird with a subspecies (*C. a. arcticola*) that migrates from nonbreeding areas endemic to avian influenza in eastern Asia to breeding grounds in northern Alaska. Using microsatellites and mitochondrial DNA, we illustrate genetic structure among six subspecies: *C. a. arcticola*, *C. a. pacifica*, *C. a. hudsonia*, *C. a. sakhalina*, *C. a. kistchinski*, and *C. a. actites*. We demonstrate that mitochondrial DNA can help distinguish *C. a. arcticola* on the Asian nonbreeding grounds with >70% accuracy depending on their relative abundance, indicating that genetics can help determine whether *C. a. arcticola* occurs where they may be exposed to highly pathogenic avian influenza (HPAI) during outbreaks. Our data reveal asymmetric intercontinental gene flow, with some *C. a. arcticola* short-stopping migration to breed with *C. a. pacifica* in western Alaska. Because *C. a. pacifica* migrates along the Pacific Coast of North America, interactions between these subspecies and other taxa provide route for transmission of HPAI into other parts of North America.

Green, L., D. T. Blumstein, and P. Fong. 2015. Macroalgal Mats in a Eutrophic Estuary Obscure Visual Foraging Cues and Increase Variability in Prey Availability for Some Shorebirds. *Estuaries and Coasts* **38**:917–926.

(Abstract)

Conservation of habitat for flagship species, such as birds, aids in the protection of biodiversity in critical ecosystems. Extensive mats of macroalgae stimulated by nutrient input to estuaries threaten critical successes in conservation made by legislation that reduces habitat destruction. Macroalgae can cover intertidal mudflats that are key foraging grounds for obligate visual foragers such as black-bellied plovers (*Pluvialis squatarola*), as well as foragers that routinely switch from visual to tactile foraging such as least sandpipers (*Calidris minutilla*), western sandpipers (*Calidris mauri*), and willets (*Tringa semipalmata*), and predominately

tactile foragers such as marbled godwits (*Limosa fedoa*). We hypothesized that macroalgae would affect shorebirds directly by altering foraging behavior and indirectly by reducing prey availability. Mats reduced visual foraging (pecking) for sandpipers and marbled godwits and caused them to probe more often. Willets spent overall less time foraging than sandpipers and marbled godwits and did not alter their foraging strategy due to macroalgae. While foraging, black-bellied plovers, marbled godwits, and willets avoided macroalgae while sandpipers did not select between habitat types. This suggests macroalgae may have negative effects on plovers, marbled godwits, and willets by reducing foraging area but that sandpipers may utilize both macroalgae and bare sediments. Macroalgal mats indirectly influenced shorebirds by enhancing variability in prey availability across the mudflat landscape. By quantifying avoidance of or preference for mats, foraging behavior, and variation in prey availability, we showed that macroalgae have differential effects across shorebird foraging guilds.

Barbaree, B. A., M. E. Reiter, C. M. Hickey, and G. W. Page. 2015. Day and Night Habitat Associations of Wintering Dunlin (*Calidris alpina*) within an Agriculture-Wetland Mosaic. *Waterbirds* **38**:40-46.

(Abstract)

Darkness comprises more than half of each 24-hr cycle during winter in California's Sacramento Valley, but no studies have assessed nocturnal habitat use by wintering shorebirds at this inland site. From February to May 2013, the day and night habitat associations of radio-tagged Dunlin (*Calidris alpina*) were compared between post-harvest flooded rice fields and managed freshwater wetlands in the Sacramento Valley. Dunlin had decreasing associations with rice during both day and night from February to April. Dunlin exclusively used rice at night until 25 March, when they shifted to wetlands. During the day, Dunlin were regularly associated with both rice and wetlands until 4 March, and they exclusively used wetlands beginning 25 March. Diel movements by individual Dunlin revealed that birds using rice during the day also used rice during the subsequent night. Our findings suggest that flooded rice, when available, may be more suitable as nocturnal habitat than managed wetlands, and the removal of water from rice fields in February and March causes Dunlin to either use wetlands exclusively or leave the area. Conservation of Dunlin, and likely other migratory shorebirds, may be enhanced by managing the agriculture-wetland mosaic in the Sacramento Valley to ensure that an adequate amount of shallow-water habitats remain during March and April, prior to spring migration.

Bowgen, K. M., R. A. Stillman, and R. J. H. Herbert. 2015. Predicting the effect of invertebrate regime shifts on wading birds: Insights from Poole Harbour, UK. *Biological Conservation* **186**:60–68.

(Abstract)

Regime shifts in benthic invertebrates within coastal ecosystems threaten the survival of wading birds (Charadrii). Predicting how invertebrate regime shifts will affect wading birds allows conservation management and mitigation measures to be implemented, including protection of terrestrial feeding areas. An individual-based model was used to investigate the impact of regime shifts on wading birds through their prey (marine worms and bivalves) in the estuarine system Poole Harbour, (UK). The model predicted the number of curlew (*Numenius arquata*), oystercatcher (*Haematopus ostralegus*), black-tailed godwit (*Limosa limosa*), redshank (*Tringa totanus*) and dunlin (*Calidris alpina*) supported in the Harbour during the non-breeding season (autumn and winter months). The most dramatic declines in bird numbers were for regime shifts that reduced the abundance of the largest invertebrates, particularly marine worms. The least adaptable bird species (those with the most restrictive diets) were unable to compensate by consuming other prey. Generally, as birds adapt to changes by switching to alternative prey species and size classes, changes in invertebrate size and species distribution do not necessarily affect the number of birds that the Harbour can support. Our predictions reveal a weakness in using birds as indicators of site health and invertebrate regime shifts. Differences in bird populations would not necessarily be detected by standard survey methods until extreme changes in invertebrate communities had occurred, potentially beyond the point at which these changes could be reversed. Therefore, population size of wading birds should not be used in isolation when assessing the conservation status of coastal sites.

Duijns, S., I. E. Knot, T. Piersma, and J. A. van Gils. 2015. Field measurements give biased estimates of functional response parameters, but help explain foraging distributions. *Journal of Animal Ecology* **84**:565–575.

(Abstract)

1. Mechanistic insights and predictive understanding of the spatial distributions of foragers are typically derived by fitting either field measurements on intake rates and food abundance, or observations from controlled experiments, to functional response models. It has remained unclear, however, whether and why one approach should be favoured above the other, as direct comparative studies are rare.

2. The field measurements required to parameterize either single or multi-species functional response models are relatively easy to obtain, except at sites with low food densities and at places with high food densities, as the former will be avoided and the second will be rare. Also, in foragers facing a digestive bottleneck, intake rates (calculated over total time) will be constant over a wide range of food densities. In addition, interference effects may depress intake rates further. All of this hinders the appropriate estimation of parameters such as the ‘instantaneous area of discovery’ and the handling time, using a type II functional response model also known as ‘Holling’s disc equation’.

3. Here we compare field- and controlled experimental measurements of intake rate as a function of food abundance in female bar-tailed godwits *Limosa lapponica* feeding on lugworms *Arenicola marina*.

4. We show that a fit of the type II functional response model to field measurements predicts lower intake rates (about 2.5 times), longer handling times (about 4 times) and lower 'instantaneous areas of discovery' (about 30–70 times), compared with measurements from controlled experimental conditions.

5. In agreement with the assumptions of Holling's disc equation, under controlled experimental settings both the instantaneous area of discovery and the handling time remained constant with an increase in food density. The field data, however, would lead us to conclude that although handling time remains constant, the instantaneous area of discovery decreased with increasing prey densities. This will result into highly underestimated sensory capacities when using field data.

6. Our results demonstrate that the elucidation of the fundamental mechanisms behind prey detection and prey processing capacities of a species necessitates measurements of functional response functions under the whole range of prey densities on solitary feeding individuals, which is only possible under controlled conditions. Field measurements yield 'consistency tests' of the distributional patterns in a specific ecological context.

van Gils, J. A., M. van der Geest, B. De Meulenaer, H. Gillis, T. Piersma, and E. O. Folmer. 2015. Moving on with foraging theory: incorporating movement decisions into the functional response of a gregarious shorebird. *Journal of Animal Ecology* **84**:554–564.

(Abstract)

1. Models relating intake rate to food abundance and competitor density (generalized functional response models) can predict forager distributions and movements between patches, but we lack understanding of how distributions and small-scale movements by the foragers themselves affect intake rates.

2. Using a state-of-the-art approach based on continuous-time Markov chain dynamics, we add realism to classic functional response models by acknowledging that the chances to encounter food and competitors are influenced by movement decisions, and, vice versa, that movement decisions are influenced by these encounters.

3. We used a multi-state modelling framework to construct a stochastic functional response model in which foragers alternate between three behavioural states: searching, handling and moving.

4. Using behavioural observations on a molluscivore migrant shorebird (red knot, *Calidris canutus canutus*), at its main wintering area (Banc d'Arguin, Mauritania), we estimated transition rates between foraging states as a function of conspecific densities and densities of the two main bivalve prey.

5. Intake rate decreased with conspecific density. This interference effect was not due to decreased searching efficiency, but resulted from time lost to avoidance movements.

6. Red knots showed a strong functional response to one prey (*Dosinia isocardia*), but a weak response to the other prey (*Loripes lucinalis*). This corroborates predictions from a recently developed optimal diet model that accounts for the mildly toxic effects due to consuming *Loripes*.

7. Using model averaging across the most plausible multi-state models, the fully parameterized functional response model was then used to predict intake rate for an independent data set on habitat choice by red knot.

8. Comparison of the sites selected by red knots with random sampling sites showed that the birds fed at sites with higher than average *Loripes* and *Dosinia* densities, that is sites for which we predicted higher than average intake rates.

9. We discuss the limitations of Holling's classic functional response model which ignores movement and the limitations of contemporary movement ecological theory that ignores consumer–resource interactions. With the rapid advancement of technologies to track movements of individual foragers at fine spatial scales, the time is ripe to integrate descriptive tracking studies with stochastic movement-based functional response models.

Rolet, C., N. Spilmont, D. Davoult, E. Goberville, and C. Luczak. 2015. Anthropogenic impact on macrobenthic communities and consequences for shorebirds in Northern France: A complex response. *Biological Conservation* **184**:396–404.

(Abstract)

Shorebird populations are declining worldwide due to the combined effect of climate change and anthropogenic forcing, the ongoing coastal urbanisation amplifying the alteration of their habitat in both rate and magnitude. By focusing on a highly anthropogenically-influenced region in Northern France, we studied the impact of a seawall construction on wintering shorebird populations through potential alterations in the abundance and availability of their food resources. We concurrently investigated changes in the spatial distribution of muddy-sand beach macrobenthic communities between two periods of contrasting anthropogenic impacts and examined year-to-year trends of wintering shorebirds. Our study reveals that the seawall construction led to a major spatial reorganisation of the macrobenthic communities with a drastic reduction of the muddy-sand community. However, no relation between macrobenthic changes and shorebird abundances was detected. Fluctuations in shorebird abundances appeared to be congruent with flyway population trends. This result suggests that the response of shorebirds to human-induced perturbations is much more complex than expected. While an assessment of potential disturbances induced by coastal engineering constructions is needed, the pathways by which alterations could propagate through an ecosystem are not linear and as such difficult to determine. Ecosystems appear as complex adaptive systems in which macroscopic dynamics emerge from non-linear interactions at

entangled smaller/larger scales. Our results confirm that an in-depth knowledge of the local, regional and global factors that influence trends of shorebirds and their habitat use is essential for accurate and effective management and conservation strategies.

Sturbois, A., A. Ponsero, N. Desroy, P. Le Mao, and J. Fournier. 2015. Exploitation of intertidal feeding resources by the red knot Calidris canutus under megatidal conditions (Bay of Saint-Brieuc, France). *Journal of Sea Research* **96**:23–30.

(Abstract)

The feeding ecology of the red knot has been widely studied across its wintering range. Red knots mainly select bivalves and gastropods, with differences between sites due to variation in prey availability. The shorebird's diet is also influenced or controlled by the tidal regime. The aim of this paper is to demonstrate the adaptation of foraging red knots to the megatidal environment. The variation in their diet during tidal cycles was studied in the bay of Saint-Brieuc, a functional unit for this species. The method used combined macrofauna, distribution of foraging birds and diet data. Comparative spatial analyses of macrofauna and distribution of foraging red knots have shown that the bay's four benthic assemblages are exploited by birds. By analysing droppings, we highlighted that bivalve molluscs are the main component of their diet, as shown in most overwintering sites. Fifteen types of prey were identified and *Donax vittatus* was discovered to be a significant prey item. The relative proportion of each main prey item differs significantly depending on the benthic assemblage used to forage. All available benthic assemblages and all potential feeding resources can be used during a single tidal cycle, reflecting an adaptation to megatidal conditions. This approach develops accurate knowledge about the feeding ecology of birds which managers need in order to identify optimal areas for the conservation of waders based on the areas and resources actually used by the birds.

Que, P., Y. Chang, L. Eberhart-Phillips, Y. Liu, T. Székely, and Z. Zhang. 2015. Low nest survival of a breeding shorebird in Bohai Bay, China. *Journal of Ornithology* **156**:297–307.

(Abstract)

Nest survival plays an important role in avian demography because of its influence on both individual fitness and population growth. It is also known to vary within species due to local factors such as climate, predation, substrate, and disturbance, among others. Therefore, an understanding of the relative influence of local factors on nest survival is of critical importance for the formulation of appropriate avian conservation and management policies/programs. Over the past 50 years the Yellow Sea has lost almost 65 % of its original intertidal habitats due to land reclamation and development. There has also been a concomitant and rapid

decline in the populations of Kentish plover (*Charadrius alexandrinus*) in East Asia, but the proximate causes of this decline are poorly understood. To gain a better understanding of this conservation issue, we investigated Kentish plover nest survival in Bohai Bay, China, using Program MARK to model the daily survival rate (DSR) of 417 nests. We found that in terms of nest survival, that for the Kentish plover populations in Bohai Bay [0.925 ± 0.004 (±95 % confidence interval)] is the lowest reported worldwide for this species. The most common cause of nest failure was related to anthropogenic disturbance. We determined that nests occupying salt crystallization habitat had the highest hatching success and that initiation date, nest age, and nest density had quadratic effects on DSR. If low nest survival persists for consecutive years, fecundity will unlikely compensate for adult mortality, resulting in dramatic population declines of plovers in Bohai Bay. We therefore recommend that the Local Authority managers responsible for local environmental management act accordingly to create protected alternative nesting habitat for plovers in this region.

Peng, H., N. Hua, C.-Y. Choi, D. S. Melville, Y. Gao, Q. Zhou, Y. Chen, W. Xue, Q. Ma, W. Wu, C. Tang, and Z. Ma. 2015. Adjusting migration schedules at stopping sites: time strategy of a long-distance migratory shorebird during northward migration. *Journal of Ornithology* **156**:191–199.

(Abstract)

Selection of timing to match optimal environments is crucial for migrants that breed at high latitudes where there is a narrow time window suitable for breeding. However, birds generally depart from non-breeding grounds in a broad time window. How birds adjust their migration schedule to match optimal timing of arrival at breeding grounds is largely unexplored. We radio-tracked Great Knots *Calidris tenuirostris* at stopping sites in the southern and northern Yellow Sea during the entire stopping periods to determine their time schedules during northward migration. Great Knots stayed for 40.7 ± 9.2 days (n = 11) in the whole Yellow Sea, with the early arrivals having a longer length of stay than the late arrivals. There was no significant difference in the length of stay between birds that arrived on various dates in the southern Yellow Sea, while the late arrivals spent less time during flights from the southern to the northern Yellow Sea, and stayed for a shorter time than the early arrivals in the northern Yellow Sea. We estimated that the later arrivals can still moult into full breeding plumage and deposit enough fuel for a flight to the breeding grounds before departure. We propose that early and latter migration are the two ends of migratory schedule, with the former adapting to unpredictable and rigorous environments and the latter to stable and favourable environments en route. Stopping sites play an important role for birds to adjust their migration schedule to meet optimal timing of arrival at migratory destination.

Choi, C.-Y., P. F. Battley, M. A. Potter, K. G. Rogers, and Z. Ma. 2015. The importance of Yalu Jiang coastal wetland in the north Yellow Sea to Bar-tailed Godwits Limosa lapponica and Great Knots Calidris tenuirostris during northward migration. *Bird Conservation International* **25**:53-70.

(Abstract)

Bar-tailed Godwits *Limosa lapponica* and Great Knots *Calidris tenuirostris* are long-distance migratory shorebirds with declining numbers in the East Asian-Australasian Flyway. One of the most important staging sites for these two species during northward migration is Yalu Jiang coastal wetland in the north Yellow Sea. Historical counts have been limited to once a year and conducted at different periods; these yield inadequate data for population monitoring. We estimated the numbers of Bar-tailed Godwits and Great Knots and described their migration phenology during northward migration from 2010 to 2012 at the Yalu Jiang coastal wetland, using a combination of periodic area-wide counts over the migration period and a modelling approach that estimates passage times and total numbers of birds transiting. The mean arrival date for *L. l. baueri* godwits was 29 March and mean departure date was 8 May. Corresponding dates were 11 April and 15 May for *L. l. menzbieri* godwits and 7 April and 14 May for Great Knots. We estimated that an annual average of over 68,000 Bar-tailed Godwits and 44,000 Great Knots used the area on northward migration from 2010–2012. Our results indicate that the Yalu Jiang coastal wetland supports on average at least 42% of the flyway's northward-migrating *L. l. baueri* godwits, 19% of *L. l. menzbieri* godwits, and 22% of the Great Knots. Comparisons with historical counts conducted during peak migration periods indicate a 13% decline in Bar-tailed Godwits since 2004 and an 18% decline in Great Knots since 1999. Our results confirm that the study area remains the most important northward migration staging site for Bar-tailed Godwits and indicate that it has become the most important northward migration staging site for Great Knots along the flyway.

Meissner, W. 2015. Immature dunlins *Calidris alpina* migrate towards wintering grounds later than adults in years of low breeding success. *Journal of Ornithology* **156**:47–53.

(Abstract)

Dunlin (*Calidris alpina*) females migrate ahead of males towards their wintering grounds, but the factors influencing the timing of this migration is incompletely understood. In our long-term (1991–2000) study of the autumn migration phenology of male and female dunlins, as adult and immature birds separately, we noted that the difference in mean migration dates between sexes was the greatest in years of high breeding success, reaching 5 days in immature birds and 7 days in adult birds. In other, relatively less successful years, this difference could reach 2 days in immature birds and 3 days in adult birds. As Dunlin females are not fully involved in parental care, the timing of their migration appears to be determined mainly by the timing of the start of the breeding season. In males, the timing of the autumn migration appears to depend primarily on the time spent on breeding and parental care. Hence, in years of high breeding success, with a high number of offspring, the males stayed longer at the breeding

grounds. In the years with a high and moderate production of offspring, immature birds departed ahead of adults, probably due to their very low breeding success. A novel finding of our study is that in the years of overall low breeding success the opposite was true: immature birds migrated later than adults and much later than in other years. The plausible explanation is that lack of experience may result in greater tendency of immature birds to renest after failure of the first clutch, especially when high breeding failures of earlier arriving adult Dunlins may lead to decreasing competition at the breeding ground. However, in years of low breeding success, there was no difference in mean migration date between immature males and females, indicating that although immature birds stayed longer at the breeding grounds, they had a very low breeding success.

Jiménez, A., R. W. Elner, C. Favaro, K. Rickards, and R. C. Ydenberg. 2015. Intertidal biofilm distribution underpins differential tide-following behavior of two sandpiper species (*Calidris mauri* and *Calidris alpina*) during northward migration. Estuarine, *Coastal and Shelf Science***155**:8-16.

(Abstract)

The discovery that some shorebird species graze heavily on biofilm adds importance to elucidating coastal processes controlling biofilm, as well as impetus to better understand patterns of shorebird use of intertidal flats. Western sandpipers (*Calidris mauri*) and dunlin (*Calidris alpina*) stopover in the hundreds of thousands on the Fraser River estuary, British Columbia, Canada, during northward migration to breeding areas. Western sandpipers show greater modification of tongue and bill morphology for biofilm feeding than dunlin, and their diet includes more biofilm. Therefore, we hypothesized that these congeners differentially use the intertidal area. A tide following index (TFI) was used to describe their distributions in the upper intertidal during ebbing tides. Also, we assessed sediment grain size, biofilm (=microphytobenthic or MPB) biomass and invertebrate abundance. Foraging dunlin closely followed the ebbing tide line, exploiting the upper intertidal only as the tide retreated through this area. In contrast, western sandpipers were less prone to follow the tide, and spent more time in the upper intertidal. Microphytobenthic biomass and sediment water content were highest in the upper intertidal, indicating greater biofilm availability for shorebirds in the first 350 m from shore. Invertebrate density did not differ between sections of the upper intertidal. Overall, western sandpiper behaviour and distribution more closely matched MPB biofilm availability than invertebrate availability. Conservation of sandpipers should consider physical processes, such as tides and currents, which maintain the availability of biofilm, a critical food source during global migration.

Drouet, S., V. Turpin, L. Godet, B. Cognie, R. P. Cosson, and P. Decottignies. 2015. Utilisation

of intertidal mudflats by the Dunlin *Calidris alpina* in relation to microphytobenthic biofilms. *Journal of Ornithology* **156**:75–83.

(Abstract)

The small-scale spatial distribution of Dunlin *Calidris alpina* staging and wintering in Bourgneuf Bay (France) was investigated on two different mudflats colonized by either epipsammic- or epipelic-dominated microphytobenthos assemblages. Shorebird counts were conducted monthly at ebb tide from October 2011 to May 2012 and from November 2012 to May 2013. Multiple linear regressions followed by hierarchical partitioning of variance showed that microphytobenthos biomass was not a significant factor to explain Dunlin densities. However, on epipelic-dominated mudflats, Dunlins did not show their typical ‘‘tide follower’’ behaviour and instead significantly selected the highest microphytobenthos biomass zones. The biomass of a gastropod predator of an important local Dunlin prey, *Retusa obtusa*, was negatively correlated with Dunlin densities. This paper provides new suggestions in the ways that biofilms on mudflats affect small shorebird foraging.

Dietz, M. W., K. G. Rogers, J. S. Gutiérrez, and T. Piersma. 2015. Body mass and latitude both correlate with primary moult duration in shorebirds. *Ibis* **157**:147–153.

(Abstract)

We investigated the effects of body mass and latitude on primary moult duration from published data of migrating shorebirds that moult exclusively on the wintering grounds. Non-phylogenetic and phylogenetic models demonstrated that body mass and latitude correlate with moult duration in a non-additive way: the models predict different latitudinal relationships for smaller and larger shorebirds, and in the northern hemisphere, primary moult duration increased allometrically with body mass (exponent = 0.17), whereas in the southern hemisphere, primary moult duration was not correlated with body mass. If birds optimize feather quality and if slower moult yields sturdier feathers, the fast primary moult of northerly wintering shorebirds indicates additional selection pressures at work.

Riegen, A. C., G. Vaughan, and K. G. Rogers. 2014. Yalu Jiang Estuary Shorebird Survey Report 1999 – 2010., Yalu Jiang Estuary Wetland National Nature Reserve, China and Miranda Naturalists’ Trust, New Zealand.

(Abstract)

The Yalu Jiang Estuary Wetland National Nature Reserve (the Reserve) in NE China, adjacent to North Korea (DPRK) covers a total area of 101,000 hectares of intertidal mudflats, coastal aquaculture ponds, rice paddies, reedbeds and part of the shallow seabed, along 60km of

coastline westwards from the Yalu River. In 1999 it was discovered that the reserve and the adjacent areas are a major shorebird staging region on the East Asian-Australasian Flyway (EAAF). In 2002 the reserve was identified as one of nine mega sites, sites used by more than 100,000 shorebirds, in the Yellow Sea during migration. The Miranda Naturalists' Trust signed a partnership agreement with the reserve in 2004 and since then joint surveys with reserve staff have shown Yalu Jiang Estuary to be the most important staging site on the EAAF for migratory shorebirds with at least 250,000 passing through the area during northward migration (March–May). This report outlines the results of nine surveys that occurred between 1999 and 2010. A total of 41 shorebird species have been recorded in the reserve, 15 of these species occur annually or regularly in internationally important numbers (Ramsar Criteria). Included in this group is the critically endangered Spotted Greenshank. The Reserve and River are without doubt the most critical sites for Bar-tailed Godwit, with an estimated 90,000+ using the area while migrating north. The use of the reserve by the different godwit subspecies is under investigation but it is estimated that 70%-80% of all godwits migrating north from New Zealand will pass through the reserve. In 2007 the godwit 'E7' (being tracked by satellite (page 65)), flew 10,200km non-stop from Miranda in New Zealand to the Yalu Jiang Estuary a journey taking over seven days. It is estimated that 70,000-80,000 Great Knot, and 22,000 Eurasian and Eastern Curlews also pass through the reserve on northward migration. Migrating population estimates are given for five more species in this report; minimum numbers are given for those species where an estimate cannot yet be made. Shorebirds gather at 15 main areas (known as Sites) along the reserve's 60km of coastline on the incoming tide, before moving to aquaculture ponds and the River to roost. Birds were counted at these sites during surveys. The sites with the highest counts of shorebirds were concentrated at the eastern end of the reserve (near Donggang) with the highest count being 73,583 recorded in late April. A further seven sites have counts of over 20,000 each. These counts focus on roosting distribution, which may differ from feeding distribution. Over 1,000 banded and other marked shorebirds from 19 regions in 8 countries have been identified in the reserve and River, highlighting Yalu Jiang Estuary's location as a focal point during migration for shorebirds from many parts of the flyway. Recommendations for the protection of shorebirds at Yalu Jiang Estuary Wetland National Nature Reserve are presented. It is hoped these suggestions and recommendations can provide a reference for effecting the conservation of the Yalu Jiang Estuary Wetland. New Zealand and China are tied together by the epic journey of the Bar-tailed Godwit. To protect this and the other species, we must work together.

Choi C, Battley PF, Potter MA, Ma Z, Liu W. 2014. Factors Affecting the Distribution Patterns of Benthic Invertebrates at a Major Shorebird Staging Site in the Yellow Sea, China. *Wetlands* **34**:1085–1096.

(Abstract)

The tidal flats of the Yellow Sea support benthic communities that are vitally important to migratory birds, but baseline information on benthic community structure and variability is largely lacking. We investigated spatial and temporal patterns of macrobenthic invertebrates

in areas used by large numbers of shorebirds and how these patterns related to environmental factors at Yalu Jiang coastal wetland in the north Yellow Sea during boreal spring (March–May) from 2010 to 2012. At least 61 species were documented during the study. Monthly benthos sampling from 54 stations indicated that polychaetes and bivalves dominated the benthic communities, with capitellid or maldanid polychaetes dominating upper tidal flats and the bivalve *Potamocorbula laevis* dominating intermediate and lower tidal flats. The middle and eastern sites approximately 10 km apart showed substantial differences in benthic species abundance and distribution, with bivalves dominating in the middle but not the eastern site. The spatial distribution of benthos was correlated with both exposure time during the tidal cycle and sediment particle size. Benthic communities showed both annual and within season variation. Two of the frequent prey for migratory birds, namely ghost shrimps *Nihonotrypaea japonica* and young *Potamocorbula laevis*, were relatively common in 2010 and 2011, respectively, but not in 2012.

Navedo JG, Fernández G, Fonseca J, Drever MC. 2014 in press. A Potential Role of Shrimp Farms for the Conservation of Nearctic Shorebird Populations. *Estuaries and Coasts*.

(Abstract)

Shrimp aquaculture farms have greatly expanded at tropical areas worldwide, especially during the past three decades. One of the main core areas of this expansion was the northwestern coast of Mexico, prompting conservation concern for the shorebird populations that spend the nonbreeding period (October to March) in the region. We conducted a series of counts and behavioral observations to evaluate the importance of a shrimp farm as foraging habitat for shorebirds, relative to adjacent intertidal areas, during and after the shrimp harvest period at a tropical wetland in Sinaloa, Mexico, 2012 and 2013. Overall, low-tide counts within the entire wetland had an average of 3,168±605 (SE) shorebirds during the shrimp harvest period (October–November) and subsequently dropped to 1,408±373 birds following harvest (December to January), when shrimp ponds were emptied and foraging opportunities were reduced. The proportion of counts at the shrimp farm relative to total counts over the entire wetland ranged from 10 to 80%for different shorebird species and dropped to 0 to 10%in the postharvest period. During the harvesting period, black-necked stilt, American avocet, willet, and whimbrel selected shrimp ponds over intertidal areas to forage during low tide, while marbled godwit, western sandpiper, and dowitchers did not. The proportion of shorebirds observed feeding at the shrimp farm ranged between 60 and 90%for most species and did not differ between low- and high-tide counts. These results suggest that shrimp farms can provide ephemeral but important complementary foraging areas for shorebirds, and appropriate management of existing farms may aid in conservation efforts for these species.

Douglas, D. J. T., and J. W. Pearce-Higgins. 2014. Relative importance of prey abundance and habitat structure as drivers of shorebird breeding success and abundance. *Animal Conservation***17**:535–543.

(Abstract)

Understanding large-scale drivers of animal breeding densities and demography has a range of important uses, including informing conservation management. Given the threat of climate change, the importance of developing a process-based understanding of variation in animal populations is increased to inform adaptive management. For a climate-change sensitive species, the European Golden Plover *Pluvialis apricaria*, we use novel field-collected data on large-scale spatial variation in prey abundance and vegetation structure to understand drivers of breeding abundance and breeding success, and inform potential management responses. The abundance of the key prey, crane flies (Tipulidae), increased with altitude (a surrogate for temperature) and peat depth (a surrogate for soil moisture). Golden plover breeding densities were highest where vegetation was shortest, probably reflecting greater prey accessibility. In contrast, breeding success was not strongly related to vegetation height, but positively correlated with both crane fly abundance and daily minimum temperatures. When combined to model the number of likely successful pairs in any 1 year, the magnitude of vegetation height effect far exceeded that of crane fly abundance. Thus, for golden plover and other shorebirds sharing similar habitats, management to optimize breeding habitat (grazing or burning to promote short vegetation) may differ from management to promote breeding success (drain blocking to increase soil moisture and prey abundance). Adaptive management in the face of climate change should therefore include appropriate vegetation management, as well as maximizing prey abundance. More broadly, as the drivers of breeding density and demographic parameters may differ, we advocate that conservation practitioners collect not just information on species' distributions but also underpinning demographic processes when using science to inform management.

Susanto, H., I. Taufiqurrahman, and S. van Balen. 2014. Waders of Karimunjawa National Park, Central Java, Indonesia. *Stilt* **66**:1–9.

(Abstract)

Wader surveys were carried out between December 2007 and December 2013 covering eight areas in Karimunjawa National Park, Central Java, Indonesia. As a result, 23 wader species were recorded, with 10 new records for the park. Terusan on Kemujan Island is an intertidal area of approximately 10 hectares and had the highest number of species recorded. In Terusan, there were 17 species recorded with nine species not recorded elsewhere on the park. Oriental Pratincole (*Glareola maldivarum*), Whimbrel (*Numenius phaeopus*), Grey-tailed Tattler (*Heteroscelus brevipes*) and Common Sandpiper (*Actitis hypoleucos*) were the most common and widespread waders in Karimunjawa National Park. A compilation of all wader species listed for Karimunjawa NP, including historical records, is presented.

Crossland, A. C., A. W. Sitorus, and A. S. Sitorus. 2014. Land use change impacts shorebird habitat at an important site for Javan Plover *Charadrius javanicus* and Sanderling *Calidris alba*in Java, Indonesia. *Stilt* **66**:30–36.

(Abstract)

Pantai Glagah, a coastal wetland on the south coast of Java, Indonesia, is a breeding site for Javan Plover *Charadrius javanicus* and is both a nationally and internationally significant migration staging and non-breeding site for Sanderling *Calidris alba*. These species are classified as near threatened and least concern, respectively, by BirdLife International (2014). Visits, seven years apart, recorded substantial land use changes associated with a marked expansion in human recreational use of this site. We document a number of pressures that are likely to be detrimental to shorebirds. These pressures include high levels of habitat modification and degradation, human disturbance, and increased risk of nest trampling and predation by wandering domestic animals. We identify the need for management interventions to protect the notable wildlife values of Pantai Glagah and similar sites. Recommendations include identification and protection of high value areas for shorebirds,, restriction of public access to Javan Plover breeding sites,, habitat enhancement, community outreach and visitor education.

Chowdhury, S. U., M. A. Abu Diyan, C. Zöckler, M. Foysal, and H. W. Lemke. 2014. A survey of shorebirds in the Sundarbans of Bangladesh. *Stilt* **66**:10–13.

(Abstract)

A survey of shorebirds targeting the Critically Endangered Spoon-billed Sandpiper was carried out in the Sundarbans of Bangladesh between 14 and 16 January 2013. A total of 1691 shorebirds of 17 species were counted and the most abundant species was Lesser Sand Plover *Charadrius mongolus*, followed by Kentish Plover *Charadrius alexandrinus*, Common Redshank *Tringa totanus* and Greater Sand Plover *Charadrius leschenaultii*. Three notable species were recorded during surveys: the Near Threatened Eurasian Curlew *Numenius arquata* (n=68), Great Thick-knee *Esacus recurvirostris* (n=7) and the locally rare Eurasian Oystercatcher *Haematopus ostralegus longipes* (n=3). We find that the Sundarbans, which is designated as a Ramsar site and is still relatively intact, holds moderate numbers of shorebirds and is also an important site for Great Thick-knee. However, the site is under threat from a proposed power station and therefore warrants continued monitoring.

Zöckler, C., Z. Thet Naing, S. Moses, Y. Naung Soe, and T. Htin Hla. 2014. The importance of the Myanmar coast for water birds. *Stilt* **66**:37–51.

(Abstract)

Surveys of water birds at eight sites along the 3000 km long coast of Myanmar from 2008-2013 have shown that the country hosts a number of significant intertidal mudflat areas. It regularly provides home to more than 150,000 wintering and migrating water birds of 80 different species. The large majority of these birds occur in the Gulf of Mottama and in the adjacent Ayeyarwaddy Delta. Together with other sites, the Myanmar coast proved to be important for many water birds, and included a total of 10 globally threatened species. The waders were most prominent with 39 species being recorded. Among those was the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmeus*) for which coastal habitats in Myanmar hold more than 50% of the world population. Also, the Endangered Nordmann's Greenshank (*Tringa guttifer*) has been found in significant numbers and is one of 24 species where at least 1% of the global population is occurring on Myanmar's coast. Often, the combination of the intertidal mudflats with adjacent mangroves proved to be crucial for several water bird species, as shown in the case of the Vulnerable Lesser Adjutant Stork (*Leptoptilos javanicus*). Despite the significance of this coastline for water birds, hardly any of the intertidal sites or adjacent mangroves has any formal protection. With rapid coastal development threatening most of the sites, the protection of the most important of these sites is of high priority.

Norazlimi, N., and R. Ramli. 2014. Temporal Variation of Shorebirds Population in Two Different Mudflats Areas. *International Journal of Biological, Veterinary, Agricultural and Food Engineering***8**:1106-1112.

(Abstract)

A study was conducted to determine the diversity and abundance of shorebird species habituating the mudflat area of Jeram Beach and Remis Beach, Selangor, Peninsular Malaysia. Direct observation technique (using binoculars and video camera) was applied to record the presence of bird species in the sampling sites from August 2013 until July 2014. A total of 32 species of shorebird were recorded during both migratory and non-migratory seasons. Of these, eleven species (48%) are migrants, six species (26%) have both migrant and resident populations, four species (17%) are vagrants and two species (9%) are residents. The compositions of the birds differed significantly in all months ($\chi 2 = 84.35$, $p < 0.001$). There is a significant difference in avian abundance between migratory and non-migratory seasons (Mann-Whitney, $t = 2.39$, $p = 0.036$). The avian abundance were differed significantly in Jeram and Remis Beaches during migratory periods ($t = 4.39$, $p = 0.001$) but not during non-migratory periods ($t = 0.78$, $p = 0.456$). Shorebird diversity was also affected by tidal cycle. There is a significance difference between high tide and low tide (Mann-Whitney, $t = 78.0$, $p < 0.005$). Frequency of disturbance also affected the shorebird distribution (Mann-Whitney, $t = 57.0$, $p = 0.0134$). Therefore, this study concluded that tides and disturbances are two factors that

affecting temporal distribution of shorebird in mudflats area.

Bijleveld, A. I., G. Massourakis, A. van der Marel, A. Dekinga, B. Spaans, J. A. van Gils, and T. Piersma. 2014. Personality drives physiological adjustments and is not related to survival. *Proceedings of the Royal Society of London*, **B 281**:20133135.

(Abstract)

The evolutionary function and maintenance of variation in animal personality is still under debate. Variation in the size of metabolic organs has recently been suggested to cause and maintain variation in personality. Here, we examine two main underlying notions: (i) that organ sizes vary consistently between individuals and cause consistent behavioural patterns, and (ii) that a more exploratory personality is associated with reduced survival. Exploratory behaviour of captive red knots (*Calidris canutus*, a migrant shorebird) was negatively rather than positively correlated with digestive organ (gizzard) mass, as well as with body mass. In an experiment, we reciprocally reduced and increased individual gizzard masses and found that exploration scores were unaffected. Whether or not these birds were resighted locally over the 19 months after release was negatively correlated with their exploration scores. Moreover, a long-term mark–recapture effort on free-living red knots with known gizzard masses at capture confirmed that local resighting probability (an inverse measure of exploratory behaviour) was correlated with gizzard mass without detrimental effects on survival. We conclude that personality drives physiological adjustments, rather than the other way around, and suggest that physiological adjustments mitigate the survival costs of exploratory behaviour. Our results show that we need to reconsider hypotheses explaining personality variation based on organ sizes and differential survival.

Iwamura, T., R. A. Fuller, and H. P. Possingham. 2014. Optimal Management of a Multispecies Shorebird Flyway under Sea-Level Rise. *Conservation Biology* **28**:1710–1720.

(Abstract)

Every year, millions of migratory shorebirds fly through the East Asian–Australasian Flyway between their arctic breeding grounds and Australasia. This flyway includes numerous coastal wetlands in Asia and the Pacific that are used as stopover sites where birds rest and feed. Loss of a few important stopover sites through sea-level rise (SLR) could cause sudden population declines. We formulated and solved mathematically the problem of how to identify the most important stopover sites to minimize losses of bird populations across flyways by conserving land that facilitates upshore shifts of tidal flats in response to SLR. To guide conservation investment that minimizes losses of migratory bird populations during migration, we developed a spatially explicit flyway model coupled with a maximum flow algorithm.

Migratory routes of 10 shorebird taxa were modeled in a graph theoretic framework by representing clusters of important wetlands as nodes and the number of birds flying between 2 nodes as edges. We also evaluated several resource allocation algorithms that required only partial information on flyway connectivity (node strategy, based on the impacts of SLR at nodes; habitat strategy, based on habitat change at sites; population strategy, based on population change at sites; and random investment). The resource allocation algorithms based on flyway information performed on average 15% better than simpler allocations based on patterns of habitat loss or local bird counts. The Yellow Sea region stood out as the most important priority for effective conservation of migratory shorebirds, but investment in this area alone will not ensure the persistence of species across the flyway. The spatial distribution of conservation investments differed enormously according to the severity of SLR and whether information about flyway connectivity was used to guide the prioritizations. With the rapid ongoing loss of coastal wetlands globally, our method provides insight into efficient conservation planning for migratory species.

Cheverie, A. V., D. J. Hamilton, M. R. S. Coffin, and M. A. Barbeaub. 2014. Effects of shorebird predation and snail abundance on an intertidal mudflat community. *Journal of Sea Research* **92**:102–114.

(Abstract)

Top-down effects of predation are well documented in a variety of ecological communities, including marine soft-sediment systems. It has been proposed that intertidal mudflats in the upper Bay of Fundy, Canada, which host a large population of foraging shorebirds each summer, may exhibit this community dynamic. Biofilm (consisting mainly of diatoms) forms the base of the mudflat community food web, which is dominated by the amphipod Corophium volutator. To assess the potential for a trophic cascade, we conducted a manipulative field experiment examining individual and combined effects of the shorebird Calidris pusilla, a primary predator of C. volutator, and the eastern mudsnail (Nassarius obsoletus), an intraguild predator, on community structure (including macrofauna and large meiofauna retained by a 250-μm screen). Snails exhibited density-dependent top-down effects, primarily from strong negative interactions with juvenile and adult C. volutator, likely due to interference, consumption and emigration. Medium and high densities of snails reduced chlorophyll a concentration (a measure of diatom abundance), likely through consumption and disturbance of the sediment. When present at higher densities, snails also increased variability in community structure. Shorebirds were less influential in determining community structure. They reduced C. volutator biomass through consumption, but there was no resulting effect on primary production. Top-down effects of snails and birds were cumulative on C. volutator, but did not generate a trophic cascade. We suggest that a combination of omnivory and intraguild predation by shorebirds and snails, coupled with relatively low grazing pressure by C. volutator, prevented transmission of top-down effects.

Bocher, P., F. Robin, J. Kojadinovic, P. Delaporte, P. Rousseau, C. Dupuy, and P. Bustamante. 2014. Trophic resource partitioning within a shorebird community feeding on intertidal mudflat habitats. *Journal of Sea Research* **92**:115–124.

(Abstract)

In ecological systems, it is necessary to describe the trophic niches of species and their segregation or overlap to understand the distribution of species in the community. In oceanic systems, the community structure of top predators such as seabird communities has been well documented with many studies in several biogeographical areas. But for coastal habitats, very few investigations on the trophic structure have been carried out in avian communities. In this study, the trophic resource partitioning was investigated on eight of the most abundant species of a shorebird community on the central Atlantic coast of France. Our work comprised a comprehensive sample of birds with different ecomorphogical patterns and data on their main prey to encompass potential sources of overlap and segregation in this community. We examined the stable carbon (δ13C) and nitrogen (δ15N) isotopic composition of blood to investigate the trophic structure (1) on a temporal scale by comparing migration and wintering periods; (2) on a spatial scale through inter-site comparisons; and (3) on the community level within groups of phylogenetically related species. Diets appeared different in several cases between periods, between sites and between juveniles and adults for the same sites. A clear trophic partitioning was established with four functional groups of predators in winter inside the community. The Grey Plover, the Bar-tailed Godwit, the Curlew and a majority of the dunlins were worm-eaters mainly feeding on Nereis diversicolor or Nephtys hombergii. Two species were predominantly deposit-suspensivorous mollusc-eaters, including the Red Knot and the Black-tailed Godwit feeding mainly on Macoma balthica. The Oystercatcher fed mainly on suspensivorous molluscs like Cerastodrema edule and two species including the Redshank and some dunlins adopted opportunistic behaviours feeding on mudflat and/or in marshes.

Grond, K., H. Ryu, A. J. Baker, J. W. Santo Domingo, and D. M. Buehler. 2014. Gastro-intestinal microbiota of two migratory shorebird species during spring migration staging in Delaware Bay, USA. *Journal of Ornithology* **155**: 969–977.

(Abstract)

Migratory birds travel long distances and use diverse habitats, potentially exposing them to a broad range of microbes that could negatively affect their health and survival. Gut microbiota composition may be related to organismal health especially during periods of impaired immunity due to stress, by functioning as a reservoir for potential pathogens. We provide an insight into the composition of the gastrointestinal microbiota in migratory Red Knot (Calidris canutus) and Ruddy Turnstone (Arenaria interpres) staging in Delaware Bay, USA, by analyzing fecal bacterial communities of three individuals per species with 16S rRNA clone

libraries. In the 313 bacterial sequences we analysed from Red Knots, we identified 19 bacterial classes across 29 genera, and from the 218 Ruddy Turnstone sequences, we identified 11 bacterial classes across 17 genera. In Red Knots and Ruddy Turnstones, 27 and 41% of all sequences were closely related to Campylobacter spp., which include several human pathogens. Only 5 of the 46 genera, and 8 out of 124 operational taxonomic units were shared between species, suggesting that gut microbial community structure can be species-specific under environmentally similar conditions. Our study provides baseline information that can be used in future studies to better understand diversity and function of gut microbes, and can be expanded to investigate how gut microbiota of migratory birds affects their body condition, immune function, and demographic performance.

Jamieson, S. E., R. C. Ydenberg, and D. B. Lank. 2014. Does predation danger on southward migration curtail parental investment by female western sandpipers? *Animal Migration* **2**: 34–43.

(Abstract)

Theory predicts that if extending parental care delays migratory departure, and if later migration is more dangerous, then parental care should be curtailed to make an earlier departure. Adult western sandpipers (*Calidris mauri*) depart Alaska in July, and the presence of peregrine falcons (*Falco peregrinus*) along their route rises steeply during the migratory period. Pacific dunlins (*C. alpina pacifica*) are ecologically similar, but do not depart Alaska until October, after peregrine passage has peaked. Because peregrine migration begins earlier in years with early snowmelt, we predicted that the curtailment of parental investment by western sandpiper, but not of Pacific dunlins, should be more pronounced in these more dangerous years. We measured breeding phenology of these species on the Yukon Delta National Wildlife Refuge during three seasons with strongly differing snowmelt timing. We found that they initiated breeding simultaneously, and that western sandpipers, but not Pacific dunlins, ceased laying increasingly earlier, provided increasingly less parental care and departed increasingly sooner as snowmelt was earlier. Advancing departure date by the overall average of 5.2 d relative to dunlin reduces migratory exposure to peregrines by an estimated 18%. Our results support the hypothesis that natural selection has favored curtailment of parental investment by western sandpipers to advance migratory departure.

Kuwae, T., E. Miyoshi, S. Hosokawa, K. Ichimi, J. Hosoya, T. Amano, T. Moriya, M. Kondoh, R. C. Ydenberg, and R. W. Elner. 2012. Variable and complex food web structures revealed by exploring missing trophic links between birds and biofilm. *Ecology Letters* **15**:347–356.

(Abstract)

Food webs are comprised of a network of trophic interactions and are essential to elucidating ecosystem processes and functions. However, the presence of unknown, but critical networks hampers understanding of complex and dynamic food webs in nature. Here, we empirically demonstrate a missing link, both critical and variable, by revealing that direct predator-prey relationships between shorebirds and biofilm are widespread and mediated by multiple ecological and evolutionary determinants. Food source mixing models and energy budget estimates indicate that the strength of the missing linkage is dependent on predator traits (body mass and foraging action rate) and the environment that determines food density. Morphological analyses, showing that smaller bodied species possess more developed feeding apparatus to consume biofilm, suggest that the linkage is also phylogenetically dependent and affords a compelling re-interpretation of niche differentiation. We contend that exploring missing links is a necessity for revealing true network structure and dynamics.

Kuwae, T., E. Miyoshi, S. Sassa, and Y. Watabe. 2010. Foraging mode shift in varying environmental conditions by dunlin Calidris alpina. *Marine Ecology Progress Series* **406**: 281–289.

(Abstract)

Predators may have a series of alternative foraging modes. Under the food resource maximization hypothesis, predators are expected to shift between foraging modes such that they attain the highest intake rate in response to prey availability and constraints varying with environmental conditions. To test this hypothesis, we measured foraging action rate (actions per unit time), capture rate (captures per unit time), and intake rate (amount of energy and nutrients per unit time) for 2 foraging modes, pecking (feeding on epifauna at the sediment surface) and probing (feeding on infauna by inserting the bill into the sediment), in dunlin Calidris alpina on an intertidal sandflat. The birds chose their foraging mode to attain higher feeding success, i.e. individuals that obtained higher capture and intake rates by pecking allocated a higher proportion of foraging effort to pecking, and vice versa. The birds shifted foraging mode from probing to pecking with increased time after emersion. The shift may be related to decreasing efficiency of probing due to increases in the costs of energy and time caused by decreasing sediment penetrability (increasing hardness) with time after emersion. Our in situ study empirically suggests that, while environmental constraints reduce the predators' foraging mode flexibility, the birds show individual-based appropriate adjustments in their foraging mode to attain a higher intake rate at a given time and patch. This extends the ideal forager model for patch choice into foraging mode choice.

Lim, H. C., and M. R. C. Posa. 2014. Distribution and prey of migratory shorebirds on the northern coastline of Singapore. *Raffles Bulletin Of Zoology* **62**: 701–717.

(Abstract)

Singapore is a part of the East Asian-Australasian Flyway. The identification and continued protection of breeding, wintering and stopover sites within the flyway are essential for the survival of the flyway's migratory shorebirds. Here, we conducted 11 monthly (March 2003 to January 2004) high tide and low tide surveys of shorebirds in eight wetland sites (comprising mainly mangroves and intertidal mudflats) along the northern coast of Singapore. Internationally important numbers of common redshank, common greenshank and Pacific golden plover were found during the southward migration period in two sites. Other common shorebird species in our sites were: whimbrel, marsh sandpiper, common sandpiper, curlew sandpiper and lesser sand plover. Our data suggest that at least common redshank and Pacific golden plover used Singapore's wetlands for staging during southward migration. Two species, curlew sandpiper and lesser sand plover, did not use our sites for wintering, although the latter were found in other, sandier intertidal habitats in Singapore during countrywide winter counts. Mud coring and diet analysis revealed that polychaetes (in particular Family Nereididae) were dominant members of the benthic infauna, and were commonly depredated by shorebirds. The benthic infauna communities of the study sites were rich, with sites containing polychaetes belonging to 8–15 families. At the level of ponds or mudflat patches, we found a weak positive influence of nereidid polychaete density on shorebird abundance during low tides. Given the recent loss of natural habitats from Singapore's shores, we suggest that some of these sites be protected to serve conservation and educational purposes.

Liebezeit JR, Gurney KEB, Budde M, Zack S, Ward D. 2014. Phenological advancement in arctic bird species: relative importance of snow melt and ecological factors. *Polar Biology* **37**, 1309-1320.

(Abstract)

Previous studies have documented advancement in clutch initiation dates (CIDs) in response to climate change, most notably for temperate-breeding passerines. Despite accelerated climate change in the Arctic, few studies have examined nest phenology shifts in arctic breeding species. We investigated whether CIDs have advanced for the most abundant breeding shorebird and passerine species at a long-term monitoring site in arctic Alaska. We pooled data from three additional nearby sites to determine the explanatory power of snow melt and ecological variables (predator abundance, green-up) on changes in breeding phenology. As predicted, all species (semipalmated sandpiper, *Calidris pusilla*, pectoral sandpiper, *Calidris melanotos*, red-necked phalarope, *Phalaropus lobatus*, red phalarope, *Phalaropus fulicarius*, Lapland longspur, *Calcarius lapponicus*) exhibited advanced CIDs ranging from 0.40 to 0.80 days/year over 9 years. Timing of snow melt was the most important variable in explaining clutch initiation advancement (''climate/snow hypothesis'') for four of the five species, while green-up was a much less important explanatory factor. We found no evidence that high predator abundances led to earlier laying dates (''predator/re-nest hypothesis''). Our results support previous arctic studies in that climate change in the cryosphere will have a strong impact on nesting phenology although factors

explaining changes in nest phenology are not necessarily uniform across the entire Arctic. Our results suggest some arctic-breeding shorebird and passerine species are altering their breeding phenology to initiate nesting earlier enabling them to, at least temporarily, avoid the negative consequences of a trophic mismatch.

Whitfield DP, Rae R. 2014. Human disturbance of breeding Wood Sandpipers *Tringa glareola*: implications for “alert distances” in prescribing protective buffer zones. *Ornis Fennica* **91**, 57–66.

(Abstract)

Separation of animals and humans using a protective set-back distance (Minimum Approaching Distance) is a popular tool for conservation managers to promote wildlife-human coexistence. In several cases, Minimum Approaching Distance is based on how animals respond to an approaching human, using Flight Initiation Distance or Alert Distance. Alert Distance, when animals first show increased vigilance to an approaching human, is considered the best basis for Minimum Approaching Distance because animals have time to adapt their response. Alert Distance is frequently difficult or impossible to measure in practice, however, especially in breeding birds. Using a study of breeding Wood Sandpipers *Tringa glareola*, in which Alert Distance could not be measured directly, we tested three possible solutions to this dilemma. Alarm Call Distance did not appear to provide a useful substitute for Alert Distance because sandpipers probably alarm called after they had first detected a human. Published predictions of Alert Distance using body mass also failed to provide realistic estimates of disturbance distances in Wood Sandpipers. The “fixed-slope rule”, which predicts that Alert Distance is about double Flight Initiation Distance, was not supported by relationships between Alarm Call Distance and Flight Initiation Distance, but was supported by a relationship between an estimated Alert Distance surrogate and Flight Initiation Distance. This suggests that this rule may have general utility in predicting Alert Distance when only the more readily measured Flight Initiation Distance metric is known. A Minimum Approaching Distance (protective buffer zone) of 160 m is recommended for breeding Wood Sandpipers.

Santiago-Quesada F, Estrella SM, Sanchez-Guzman JM, Masero JA. 2014. Why water birds forage at night: a test using black-tailed godwits *Limosa limosa* during migratory periods. *Journal of Avian Biology* **45**, 406–409.

(Abstract)

Many migratory water birds are known to feed both during day and night outside the breeding season, but the underlying factors and mechanisms determining this foraging pattern are poorly understood. We addressed this topic by comparing both diurnal and nocturnal foraging

activity (FA) and metabolizable energy intake rate (MEIR) in migrating black-tailed godwits *Limosa limosa* staging in two different habitats, rice fields and coastal salt pans. Black-tailed godwits staging in rice fields during pre-breeding migration fed on rice seeds, and only foraged during the daylight period (FA: 81.89 +/- 3.03%; MEIR: 1.15 +/- 0.03 kJ/min). Daily energy consumption (DEC) of godwits relying on seeds was enough to meet the theoretical daily energy expenditure (DEE). In contrast, black-tailed godwits staging in salt pans during post-breeding migration fed on chironomid larvae, and they foraged during both daylight (FA: 67.36 +/- 4.30%; MEIR: 0.27 +/- 0.01 kJ/min) and darkness (FA: 69.89 +/- 6.89%; MEIR: 0.26 +/- 0.00 kJ/min). Nocturnal energy intake contributed 31.7% to DEC, the latter being insufficient to fully meet DEE. Our findings give empirical support to the view that diurnal foraging is the norm in many migratory water birds outside the breeding season, and nocturnal foraging occurs when the daily energy requirements are not met during the daylight period, supporting the supplementary food hypothesis.

Lucia M, Bocher P, Chambosse M, Delaporte P, Bustamante P. 2014. Trace element accumulation in relation to trophic niches of shorebirds using intertidal mudflats. *Journal of Sea Research* **92**, 134-143.

(Abstract)

This study investigated the link between trace element concentrations and respective diets of two shorebird species present in the Pertuis Charentais, Atlantic coast of France: the Dunlin (*Calidris alpina*) and Redshank (*Tringa totanus*). Trace element concentrations (Ag, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn) were investigated in the liver, kidney, muscle and feathers of 28 dunlins and 15 redshanks accidentally dead during catches by mist net. Analyses of carbon and nitrogen stable isotope ratios were carried out in liver, muscle and feathers to determine whether differences in diet explained the variations in elemental levels. These results were compared to previous data obtained on two other shorebird species present on the same sites: the Black-tailed Godwit (*Limosa limosa*) and the Red Knot (*Calidris canutus*). This study demonstrated that shorebirds of the Pertuis Charentais were characterized by differential trace element bioaccumulation. Arsenic and Se concentrations in internal tissues were elevated in red knots and dunlins, whereas redshanks displayed higher Cd concentrations. These trace element bioaccumulation discrepancies could mainly come from divergences of trophic habits between shorebirds. Species with the highest trophic position displayed the highest Hg concentrations in the liver, muscle and feathers demonstrating therefore the biomagnification potential of this metal, as opposed to Cd and Pb. The same trend was observed in muscle and feathers for Se and only in feathers for As. These data highlighted the need to study several tissues to obtain a full comprehension of trace element exposure and pathways especially for long-distance migrating species using various habitats and sites.

Smart J, Wotton SR, Dillon IA, Cooke AI, Diack I, Drewitt AL, Grice PV, Gregory RD. 2014. Synergies between site protection and agri-environment schemes for the conservation of waders on lowland wet grasslands. *Ibis* **156**, 576–590.

(Abstract)

Two conservation strategies have been put in place in Europe to address precipitous population declines of wading birds that breed on lowland wet grasslands. These are site protection and agri-environment schemes (AESs) and the two are rarely compared, or their synergy assessed. Increasingly, efforts to recover populations of previously widespread species follow a landscape-scale approach whereby habitat improvement takes place at key sites through partially overlapping protected area management and AESs. To investigate whether site protection and AESs improve the conservation status of breeding waders and how these interact, we partially repeated a 2002 survey of breeding waders on protected areas (nature reserves and Sites of Special Scientific Interest) and sites with wader-specific AES options in England in 2009 and 2010. We then assessed the individual and combined effects of these delivery mechanisms on field occupancy, breeding density and population change of four species of declining wader (Northern Lapwing *Vanellus vanellus*, Common Snipe *Gallinago gallinago*, Eurasian Curlew *Numenius arquata* and Common Redshank *Tringa totanus*). Although results for Curlew differed from the other species, in general field occupancy was positively influenced by conservation delivery mechanisms, with the highest occupancy and breeding densities on land where site protection was combined with wader-specific AES options. Field occupancy varied between different types of AES, with higher occupancy associated with higher-level options in fields, particularly those on nature reserves. Outside nature reserves, the history of AES management did not influence wader populations, but within nature reserves and on fields that gained AES management between 2002 and 2009–2010, populations of Curlew and Snipe were more likely to have persisted and population change in Snipe and Lapwing was more positive. We conclude that the conservation of breeding waders will be most effective when site protection and AES management are combined on the same land. Using limited AES money to support management for breeding waders on, around and between the existing network of protected sites will protect remaining populations while presenting opportunities for population expansion in future.

Lanctot RB, Brown S, Sandercock BK. 2014. '2010 – 2013 Progress Report: Using a Network of Sites to Evaluate How Climate-mediated Changes in the Arctic Ecosystem are Affecting Shorebird Distribution, Ecology and Demography.' Unpublished report by the U.S. Fish and Wildlife Service, Manomet Center for Conservation Sciences and Kansas State University to the Arctic Landscape Conservation Cooperative. U.S. Fish and Wildlife Service, Anchorage, AK.

(Abstract)

To obtain a better understanding of how shorebirds will respond to climate-mediated changes in the Arctic's morphology and ecology, we have established a network of sites, known as the Arctic Shorebird Demographics Network (ASDN), wherein we collected information on a suite of predictor variables thought to be responsive to climate change, with a future goal of correlating these variables with measures of shorebird distribution, ecology, and demography. Starting in 2010, we established nine field sites across the Arctic, from Nome, Alaska to Hudson Bay, Nunavut. The number of sites was expanded from 9 to 11 sites in 2011, 11 to 14 in 2012, and 14 to 16 in 2013. Protocols were adopted/modified from prior studies in the Arctic to create a standardized protocol that has been updated prior to each field season. We have compiled all of the data from the various sites during the first four years of the ASDN operation, and results from all four field seasons are presented here. A total of 6,691 nests belonging to 38 species were located in the first four years of the study. The largest number of nests belonged to the five ASDN focal species: Dunlin, Semipalmated Sandpipers, Red and Red-necked Phalaropes, and Pectoral Sandpipers. Unexpectedly high number of Western Sandpiper and American Golden-Plovers were also discovered. Nest initiation dates varied tremendously across sites for the focal shorebird species investigated during this study. Apparent nest success was 48% across all sites and species; rates varied between years within sites, and also between sites within years. An investigation into what environmental variables best explain the variation in nest success is underway. A total of 5,237 adults belonging to 29 species were banded in the first four years of the study. The number of adults banded per species ranged from 1 to 1,422 during the study (mean ± SD = 180.6 ± 329.0). ASDN focal species were again captured the most frequently, but like nests, high numbers of Western Sandpipers and American Golden-Plovers were also captured. The highest returns of color-marked adults were observed in Dunlin, Red-necked Phalarope, Semipalmated Sandpiper, Western Sandpiper, and Whimbrel, which should allow adult survival estimates to be made (detailed analysis beginning now). Besides the shorebird data, field personnel kept daily species lists, and established sampling stations to document aquatic and terrestrial invertebrate diversity, phenology, and abundance. In addition, data were collected on predators, small mammals and other alternative prey for predators of shorebirds, snow and surface water, and general climatic variables. ASDN principal investigators and other partners are collaborating on 18 projects that use the geographically vast and taxonomically rich ASDN data. ASDN studies include investigations of the potential for an ecological mismatch between invertebrate emergence and shorebird hatching, variation in shorebird nest predation across the Arctic, assessment of predator diversity and abundance in relation to human development, and factors affecting shorebird settlement patterns. Avian health issues being investigated include avian influenza, avian malaria, gut microbiota, and mercury exposure. Migratory connectivity studies include projects using light-level geolocators to document migratory pathways and wintering areas of American Golden-Plover, Dunlin, and Semipalmated Sandpipers. An additional study is using stable isotope signatures to document connections between breeding, migration and wintering areas of Semipalmated Sandpipers. Other studies are focusing on the effects of spring phenology on timing of breeding in shorebirds, invertebrate phenology in relation to habitat and weather, long-distance dispersion of moss by shorebirds, and the distribution of Arctic invertebrates. The ASDN principal investigators have been highly successful at producing products from the data collected at their field sites. Although the major analyses and publications that will address core objectives of the ASDN have not been completed, investigators have collectively produced 24 peer-reviewed publications, 25 reports, and 57 presentations. We anticipate that many more publications will

be produced in the coming years. Although this report summarizes information collected between 2010 and 2013, we are preparing for the fifth of five originally proposed field seasons. A report summarizing the fifth field season will be available in March 2015.

Eiamampai K, Nimnuan S, Sornsa T, Phothieng D, Thong-Aree S, Ittiporn K, Rogers KG, Round PD. 2014. Proportions of first-year individuals in cannon-net catches of waders in Thailand with a comparison to Australia. *Stilt* **65**, 17-24.

(Abstract)

The paper presents information on proportions of juveniles (first-years) in cannon net catches made in the non-breeding season at two locations in Thailand, the Andaman Seaboard and the Inner Gulf of Thailand, since large-scale banding of waders started in that country in 2007/ 2008. We conclude that, for species common to the two countries, observed juvenile proportions in Thailand are consistent with those observed in Australia and, as a different suite of birds over-winters in Thailand, that monitoring of Thai birds adds to our knowledge of wader recruitment in the East Asian-Australasian Flyway.

D'Amico VL, González PM, Morrison RIG, Baker AJ. 2014. Reverse Movements of Red Knots *Calidris canutus* During Northward Migration in Argentina. *Ardeola* **61**, 63-76.

(Abstract)

Migratory birds are sometimes known to make reverse movements to seek better fuelling sites before undertaking long-distance migratory flights across ecological barriers. Red knots *Calidris canutus rufa* regularly make prodigious migratory flights of ~ 8,000 km from southern South America to North America; these flights depend critically on the birds being able to store adequate fuel at southern staging sites. Knots staging at San Antonio Oeste (SAO) in northern Patagonia in Argentina could potentially backtrack ~200 km southwards to complete refuelling at Península Valdés (PV). We therefore analysed resightings of birds individually marked in SAO or the flyway at these two staging sites in 2006, 2007, 2009 and 2010 to investigate whether reverse movements occurred between them. In the four-year period, 63 detected individuals backtracked south from SAO to PV in one or more years. These movements occurred in all years of the study thus demonstrating the annual occurrence of flights of ~200 km in the opposite direction to the normal northward migration. There was no significant difference in body condition (mass), sex or day of first sighting in SAO between birds that made or did not make reverse movements to PV. However, individuals (N = 11) that backtracked to PV from SAO had significantly lower hematocrit levels at the time of capture than SAO resident birds (N = 205). Because migrating shorebirds have been shown to restore low hematocrit levels before undertaking rapid fuel storage to power long flights, we

hypothesise that red knots backtracking to PV were probably behind schedule on migration, and thus may have traded-off the small cost of a ~200 km flight for the increased foraging time and high quality soft-shell prey available late in the season at PV. This hypothesis helps to explain the later staging phenology of red knots using PV, and its role as an alternative staging area in the northward migration.

Furnell J, Hull SL. 2014. Cliff top habitats provide important alternative feeding resources for wading birds of conservation importance wintering on non-estuarine coasts. *Estuarine, Coastal and Shelf Science* **139**, 119-126.

(Abstract)

Rocky shores and beaches are important over-wintering areas for non-estuarine waders but have rarely been studied. We examined cliff top habitat use by 6 species of wader over 75 km of coast to assess their potential value as alternative feeding sites to rocky and sandy shores. Both the regional and local survey showed that waders occurred on golf courses and recreational grasslands in higher frequencies than expected but arable and pasture use was lower than expected. We also compared local wader densities on rocky and sandy shores, pastures, golf courses, caravan parks and recreational grasslands over two winters. Sanderling predominantly fed on the beach whereas Oystercatcher, Dunlin, Turnstone and Redshank numbers significantly increased on golf courses and recreational grasslands over the winter period, with pasture being rarely used. General linear models were used to relate environmental factors to the presence and absence of each species on the cliff top habitats. Redshank was the only species that showed a higher probability of occurrence on cliff top habitats at high tide whereas the probability of Turnstone, Oystercatcher and Redshank occurring increased as temperatures declined. Using core sampling, we determined that invertebrate richness and abundance was significantly higher on the recreational grasslands and golf courses than on the pasture or the beach. Our data demonstrated that cliff top habitats are important alternative feeding areas for over-wintering waders in areas where the intertidal is bounded by cliffs. Current management creates short sward, open field habitats with a diverse and abundant invertebrate food supply exploited by waders. Any alterations to the land use of these areas should be carefully considered by planning authorities in light of the fact that they support species that are of conservation concern.

Reneerkens J, van Veelen P, van der Velde M, Luttikhuizen P, Piersma T. 2014. Within-population variation in mating system and parental care patterns in the Sanderling (*Calidris alba*) in northeast Greenland. *The Auk* **131**, 235-247.

(Abstract)

Sandpipers and allies (Scolopacidae) show an astounding diversity in mating and parental care strategies. Comparative studies have tried to interpret this variation in terms of phylogenetic constraints and ecological shaping factors. In such analyses, mating and parental care systems are necessarily discretely classified at the species level. The few available descriptive studies on breeding strategies of the Sanderling (*Calidris alba*) came to variable conclusions, which, in turn, were inconsistently used in these comparative studies. We provide empirical data on mating and parental care patterns in Sanderlings studied during six summers in northeast Greenland. In 135 clutches, we determined parental care from incubation profiles using temperature loggers and confirmed that both uniparental incubation by both sexes and biparental incubation (45 and 90 clutches, respectively) occurred. We used microsatellite-based parentage analyses to describe the degree of extrapair mating. In 48 completely assayed families, we found 6 cases of polygamy (4 cases of polyandry, 2 cases of polygyny) that involved both uniparental and biparental clutches. This implies substantial variation in the patterns of mating and parental care, defying categorical assignments even at the local level. We conclude that the classification of mating strategy and parental care pattern for the Sanderling has been rather coarse, and that comparative analyses have not taken the observed intrapopulation variability into account. Because sandpipers show such variable reproductive behavior, between and within species, more detailed descriptive studies using parentage analyses are required to revisit previous statements about the intensity of sexual selection, including sexual size dimorphism, in shorebirds. In view of the great variability, methods of comparison will need elaboration too.

Duijns S, Piersma T. 2014. Interference competition in a sexually dimorphic shorebird: prey behaviour explains intraspecific competition. *Animal Behaviour* **92**, 195-201.

(Abstract)

When males and females come in distinct sizes and shapes they often forage at different sites, selecting different prey. In the sexually dimorphic bar-tailed godwit, *Limosa lapponica*, females generally forage along the tideline, whereas the smaller (and subordinate) males generally forage across dry mudflats. On this basis we predicted that interference competition would occur within, rather than between, the sexes. We tested whether density-dependent aspects of foraging behaviour are indeed sex specific and additionally examined the roles of sex-specific prey types. With increasing conspecific densities, intake rates levelled off in females, but not in males. At increasing densities, both sexes engaged in more agonistic interactions, but females more than males. Consequently, females lost more foraging time than males. However, time lost to interactions could not explain the density-dependent decrease in their intake rate. As lugworms, *Arenicola marina*, contributed 71% to the energy intake of females and 18% in males, we experimentally tested whether the burying behaviour of lugworms explained the sex difference in interference. Both in the field and in the laboratory, lugworms responded to probes. In experimentally probed plots in the field, lugworms produced fewer casts per unit time, indicating a decrease in near-surface presence. In laboratory settings, increased experimental probing intensity resulted in deeper burying by lugworms. We

therefore argue that prey depression is responsible for most of the reduction in intake rates of females foraging at high conspecific densities. The search for undisturbed shallow-living lugworms would explain why female bar-tailed godwits tend to forage along the moving tideline.

Oudman T, Onrust J, de Fouw J, Spaans B, Piersma T, van Gils JA. 2014. Digestive Capacity and Toxicity Cause Mixed Diets in Red Knots That Maximize Energy Intake Rate. *The American Naturalist* **183**, 650-659.

(Abstract)

Among energy-maximizing animals, preferences for different prey can be explained by ranking the prey according to their energetic content. However, diet choice also depends on characteristics of the predator, such as the need to ingest necessary nutrients and the constraints imposed by digestion and toxins in food. In combination, these factors can lead to mixed diets in which the energetically most profitable food is not eaten exclusively even when it is abundant. We studied diet choice in red knots (*Calidris canutus canutus*) feeding on mollusks at a West African wintering site. At this site, the birds fed primarily on two species of bivalves, a thick-shelled one (*Dosinia isocardia*) that imposed a digestive constraint and a thin-shelled one (*Loripes lucinalis*) that imposed a toxin constraint. The latter species is toxic due to its symbiotic association with sulfide-oxidizing bacteria. We estimated experimentally the parameters of a linear programming model that includes both digestive and toxin constraints, leading to the prediction that red knots should eat a mixture of both mollusk species to maximize energy intake. The model correctly predicted the preferences of the captive birds, which depended on the digestive quality and toxicity of their previous diet. At our study site, energy-maximizing red knots appear to select a mixed diet as a result of the simultaneous effects of digestive and toxin constraints.

Hooijmeijer JCEW, Gill Jr RE, Mulcahy DM, Tibbitts TL, Kentie R, Gerritsen GJ, Bruinzeel LW, Tijssen DC, Harwood CM, Piersma T. 2014. Abdominally implanted satellite transmitters affect reproduction and survival rather than migration of large shorebirds. *Journal of Ornithology* **155**, 447–457.

(Abstract)

Satellite telemetry has become a common technique to investigate avian life-histories, but whether such tagging will affect fitness is a critical unknown. In this study, we evaluate multi-year effects of implanted transmitters on migratory timing and reproductive performance in shorebirds. Shorebirds increasingly are recognized as good models in ecology and evolution. That many of them are of conservation concern adds to the research responsibilities. In May 2009, we captured 56 female Black-tailed Godwits *Limosa limosa limosa* during late

incubation in The Netherlands. Of these, 15 birds were equipped with 26-g satellite transmitters with a percutaneous antenna (7.8 % ± 0.2 SD of body mass), surgically implanted in the coelom. We compared immediate nest survival, timing of migration, subsequent nest site fidelity and reproductive behaviour including egg laying with those of the remaining birds, a comparison group of 41 females. We found no effects on immediate nest survival. Fledging success and subsequent southward and northward migration patterns of the implanted birds conformed to the expectations, and arrival time on the breeding grounds in 2010–2012 did not differ from the comparison group. Compared with the comparison group, in the year after implantation, implanted birds were equally faithful to the nest site and showed equal territorial behaviour, but a paucity of behaviours indicating nests or clutches. In the 3 years after implantation, the yearly apparent survival of implanted birds was 16 % points lower. Despite intense searching, we found only three eggs of two implanted birds; all were deformed. A similarly deformed egg was reported in a similarly implanted Whimbrel *Numenius phaeopus* returning to breed in central Alaska. The presence in the body cavity of an object slightly smaller than a normal egg may thus lead to egg malformation and, likely, reduced egg viability. That the use of implanted satellite transmitters in these large shorebirds reduced nesting propensity and might also lead to fertility losses argues against the use of implanted transmitters for studies on breeding biology, and for a careful evaluation of the methodology in studies of migration.

D'Amico VL, Gonzalez PM, Baker AJ, Buehler DM, Bertellotti M. 2014. Multi-year surveillance of selected avian pathogens in the migrant shorebird Red Knot (*Calidris canutus rufa*) at its main stopover site in Patagonia, Argentina. *Journal of Ornithology* **155**, 555-559.

(Abstract)

To investigate possible reasons for recent declines in Red Knot (*Calidris canutus rufa*) populations we surveyed for selected pathogens in Red Knots captured in San Antonio Bay, Argentina, on their northward migration during the period 2006–2011. Blood, cloacal swabs and faeces were analysed for bacteria [*Salmonella* sp., *Shigella* sp., enteropathogenic *Escherichia coli* (N = 42) and other coliforms (N = 35)], viral agents [responsible for avian influenza (N = 239), St. Louis encephalitis (N = 51) and Newcastle disease (N = 239)] and avian malaria parasites [*Plasmodium* sp. and *Haemoproteus* sp. (N = 284)]. All 698 samples taken from 303 individuals were negative, providing no evidence that Red Knots sampled at this stopover site were infected with these pathogens at the time of sampling.

Douglas DJT, Bellamy PE, Stephen LS, Pearce-Higgins JW, Wilson JD, Grant MC. 2014. Upland land use predicts population decline in a globally near-threatened wader. *Journal of*

Applied Ecology **51**, 194–203.

(Abstract)

1. Changes in large-scale land use may fragment and degrade habitats, affecting animal species adapted to these habitats. In the UK uplands for example, changes in sheep and game management, and afforestation, have altered the configuration of internationally important moorland habitat and are predicted to have increased predation pressure for a globally unique suite of breeding birds of international conservation importance.

2. Some of these upland bird species have declined, with particular concern over ground-nesting waders. Using resurveys of the rapidly declining Eurasian curlew *Numenius arquata* as a focal species of global conservation concern, we investigate whether upland land use predicts low nesting success and population decline.

3. Curlew population changes over an 8- to 10-year period were positively related to game-keeper density (a surrogate of predator control intensity) and inversely to the area of woodland surrounding sites, as a likely source of predators to adjacent open ground. Model predictions suggest that increasing woodland cover from 0% to 10% of the land area within 1 km of populated sites requires an increase in human predator control effort of about 48%, to a level associated with high-intensity grouse production, to achieve curlew population stability.

4. Curlew nesting success, known to be a key driver of population trends, was also positively related to game-keeper density and inversely to woodland area surrounding sites, providing a plausible mechanistic link between land use and population change.

5. Synthesis and applications. Upland land use is associated with curlew declines, with predation a likely mechanism, and this may apply to other breeding waders. The removal of isolated woodland plantations from otherwise unafforested landscapes may help reduce predation pressure across a range of systems including moorland. However, direct predator control may also be important to conserve ground-nesting birds in these landscapes, for example, where moorland management and forestry coexist as major land uses. Predator control may also mitigate climate change effects by enhancing wader productivity, particularly where climate effects coincide with changing land use. Emerging land uses in open landscapes, including native woodland restoration and wind farms, require careful siting to minimize further impacts on open-area breeding birds.

Clemens RS, Herrod A, Weston MA. 2014. Lines in the mud, revisiting the boundaries of important shorebird areas. *Journal for Nature Conservation* **22**, 59–67.

(Abstract)

Many shorebird populations are declining throughout the world, concurrent with declines and degradation of wetland habitats. Such declines necessitate a more consistent approach toward conserving habitats used by shorebird populations. Individuals of many shorebird

species congregate in specific areas during their non-breeding season. Worldwide, non-breeding areas are designated as 'important' for shorebird conservation based primarily on the abundance of birds found in an area. However, the boundaries of any area are often defined with incomplete information regarding how shorebirds use that habitat. This paper discusses examples in Australia where improved knowledge of shorebird habitat use led to the identification of very different boundaries of important shorebird areas than those identified originally. We highlight how simple questioning of those who count shorebirds in an area, led to an improved understanding of which areas were apparently used by the same local population of non-breeding shorebirds. Subsequent analysis of available count, recapture and/or home range data of particular shorebird species is needed to verify expert opinion regarding most of these boundaries. We review how enhanced boundaries improve the ability of shorebird monitoring to detect population changes; allow management of shorebird habitats at relevant spatial scales; and lead to appropriate designations of important areas. While the kinds of approaches to boundary setting described here are not new, they are not consistently applied worldwide. We suggest additional guidelines to those produced under the Ramsar Convention in regard to designating important areas. We also call for more studies on the movements of migratory shorebirds during the non-breeding season to direct more consistent boundary setting around important non-breeding habitats used by local populations of migratory shorebirds.

Catry T, Alves JA, Gill JA, Gunnarsson TG, Granadeiro JP. 2014. Individual specialization in a shorebird population with narrow foraging niche. *Acta Oecologica* **56**, 56-65.

(Abstract)

Individual specialization in resource use is a widespread driver for intra-population trait variation, playing a crucial evolutionary role in free-living animals. We investigated the individual foraging specialization of Black-tailed Godwits (*Limosa limosa islandica*) during the wintering period. Godwits displayed distinct degrees of individual specialization in diet and microhabitat use, indicating the presence of both generalist and specialist birds. Females were overall more specialist than males, primarily consuming polychaetes. Specialist males consumed mainly bivalves, but some individuals also specialized on gastropods or polychaetes. Sexual dimorphism in bill length is probably important in determining the differences in specialization, as longer-billed individuals have access to deep-buried polychaetes inaccessible to most males. Different levels of specialization within the same sex, unrelated to bill length, were also found, suggesting that mechanisms other traits are involved in explaining individual specialization. Godwits specialized on bivalves achieved higher intake rates than nonspecialist birds, supporting the idea that individual foraging choices or skills result in different short-term payoffs within the same population. Understanding whether short-term payoffs are good indicators of long-term fitness and how selection operates to favour the prevalence of specialist or generalist godwits is a major future challenge.

Lunardi VO, Macedo RH. 2014. Shorebirds can adopt foraging strategies that take advantage of human fishing practices. *Emu* **114**, 50–60.

(Abstract)

Human presence and activities are considered to be a potential threat to many species, mainly because they interfere with the abilities of many animals to exploit essential resources. In this study we investigate the influence of human presence and activities on the behaviour of nine shorebird species in an intertidal area at Baía de Todos os Santos, northeastern Brazil. The area is used both by shorebirds and traditional human community to extract invertebrates for food, and also used by people for recreation. We analyse and compare the foraging behaviour of shorebirds under three different conditions: absence of humans, presence of humans manually gathering shellfish (shellfishing), and presence of humans engaged in recreational activity. Recreational activity was associated with greater behavioural change to the shorebirds than shellfishing. Shorebirds were less plentiful, showed lower foraging rates and moved around more when exposed to recreational activity. Larger shorebirds were less abundant when shellfishing or recreational activities were taking place. Intertidal areas of sediment manually overturned by shellfishers had higher rates of shorebird foraging and agonistic encounters, suggesting that shorebirds' foraging strategies take advantage of human shellfishing. These results can be interpreted within a conservation framework to provide guidelines for the management decisions in areas used by shorebirds.

Santiago-Quesada F, Masero JA, Albano N, Sánchez-Guzmán JM. 2014. Roost location and landscape attributes influencing habitat selection of migratory waterbirds in rice fields. *Agriculture, Ecosystems and Environment* **188**, 97–102.

(Abstract)

An analysis of habitat selection and use patterns by the near-threatened black-tailed godwit (*Limosa limosa*), a long-distance migratory waterbird, was conducted in rice fields of southern Europe during their northwards migration. A complete set of factors was assessed, including food availability, crop management, predation risk, human disturbance, habitat structure, and the presence of roosting areas. Additionally, by tracking radio-tagged godwits, the home range of this waterbird species was established while staging in the rice fields. Godwits selected as foraging grounds flooded, rolled pans that minimised their movements (average home range: 4919 ± 2226 ha) between the roosting and foraging grounds. The presence of power lines in the rice fields was the most important landscape factor affecting the location of the godwits' roosts, which were also flooded, rolled pans. The quality of rice fields as a key staging area for godwits lay in the presence not only of suitable foraging areas, but also of roosting sites. This study highlights for first time the key role of some facilities and the availability of roosting sites in determining the use of rice fields by migratory waterbirds such as godwits.

Martins RC, Catry T, Granadeiro JP. 2014. Crossbow-netting: a new method for capturing shorebirds. *Journal of Field Ornithology* **85**, 84-90.

(Abstract)

Capturing shorebirds during the non-breeding season can be challenging because they are usually scattered over wide-open intertidal areas while foraging and are sensitive to human disturbance at roosts where they gather during high tide in large vigilant flocks. Several techniques are available for capturing shorebirds, but, for a study of stopover ecology, we needed a method that would allow us to capture Dunlins (*Calidris alpina*) on a regular basis at high-tide roosts during the day (ruling out mist-nets), did not require the use of gun-powder (ruling out cannon-nets), and that would deploy a net faster than clap nets, whoosh nets, and wilsternets. Therefore, we developed a new method to capture shorebirds where a crossbow is used to pull a mist-net over flocks of roosting birds. We tested this technique in four habitats (saltpans, salt marshes, beaches, and mudflats) in the Tagus estuary, Portugal, and captured over 380 birds representing eight different species. Advantages of this technique compared to other methods (e.g., mist-nets, clap- and whoosh nets, and cannon-nets) include (1) portability, (2) ease of set up, (3) minimal disturbance of birds near the capture area, and (4) no explosive materials are needed. Our results suggest that crossbow-netting is a safe and useful capture technique, especially for studies requiring the capture of small numbers of birds on a regular basis.

Salem MVA, van der Geest M, Piersma T, Saoud Y, van Gils JA. 2014. Seasonal changes in mollusc abundance in a tropical intertidal ecosystem, Banc d'Arguin (Mauritania): Testing the 'depletion by shorebirds' hypothesis. *Estuarine, Coastal and Shelf Science* **136**, 26-34.

(Abstract)

At temperate latitudes densities and biomass of intertidal molluscs tend to be strongly seasonal. Here we provide a comparative study on seasonality of bivalves and gastropods in the tropical intertidal seagrass-covered soft sediment environment of Banc d'Arguin, Mauritania (20^{o}N, 16^{o}W). In this system, benthivorous shorebirds exert considerable predation pressure with strong seasonal variations. It has been proposed that during the period when (adult) shorebirds are absent (May-August) benthic biomass would be able to recover, but a first test was inconclusive. Over a full year (March 2011-February 2012), each month we sampled benthic invertebrates at sixteen permanent sites. The total of 3763 specimens comprised 20 species, representing eight orders and 19 families. Bivalves were much more common than gastropods. The bivalve *Loripes lucinalis* dominated the assemblage throughout the year (58% of total number), followed by *Dosinia isocardia* (10%), *Senilia senilis* (8%) and the gastropod *Gibbula umbilicalis* (6%). Average biomass amounted to 32 g

AFDM/m^2, of which the large West-African bloody cockle *Senilia* made up three-quarter, *Loripes* 16%, *Gibbula* 2% and *Dosinia* 1%. Across the 20 species, lowest densities were reached in late spring (May) and summer (Aug.), whereas highest densities occurred in autumn (Oct.). The lowest overall density of 676 specimens/m^2 in August more than doubled to a peak density of 1538 specimens/m^2 in October, most of the increase being due to strong recruitment in both *Loripes* (densities increasing from 322 specimens/m^2 in Sept. to 785 specimens/m^2in Oct.) and *Dosinia* (densities increasing from 18 specimens/m^2 in Aug. to 265 specimens/m^2 in Sept.). Our results suggest that by the time the feathered molluscivore predators returned in high numbers to Banc d'Arguin (after their summer breeding season in the Arctic), benthic animals were at a peak. In order to quantitatively understand the seasonal changes in mollusc abundance, we build upon a recently published optimal diet model in which the most abundant molluscivore shorebird, the red knot (*Calidris canutus*), could choose between *Loripes* and *Dosinia*. Observed changes in densities of these two bivalves closely match depletion trajectories predicted by the model. We conclude that molluscivore shorebirds are able to deplete their food stocks in the course of their 'winter' in a tropical intertidal area.

Senner NR, Hochachka WM, Fox JW, Afanasyev V. 2014. An Exception to the Rule: Carry-Over Effects Do Not Accumulate in a Long-Distance Migratory Bird. *PLoS ONE* **9**, e86588.

(Abstract)

Recent years have seen a growing consensus that events during one part of an animal's annual cycle can detrimentally affect its future fitness. Notably, migratory species have been shown to commonly display such carry-over effects, facing severe time constraints and physiological stresses that can influence events across seasons. However, to date, no study has examined a full annual cycle to determine when these carry-over effects arise and how long they persist within and across years. Understanding when carry-over effects are created and how they persist is critical to identifying those periods and geographic locations that constrain the annual cycle of a population and determining how selection is acting upon individuals throughout the entire year. Using three consecutive years of migration tracks and four consecutive years of breeding success data, we tested whether carry-over effects in the form of timing deviations during one migratory segment of the annual cycle represent fitness costs that persist or accumulate across the annual cycle for a long-distance migratory bird, the Hudsonian godwit, *Limosa haemastica*. We found that individual godwits could migrate progressively later than population mean over the course of an entire migration period, especially southbound migration, but that these deviations did not accumulate across the entire year and were not consistently detected among individuals across years. Furthermore, neither the accumulation of lateness during previous portions of the annual cycle nor arrival date at the breeding grounds resulted in individuals suffering reductions in their breeding success or survival. Given their extreme life history, such a lack of carry-over effects suggests that strong selection exists on godwits at each stage of the annual cycle and that carry-over effects may not be able to persist in such a system, but also emphasizes that high-quality stopover and wintering sites are critical to the maintenance of long-distance migratory

populations.

Trimbos KB, Doorenweerd C, Kraaijeveld K, Musters CJM, Groen NM, de Knijff P, Piersma T, de Snoo GR. 2014. Patterns in Nuclear and Mitochondrial DNA Reveal Historical and Recent Isolation in the Black-Tailed Godwit (*Limosa limosa*). *PLoS ONE* **9**, e83949.

(Abstract)

On the basis of morphological differences, three subspecies of Black-tailed Godwit (*Limosa limosa*) have been recognized (*L. l. limosa*, *L. l. islandica* and *L. l. melanuroides*). In previous studies mitochondrial DNA (mtDNA) sequence data showed minimal genetic divergence between the three subspecies and an absence of sub-structuring within *L. l. limosa*. Here, population genetic structure and phylogeographic patterns have been analyzed using COI, HVR1 and HVR2 mtDNA sequence data as well as 12 microsatellite loci (nuDNA). The nuDNA data suggest genetic differentiation between *L. l. limosa* from Sweden and The Netherlands, between *L. l. limosa* and *L. l. islandica*, but not between *L. l. limosa* and *L. l. melanuroides*. However, the mtDNA data were not consistent with the nuDNA pattern. mtDNA did support a split between *L. l. melanuroides* and *L. l. limosa*/*L. l. islandica* and also demonstrated two *L. l. limosa* haplotype clusters that were not geographically isolated. This genetic structure can be explained by a scenario of isolation of *L. l. melanuroides* from *L. l. limosa* in Beringia during the Last Glacial Maximum. During the Pleistocene separation of *L. l. islandica* from *L. l. limosa* occurred, followed by colonization of Iceland by the *L. l. islandica* during the Holocene. Within *L. l. limosa* founder events, followed by population expansion, took place during the Holocene also. According to the patterns observed in both markers together and their geographic separation, we propose that the three traditional subspecies indeed represent three separate genetic units.

Van den Hout PJ, van Gils JA, Robin F, van der Geest M, Dekinga A, Piersma T. 2014. Interference from adults forces young red knots to forage for longer and in dangerous places. *Animal Behaviour* **88**, 137-146.

(Abstract)

In birds and mammals, juvenile and adult foragers are often found apart from each other. In this study, we found this is also true for red knots, *Calidris canutus canutus*, wintering on the intertidal flats of Banc d'Arguin, Mauritania. Not only did juveniles feed separately from adults, they also fed at places where they were more vulnerable to predation by large falcons. That the dangerous areas used by juveniles were no better feeding areas led us to reject the food-safety trade-off that explained age-related distribution differences in many earlier studies. Instead, juveniles were displaced by adults in dyadic interactions which suggests that they

suffered from interference from adults. Juveniles retreated to feeding areas that were more dangerous and yielded lower intake rates, and coped by extending foraging time by using higher, nearshore intertidal areas that were exposed for longer. When disturbed by predators in these nearshore areas, juveniles continued feeding whereas adults left. Thus, rather than compensating for increased predation danger by higher intake rates, on the Banc d'Arguin red knot juveniles foraged for longer.

Gill JA, Alves JA, Sutherland WJ, Appleton GF, Potts PM, Gunnarsson TG. 2014. Why is timing of bird migration advancing when individuals are not? *Proceedings of the Royal Society of London, B* **281**, 20132161.

(Abstract)

Recent advances in spring arrival dates have been reported in many migratory species but the mechanism driving these advances is unknown. As population declines are most widely reported in species that are not advancing migration, there is an urgent need to identify the mechanisms facilitating and constraining these advances. Individual plasticity in timing of migration in response to changing climatic conditions is commonly proposed to drive these advances but plasticity in individual migratory timings is rarely observed. For a shorebird population that has significantly advanced migration in recent decades, we show that individual arrival dates are highly consistent between years, but that the arrival dates of new recruits to the population are significantly earlier now than in previous years. Several mechanisms could drive advances in recruit arrival, none of which require individual plasticity or rapid evolution of migration timings. In particular, advances in nest-laying dates could result in advanced recruit arrival, if benefits of early hatching facilitate early subsequent spring migration. This mechanism could also explain why arrival dates of short-distance migrants, which generally return to breeding sites earlier and have greater scope for advance laying, are advancing more rapidly than long-distance migrants.

Shorebirds 2014

Riegen, A. C., G. Vaughan, and K. G. Rogers. 2014. Yalu Jiang Estuary Shorebird Survey Report 1999 – 2010., Yalu Jiang Estuary Wetland National Nature Reserve, China and Miranda Naturalists' Trust, New Zealand.

(Abstract)

The Yalu Jiang Estuary Wetland National Nature Reserve (the Reserve) in NE China, adjacent to North Korea (DPRK) covers a total area of 101,000 hectares of intertidal mudflats, coastal

aquaculture ponds, rice paddies, reedbeds and part of the shallow seabed, along 60km of coastline westwards from the Yalu River. In 1999 it was discovered that the reserve and the adjacent areas are a major shorebird staging region on the East Asian-Australasian Flyway (EAAF). In 2002 the reserve was identified as one of nine mega sites, sites used by more than 100,000 shorebirds, in the Yellow Sea during migration. The Miranda Naturalists' Trust signed a partnership agreement with the reserve in 2004 and since then joint surveys with reserve staff have shown Yalu Jiang Estuary to be the most important staging site on the EAAF for migratory shorebirds with at least 250,000 passing through the area during northward migration (March–May). This report outlines the results of nine surveys that occurred between 1999 and 2010. A total of 41 shorebird species have been recorded in the reserve, 15 of these species occur annually or regularly in internationally important numbers (Ramsar Criteria). Included in this group is the critically endangered Spotted Greenshank. The Reserve and River are without doubt the most critical sites for Bar-tailed Godwit, with an estimated 90,000+ using the area while migrating north. The use of the reserve by the different godwit subspecies is under investigation but it is estimated that 70%-80% of all godwits migrating north from New Zealand will pass through the reserve. In 2007 the godwit 'E7' (being tracked by satellite (page 65)), flew 10,200km non-stop from Miranda in New Zealand to the Yalu Jiang Estuary a journey taking over seven days. It is estimated that 70,000-80,000 Great Knot, and 22,000 Eurasian and Eastern Curlews also pass through the reserve on northward migration. Migrating population estimates are given for five more species in this report; minimum numbers are given for those species where an estimate cannot yet be made. Shorebirds gather at 15 main areas (known as Sites) along the reserve's 60km of coastline on the incoming tide, before moving to aquaculture ponds and the River to roost. Birds were counted at these sites during surveys. The sites with the highest counts of shorebirds were concentrated at the eastern end of the reserve (near Donggang) with the highest count being 73,583 recorded in late April. A further seven sites have counts of over 20,000 each. These counts focus on roosting distribution, which may differ from feeding distribution. Over 1,000 banded and other marked shorebirds from 19 regions in 8 countries have been identified in the reserve and River, highlighting Yalu Jiang Estuary's location as a focal point during migration for shorebirds from many parts of the flyway. Recommendations for the protection of shorebirds at Yalu Jiang Estuary Wetland National Nature Reserve are presented. It is hoped these suggestions and recommendations can provide a reference for effecting the conservation of the Yalu Jiang Estuary Wetland. New Zealand and China are tied together by the epic journey of the Bar-tailed Godwit. To protect this and the other species, we must work together.

Choi C, Battley PF, Potter MA, Ma Z, Liu W. 2014. Factors Affecting the Distribution Patterns of Benthic Invertebrates at a Major Shorebird Staging Site in the Yellow Sea, China. *Wetlands* **34**:1085–1096.

(Abstract)

The tidal flats of the Yellow Sea support benthic communities that are vitally important to migratory birds, but baseline information on benthic community structure and variability is

largely lacking. We investigated spatial and temporal patterns of macrobenthic invertebrates in areas used by large numbers of shorebirds and how these patterns related to environmental factors at Yalu Jiang coastal wetland in the north Yellow Sea during boreal spring (March–May) from 2010 to 2012. At least 61 species were documented during the study. Monthly benthos sampling from 54 stations indicated that polychaetes and bivalves dominated the benthic communities, with capitellid or maldanid polychaetes dominating upper tidal flats and the bivalve *Potamocorbula laevis* dominating intermediate and lower tidal flats. The middle and eastern sites approximately 10 km apart showed substantial differences in benthic species abundance and distribution, with bivalves dominating in the middle but not the eastern site. The spatial distribution of benthos was correlated with both exposure time during the tidal cycle and sediment particle size. Benthic communities showed both annual and within season variation. Two of the frequent prey for migratory birds, namely ghost shrimps *Nihonotrypaea japonica* and young *Potamocorbula laevis*, were relatively common in 2010 and 2011, respectively, but not in 2012.

Navedo JG, Fernández G, Fonseca J, Drever MC. 2014 in press. A Potential Role of Shrimp Farms for the Conservation of Nearctic Shorebird Populations. *Estuaries and Coasts*.

(Abstract)

Shrimp aquaculture farms have greatly expanded at tropical areas worldwide, especially during the past three decades. One of the main core areas of this expansion was the northwestern coast of Mexico, prompting conservation concern for the shorebird populations that spend the nonbreeding period (October to March) in the region. We conducted a series of counts and behavioral observations to evaluate the importance of a shrimp farm as foraging habitat for shorebirds, relative to adjacent intertidal areas, during and after the shrimp harvest period at a tropical wetland in Sinaloa, Mexico, 2012 and 2013. Overall, low-tide counts within the entire wetland had an average of 3,168±605 (SE) shorebirds during the shrimp harvest period (October–November) and subsequently dropped to 1,408±373 birds following harvest (December to January), when shrimp ponds were emptied and foraging opportunities were reduced. The proportion of counts at the shrimp farm relative to total counts over the entire wetland ranged from 10 to 80%for different shorebird species and dropped to 0 to 10%in the postharvest period. During the harvesting period, black-necked stilt, American avocet, willet, and whimbrel selected shrimp ponds over intertidal areas to forage during low tide, while marbled godwit, western sandpiper, and dowitchers did not. The proportion of shorebirds observed feeding at the shrimp farm ranged between 60 and 90%for most species and did not differ between low- and high-tide counts. These results suggest that shrimp farms can provide ephemeral but important complementary foraging areas for shorebirds, and appropriate management of existing farms may aid in conservation efforts for these species.

Douglas, D. J. T., and J. W. Pearce-Higgins. 2014. Relative importance of prey abundance and habitat structure as drivers of shorebird breeding success and abundance. *Animal Conservation* **17**:535–543.

(Abstract)

Understanding large-scale drivers of animal breeding densities and demography has a range of important uses, including informing conservation management. Given the threat of climate change, the importance of developing a process-based understanding of variation in animal populations is increased to inform adaptive management. For a climate-change sensitive species, the European Golden Plover *Pluvialis apricaria*, we use novel field-collected data on large-scale spatial variation in prey abundance and vegetation structure to understand drivers of breeding abundance and breeding success, and inform potential management responses. The abundance of the key prey, crane flies (Tipulidae), increased with altitude (a surrogate for temperature) and peat depth (a surrogate for soil moisture). Golden plover breeding densities were highest where vegetation was shortest, probably reflecting greater prey accessibility. In contrast, breeding success was not strongly related to vegetation height, but positively correlated with both crane fly abundance and daily minimum temperatures. When combined to model the number of likely successful pairs in any 1 year, the magnitude of vegetation height effect far exceeded that of crane fly abundance. Thus, for golden plover and other shorebirds sharing similar habitats, management to optimize breeding habitat (grazing or burning to promote short vegetation) may differ from management to promote breeding success (drain blocking to increase soil moisture and prey abundance). Adaptive management in the face of climate change should therefore include appropriate vegetation management, as well as maximizing prey abundance. More broadly, as the drivers of breeding density and demographic parameters may differ, we advocate that conservation practitioners collect not just information on species' distributions but also underpinning demographic processes when using science to inform management.

Susanto, H., I. Taufiqurrahman, and S. van Balen. 2014. Waders of Karimunjawa National Park, Central Java, Indonesia. *Stilt* **66**:1–9.

(Abstract)

Wader surveys were carried out between December 2007 and December 2013 covering eight areas in Karimunjawa National Park, Central Java, Indonesia. As a result, 23 wader species were recorded, with 10 new records for the park. Terusan on Kemujan Island is an intertidal area of approximately 10 hectares and had the highest number of species recorded. In Terusan, there were 17 species recorded with nine species not recorded elsewhere on the park. Oriental Pratincole (*Glareola maldivarum*), Whimbrel (*Numenius phaeopus*), Grey-tailed Tattler (*Heteroscelus brevipes*) and Common Sandpiper (*Actitis hypoleucos*) were the most common and widespread waders in Karimunjawa National Park. A compilation of all wader species listed for Karimunjawa NP, including historical records, is presented.

Crossland, A. C., A. W. Sitorus, and A. S. Sitorus. 2014. Land use change impacts shorebird habitat at an important site for Javan Plover *Charadrius javanicus* and Sanderling *Calidris alba*in Java, Indonesia. *Stilt* **66**:30–36.

(Abstract)

Pantai Glagah, a coastal wetland on the south coast of Java, Indonesia, is a breeding site for Javan Plover *Charadrius javanicus* and is both a nationally and internationally significant migration staging and non-breeding site for Sanderling *Calidris alba*. These species are classified as near threatened and least concern, respectively, by BirdLife International (2014). Visits, seven years apart, recorded substantial land use changes associated with a marked expansion in human recreational use of this site. We document a number of pressures that are likely to be detrimental to shorebirds. These pressures include high levels of habitat modification and degradation, human disturbance, and increased risk of nest trampling and predation by wandering domestic animals. We identify the need for management interventions to protect the notable wildlife values of Pantai Glagah and similar sites. Recommendations include identification and protection of high value areas for shorebirds,, restriction of public access to Javan Plover breeding sites,, habitat enhancement, community outreach and visitor education.

Chowdhury, S. U., M. A. Abu Diyan, C. Zöckler, M. Foysal, and H. W. Lemke. 2014. A survey of shorebirds in the Sundarbans of Bangladesh. *Stilt* **66**:10–13.

(Abstract)

A survey of shorebirds targeting the Critically Endangered Spoon-billed Sandpiper was carried out in the Sundarbans of Bangladesh between 14 and 16 January 2013. A total of 1691 shorebirds of 17 species were counted and the most abundant species was Lesser Sand Plover *Charadrius mongolus*, followed by Kentish Plover *Charadrius alexandrinus*, Common Redshank *Tringa totanus* and Greater Sand Plover *Charadrius leschenaultii*. Three notable species were recorded during surveys: the Near Threatened Eurasian Curlew *Numenius arquata* (n=68), Great Thick-knee *Esacus recurvirostris* (n=7) and the locally rare Eurasian Oystercatcher *Haematopus ostralegus longipes* (n=3). We find that the Sundarbans, which is designated as a Ramsar site and is still relatively intact, holds moderate numbers of shorebirds and is also an important site for Great Thick-knee. However, the site is under threat from a proposed power station and therefore warrants continued monitoring.

Zöckler, C., Z. Thet Naing, S. Moses, Y. Naung Soe, and T. Htin Hla. 2014. The importance of the Myanmar coast for water birds. *Stilt* **66**:37–51.

(Abstract)

Surveys of water birds at eight sites along the 3000 km long coast of Myanmar from 2008-2013 have shown that the country hosts a number of significant intertidal mudflat areas. It regularly provides home to more than 150,000 wintering and migrating water birds of 80 different species. The large majority of these birds occur in the Gulf of Mottama and in the adjacent Ayeyarwaddy Delta. Together with other sites, the Myanmar coast proved to be important for many water birds, and included a total of 10 globally threatened species. The waders were most prominent with 39 species being recorded. Among those was the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmeus*) for which coastal habitats in Myanmar hold more than 50% of the world population. Also, the Endangered Nordmann's Greenshank (*Tringa guttifer*) has been found in significant numbers and is one of 24 species where at least 1% of the global population is occurring on Myanmar's coast. Often, the combination of the intertidal mudflats with adjacent mangroves proved to be crucial for several water bird species, as shown in the case of the Vulnerable Lesser Adjutant Stork (*Leptoptilos javanicus*). Despite the significance of this coastline for water birds, hardly any of the intertidal sites or adjacent mangroves has any formal protection. With rapid coastal development threatening most of the sites, the protection of the most important of these sites is of high priority.

Norazlimi, N., and R. Ramli. 2014. Temporal Variation of Shorebirds Population in Two Different Mudflats Areas. *International Journal of Biological, Veterinary, Agricultural and Food Engineering***8**:1106-1112.

(Abstract)

A study was conducted to determine the diversity and abundance of shorebird species habituating the mudflat area of Jeram Beach and Remis Beach, Selangor, Peninsular Malaysia. Direct observation technique (using binoculars and video camera) was applied to record the presence of bird species in the sampling sites from August 2013 until July 2014. A total of 32 species of shorebird were recorded during both migratory and non-migratory seasons. Of these, eleven species (48%) are migrants, six species (26%) have both migrant and resident populations, four species (17%) are vagrants and two species (9%) are residents. The compositions of the birds differed significantly in all months ($\chi 2 = 84.35$, $p < 0.001$). There is a significant difference in avian abundance between migratory and non-migratory seasons (Mann-Whitney, $t = 2.39$, $p = 0.036$). The avian abundance were differed significantly in Jeram and Remis Beaches during migratory periods ($t = 4.39$, $p = 0.001$) but not during non-migratory periods ($t = 0.78$, $p = 0.456$). Shorebird diversity was also affected by tidal cycle. There is a significance difference between high tide and low tide (Mann-Whitney, $t = 78.0$, $p < 0.005$). Frequency of disturbance also affected the shorebird distribution (Mann-Whitney, $t = 57.0$, $p = 0.0134$). Therefore, this study concluded that tides and disturbances are two factors that

affecting temporal distribution of shorebird in mudflats area.

Bijleveld, A. I., G. Massourakis, A. van der Marel, A. Dekinga, B. Spaans, J. A. van Gils, and T. Piersma. 2014. Personality drives physiological adjustments and is not related to survival. *Proceedings of the Royal Society of London*, **B 281**:20133135.

(Abstract)

The evolutionary function and maintenance of variation in animal personality is still under debate. Variation in the size of metabolic organs has recently been suggested to cause and maintain variation in personality. Here, we examine two main underlying notions: (i) that organ sizes vary consistently between individuals and cause consistent behavioural patterns, and (ii) that a more exploratory personality is associated with reduced survival. Exploratory behaviour of captive red knots (*Calidris canutus*, a migrant shorebird) was negatively rather than positively correlated with digestive organ (gizzard) mass, as well as with body mass. In an experiment, we reciprocally reduced and increased individual gizzard masses and found that exploration scores were unaffected. Whether or not these birds were resighted locally over the 19 months after release was negatively correlated with their exploration scores. Moreover, a long-term mark–recapture effort on free-living red knots with known gizzard masses at capture confirmed that local resighting probability (an inverse measure of exploratory behaviour) was correlated with gizzard mass without detrimental effects on survival. We conclude that personality drives physiological adjustments, rather than the other way around, and suggest that physiological adjustments mitigate the survival costs of exploratory behaviour. Our results show that we need to reconsider hypotheses explaining personality variation based on organ sizes and differential survival.

Iwamura, T., R. A. Fuller, and H. P. Possingham. 2014. Optimal Management of a Multispecies Shorebird Flyway under Sea-Level Rise. *Conservation Biology* **28**:1710–1720.

(Abstract)

Every year, millions of migratory shorebirds fly through the East Asian–Australasian Flyway between their arctic breeding grounds and Australasia. This flyway includes numerous coastal wetlands in Asia and the Pacific that are used as stopover sites where birds rest and feed. Loss of a few important stopover sites through sea-level rise (SLR) could cause sudden population declines. We formulated and solved mathematically the problem of how to identify the most important stopover sites to minimize losses of bird populations across flyways by conserving land that facilitates upshore shifts of tidal flats in response to SLR. To guide conservation investment that minimizes losses of migratory bird populations during migration, we developed a spatially explicit flyway model coupled with a maximum flow algorithm.

Migratory routes of 10 shorebird taxa were modeled in a graph theoretic framework by representing clusters of important wetlands as nodes and the number of birds flying between 2 nodes as edges. We also evaluated several resource allocation algorithms that required only partial information on flyway connectivity (node strategy, based on the impacts of SLR at nodes; habitat strategy, based on habitat change at sites; population strategy, based on population change at sites; and random investment). The resource allocation algorithms based on flyway information performed on average 15% better than simpler allocations based on patterns of habitat loss or local bird counts. The Yellow Sea region stood out as the most important priority for effective conservation of migratory shorebirds, but investment in this area alone will not ensure the persistence of species across the flyway. The spatial distribution of conservation investments differed enormously according to the severity of SLR and whether information about flyway connectivity was used to guide the prioritizations. With the rapid ongoing loss of coastal wetlands globally, our method provides insight into efficient conservation planning for migratory species.

Cheverie, A. V., D. J. Hamilton, M. R. S. Coffin, and M. A. Barbeaub. 2014. Effects of shorebird predation and snail abundance on an intertidal mudflat community. *Journal of Sea Research* **92**:102–114.

(Abstract)

Top-down effects of predation are well documented in a variety of ecological communities, including marine soft-sediment systems. It has been proposed that intertidal mudflats in the upper Bay of Fundy, Canada, which host a large population of foraging shorebirds each summer, may exhibit this community dynamic. Biofilm (consisting mainly of diatoms) forms the base of the mudflat community food web, which is dominated by the amphipod Corophium volutator. To assess the potential for a trophic cascade, we conducted a manipulative field experiment examining individual and combined effects of the shorebird Calidris pusilla, a primary predator of C. volutator, and the eastern mudsnail (Nassarius obsoletus), an intraguild predator, on community structure (including macrofauna and large meiofauna retained by a 250-μm screen). Snails exhibited density-dependent top-down effects, primarily from strong negative interactions with juvenile and adult C. volutator, likely due to interference, consumption and emigration. Medium and high densities of snails reduced chlorophyll a concentration (a measure of diatom abundance), likely through consumption and disturbance of the sediment. When present at higher densities, snails also increased variability in community structure. Shorebirds were less influential in determining community structure. They reduced C. volutator biomass through consumption, but there was no resulting effect on primary production. Top-down effects of snails and birds were cumulative on C. volutator, but did not generate a trophic cascade. We suggest that a combination of omnivory and intraguild predation by shorebirds and snails, coupled with relatively low grazing pressure by C. volutator, prevented transmission of top-down effects.

Bocher, P., F. Robin, J. Kojadinovic, P. Delaporte, P. Rousseau, C. Dupuy, and P. Bustamante. 2014. Trophic resource partitioning within a shorebird community feeding on intertidal mudflat habitats. *Journal of Sea Research* **92**:115–124.

(Abstract)

In ecological systems, it is necessary to describe the trophic niches of species and their segregation or overlap to understand the distribution of species in the community. In oceanic systems, the community structure of top predators such as seabird communities has been well documented with many studies in several biogeographical areas. But for coastal habitats, very few investigations on the trophic structure have been carried out in avian communities. In this study, the trophic resource partitioning was investigated on eight of the most abundant species of a shorebird community on the central Atlantic coast of France. Our work comprised a comprehensive sample of birds with different ecomorphogical patterns and data on their main prey to encompass potential sources of overlap and segregation in this community. We examined the stable carbon (δ13C) and nitrogen (δ15N) isotopic composition of blood to investigate the trophic structure (1) on a temporal scale by comparing migration and wintering periods; (2) on a spatial scale through inter-site comparisons; and (3) on the community level within groups of phylogenetically related species. Diets appeared different in several cases between periods, between sites and between juveniles and adults for the same sites. A clear trophic partitioning was established with four functional groups of predators in winter inside the community. The Grey Plover, the Bar-tailed Godwit, the Curlew and a majority of the dunlins were worm-eaters mainly feeding on Nereis diversicolor or Nephtys hombergii. Two species were predominantly deposit-suspensivorous mollusc-eaters, including the Red Knot and the Black-tailed Godwit feeding mainly on Macoma balthica. The Oystercatcher fed mainly on suspensivorous molluscs like Cerastodrema edule and two species including the Redshank and some dunlins adopted opportunistic behaviours feeding on mudflat and/or in marshes.

Grond, K., H. Ryu, A. J. Baker, J. W. Santo Domingo, and D. M. Buehler. 2014. Gastro-intestinal microbiota of two migratory shorebird species during spring migration staging in Delaware Bay, USA. *Journal of Ornithology* **155**: 969–977.

(Abstract)

Migratory birds travel long distances and use diverse habitats, potentially exposing them to a broad range of microbes that could negatively affect their health and survival. Gut microbiota composition may be related to organismal health especially during periods of impaired immunity due to stress, by functioning as a reservoir for potential pathogens. We provide an insight into the composition of the gastrointestinal microbiota in migratory Red Knot (Calidris canutus) and Ruddy Turnstone (Arenaria interpres) staging in Delaware Bay, USA, by analyzing fecal bacterial communities of three individuals per species with 16S rRNA clone

libraries. In the 313 bacterial sequences we analysed from Red Knots, we identified 19 bacterial classes across 29 genera, and from the 218 Ruddy Turnstone sequences, we identified 11 bacterial classes across 17 genera. In Red Knots and Ruddy Turnstones, 27 and 41% of all sequences were closely related to Campylobacter spp., which include several human pathogens. Only 5 of the 46 genera, and 8 out of 124 operational taxonomic units were shared between species, suggesting that gut microbial community structure can be species-specific under environmentally similar conditions. Our study provides baseline information that can be used in future studies to better understand diversity and function of gut microbes, and can be expanded to investigate how gut microbiota of migratory birds affects their body condition, immune function, and demographic performance.

Jamieson, S. E., R. C. Ydenberg, and D. B. Lank. 2014. Does predation danger on southward migration curtail parental investment by female western sandpipers? *Animal Migration* **2**: 34–43.

(Abstract)

Theory predicts that if extending parental care delays migratory departure, and if later migration is more dangerous, then parental care should be curtailed to make an earlier departure. Adult western sandpipers (*Calidris mauri*) depart Alaska in July, and the presence of peregrine falcons (*Falco peregrinus*) along their route rises steeply during the migratory period. Pacific dunlins (*C. alpina pacifica*) are ecologically similar, but do not depart Alaska until October, after peregrine passage has peaked. Because peregrine migration begins earlier in years with early snowmelt, we predicted that the curtailment of parental investment by western sandpiper, but not of Pacific dunlins, should be more pronounced in these more dangerous years. We measured breeding phenology of these species on the Yukon Delta National Wildlife Refuge during three seasons with strongly differing snowmelt timing. We found that they initiated breeding simultaneously, and that western sandpipers, but not Pacific dunlins, ceased laying increasingly earlier, provided increasingly less parental care and departed increasingly sooner as snowmelt was earlier. Advancing departure date by the overall average of 5.2 d relative to dunlin reduces migratory exposure to peregrines by an estimated 18%. Our results support the hypothesis that natural selection has favored curtailment of parental investment by western sandpipers to advance migratory departure.

Kuwae, T., E. Miyoshi, S. Hosokawa, K. Ichimi, J. Hosoya, T. Amano, T. Moriya, M. Kondoh, R. C. Ydenberg, and R. W. Elner. 2012. Variable and complex food web structures revealed by exploring missing trophic links between birds and biofilm. *Ecology Letters* **15**:347–356.

(Abstract)

Food webs are comprised of a network of trophic interactions and are essential to elucidating ecosystem processes and functions. However, the presence of unknown, but critical networks hampers understanding of complex and dynamic food webs in nature. Here, we empirically demonstrate a missing link, both critical and variable, by revealing that direct predator-prey relationships between shorebirds and biofilm are widespread and mediated by multiple ecological and evolutionary determinants. Food source mixing models and energy budget estimates indicate that the strength of the missing linkage is dependent on predator traits (body mass and foraging action rate) and the environment that determines food density. Morphological analyses, showing that smaller bodied species possess more developed feeding apparatus to consume biofilm, suggest that the linkage is also phylogenetically dependent and affords a compelling re-interpretation of niche differentiation. We contend that exploring missing links is a necessity for revealing true network structure and dynamics.

Kuwae, T., E. Miyoshi, S. Sassa, and Y. Watabe. 2010. Foraging mode shift in varying environmental conditions by dunlin Calidris alpina. *Marine Ecology Progress Series* **406**: 281–289.

(Abstract)

Predators may have a series of alternative foraging modes. Under the food resource maximization hypothesis, predators are expected to shift between foraging modes such that they attain the highest intake rate in response to prey availability and constraints varying with environmental conditions. To test this hypothesis, we measured foraging action rate (actions per unit time), capture rate (captures per unit time), and intake rate (amount of energy and nutrients per unit time) for 2 foraging modes, pecking (feeding on epifauna at the sediment surface) and probing (feeding on infauna by inserting the bill into the sediment), in dunlin Calidris alpina on an intertidal sandflat. The birds chose their foraging mode to attain higher feeding success, i.e. individuals that obtained higher capture and intake rates by pecking allocated a higher proportion of foraging effort to pecking, and vice versa. The birds shifted foraging mode from probing to pecking with increased time after emersion. The shift may be related to decreasing efficiency of probing due to increases in the costs of energy and time caused by decreasing sediment penetrability (increasing hardness) with time after emersion. Our in situ study empirically suggests that, while environmental constraints reduce the predators' foraging mode flexibility, the birds show individual-based appropriate adjustments in their foraging mode to attain a higher intake rate at a given time and patch. This extends the ideal forager model for patch choice into foraging mode choice.

Lim, H. C., and M. R. C. Posa. 2014. Distribution and prey of migratory shorebirds on the northern coastline of Singapore. *Raffles Bulletin Of Zoology* **62**: 701–717.

(Abstract)

Singapore is a part of the East Asian-Australasian Flyway. The identification and continued protection of breeding, wintering and stopover sites within the flyway are essential for the survival of the flyway's migratory shorebirds. Here, we conducted 11 monthly (March 2003 to January 2004) high tide and low tide surveys of shorebirds in eight wetland sites (comprising mainly mangroves and intertidal mudflats) along the northern coast of Singapore. Internationally important numbers of common redshank, common greenshank and Pacific golden plover were found during the southward migration period in two sites. Other common shorebird species in our sites were: whimbrel, marsh sandpiper, common sandpiper, curlew sandpiper and lesser sand plover. Our data suggest that at least common redshank and Pacific golden plover used Singapore's wetlands for staging during southward migration. Two species, curlew sandpiper and lesser sand plover, did not use our sites for wintering, although the latter were found in other, sandier intertidal habitats in Singapore during countrywide winter counts. Mud coring and diet analysis revealed that polychaetes (in particular Family Nereididae) were dominant members of the benthic infauna, and were commonly depredated by shorebirds. The benthic infauna communities of the study sites were rich, with sites containing polychaetes belonging to 8–15 families. At the level of ponds or mudflat patches, we found a weak positive influence of nereidid polychaete density on shorebird abundance during low tides. Given the recent loss of natural habitats from Singapore's shores, we suggest that some of these sites be protected to serve conservation and educational purposes.

Liebezeit JR, Gurney KEB, Budde M, Zack S, Ward D. 2014. Phenological advancement in arctic bird species: relative importance of snow melt and ecological factors. *Polar Biology* **37**, 1309-1320.

(Abstract)

Previous studies have documented advancement in clutch initiation dates (CIDs) in response to climate change, most notably for temperate-breeding passerines. Despite accelerated climate change in the Arctic, few studies have examined nest phenology shifts in arctic breeding species. We investigated whether CIDs have advanced for the most abundant breeding shorebird and passerine species at a long-term monitoring site in arctic Alaska. We pooled data from three additional nearby sites to determine the explanatory power of snow melt and ecological variables (predator abundance, green-up) on changes in breeding phenology. As predicted, all species (semipalmated sandpiper, *Calidris pusilla*, pectoral sandpiper, *Calidris melanotos*, red-necked phalarope, *Phalaropus lobatus*, red phalarope, *Phalaropus fulicarius*, Lapland longspur, *Calcarius lapponicus*) exhibited advanced CIDs ranging from 0.40 to 0.80 days/year over 9 years. Timing of snow melt was the most important variable in explaining clutch initiation advancement (''climate/snow hypothesis'') for four of the five species, while green-up was a much less important explanatory factor. We found no evidence that high predator abundances led to earlier laying dates (''predator/re-nest hypothesis''). Our results support previous arctic studies in that climate change in the cryosphere will have a strong impact on nesting phenology although factors

explaining changes in nest phenology are not necessarily uniform across the entire Arctic. Our results suggest some arctic-breeding shorebird and passerine species are altering their breeding phenology to initiate nesting earlier enabling them to, at least temporarily, avoid the negative consequences of a trophic mismatch.

Whitfield DP, Rae R. 2014. Human disturbance of breeding Wood Sandpipers *Tringa glareola*: implications for “alert distances” in prescribing protective buffer zones. *Ornis Fennica* **91**, 57–66.

(Abstract)

Separation of animals and humans using a protective set-back distance (Minimum Approaching Distance) is a popular tool for conservation managers to promote wildlife-human coexistence. In several cases, Minimum Approaching Distance is based on how animals respond to an approaching human, using Flight Initiation Distance or Alert Distance. Alert Distance, when animals first show increased vigilance to an approaching human, is considered the best basis for Minimum Approaching Distance because animals have time to adapt their response. Alert Distance is frequently difficult or impossible to measure in practice, however, especially in breeding birds. Using a study of breeding Wood Sandpipers *Tringa glareola*, in which Alert Distance could not be measured directly, we tested three possible solutions to this dilemma. Alarm Call Distance did not appear to provide a useful substitute for Alert Distance because sandpipers probably alarm called after they had first detected a human. Published predictions of Alert Distance using body mass also failed to provide realistic estimates of disturbance distances in Wood Sandpipers. The “fixed-slope rule”, which predicts that Alert Distance is about double Flight Initiation Distance, was not supported by relationships between Alarm Call Distance and Flight Initiation Distance, but was supported by a relationship between an estimated Alert Distance surrogate and Flight Initiation Distance. This suggests that this rule may have general utility in predicting Alert Distance when only the more readily measured Flight Initiation Distance metric is known. A Minimum Approaching Distance (protective buffer zone) of 160 m is recommended for breeding Wood Sandpipers.

Santiago-Quesada F, Estrella SM, Sanchez-Guzman JM, Masero JA. 2014. Why water birds forage at night: a test using black-tailed godwits *Limosa limosa* during migratory periods. *Journal of Avian Biology* **45**, 406–409.

(Abstract)

Many migratory water birds are known to feed both during day and night outside the breeding season, but the underlying factors and mechanisms determining this foraging pattern are poorly understood. We addressed this topic by comparing both diurnal and nocturnal foraging

activity (FA) and metabolizable energy intake rate (MEIR) in migrating black-tailed godwits *Limosa limosa* staging in two different habitats, rice fields and coastal salt pans. Black-tailed godwits staging in rice fields during pre-breeding migration fed on rice seeds, and only foraged during the daylight period (FA: 81.89 +/- 3.03%; MEIR: 1.15 +/- 0.03 kJ/min). Daily energy consumption (DEC) of godwits relying on seeds was enough to meet the theoretical daily energy expenditure (DEE). In contrast, black-tailed godwits staging in salt pans during post-breeding migration fed on chironomid larvae, and they foraged during both daylight (FA: 67.36 +/- 4.30%; MEIR: 0.27 +/- 0.01 kJ/min) and darkness (FA: 69.89 +/- 6.89%; MEIR: 0.26 +/- 0.00 kJ/min). Nocturnal energy intake contributed 31.7% to DEC, the latter being insufficient to fully meet DEE. Our findings give empirical support to the view that diurnal foraging is the norm in many migratory water birds outside the breeding season, and nocturnal foraging occurs when the daily energy requirements are not met during the daylight period, supporting the supplementary food hypothesis.

Lucia M, Bocher P, Chambosse M, Delaporte P, Bustamante P. 2014. Trace element accumulation in relation to trophic niches of shorebirds using intertidal mudflats. *Journal of Sea Research* **92**, 134-143.

(Abstract)

This study investigated the link between trace element concentrations and respective diets of two shorebird species present in the Pertuis Charentais, Atlantic coast of France: the Dunlin (*Calidris alpina*) and Redshank (*Tringa totanus*). Trace element concentrations (Ag, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn) were investigated in the liver, kidney, muscle and feathers of 28 dunlins and 15 redshanks accidentally dead during catches by mist net. Analyses of carbon and nitrogen stable isotope ratios were carried out in liver, muscle and feathers to determine whether differences in diet explained the variations in elemental levels. These results were compared to previous data obtained on two other shorebird species present on the same sites: the Black-tailed Godwit (*Limosa limosa*) and the Red Knot (*Calidris canutus*). This study demonstrated that shorebirds of the Pertuis Charentais were characterized by differential trace element bioaccumulation. Arsenic and Se concentrations in internal tissues were elevated in red knots and dunlins, whereas redshanks displayed higher Cd concentrations. These trace element bioaccumulation discrepancies could mainly come from divergences of trophic habits between shorebirds. Species with the highest trophic position displayed the highest Hg concentrations in the liver, muscle and feathers demonstrating therefore the biomagnification potential of this metal, as opposed to Cd and Pb. The same trend was observed in muscle and feathers for Se and only in feathers for As. These data highlighted the need to study several tissues to obtain a full comprehension of trace element exposure and pathways especially for long-distance migrating species using various habitats and sites.

Smart J, Wotton SR, Dillon IA, Cooke AI, Diack I, Drewitt AL, Grice PV, Gregory RD. 2014. Synergies between site protection and agri-environment schemes for the conservation of waders on lowland wet grasslands. *Ibis* **156**, 576–590.

(Abstract)

Two conservation strategies have been put in place in Europe to address precipitous population declines of wading birds that breed on lowland wet grasslands. These are site protection and agri-environment schemes (AESs) and the two are rarely compared, or their synergy assessed. Increasingly, efforts to recover populations of previously widespread species follow a landscape-scale approach whereby habitat improvement takes place at key sites through partially overlapping protected area management and AESs. To investigate whether site protection and AESs improve the conservation status of breeding waders and how these interact, we partially repeated a 2002 survey of breeding waders on protected areas (nature reserves and Sites of Special Scientific Interest) and sites with wader-specific AES options in England in 2009 and 2010. We then assessed the individual and combined effects of these delivery mechanisms on field occupancy, breeding density and population change of four species of declining wader (Northern Lapwing *Vanellus vanellus*, Common Snipe *Gallinago gallinago*, Eurasian Curlew *Numenius arquata* and Common Redshank *Tringa totanus*). Although results for Curlew differed from the other species, in general field occupancy was positively influenced by conservation delivery mechanisms, with the highest occupancy and breeding densities on land where site protection was combined with wader-specific AES options. Field occupancy varied between different types of AES, with higher occupancy associated with higher-level options in fields, particularly those on nature reserves. Outside nature reserves, the history of AES management did not influence wader populations, but within nature reserves and on fields that gained AES management between 2002 and 2009–2010, populations of Curlew and Snipe were more likely to have persisted and population change in Snipe and Lapwing was more positive. We conclude that the conservation of breeding waders will be most effective when site protection and AES management are combined on the same land. Using limited AES money to support management for breeding waders on, around and between the existing network of protected sites will protect remaining populations while presenting opportunities for population expansion in future.

Lanctot RB, Brown S, Sandercock BK. 2014. '2010 – 2013 Progress Report: Using a Network of Sites to Evaluate How Climate-mediated Changes in the Arctic Ecosystem are Affecting Shorebird Distribution, Ecology and Demography.' Unpublished report by the U.S. Fish and Wildlife Service, Manomet Center for Conservation Sciences and Kansas State University to the Arctic Landscape Conservation Cooperative. U.S. Fish and Wildlife Service, Anchorage, AK.

(Abstract)

To obtain a better understanding of how shorebirds will respond to climate-mediated changes in the Arctic's morphology and ecology, we have established a network of sites, known as the Arctic Shorebird Demographics Network (ASDN), wherein we collected information on a suite of predictor variables thought to be responsive to climate change, with a future goal of correlating these variables with measures of shorebird distribution, ecology, and demography. Starting in 2010, we established nine field sites across the Arctic, from Nome, Alaska to Hudson Bay, Nunavut. The number of sites was expanded from 9 to 11 sites in 2011, 11 to 14 in 2012, and 14 to 16 in 2013. Protocols were adopted/modified from prior studies in the Arctic to create a standardized protocol that has been updated prior to each field season. We have compiled all of the data from the various sites during the first four years of the ASDN operation, and results from all four field seasons are presented here. A total of 6,691 nests belonging to 38 species were located in the first four years of the study. The largest number of nests belonged to the five ASDN focal species: Dunlin, Semipalmated Sandpipers, Red and Red-necked Phalaropes, and Pectoral Sandpipers. Unexpectedly high number of Western Sandpiper and American Golden-Plovers were also discovered. Nest initiation dates varied tremendously across sites for the focal shorebird species investigated during this study. Apparent nest success was 48% across all sites and species; rates varied between years within sites, and also between sites within years. An investigation into what environmental variables best explain the variation in nest success is underway. A total of 5,237 adults belonging to 29 species were banded in the first four years of the study. The number of adults banded per species ranged from 1 to 1,422 during the study (mean ± SD = 180.6 ± 329.0). ASDN focal species were again captured the most frequently, but like nests, high numbers of Western Sandpipers and American Golden-Plovers were also captured. The highest returns of color-marked adults were observed in Dunlin, Red-necked Phalarope, Semipalmated Sandpiper, Western Sandpiper, and Whimbrel, which should allow adult survival estimates to be made (detailed analysis beginning now). Besides the shorebird data, field personnel kept daily species lists, and established sampling stations to document aquatic and terrestrial invertebrate diversity, phenology, and abundance. In addition, data were collected on predators, small mammals and other alternative prey for predators of shorebirds, snow and surface water, and general climatic variables. ASDN principal investigators and other partners are collaborating on 18 projects that use the geographically vast and taxonomically rich ASDN data. ASDN studies include investigations of the potential for an ecological mismatch between invertebrate emergence and shorebird hatching, variation in shorebird nest predation across the Arctic, assessment of predator diversity and abundance in relation to human development, and factors affecting shorebird settlement patterns. Avian health issues being investigated include avian influenza, avian malaria, gut microbiota, and mercury exposure. Migratory connectivity studies include projects using light-level geolocators to document migratory pathways and wintering areas of American Golden-Plover, Dunlin, and Semipalmated Sandpipers. An additional study is using stable isotope signatures to document connections between breeding, migration and wintering areas of Semipalmated Sandpipers. Other studies are focusing on the effects of spring phenology on timing of breeding in shorebirds, invertebrate phenology in relation to habitat and weather, long-distance dispersion of moss by shorebirds, and the distribution of Arctic invertebrates. The ASDN principal investigators have been highly successful at producing products from the data collected at their field sites. Although the major analyses and publications that will address core objectives of the ASDN have not been completed, investigators have collectively produced 24 peer-reviewed publications, 25 reports, and 57 presentations. We anticipate that many more publications will

be produced in the coming years. Although this report summarizes information collected between 2010 and 2013, we are preparing for the fifth of five originally proposed field seasons. A report summarizing the fifth field season will be available in March 2015.

Eiamampai K, Nimnuan S, Sornsa T, Phothieng D, Thong-Aree S, Ittiporn K, Rogers KG, Round PD. 2014. Proportions of first-year individuals in cannon-net catches of waders in Thailand with a comparison to Australia. *Stilt* **65**, 17-24.

(Abstract)

The paper presents information on proportions of juveniles (first-years) in cannon net catches made in the non-breeding season at two locations in Thailand, the Andaman Seaboard and the Inner Gulf of Thailand, since large-scale banding of waders started in that country in 2007/ 2008. We conclude that, for species common to the two countries, observed juvenile proportions in Thailand are consistent with those observed in Australia and, as a different suite of birds over-winters in Thailand, that monitoring of Thai birds adds to our knowledge of wader recruitment in the East Asian-Australasian Flyway.

D'Amico VL, González PM, Morrison RIG, Baker AJ. 2014. Reverse Movements of Red Knots *Calidris canutus* During Northward Migration in Argentina. *Ardeola* **61**, 63-76.

(Abstract)

Migratory birds are sometimes known to make reverse movements to seek better fueling sites before undertaking long-distance migratory flights across ecological barriers. Red knots *Calidris canutus rufa* regularly make prodigious migratory flights of ~ 8,000 km from southern South America to North America; these flights depend critically on the birds being able to store adequate fuel at southern staging sites. Knots staging at San Antonio Oeste (SAO) in northern Patagonia in Argentina could potentially backtrack ~200 km southwards to complete refueling at Península Valdés (PV). We therefore analysed resightings of birds individually marked in SAO or the flyway at these two staging sites in 2006, 2007, 2009 and 2010 to investigate whether reverse movements occurred between them. In the four-year period, 63 detected individuals backtracked south from SAO to PV in one or more years. These movements occurred in all years of the study thus demonstrating the annual occurrence of flights of ~200 km in the opposite direction to the normal northward migration. There was no significant difference in body condition (mass), sex or day of first sighting in SAO between birds that made or did not make reverse movements to PV. However, individuals (N = 11) that backtracked to PV from SAO had significantly lower hematocrit levels at the time of capture than SAO resident birds (N = 205). Because migrating shorebirds have been shown to restore low hematocrit levels before undertaking rapid fuel storage to power long flights, we

hypothesise that red knots backtracking to PV were probably behind schedule on migration, and thus may have traded-off the small cost of a ~200 km flight for the increased foraging time and high quality soft-shell prey available late in the season at PV. This hypothesis helps to explain the later staging phenology of red knots using PV, and its role as an alternative staging area in the northward migration.

Furnell J, Hull SL. 2014. Cliff top habitats provide important alternative feeding resources for wading birds of conservation importance wintering on non-estuarine coasts. *Estuarine, Coastal and Shelf Science* **139**, 119-126.

(Abstract)

Rocky shores and beaches are important over-wintering areas for non-estuarine waders but have rarely been studied. We examined cliff top habitat use by 6 species of wader over 75 km of coast to assess their potential value as alternative feeding sites to rocky and sandy shores. Both the regional and local survey showed that waders occurred on golf courses and recreational grasslands in higher frequencies than expected but arable and pasture use was lower than expected. We also compared local wader densities on rocky and sandy shores, pastures, golf courses, caravan parks and recreational grasslands over two winters. Sanderling predominantly fed on the beach whereas Oystercatcher, Dunlin, Turnstone and Redshank numbers significantly increased on golf courses and recreational grasslands over the winter period, with pasture being rarely used. General linear models were used to relate environmental factors to the presence and absence of each species on the cliff top habitats. Redshank was the only species that showed a higher probability of occurrence on cliff top habitats at high tide whereas the probability of Turnstone, Oystercatcher and Redshank occurring increased as temperatures declined. Using core sampling, we determined that invertebrate richness and abundance was significantly higher on the recreational grasslands and golf courses than on the pasture or the beach. Our data demonstrated that cliff top habitats are important alternative feeding areas for over-wintering waders in areas where the intertidal is bounded by cliffs. Current management creates short sward, open field habitats with a diverse and abundant invertebrate food supply exploited by waders. Any alterations to the land use of these areas should be carefully considered by planning authorities in light of the fact that they support species that are of conservation concern.

Reneerkens J, van Veelen P, van der Velde M, Luttikhuizen P, Piersma T. 2014. Within-population variation in mating system and parental care patterns in the Sanderling (*Calidris alba*) in northeast Greenland. *The Auk* **131**, 235-247.

(Abstract)

Sandpipers and allies (Scolopacidae) show an astounding diversity in mating and parental care strategies. Comparative studies have tried to interpret this variation in terms of phylogenetic constraints and ecological shaping factors. In such analyses, mating and parental care systems are necessarily discretely classified at the species level. The few available descriptive studies on breeding strategies of the Sanderling (*Calidris alba*) came to variable conclusions, which, in turn, were inconsistently used in these comparative studies. We provide empirical data on mating and parental care patterns in Sanderlings studied during six summers in northeast Greenland. In 135 clutches, we determined parental care from incubation profiles using temperature loggers and confirmed that both uniparental incubation by both sexes and biparental incubation (45 and 90 clutches, respectively) occurred. We used microsatellite-based parentage analyses to describe the degree of extrapair mating. In 48 completely assayed families, we found 6 cases of polygamy (4 cases of polyandry, 2 cases of polygyny) that involved both uniparental and biparental clutches. This implies substantial variation in the patterns of mating and parental care, defying categorical assignments even at the local level. We conclude that the classification of mating strategy and parental care pattern for the Sanderling has been rather coarse, and that comparative analyses have not taken the observed intrapopulation variability into account. Because sandpipers show such variable reproductive behavior, between and within species, more detailed descriptive studies using parentage analyses are required to revisit previous statements about the intensity of sexual selection, including sexual size dimorphism, in shorebirds. In view of the great variability, methods of comparison will need elaboration too.

Duijns S, Piersma T. 2014. Interference competition in a sexually dimorphic shorebird: prey behaviour explains intraspecific competition. *Animal Behaviour* **92**, 195-201.

(Abstract)

When males and females come in distinct sizes and shapes they often forage at different sites, selecting different prey. In the sexually dimorphic bar-tailed godwit, *Limosa lapponica*, females generally forage along the tideline, whereas the smaller (and subordinate) males generally forage across dry mudflats. On this basis we predicted that interference competition would occur within, rather than between, the sexes. We tested whether density-dependent aspects of foraging behaviour are indeed sex specific and additionally examined the roles of sex-specific prey types. With increasing conspecific densities, intake rates levelled off in females, but not in males. At increasing densities, both sexes engaged in more agonistic interactions, but females more than males. Consequently, females lost more foraging time than males. However, time lost to interactions could not explain the density-dependent decrease in their intake rate. As lugworms, *Arenicola marina*, contributed 71% to the energy intake of females and 18% in males, we experimentally tested whether the burying behaviour of lugworms explained the sex difference in interference. Both in the field and in the laboratory, lugworms responded to probes. In experimentally probed plots in the field, lugworms produced fewer casts per unit time, indicating a decrease in near-surface presence. In laboratory settings, increased experimental probing intensity resulted in deeper burying by lugworms. We

therefore argue that prey depression is responsible for most of the reduction in intake rates of females foraging at high conspecific densities. The search for undisturbed shallow-living lugworms would explain why female bar-tailed godwits tend to forage along the moving tideline.

Oudman T, Onrust J, de Fouw J, Spaans B, Piersma T, van Gils JA. 2014. Digestive Capacity and Toxicity Cause Mixed Diets in Red Knots That Maximize Energy Intake Rate. *The American Naturalist* **183**, 650-659.

(Abstract)

Among energy-maximizing animals, preferences for different prey can be explained by ranking the prey according to their energetic content. However, diet choice also depends on characteristics of the predator, such as the need to ingest necessary nutrients and the constraints imposed by digestion and toxins in food. In combination, these factors can lead to mixed diets in which the energetically most profitable food is not eaten exclusively even when it is abundant. We studied diet choice in red knots (*Calidris canutus canutus*) feeding on mollusks at a West African wintering site. At this site, the birds fed primarily on two species of bivalves, a thick-shelled one (*Dosinia isocardia*) that imposed a digestive constraint and a thin-shelled one (*Loripes lucinalis*) that imposed a toxin constraint. The latter species is toxic due to its symbiotic association with sulfide-oxidizing bacteria. We estimated experimentally the parameters of a linear programming model that includes both digestive and toxin constraints, leading to the prediction that red knots should eat a mixture of both mollusk species to maximize energy intake. The model correctly predicted the preferences of the captive birds, which depended on the digestive quality and toxicity of their previous diet. At our study site, energy-maximizing red knots appear to select a mixed diet as a result of the simultaneous effects of digestive and toxin constraints.

Hooijmeijer JCEW, Gill Jr RE, Mulcahy DM, Tibbitts TL, Kentie R, Gerritsen GJ, Bruinzeel LW, Tijssen DC, Harwood CM, Piersma T. 2014. Abdominally implanted satellite transmitters affect reproduction and survival rather than migration of large shorebirds. *Journal of Ornithology* **155**, 447–457.

(Abstract)

Satellite telemetry has become a common technique to investigate avian life-histories, but whether such tagging will affect fitness is a critical unknown. In this study, we evaluate multi-year effects of implanted transmitters on migratory timing and reproductive performance in shorebirds. Shorebirds increasingly are recognized as good models in ecology and evolution. That many of them are of conservation concern adds to the research responsibilities. In May 2009, we captured 56 female Black-tailed Godwits *Limosa limosa limosa* during late

incubation in The Netherlands. Of these, 15 birds were equipped with 26-g satellite transmitters with a percutaneous antenna (7.8 % ± 0.2 SD of body mass), surgically implanted in the coelom. We compared immediate nest survival, timing of migration, subsequent nest site fidelity and reproductive behaviour including egg laying with those of the remaining birds, a comparison group of 41 females. We found no effects on immediate nest survival. Fledging success and subsequent southward and northward migration patterns of the implanted birds conformed to the expectations, and arrival time on the breeding grounds in 2010–2012 did not differ from the comparison group. Compared with the comparison group, in the year after implantation, implanted birds were equally faithful to the nest site and showed equal territorial behaviour, but a paucity of behaviours indicating nests or clutches. In the 3 years after implantation, the yearly apparent survival of implanted birds was 16 % points lower. Despite intense searching, we found only three eggs of two implanted birds; all were deformed. A similarly deformed egg was reported in a similarly implanted Whimbrel *Numenius phaeopus* returning to breed in central Alaska. The presence in the body cavity of an object slightly smaller than a normal egg may thus lead to egg malformation and, likely, reduced egg viability. That the use of implanted satellite transmitters in these large shorebirds reduced nesting propensity and might also lead to fertility losses argues against the use of implanted transmitters for studies on breeding biology, and for a careful evaluation of the methodology in studies of migration.

D'Amico VL, Gonzalez PM, Baker AJ, Buehler DM, Bertellotti M. 2014. Multi-year surveillance of selected avian pathogens in the migrant shorebird Red Knot (*Calidris canutus rufa*) at its main stopover site in Patagonia, Argentina. *Journal of Ornithology* **155**, 555-559.

(Abstract)

To investigate possible reasons for recent declines in Red Knot (*Calidris canutus rufa*) populations we surveyed for selected pathogens in Red Knots captured in San Antonio Bay, Argentina, on their northward migration during the period 2006–2011. Blood, cloacal swabs and faeces were analysed for bacteria [*Salmonella* sp., *Shigella* sp., enteropathogenic *Escherichia coli* (N = 42) and other coliforms (N = 35)], viral agents [responsible for avian influenza (N = 239), St. Louis encephalitis (N = 51) and Newcastle disease (N = 239)] and avian malaria parasites [*Plasmodium* sp. and *Haemoproteus* sp. (N = 284)]. All 698 samples taken from 303 individuals were negative, providing no evidence that Red Knots sampled at this stopover site were infected with these pathogens at the time of sampling.

Douglas DJT, Bellamy PE, Stephen LS, Pearce-Higgins JW, Wilson JD, Grant MC. 2014. Upland land use predicts population decline in a globally near-threatened wader. *Journal of*

Applied Ecology **51**, 194–203.

(Abstract)

1. Changes in large-scale land use may fragment and degrade habitats, affecting animal species adapted to these habitats. In the UK uplands for example, changes in sheep and game management, and afforestation, have altered the configuration of internationally important moorland habitat and are predicted to have increased predation pressure for a globally unique suite of breeding birds of international conservation importance.

2. Some of these upland bird species have declined, with particular concern over ground-nesting waders. Using resurveys of the rapidly declining Eurasian curlew *Numenius arquata* as a focal species of global conservation concern, we investigate whether upland land use predicts low nesting success and population decline.

3. Curlew population changes over an 8- to 10-year period were positively related to game-keeper density (a surrogate of predator control intensity) and inversely to the area of woodland surrounding sites, as a likely source of predators to adjacent open ground. Model predictions suggest that increasing woodland cover from 0% to 10% of the land area within 1 km of populated sites requires an increase in human predator control effort of about 48%, to a level associated with high-intensity grouse production, to achieve curlew population stability.

4. Curlew nesting success, known to be a key driver of population trends, was also positively related to game-keeper density and inversely to woodland area surrounding sites, providing a plausible mechanistic link between land use and population change.

5. Synthesis and applications. Upland land use is associated with curlew declines, with predation a likely mechanism, and this may apply to other breeding waders. The removal of isolated woodland plantations from otherwise unafforested landscapes may help reduce predation pressure across a range of systems including moorland. However, direct predator control may also be important to conserve ground-nesting birds in these landscapes, for example, where moorland management and forestry coexist as major land uses. Predator control may also mitigate climate change effects by enhancing wader productivity, particularly where climate effects coincide with changing land use. Emerging land uses in open landscapes, including native woodland restoration and wind farms, require careful siting to minimize further impacts on open-area breeding birds.

Clemens RS, Herrod A, Weston MA. 2014. Lines in the mud, revisiting the boundaries of important shorebird areas. *Journal for Nature Conservation* **22**, 59–67.

(Abstract)

Many shorebird populations are declining throughout the world, concurrent with declines and degradation of wetland habitats. Such declines necessitate a more consistent approach toward conserving habitats used by shorebird populations. Individuals of many shorebird

species congregate in specific areas during their non-breeding season. Worldwide, non-breeding areas are designated as 'important' for shorebird conservation based primarily on the abundance of birds found in an area. However, the boundaries of any area are often defined with incomplete information regarding how shorebirds use that habitat. This paper discusses examples in Australia where improved knowledge of shorebird habitat use led to the identification of very different boundaries of important shorebird areas than those identified originally. We highlight how simple questioning of those who count shorebirds in an area, led to an improved understanding of which areas were apparently used by the same local population of non-breeding shorebirds. Subsequent analysis of available count, recapture and/or home range data of particular shorebird species is needed to verify expert opinion regarding most of these boundaries. We review how enhanced boundaries improve the ability of shorebird monitoring to detect population changes; allow management of shorebird habitats at relevant spatial scales; and lead to appropriate designations of important areas. While the kinds of approaches to boundary setting described here are not new, they are not consistently applied worldwide. We suggest additional guidelines to those produced under the Ramsar Convention in regard to designating important areas. We also call for more studies on the movements of migratory shorebirds during the non-breeding season to direct more consistent boundary setting around important non-breeding habitats used by local populations of migratory shorebirds.

Catry T, Alves JA, Gill JA, Gunnarsson TG, Granadeiro JP. 2014. Individual specialization in a shorebird population with narrow foraging niche. *Acta Oecologica* **56**, 56-65.

(Abstract)

Individual specialization in resource use is a widespread driver for intra-population trait variation, playing a crucial evolutionary role in free-living animals. We investigated the individual foraging specialization of Black-tailed Godwits (*Limosa limosa islandica*) during the wintering period. Godwits displayed distinct degrees of individual specialization in diet and microhabitat use, indicating the presence of both generalist and specialist birds. Females were overall more specialist than males, primarily consuming polychaetes. Specialist males consumed mainly bivalves, but some individuals also specialized on gastropods or polychaetes. Sexual dimorphism in bill length is probably important in determining the differences in specialization, as longer-billed individuals have access to deep-buried polychaetes inaccessible to most males. Different levels of specialization within the same sex, unrelated to bill length, were also found, suggesting that mechanisms other traits are involved in explaining individual specialization. Godwits specialized on bivalves achieved higher intake rates than nonspecialist birds, supporting the idea that individual foraging choices or skills result in different short-term payoffs within the same population. Understanding whether short-term payoffs are good indicators of long-term fitness and how selection operates to favour the prevalence of specialist or generalist godwits is a major future challenge.

Lunardi VO, Macedo RH. 2014. Shorebirds can adopt foraging strategies that take advantage of human fishing practices. *Emu* **114**, 50–60.

(Abstract)

Human presence and activities are considered to be a potential threat to many species, mainly because they interfere with the abilities of many animals to exploit essential resources. In this study we investigate the influence of human presence and activities on the behaviour of nine shorebird species in an intertidal area at Baía de Todos os Santos, northeastern Brazil. The area is used both by shorebirds and traditional human community to extract invertebrates for food, and also used by people for recreation. We analyse and compare the foraging behaviour of shorebirds under three different conditions: absence of humans, presence of humans manually gathering shellfish (shellfishing), and presence of humans engaged in recreational activity. Recreational activity was associated with greater behavioural change to the shorebirds than shellfishing. Shorebirds were less plentiful, showed lower foraging rates and moved around more when exposed to recreational activity. Larger shorebirds were less abundant when shellfishing or recreational activities were taking place. Intertidal areas of sediment manually overturned by shellfishers had higher rates of shorebird foraging and agonistic encounters, suggesting that shorebirds' foraging strategies take advantage of human shellfishing. These results can be interpreted within a conservation framework to provide guidelines for the management decisions in areas used by shorebirds.

Santiago-Quesada F, Masero JA, Albano N, Sánchez-Guzmán JM. 2014. Roost location and landscape attributes influencing habitat selection of migratory waterbirds in rice fields. *Agriculture, Ecosystems and Environment* **188**, 97–102.

(Abstract)

An analysis of habitat selection and use patterns by the near-threatened black-tailed godwit (*Limosa limosa*), a long-distance migratory waterbird, was conducted in rice fields of southern Europe during their northwards migration. A complete set of factors was assessed, including food availability, crop management, predation risk, human disturbance, habitat structure, and the presence of roosting areas. Additionally, by tracking radio-tagged godwits, the home range of this waterbird species was established while staging in the rice fields. Godwits selected as foraging grounds flooded, rolled pans that minimised their movements (average home range: 4919 ± 2226 ha) between the roosting and foraging grounds. The presence of power lines in the rice fields was the most important landscape factor affecting the location of the godwits' roosts, which were also flooded, rolled pans. The quality of rice fields as a key staging area for godwits lay in the presence not only of suitable foraging areas, but also of roosting sites. This study highlights for first time the key role of some facilities and the availability of roosting sites in determining the use of rice fields by migratory waterbirds such as godwits.

Martins RC, Catry T, Granadeiro JP. 2014. Crossbow-netting: a new method for capturing shorebirds. *Journal of Field Ornithology* **85**, 84-90.

(Abstract)

Capturing shorebirds during the non-breeding season can be challenging because they are usually scattered over wide-open intertidal areas while foraging and are sensitive to human disturbance at roosts where they gather during high tide in large vigilant flocks. Several techniques are available for capturing shorebirds, but, for a study of stopover ecology, we needed a method that would allow us to capture Dunlins (*Calidris alpina*) on a regular basis at high-tide roosts during the day (ruling out mist-nets), did not require the use of gun-powder (ruling out cannon-nets), and that would deploy a net faster than clap nets, whoosh nets, and wilsternets. Therefore, we developed a new method to capture shorebirds where a crossbow is used to pull a mist-net over flocks of roosting birds. We tested this technique in four habitats (saltpans, salt marshes, beaches, and mudflats) in the Tagus estuary, Portugal, and captured over 380 birds representing eight different species. Advantages of this technique compared to other methods (e.g., mist-nets, clap- and whoosh nets, and cannon-nets) include (1) portability, (2) ease of set up, (3) minimal disturbance of birds near the capture area, and (4) no explosive materials are needed. Our results suggest that crossbow-netting is a safe and useful capture technique, especially for studies requiring the capture of small numbers of birds on a regular basis.

Salem MVA, van der Geest M, Piersma T, Saoud Y, van Gils JA. 2014. Seasonal changes in mollusc abundance in a tropical intertidal ecosystem, Banc d'Arguin (Mauritania): Testing the 'depletion by shorebirds' hypothesis. *Estuarine, Coastal and Shelf Science* **136**, 26-34.

(Abstract)

At temperate latitudes densities and biomass of intertidal molluscs tend to be strongly seasonal. Here we provide a comparative study on seasonality of bivalves and gastropods in the tropical intertidal seagrass-covered soft sediment environment of Banc d'Arguin, Mauritania (20^{o}N, 16^{o}W). In this system, benthivorous shorebirds exert considerable predation pressure with strong seasonal variations. It has been proposed that during the period when (adult) shorebirds are absent (May-August) benthic biomass would be able to recover, but a first test was inconclusive. Over a full year (March 2011-February 2012), each month we sampled benthic invertebrates at sixteen permanent sites. The total of 3763 specimens comprised 20 species, representing eight orders and 19 families. Bivalves were much more common than gastropods. The bivalve *Loripes lucinalis* dominated the assemblage throughout the year (58% of total number), followed by *Dosinia isocardia* (10%), *Senilia senilis* (8%) and the gastropod *Gibbula umbilicalis* (6%). Average biomass amounted to 32 g

AFDM/m^2, of which the large West-African bloody cockle *Senilia* made up three-quarter, *Loripes* 16%, *Gibbula* 2% and *Dosinia* 1%. Across the 20 species, lowest densities were reached in late spring (May) and summer (Aug.), whereas highest densities occurred in autumn (Oct.). The lowest overall density of 676 specimens/m^2 in August more than doubled to a peak density of 1538 specimens/m^2 in October, most of the increase being due to strong recruitment in both *Loripes* (densities increasing from 322 specimens/m^2 in Sept. to 785 specimens/m^2in Oct.) and *Dosinia* (densities increasing from 18 specimens/m^2 in Aug. to 265 specimens/m^2 in Sept.). Our results suggest that by the time the feathered molluscivore predators returned in high numbers to Banc d'Arguin (after their summer breeding season in the Arctic), benthic animals were at a peak. In order to quantitatively understand the seasonal changes in mollusc abundance, we build upon a recently published optimal diet model in which the most abundant molluscivore shorebird, the red knot (*Calidris canutus*), could choose between *Loripes* and *Dosinia*. Observed changes in densities of these two bivalves closely match depletion trajectories predicted by the model. We conclude that molluscivore shorebirds are able to deplete their food stocks in the course of their 'winter' in a tropical intertidal area.

Senner NR, Hochachka WM, Fox JW, Afanasyev V. 2014. An Exception to the Rule: Carry-Over Effects Do Not Accumulate in a Long-Distance Migratory Bird. *PLoS ONE* **9**, e86588.

(Abstract)

Recent years have seen a growing consensus that events during one part of an animal's annual cycle can detrimentally affect its future fitness. Notably, migratory species have been shown to commonly display such carry-over effects, facing severe time constraints and physiological stresses that can influence events across seasons. However, to date, no study has examined a full annual cycle to determine when these carry-over effects arise and how long they persist within and across years. Understanding when carry-over effects are created and how they persist is critical to identifying those periods and geographic locations that constrain the annual cycle of a population and determining how selection is acting upon individuals throughout the entire year. Using three consecutive years of migration tracks and four consecutive years of breeding success data, we tested whether carry-over effects in the form of timing deviations during one migratory segment of the annual cycle represent fitness costs that persist or accumulate across the annual cycle for a long-distance migratory bird, the Hudsonian godwit, *Limosa haemastica*. We found that individual godwits could migrate progressively later than population mean over the course of an entire migration period, especially southbound migration, but that these deviations did not accumulate across the entire year and were not consistently detected among individuals across years. Furthermore, neither the accumulation of lateness during previous portions of the annual cycle nor arrival date at the breeding grounds resulted in individuals suffering reductions in their breeding success or survival. Given their extreme life history, such a lack of carry-over effects suggests that strong selection exists on godwits at each stage of the annual cycle and that carry-over effects may not be able to persist in such a system, but also emphasizes that high-quality stopover and wintering sites are critical to the maintenance of long-distance migratory

populations.

Trimbos KB, Doorenweerd C, Kraaijeveld K, Musters CJM, Groen NM, de Knijff P, Piersma T, de Snoo GR. 2014. Patterns in Nuclear and Mitochondrial DNA Reveal Historical and Recent Isolation in the Black-Tailed Godwit (*Limosa limosa*). *PLoS ONE* **9**, e83949.

(Abstract)

On the basis of morphological differences, three subspecies of Black-tailed Godwit (*Limosa limosa*) have been recognized (*L. l. limosa*, *L. l. islandica* and *L. l. melanuroides*). In previous studies mitochondrial DNA (mtDNA) sequence data showed minimal genetic divergence between the three subspecies and an absence of sub-structuring within *L. l. limosa*. Here, population genetic structure and phylogeographic patterns have been analyzed using COI, HVR1 and HVR2 mtDNA sequence data as well as 12 microsatellite loci (nuDNA). The nuDNA data suggest genetic differentiation between *L. l. limosa* from Sweden and The Netherlands, between *L. l. limosa* and *L. l. islandica*, but not between *L. l. limosa* and *L. l. melanuroides*. However, the mtDNA data were not consistent with the nuDNA pattern. mtDNA did support a split between *L. l. melanuroides* and *L. l. limosa*/*L. l. islandica* and also demonstrated two *L. l. limosa* haplotype clusters that were not geographically isolated. This genetic structure can be explained by a scenario of isolation of *L. l. melanuroides* from *L. l. limosa* in Beringia during the Last Glacial Maximum. During the Pleistocene separation of *L. l. islandica* from *L. l. limosa* occurred, followed by colonization of Iceland by the *L. l. islandica* during the Holocene. Within *L. l. limosa* founder events, followed by population expansion, took place during the Holocene also. According to the patterns observed in both markers together and their geographic separation, we propose that the three traditional subspecies indeed represent three separate genetic units.

Van den Hout PJ, van Gils JA, Robin F, van der Geest M, Dekinga A, Piersma T. 2014. Interference from adults forces young red knots to forage for longer and in dangerous places. *Animal Behaviour* **88**, 137-146.

(Abstract)

In birds and mammals, juvenile and adult foragers are often found apart from each other. In this study, we found this is also true for red knots, *Calidris canutus canutus*, wintering on the intertidal flats of Banc d'Arguin, Mauritania. Not only did juveniles feed separately from adults, they also fed at places where they were more vulnerable to predation by large falcons. That the dangerous areas used by juveniles were no better feeding areas led us to reject the food-safety trade-off that explained age-related distribution differences in many earlier studies. Instead, juveniles were displaced by adults in dyadic interactions which suggests that they

suffered from interference from adults. Juveniles retreated to feeding areas that were more dangerous and yielded lower intake rates, and coped by extending foraging time by using higher, nearshore intertidal areas that were exposed for longer. When disturbed by predators in these nearshore areas, juveniles continued feeding whereas adults left. Thus, rather than compensating for increased predation danger by higher intake rates, on the Banc d'Arguin red knot juveniles foraged for longer.

Gill JA, Alves JA, Sutherland WJ, Appleton GF, Potts PM, Gunnarsson TG. 2014. Why is timing of bird migration advancing when individuals are not? *Proceedings of the Royal Society of London, B* **281**, 20132161.

(Abstract)

Recent advances in spring arrival dates have been reported in many migratory species but the mechanism driving these advances is unknown. As population declines are most widely reported in species that are not advancing migration, there is an urgent need to identify the mechanisms facilitating and constraining these advances. Individual plasticity in timing of migration in response to changing climatic conditions is commonly proposed to drive these advances but plasticity in individual migratory timings is rarely observed. For a shorebird population that has significantly advanced migration in recent decades, we show that individual arrival dates are highly consistent between years, but that the arrival dates of new recruits to the population are significantly earlier now than in previous years. Several mechanisms could drive advances in recruit arrival, none of which require individual plasticity or rapid evolution of migration timings. In particular, advances in nest-laying dates could result in advanced recruit arrival, if benefits of early hatching facilitate early subsequent spring migration. This mechanism could also explain why arrival dates of short-distance migrants, which generally return to breeding sites earlier and have greater scope for advance laying, are advancing more rapidly than long-distance migrants.

Shorebirds 2013

Steiger, S. S., M. Valcu, K. Spoelstra, B. Helm, M. Wikelski, and B. Kempenaers. 2013. When the sun never sets: diverse activity rhythms under continuous daylight in free-living arctic-breeding birds. *Proceedings of the Royal Society B: Biological Sciences* **280**:20131016.

(Abstract)

Circadian clocks are centrally involved in the regulation of daily behavioural and physiological processes. These clocks are synchronized to the 24 h day by external cues (Zeitgeber), the

most important of which is the light–dark cycle. In polar environments, however, the strength of the Zeitgeber is greatly reduced around the summer and winter solstices (continuous daylight or continuous darkness). How animals time their behaviour under such conditions has rarely been studied in the wild. Using a radio-telemetry-based system, we investigated daily activity rhythms under continuous daylight in Barrow, Alaska, throughout the breeding season in four bird species that differ in mating system and parental behaviour. We found substantial diversity in daily activity rhythms depending on species, sex and breeding stage. Individuals exhibited either robust, entrained 24 h activity cycles, were continuously active (arrhythmic) or showed 'free-running' activity cycles. In semipalmated sandpipers, a shorebird with biparental incubation, we show that the free-running rhythm is synchronized between pair mates. The diversity of diel timekeeping under continuous daylight emphasizes the plasticity of the circadian system, and the importance of the social and life-history context. Our results support the idea that circadian behaviour can be adaptively modified to enable species-specific time-keeping under polar conditions.

Lehnen, S. E., and D. G. Krementz. 2013. Use of Aquaculture Ponds and Other Habitats by Autumn Migrating Shorebirds Along the Lower Mississippi River. *Environmental Management*, **52**:417–426.

(Abstract)

Populations of many shorebird species are declining; habitat loss and degradation are among the leading causes for these declines. Shorebirds use a variety of habitats along interior migratory routes including managed moist soil units, natural wetlands, sandbars, and agricultural lands such as harvested rice fields. Less well known is shorebird use of freshwater aquaculture facilities, such as commercial cat- and crayfish ponds. We compared shorebird habitat use at drained aquaculture ponds, moist soil units, agricultural areas, sandbars and other natural habitat, and a sewage treatment facility in the in the lower Mississippi River Alluvial Valley (LMAV) during autumn 2009. Six species: Least Sandpiper (*Calidris minutilla*), Killdeer (*Charadrius vociferous*), Semipalmated Sandpiper (*Calidris pusilla*), Pectoral Sandpiper (*C. melanotos*), Black-necked Stilt (*Himantopus himantopus*), and Lesser Yellowlegs (*Tringa flavipes*), accounted for 92% of the 31,165 individuals observed. Sewage settling lagoons (83.4, 95 % confidence interval [CI] 25.3–141.5 birds/ha), drained aquaculture ponds (33.5, 95 % CI 22.4–44.6 birds/ha), and managed moist soil units on public lands (15.7, CI 11.2–20.3 birds/ha) had the highest estimated densities of shorebirds. The estimated 1,100 ha of drained aquaculture ponds available during autumn 2009 provided over half of the estimated requirement of 2,000 ha by the LMAV Joint Venture working group. However, because of the decline in the aquaculture industry, autumn shorebird habitats in the LMAV may be limited in the near future. Recognition of the current aquaculture habitat trends will be important to the future management activities of federal and state agencies. Should these aquaculture habitat trends continue, there may be a need for wildlife biologists to investigate other habitats that can be managed to offset the current and expected loss of aquaculture acreages. This study illustrates the potential for freshwater aquaculture to provide habitat for

a taxa at risk. With the rapid growth of aquaculture worldwide, the practices of this industry deserve attention to identify benefits as well as risks to wildlife.

Minton CDT, Jessop RE, Hassell C. 2013. Wader breeding success in the 2012 arctic summer, based on juvenile ratios of birds which spend the nonbreeding season in Australia. *Stilt* 63-64, 56-58.

(No abstract available)

Iqbal M, Wibowo WK, Fatimah S. 2013. Overlooked evidence of Java (Indonesia) as a potentially important staging area for Red-Necked Stint *Calidris ruficollis* in the East Asian-Australasian Flyway. *Stilt* 63-64, 36-38.

(No abstract available)

Jukema J, Bunskoeke EJ, Piersma T, Pieters T, Koolhaas A, van Rhijn JG. 2013. Incomplete and irregular annual replacement of secondaries in Eurasian Golden Plovers, *Pluvialis apricaria*. *Wader Study Group Bulletin* **120**:102–107.

(Abstract)

In most waders (Charadrii) replacement of old by new feathers during moult of primaries occurs in a fixed order and in such a way that flight capacities are maintained. Moult of the secondaries of the Eurasian Golden Plover *Pluvialis apricaria* deviates from this general pattern. The sequence of secondary moult is irregular and – in most cases – asymmetric between wings. In addition, only about half the secondaries are renewed every year. Secondary moult is arrested in October and not resumed in spring. This can be deduced from the moult scores of >900 adults that were caught in autumn and spring when staging in the Netherlands, and from inspection of three birds caught on their nests in Iceland. It is also confirmed by the moult scores of seven birds (from a group of about 1,500) that were recaptured after their first complete moult. As their juvenile secondaries had been marked with picric acid the year before, all non-dyed secondaries had evidently been renewed – and all dyed ones were old. As irregular moult of the secondaries also occurs in other Charadriidae plovers, this characteristic might have originated from a common ancestor. Irregular and incomplete secondary moult may be explained by birds avoiding the costly moult of feathers

that experience little wear. With most moult studies focusing on primary moult, this aspect of secondary moult has previously remained undiscovered.

Malpas LR, Smart J, Drewitt A, Sharps E, Garbutt A. 2013. Continued declines of Redshank *Tringa totanus* breeding on saltmarsh in Great Britain: is there a solution to this conservation problem? *Bird Study* **60**:370-383.

(Abstract)

Capsule – Over 50% of saltmarsh breeding Common Redshank have been lost since 1985, with current conservation management having only limited success at halting these declines.

Aims: To update population size and trend estimates for saltmarsh-breeding Redshank in Britain, and to determine whether conservation management implemented since 1996 has been successful in influencing grazing intensity and Redshank population trends.

Methods: A repeat national survey of British saltmarsh was conducted in 2011 at sites previously visited in 1985 and 1996. Redshank breeding density and grazing pressure were recorded at all sites; the presence of conservation management was additionally recorded for English sites. Results from all three national surveys were used to update population size and trend estimates, and to investigate changes in grazing pressure and breeding density on sites with and without conservation management.

Results: Of the 21 431 pairs breeding on saltmarsh in 1985, 11 946 pairs remained in 2011, with the highest proportion of this population found in East Anglia. From 1985, British breeding densities declined at a rate of 1 pair km−2 year−1, representing a loss of 52.8% of breeding pairs over 26 years, although regional trends varied across different time periods. Grazing pressures did not change markedly with conservation management. Redshank declines were less severe on conservation-managed sites in East Anglia and the South of England where grazing pressures remained low, though were more severe on conservation-managed sites in the North West where heavy grazing persisted.

Conclusion: Saltmarsh-breeding Redshank declines continue and are likely to be driven by a lack of suitable nesting habitat. Conservation management schemes and site protection implemented since 1996 appear not to be delivering the grazing pressures and associated habitat conditions required by this species, particularly in the North West of England, though habitat changes may not be linked to unsuitable grazing management in all regions. An in-depth understanding of grazing practices, how conservation management guidelines could be improved, and the likely success of more long-term management solutions is needed urgently.

Hooijmeijer JCEW, Senner NR, Tibbitts TL, Gill Jr RE, Douglas DC, Bruinzeel LW, Wymenga E, Piersma T. 2013. Post-breeding migration of Dutch-breeding Black-tailed Godwits: timing, routes, use of stopovers, and nonbreeding destinations. *Ardea* **101**:141-152.

(Abstract)

Conservation of long-distance migratory shorebirds is complex because these species use habitats spread across continents and hemispheres, making identification of critical habitats and potential bottlenecks in the annual cycle especially difficult. The population of Black-tailed Godwits that breeds in Western Europe, *Limosa limosa limosa*, has declined precipitously over the past few decades. Despite significant efforts to identify the root causes of this decline, much remains unclear. To better understand the migratory timing, use of stopover and nonbreeding sites, and the potential impact of breeding success on these parameters, we attached 15 Argos satellite transmitters and 10 geolocation tracking devices to adult godwits nearing completion of incubation at breeding sites in southwest Friesland, The Netherlands during the spring of 2009. We successfully tracked 16 adult godwits for their entire southward migration and two others for part of it. Three migration patterns and four regions of use were apparent. Most godwits left their breeding sites and proceeded south directly to stopover sites in the Mediterranean – e.g. Spain, Portugal, and Morocco – before flying on to non-breeding sites in West Africa. Other individuals spent the entire nonbreeding season in the Mediterranean. A third pattern included a few individuals that flew nonstop from their Dutch breeding sites to nonbreeding sites in West Africa. Tracking data from this study will be immediately useful for conservation efforts focused on preserving the dispersed network of sites used by godwits during their southward migration.

Ruthrauff DR, Dekinga A, Gill Jr RE, Summers RW, Piersma T. 2013. Ecological correlates of variable organ sizes and fat loads in the most northerly wintering shorebirds. *Canadian Journal of Zoology* **91**:698–705.

(Abstract)

Shorebirds at northern latitudes during the nonbreeding season typically carry relatively large lipid stores and exhibit an up-regulation of lean tissues associated with digestion and thermogenesis. Intraspecific variation in these tissues across sites primarily reflects differences in environmental conditions. Rock (*Calidris ptilocnemis* (Coues, 1873)) and Purple (*Calidris maritima* (Brünnich, 1764)) sandpipers are closely related species having the most northerly nonbreeding distributions among shorebirds, living at latitudes up to 61°N in Cook Inlet, Alaska, and up to _71°N in northern Norway, respectively. Cook Inlet is the coldest known site used by nonbreeding shorebirds, and the region's mudflats annually experience extensive coverage of foraging sites by sea and shore-fast ice. Accordingly, Rock Sandpipers increase their fat stores to nearly 20% of body mass during winter. In contrast, Purple Sandpipers exploit predictably ice-free rocky intertidal foraging sites and maintain low (<6.5%) fat stores. Rock Sandpipers increase the mass of lean tissues from fall to winter, including

contour feathers, stomach, and liver components. They also have greater lean pectoralis and supracoracoideus muscle and liver and kidney tissues compared with Purple Sandpipers in winter. This demonstrates a combined emphasis on digestive processes and thermogenesis, whereas Purple Sandpipers primarily augment organs associated with digestive processes. The high winter fat loads and increased lean tissues of Rock Sandpipers in Cook Inlet reflect the region's persistent cold and abundant but sporadically unavailable food resources.

Hobson KA, Slater GL, Lank DB, Milner RL, Gardiner R. 2013. Agricultural Lands Subsidize Winter Diet of the Dunlin at Two Major Estuaries. *The Condor* **115**:515-524.

(Abstract)

On the western coast of North America, several estuaries provide shorebirds with important winter and stopover habitat. These habitats include not only aquatic estuarine resources but also adjacent upland agricultural lands. The extent to which shorebirds use estuarine vs. upland habitats at these stopover sites is difficult to quantify but crucial to designing strategies for their conservation. We measured stable isotopes (δ13C, δ15N) in whole blood of Dunlins (*Calidris alpina*) and their prey from two major estuaries in north Puget Sound, Washington, USA, to estimate their relative use of estuarine vs. upland agricultural zones. We identified four isotopically distinct dietary inputs (agriculture high in 15N, other agriculture, marsh/marine, and freshwater plume). Isotopic sampling and modeling was informed by movements and habitat use derived from radiotelemetry. This isotopic structure allowed us to conclude that these Dunlins obtained about 62% of the protein in their diet from agricultural lands and 38% from the estuary. Our results underline the urgent need to combine management of estuaries and upland agricultural areas in strategies for shorebird conservation.

Summers RW, Pálsson S, Corse C, Etheridge B, Foster S, Swann B. 2013. Sex ratios of waders at the northern end of the East Atlantic flyway in winter. *Bird Study* **60**:437-445.

(Abstract)

Capsule: Sex ratios were determined for 11 wader species at the northern end of the East Atlantic flyway in winter. The ratio was even for six species, there were more males for four species, and more females for one species.

Aims: To describe the sex ratio of adult waders in northern Scotland and examine departures from parity.

Methods: Molecular sexing and biometrics were used to estimate the sex ratio (percentage male) in adult populations of 11 waders wintering on estuaries and open shores in northern

Scotland (Moray Firth and Orkney), at the northern part of the East Atlantic flyway. Departures from parity were examined in relation to three possibilities: (1) that there was local variation in the distribution of the sexes; (2) that the sexes differed in their winter ranges and (3) that there was an uneven sex ratio in the entire population.

Results: The percentage of males did not differ significantly from 50% for Lapwing, Ringed Plover, Dunlin, Knot, Sanderling and Turnstone. There were significant differences from parity for Oystercatcher, Redshank, Bar-tailed Godwit and Curlew at some sites, suggesting local segregation of the sexes that may be related to habitat. It was difficult to examine possibilities 2 and 3 due to the lack of data from other parts of the flyway. Only some populations of Purple Sandpipers and perhaps Bar-tailed Godwits exhibited an uneven sex ratio in favour of males across the flyway. For these species, the uneven sex ratio in favour of males was already apparent in first-year birds, showing that higher mortality amongst juvenile females, rather than higher mortality amongst breeding females probably causes the imbalance.

Conclusion: Some waders showed significant deviations from parity in their sex ratio. These may be due to sex-dependent habitat selection and differential mortality rates.

Hunt KL, Catlin DH, Felio JH, Fraser JD. 2013. Effect of capture frequency on the survival of Piping Plover chicks. *Journal of Field Ornithology* **84**:299-303.

(Abstract)

Evaluating the possible effects of intensive research on species being studied and on the results of studies is important for both ethical and scientific reasons. We captured, banded, recaptured, and measured prefledged Piping Plover (*Charadrius melodus*) chicks during the 2010 breeding season at Lewis and Clark Lake on theMissouri River in South Dakota. We evaluated the potential for increased mortality related to frequent handling of chicks with an experiment that compared the survival of chicks handled a single time for banding (N = 48) to chicks handled repeatedly from hatch to fledge (N = 50). Estimates of daily survival rate (φ) for chicks in the two treatments did not differ ($\varphi_{\text{single-capture}} = 0.984 \pm 0.006$, $\varphi_{\text{multiple-capture}} = 0.985 \pm 0.006$). Similar to previous studies, we found little evidence of increased prefledge mortality associated with frequent handling of Piping Plover chicks. However, because the effects of frequent handling of shorebird chicks may vary among species and other factors such as habitat quality (e.g., food availability), we suggest that, where possible, researchers include experiments similar to ours to evaluate possible research impacts, especially when studying threatened and endangered species.

Gill Jr RE, Handel CM, Ruthrauff DR. 2013. Intercontinental Migratory Connectivity and Population Structuring of Dunlins from Western Alaska. *The Condor* **115**:525-534.

(Abstract)

The Dunlin (*Calidris alpina*) is a polytypic shorebird with complex patterns of distribution and migration throughout its holarctic range. We analyzed mark–resighting data obtained between 1977 and 2010 from birds captured at two major staging areas in western Alaska to test the hypothesis that the migration patterns of Alaskan populations are a mixture of parallel and chain, similar to those of Dunlin populations in the western Palearctic. Birds marked on the Yukon–Kuskokwim Delta were found wintering in both Asia and North America, which documented the unexpected mixing of *C. a. arcticola*from northern Alaska and *C. a. pacifica* from western Alaska and contradicted our initial prediction of parallel migration pathways for these two subspecies. In its North American winter range *C. a. pacifica* segregated according to location of marking, confirming our prediction of a chain migration pattern within this population. Individuals of *C. a. pacifica* marked on the delta were resighted significantly farther north, mostly in southern British Columbia and Washington, than birds marked on the second, more southerly staging area on the Alaska Peninsula, which were resighted primarily in the San Francisco Bay area of northern California. We recommend additional studies use a combination of intrinsic and extrinsic markers to quantify the strength of migratory connectivity between breeding, staging, and wintering areas. Such information is needed to guide conservation efforts because the Dunlin and other waterbirds are losing intertidal habitats at an unprecedented rate and scale, particularly in the Yellow Sea and other parts of Asia.

Smith DR, McGowan CP, Daily JP, Nichols JD, Sweka JA, Lyons JE. 2013. Evaluating a multispecies adaptive management framework: must uncertainty impede effective decision-making? *Journal of Applied Ecology* **50**:1431–1440.

(Abstract)

1. Application of adaptive management to complex natural resource systems requires careful evaluation to ensure that the process leads to improved decision-making. As part of that evaluation, adaptive policies can be compared with alternative nonadaptive management scenarios. Also, the value of reducing structural (ecological) uncertainty to achieving management objectives can be quantified.

2. A multispecies adaptive management framework was recently adopted by the Atlantic States Marine Fisheries Commission for sustainable harvest of Delaware Bay horseshoe crabs *Limulus polyphemus*, while maintaining adequate stopover habitat for migrating red knots *Calidris canutus rufa*, the focal shorebird species. The predictive model set encompassed the structural uncertainty in the relationships between horseshoe crab spawning, red knot weight gain and red knot vital rates. Stochastic dynamic programming was used to generate a state-dependent strategy for harvest decisions given that uncertainty. In this paper, we employed a management strategy evaluation approach to evaluate the

performance of this adaptive management framework. Active adaptive management was used by including model weights as state variables in the optimization and reducing structural uncertainty by model weight updating.

3. We found that the value of information for reducing structural uncertainty is expected to be low, because the uncertainty does not appear to impede effective management. Harvest policy responded to abundance levels of both species regardless of uncertainty in the specific relationship that generated those abundances. Thus, the expected horseshoe crab harvest and red knot abundance were similar when the population generating model was uncertain or known, and harvest policy was robust to structural uncertainty as specified.

4. Synthesis and applications. The combination of management strategy evaluation with state-dependent strategies from stochastic dynamic programming was an informative approach to evaluate adaptive management performance and value of learning. Although natural resource decisions are characterized by uncertainty, not all uncertainty will cause decisions to be altered substantially, as we found in this case. It is important to incorporate uncertainty into the decision framing and evaluate the effect of reducing that uncertainty on achieving the desired outcomes.

Pellissier L, Meltofte H, Hansen J, Schmidt NM, Tamstorf MP, Maiorano L, Aastrup P, Olsen J, Guisan A, Wisz MS. 2013. Suitability, success and sinks: how do predictions of nesting distributions relate to fitness parameters in high arctic waders? *Diversity and Distributions* **19**:1496–1505.

(Abstract)

Abstract: Aim Although habitat suitability maps derived from species distribution models (SDMs) are often assumed to highlight locations that can sustain healthy populations over time, the relationship between suitability scores and fitness parameters has rarely been tested thoroughly.

Location: Zackenberg Valley, north-east Greenland.

Methods: Using 14 years of data (1997–2010) representing three wader species (dunlin *Calidris alpina*, sanderling *Calidris Alba* and ruddy turnstone *Arenaria interpres*), we tested the relationships between modelled suitability and fitness parameters at nesting locations.

Results: Among the three species examined, only the ruddy turnstone exhibited significant relationships between suitability and nest success, but over time rather than space. During years with extensive snow cover in the landscape, the nesting sites of ruddy turnstone occurred in different habitats than were typically used across years. Moreover, in years with extensive snow cover, the ruddy turnstone initiated nests later and suffered from higher egg predation rates.

Main conclusion: Our results suggest that SDMs derived from species occurrences that include years of low reproductive success may over-estimate the potential suitable habitat in the landscape. Whenever possible, variation in reproductive success should be considered when building models to inform species' response to environmental change.

Martins RC, Catry T, Santos CD, Palmeirim JM, Granadeiro JP. 2013. Seasonal Variations in the Diet and Foraging Behaviour of Dunlins *Calidris alpina* in a South European Estuary: Improved Feeding Conditions for Northward Migrants. *PLoS ONE* **8**:e81174.

(Abstract)

During the annual cycle, migratory waders may face strikingly different feeding conditions as they move between breeding areas and wintering grounds. Thus, it is of crucial importance that they rapidly adjust their behaviour and diet to benefit from peaks of prey abundance, in particular during migration, when they need to accumulate energy at a fast pace. In this study, we compared foraging behaviour and diet of wintering and northward migrating dunlins in the Tagus estuary, Portugal, by video-recording foraging birds and analysing their droppings. We also estimated energy intake rates and analysed variations in prey availability, including those that were active at the sediment surface. Wintering and northward migrating dunlins showed clearly different foraging behaviour and diet. In winter, birds predominantly adopted a tactile foraging technique (probing), mainly used to search for small buried bivalves, with some visual surface pecking to collect gastropods and crop bivalve siphons. Contrastingly, in spring dunlins generally used a visual foraging strategy, mostly to consume worms, but also bivalve siphons and shrimps. From winter to spring, we found a marked increase both in the biomass of invertebrate prey in the sediment and in the surface activity of worms and siphons. The combination of these two factors, together with the availability of shrimps in spring, most likely explains the changes in the diet and foraging behaviour of dunlins. Northward migrating birds took advantage from the improved feeding conditions in spring, achieving 65% higher energy intake rates as compared with wintering birds. Building on these results and on known daily activity budgets for this species, our results suggest that Tagus estuary provides high-quality feeding conditions for birds during their stopovers, enabling high fattening rates. These findings show that this large wetland plays a key role as a stopover site for migratory waders within the East Atlantic Flyway.

Maguire GS, Rimmer JM, Weston MA. 2013. Stakeholder Perceptions of Threatened Species and Their Management on Urban Beaches. *Animals* **3**:1002-1020.

(Abstract)

We surveyed 579 recreationists regarding management of the threatened, beach-dwelling Hooded Plover *Thinornis rubricollis*. We postulated that: (1) lower awareness of the species and higher 'inconvenience' of management would engender less favourable perceptions of conservation and management; and (2) that frequency of beach use and dog ownership may mediate perceptions and levels of awareness and inconvenience. Overall, inconvenience was low while awareness and support for plover conservation were high. Education and awareness strategies were considered less effective than regulations; exclusion and regulations were considered less desirable than on-ground protective measures. Awareness, frequency of beach use and dog walking did not influence the perceived effectiveness of different managements. More frequent beach users had greater awareness of the species and their plight but reported greater inconvenience associated with management. Respondents with high awareness rated the severity of human-related threats higher; low awareness was associated with more inconvenience associated with on-ground protection, and exclusion and regulations. Dog walkers reported more inconvenience associated with exclusions and regulations than non-dog walkers. Dog walkers who used the beach infrequently rated threats significantly higher than frequent beach users. Conservation and education strategies could usefully be tailored to beach users' level of use and pet ownership.

Neuman KK, Stenzel LE, Warriner JC, Page GW, Erbes JL, Eyster CR, Miller E, Henkel LA. 2013. Success of captive-rearing for a threatened shorebird. *Endangered Species Research* **22**:85–94.

Captive-breeding and -rearing programs have been widely used for the conservation and recovery of imperiled species, and the success of such programs should be rigorously evaluated. In this study, we assessed the success of captive-rearing for a threatened shorebird, the snowy plover *Charadrius nivosus*, by comparing the survival and reproductive success of captive-reared and wild-reared individuals on the central California coast from 2001 to 2010. We used mark-recapture analysis, implemented in the program MARK, to estimate apparent annual survival (φ) and encounter occasion detection probability (p) from capture and sighting data of marked plovers. We compared 3 measures of reproductive success (hatch rate, fledge rate and juveniles fledged per year) using stratified randomization tests based on individual breeding histories where captive- and wild-reared plovers were matched for age, sex and year. Captive- and wild-reared snowy plovers had similar apparent survival and reproductive rates and paired with mates of similar age in their first breeding year. The only exception was that captive males after their first breeding year had lower fledging rates than males from the overall population, but this did not affect the annual productivity rate. We conclude that releasing captive-reared individuals is a valuable part of ongoing efforts to restore the snowy plover population in California, and is also useful in cases where plover nests may need to be salvaged to protect them from oil contamination or other catastrophic events.

Gates HR, Yezerinac S, Powell AN, Tomkovich PS, Valchuk OP, Lanctot RB. 2013. Differentiation of subspecies and sexes of Beringian Dunlins using morphometric measures. *Journal of Field Ornithology* **84**:389–402.

(Abstract)

Five subspecies of Dunlins (*Calidris alpina*) that breed in Beringia are potentially sympatric during the non-breeding season. Studying their ecology during this period requires techniques to distinguish individuals by subspecies. Our objectives were to determine (1) if five morphometric measures (body mass, culmen, head, tarsus, and wing chord) differed between sexes and among subspecies (*C. a. actites*, *arcticola*, *kistchinski*, *pacifica*, and *sakhalina*), and (2) if these differences were sufficient to allow for correct classification of individuals using equations derived from discriminant function analyses. We conducted analyses using morphometric data from 10 Dunlin populations breeding in northern Russia and Alaska, USA. Univariate tests revealed significant differences between sexes in most morphometric traits of all subspecies, and discriminant function equations predicted the sex of individuals with an accuracy of 83–100% for each subspecies. We provide equations to determine sex and subspecies of individuals in mixed subspecies groups, including the (1) Western Alaska group of *arcticola* and *pacifica* (known to stage together in western Alaska) and (2) East Asia group of *arcticola*, *actites*, *kistchinski*, and *sakhalina* (known to winter together in East Asia). Equations that predict the sex of individuals in mixed groups had classification accuracies between 75% and 87%, yielding reliable classification equations. We also provide equations that predict the subspecies of individuals with an accuracy of 22–96% for different mixed subspecies groups. When the sex of individuals can be predetermined, the accuracy of these equations is increased substantially. Investigators are cautioned to consider limitations due to age and feather wear when using these equations during the nonbreeding season. These equations will allow determination of sexual and subspecies segregation in non-breeding areas, allowing implementation of taxonomic-specific conservation actions.

Barth JMI, Matschiner M, Robertson BC. 2013. Phylogenetic Position and Subspecies Divergence of the Endangered New Zealand Dotterel (*Charadrius obscurus*). *PLoS ONE* **8**:e78068.

(Abstract)

The New Zealand Dotterel (*Charadrius obscurus*), an endangered shorebird of the family Charadriidae, is endemic to New Zealand where two subspecies are recognized. These subspecies are not only separated geographically, with *C. o. aquilonius* being distributed in the New Zealand North Island and *C. o. obscurus* mostly restricted to Stewart Island, but also differ substantially in morphology and behavior. Despite these divergent traits, previous work has failed to detect genetic differentiation between the subspecies, and the question of when and where the two populations separated is still open. Here, we use mitochondrial and nuclear markers to address molecular divergence between the subspecies, and apply maximum

likelihood and Bayesian methods to place *C. obscurus* within the non-monophyletic genus *Charadrius*. Despite very little overall differentiation, distinct haplotypes for the subspecies were detected, thus supporting molecular separation of the northern and southern populations. Phylogenetic analysis recovers a monophyletic clade combining the New Zealand Dotterel with two other New Zealand endemic shorebirds, the Wrybill and the Double-Banded Plover, thus suggesting a single dispersal event as the origin of this group. Divergence dates within Charadriidae were estimated with BEAST 2, and our results indicate a Middle Miocene origin of New Zealand endemic Charadriidae, a Late Miocene emergence of the lineage leading to the New Zealand Dotterel, and a Middle to Late Pleistocene divergence of the two New Zealand Dotterel subspecies.

Minton, C., Jessop, R. & Hassell, C. 2013. Wader breeding success in the 2012 Arctic summer, based on juvenile ratios of birds which spend the non-breeding season in Australia.

(Abstract)

Overall, 2012 was again a poor breeding season for most wader species which spend their non-breeding season in Australia. Given the pressures on many species of waders caused by loss of feeding habitat in key stopover locations in the Flyway it is desirable that they have the opportunity of offsetting survival losses due to this cause by having good breeding success when they are in the Arctic or elsewhere in Siberia. Arctic waders, in particular, badly need an above-average breeding outcome in 2013.

Minton, C., Jessop, R. & Hassell, C. 2013. Wader breeding success in the 2011 Arctic summer, based on juvenile ratios of birds which spend the non-breeding season in Australia.

(Abstract)

Overall 2011 was a poor breeding season for most wader species which come to Australia. This was not unexpected given that the two previous breeding seasons both appear to have been above average (with 2010 being particularly good). Sampling will continue in SEA and NWA in the 2012/2013 season. Let us hope for an improved outcome.

Minton, C., Jessop, R. & Hassell, C. 2013. Wader breeding success in the 2010 Arctic summer, based on juvenile ratios of birds which spend the non-breeding season in Australia.

(Abstract)

It is particularly pleasing to have now had two successive good breeding seasons in the Arctic, in 2009 and 2010. With so many wader populations in marked decline in the East Asian–Australasian Flyway this will be of particular benefit in trying to make good some of the losses. Hopefully wader migration patterns within Australia will return to normal in the 2011/2012 season thereby enabling population counts to be more realistic indicators of population trends. Monitoring of the juvenile content of wader populations in SEA and NWA will be continued in the 2011/2012 season.

Fort, Jerome; Steen, Harald; Strom, Hallvard; *et al.* 2013. Energetic consequences of contrasting winter migratory strategies in a sympatric Arctic seabird duet. *Journal of Avian biology* **44**:255-262

(Abstract)

At the onset of winter, warm-blooded animals inhabiting seasonal environments may remain resident and face poorer climatic conditions, or migrate towards more favourable habitats. While the origins and evolution of migratory choices have been extensively studied, their consequences on avian energy balance and winter survival are poorly understood, especially in species diffi cult to observe such as seabirds. Using miniaturized geolocators, time-depth recorders and a mechanistic model, we investigated the migratory strategies, the activity levels and the energy expenditure of the closelyrelated, sympatrically breeding Brünnich's guillemots *Uria lomvia* and common guillemots *Uria aalge* from Bjørnøya, Svalbard. Th e two guillemot species from this region present contrasting migratory strategies and wintering quarters: Brünnich's guillemots migrate across the North Atlantic to overwinter off southeast Greenland and Faroe Islands, while common guillemots remain resident in the Barents, the Norwegian and the White Seas. Results show that both species display a marked behavioural plasticity to respond to environmental constraint, notably modulating their foraging effort and diving behaviour. Nevertheless, we provide evidence that the migratory strategy adopted by guillemots can have important consequences for their energy balance. Overall energy expenditure estimated for the non-breeding season is relatively similar between both species, suggesting that both southward migration and high-arctic winter residency are energetically equivalent and suitable strategies. However, we also demonstrate that the migratory strategy adopted by Brünnich ' s guillemots allows them to have reduced daily energy expenditures during the challenging winter period. We therefore speculate that 'resident' common guillemots are more vulnerable than 'migrating' Brünnich's guillemots to harsh winter environmental conditions.

Kim KM, Moon YM, Yoo JC. 2013. Environmental factors affecting roost use of shorebirds in the southern Kanghwa Island, Republic of Korea. *Journal of Wetlands Research* **15**:251-264.

(Abstract)

There are some factors affecting the shorebirds in selecting a coastal inland roost site where they have to stay during the high tide when the entire intertidal zone is covered with water. We investigated eight species (Eastern Curlews *Numenius madagascariensis*, Green Shanks *Tringa nebularia*, Bar-tailed Godwits *Limosa lapponica*, Grey Plovers *Pluvialis squatarola*, Dunlins *Calidris alpina*, Whimbrels *Numenius phaeopus*, Eurasian Curlews *Numenius arquata* and Terek Sandpipers *Xenus cinereus*) to identify the spatial and temporal variability in coastal inland roost use in the area and the factors influencing the use. We considered the area and length of the standing water in the roost site, temperature, wind speed, the time of migration and the intensity of disturbance. As a result, number of individuals and type of species using the roost site varied across spatial and temporal scales. And the factors affecting the roost use was species-specific. The roost site of the study area was a closed shrimp farm however, it has been converted to a *Salicornia herbacea*, a salt marsh plant, farm recently. In a situation where coastal inland roost site is needed, we hereby describe a resolution for the juxtaposition of shorebirds and farming.

Nebel S, Rogers KG, Minton CDT, Rogers DI. 2013. Is geographical variation in the size of Australian shorebirds consistent with hypotheses on differential migration? *Emu* **113**:99–111.

(Abstract)

In differential migrants the members of different age-classes or sex travel to geographically separate nonbreeding areas. Here, we test five competing hypotheses explaining differential migration using more than 40 000 records of 22 species of shorebirds (Charadriiformes) occurring at two non-breeding areas at different distance from the breeding grounds and that also differ in climate. Weshowed that across species, the larger sex was more abundant in south-eastern than in north-western Australia. Size, as indicated by wing-length, was greater in the south-east than in the north-west for both males and females, whereas bill-length showed the opposite pattern. Based on these trends we conclude that the interaction between ambient temperature, body-size and bill-length determines the geographical distribution of shorebirds wintering in Australia. Ourfindings are not consistent with the resource partitioning, dominance and arrival time hypotheses. This is the first study that disassociates overlapping predictions of competing hypotheses on differential migration, thus contributing to our understanding of the evolution of differential migration in birds.

Fuller RA, Bearhop S, Metcalfe NB, Piersma T. 2013. The effect of group size on vigilance in Ruddy Turnstones *Arenaria interpres* varies with foraging habitat. *Ibis* **155**:246–257.

(Abstract)

Foraging birds can manage time spent vigilant for predators by forming groups of various sizes. However, group size alone will not always reliably determine the optimal level of vigilance. For example, variation in predation risk or food quality between patches may also be influential. In a field setting, we assessed how simultaneous variation in predation risk and intake rate affects the relationship between vigilance and group size in foraging Ruddy Turnstones *Arenaria interpres.* We compared vigilance, measured as the number of 'head-ups' per unit time, in habitat types that differed greatly in prey energy content and proximity to cover from which predators could launch surprise attacks. Habitats closer to predator cover provided foragers with much higher potential net energy intake rates than habitats further from cover. Foragers formed larger and denser flocks on habitats closer to cover. Individual vigilance of foragers in all habitats declined with increasing flock size and increased with flock density. However, vigilance by foragers on habitats closer to cover was always higher for a given flock size than vigilance by foragers on habitats further from cover, and habitat remained an important predictor of vigilance in models including a range of potential confounding variables. Our results suggest that foraging Ruddy Turnstones can simultaneously assess information on group size and the general likelihood of predator attack when determining their vigilance contribution.

Conklin JR, Battley PF, Potter MA. 2013. Absolute Consistency: Individual versus Population Variation in Annual-Cycle Schedules of a Long-Distance Migrant Bird. *PLoS ONE* **8**:e54535.

(Abstract)

Flexibility in scheduling varies throughout an organism's annual cycle, reflecting relative temporal constraints and fitness consequences among life-history stages. Time-selection can act at different scales, either by limiting the range of alternative strategies in the population, or by increasing the precision of individual performance. We tracked individual bar-tailed godwits *Limosa lapponica baueri* for two full years (including direct observation during non-breeding seasons in New Zealand and geolocator tracking of round-trip migrations to Alaska) to present a full annual-cycle view of molt, breeding, and migration schedules. At both population and individual scales, temporal variation was greater in post-breeding than pre-breeding stages, and greater in molts than in movements, but schedules did not tighten across successive stages of migration toward the breeding grounds. In general, individual godwits were quite consistent in timing of events throughout the year, and repeatability of pre-breeding movements was particularly high ($r = 0.82–0.92$). However, we demonstrate that r values misrepresent absolute consistency by confounding inter- and intra-individual variation; the biological significance of r values can only be understood when these are considered separately. By doing so, we show that some stages have considerable tolerance for alternative strategies within the population, whereas scheduling of northbound migratory movements was

similar for all individuals. How time-selection simultaneously shapes both individual and population variation is central to understanding and predicting adaptive phenological responses to environmental change.

Hua N, Piersma T, Ma Z. 2013. Three-Phase Fuel Deposition in a Long-Distance Migrant, the Red Knot (*Calidris canutus piersmai*), before the Flight to High Arctic Breeding Grounds. *PLoS ONE***8**:e62551.

(Abstract)

Refuelling by migratory birds before take-off on long flights is generally considered a two-phase process, with protein accumulation preceding rapid fat deposition. The first phase expresses the demands for a large digestive system for nutrient storage after shrinkage during previous flights, the second phase the demands for fat stores to fuel the subsequent flight. At the last staging site in northward migration, this process may include expression of selection pressures both en route to and after arrival at the breeding grounds, which remains unascertained. Here we investigated changes in body composition during refuelling of High Arctic breeding red knots (*Calidris canutus piersmai*) in the northern Yellow Sea, before their flight to the tundra. These red knots followed a three-phase fuel deposition pattern, with protein being stored in the first and last phases, and fat being deposited mainly in the second phase. Thus, they did not shrink nutritional organs before take-off, and even showed hypertrophy of the nutritional organs. These suggest the build up of strategic protein stores before departure to cope with a protein shortage upon arrival on the breeding grounds. Further comparative studies are warranted to examine the degree to which the deposition of stores by migrant birds generally reflects a balance between concurrent and upcoming environmental selection pressures.

Kelsey P. Obernuefemann, Jaime A. Collazo and James E. Lyons. 2013. Local Movements and Wetland Connectivity at a Migratory Stopover of Semipalmated Sandpipers (*Calidris pusilla*) in the Southeastern United States Waterbirds **36(1)**:63-76.

(Abstract)

Semipalmated Sandpipers (*Calidris pusilla*) use coastal wetlands in the southeastern United States during spring migration, some engaging in short-distance movements and brief refueling stops. Knowledge about the scale and factors that influence these movements could guide conservation planning, but often this information is not available. The influence of inter-wetland distance, prey biomass, amount of foraging habitat at depths of 0–4 cm, and density of migrating Semipalmated Sandpipers on their movement and stopover residency was investigated at the Tom Yawkey Wildlife Center in South Carolina in spring 2007. Tom Yawkey

Wildlife Center contains three clusters of coastal wetlands separated by 2.6, 2.8 and 4.1 km. Probability of moving among wetland clusters and stopover residency were estimated using multi-state mark-recapture models and encounter histories from 502 marked Semipalmated Sandpipers. Sixty-four percent of Semipalmated Sandpipers remained within 2 km of site-of-capture for the duration of the study. Movement probabilities were negatively influenced by inter-cluster distance and Semipalmated Sandpiper density. Probability of moving between clusters 2.6–2.8 km apart was higher than clusters separated by 4.1 km. Semipalmated Sandpipers were more likely to depart the study area and resume migration after feeding in wetland clusters with abundant prey and accessible habitat. The interaction between prey and accessible habitat led to instances where Semipalmated Sandpipers were more likely to remain in wetlands with low prey levels, but high accessible habitat, or low accessible habitat, but high prey levels. Local movements among alternative foraging locations were facilitated when wetlands were < 2.8 km apart, highlighting the benefits of integrated management at small scales.

Gogga P, Karbowska J, Kochan Z, Meissne W. 2013. Circulating leptin levels donot reflect the amount of body fat in the dunlin *Calidris alpina* during migration. *General and Comparative Endocrinology* **187**:74-78.

(Abstract)

Leptin is a peptide hormone that plays an important role inthe regulation of energy homeostasis. Studies in mammals have shown that circulating leptin levels reflect adiposity and that this adipocyte-derived cytokine acts as an afferent satiety signal to the brain, decreasing food intake and increasing energy expenditure. Since leptin has been found in the liver and adipose tissue of migratory birds that are able to accumulate fat reserves as endogenous fuel for flight, we hypothesized that individuals with higher fat score would have higher plasma leptin levels, as it had been found previously in mammals. The aim of this study was to determine if circulating leptin levels correlate with the amount of body fat in a migratory bird, the dunlin *Calidris alpina*. Adult dunlins were caught during autumn migration on the Baltic coast, and their fat score was determined. Blood samples from 150 birds were used to assess the levels of circulating leptin. We did not find any statistical differences between dunlins with various fat scores. In fact, plasma leptin levels tended to be lower in fat birds than in lean individuals. Our data indicate that in wild birds inmigration mode leptin does not reflect the amount of accumulated fat. It suggests that leptin in birds during migration is neither involved in the regulation of energy homeostasis nor acts as a signal to control the amount of body fat.

Leyrer J, Lok T, Brugge M, Spaans B, Sandercock BK, Piersma T. 2013. Mortality within the annual cycle: seasonal survival patterns in Afro-Siberian Red Knots *Calidris canutus canutus. Journal of Ornithology* **154(4)**: 933-943.

(Abstract)

Estimates of seasonal mortality for long-distance migrant birds are extremely challenging to collect and consequently reports are scarce. Determining when and where mortality occurs within the annual cycle is important for an understanding of population dynamics and the evolutionary drivers of long-distance migration. We collected data on seasonal survival in a mark–recapture study of colour-marked Red Knots Calidris canutus canutus in their main wintering area at tropical Banc d'Arguin, Mauritania, West Africa. Our study population breeds 9,000 km to the northeast on Taymyr Peninsula, central northern Siberia. Our results show that annual apparent survival decreased from 0.87 ± 0.01 (SE) in 2002–2005 to 0.78 ± 0.02 in 2006–2009. During the 3-year time-window between 2006 and 2009, additional resightings just before migration and after return to the wintering grounds allowed us to partition the year into two periods: the nonbreeding period on the Banc d'Arguin, and the migration and breeding period away from it.We estimated that, on the Banc d'Arguin, the 2-month apparent survival rate was 0.94 ± 0.01, whereas 2-month survival approached unity during the rest of year. Hence, most mortality occurred on the tropical wintering grounds. We review the possible physiological and ecological stressors involved and discuss the generality of these results.

Alves JA, Gunnarsson TG, Potts PM, Sutherland WJ, Gill JA. 2013. Sex-biases in distribution and resource use at different spatial scales in a migratory shorebird. *Ecology and Evolution* **3**:1079–1090.

(Abstract)

In migratory species, sexual size dimorphism can mean differing energetic requirements for males and females. Differences in the costs of migration and in the environmental conditions occurring throughout the range may therefore result in sex-biases in distribution and resource use at different spatial scales. In order to identify the scale at which sexual segregation operates, and thus the scale at which environmental changes may have sex-biased impacts, we use range-wide tracking of individually color-ringed Icelandic black-tailed godwits (*Limosa limosa islandica*) to quantify sexual segregation at scales ranging from the occupation of sites throughout the non-breeding range to within-site differences in distribution and resource use. Throughout the range of this migratory shorebird, there is no evidence of large-scale sex differences in distribution during the non-breeding season. However, the sexes differ in their selection of prey types and sizes, which results in small-scale sexual segregation within estuaries. The scale of sexual segregation therefore depends on the scale of variation in resource distribution, which, in this system, is primarily within estuaries. Sexual segregation in within-site distribution and resource use means that local-scale anthropogenic impacts on estuarine benthic prey communities may disproportionately affect the sexes in these migratory shorebirds.

Nebel S, Buehler DM, MacMillan A, Guglielmo CG. 2013. Flight performance of western sandpipers, Calidris mauri, remains uncompromised when mounting an acute phase immune response. *The Journal of Experimental Biology* **216**:2752-2759.

(Abstract)

Migratory birds have been implicated in the spread of some zoonotic diseases, but how well infected individuals can fly remains poorly understood. We used western sandpipers, Calidris mauri, to experimentally test whether flight is affected when longdistance migrants are mounting an immune response and whether migrants maintain immune defences during a flight in a wind tunnel. We measured five indicators of innate immunity in 'flown-healthy' birds (flying in a wind tunnel without mounting an immune response), 'flown-sick' birds (flying while mounting an acute phase response, which is part of induced innate immunity), and a non-flying control group ('not-flown'). Voluntary flight duration did not differ between flown-healthy and flown-sick birds, indicating that mounting an acute phase response to simulated infection did not hamper an individual's ability to fly for up to 3 h. However, in comparison to not-flown birds, bacterial killing ability of plasma was significantly reduced after flight in flown-sick birds. In flown-healthy birds, voluntary flight duration was positively correlated with bacterial killing ability and baseline haptoglobin concentration of the blood plasma measured 1–3 weeks before experimental flights, suggesting that high quality birds had strong immune systems and greater flight capacity. Our findings indicate that flight performance is not diminished by prior immune challenge, but that flight while mounting an acute phase response negatively affects other aspects of immune function. These findings have important implications for our understanding of the transmission of avian diseases, as they suggest that birds can still migrate while fighting an infection.

Barshep Y, Minton CDT, Underhill LG, Erni B, Tomkovich PS. 2013. Flexibility and constraints in the molt schedule of long-distance migratory shorebirds: causes and consequences. *Ecology and Evolution* **3**:1967-1976.

(Abstract)

Molt is a major component of the annual cycle of birds, the timing and extent of which can affect body condition, survival, and future reproductive success through carry-over effects. The way in which molt is fitted into the annual cycle seems to be a somewhat neglected area which is both of interest and of importance. Study of the causes of annual variation in the timing of molt and its potential consequence in long-distance migratory birds was examined using the Curlew Sandpiper, *Calidris ferruginea*, as a model species. Using the maximum likelihood molt models of Underhill and Zucchini (1988, Ibis 130:358–372), the relationship

between annual variability in the start dates of molt at the population level with conditions on the breeding area was explored. Adult males typically started early in years when temperature in June on the Arctic breeding grounds were high compared to cold years while adult females molted later in years of high breeding success and/or warm July temperature and vice versa. When molt started later, the duration was often shorter, indicating that late completion of molt might have fitness consequences, probably jeopardizing survival. Evidence of this was seen in the low body condition of birds in years when molt was completed late. The results indicate that these migratory shorebirds follow a fine-tuned annual life cycle, and disturbances at a certain stage can alter next biological events through carry-over effects.

Shorebirds 2012

Bart, J., V. Johnston, P. A. Smith, and J. Rausch. 2012. Arctic Shorebirds in North America: A Decade of Monitoring. *University of California Press*, Berkeley.

(Abstract)

During the field research in the south of the Magadan region in 2010–2011, we recorded a number of interesting species of shorebirds. Some of them are listed in Red Books of the Russian Federation, Magadan Region, Kamchatka, and Chukotka, another one are known in the study area only as vagrants.

Chowdhury, S. U. 2012. A survey of over-summering shorebirds at Sonadia Island, Cox's Bazar, Bangladesh. *Stilt* **61**:34-36.

(Abstract)

An over-summering shorebird survey was carried out at Sonadia Island, Cox's Bazar, Bangladesh, in April and May 2011. A total of 16 species were recorded, comprising 285 individuals at Tajiakata and Kaladia in mid-May, and 322 individuals at Tajiataka in early-June 2011 including one globally threatened Nordmann's Greenshank *Tringa guttifer*, seven Great Knot *Calidris tenuirostris* and 27 Eurasian Curlew *Numenius arquata*. The three most abundant species were Lesser Sand Plover *Charadrius mongolus* (129 in May and 220 in June), Greater Sand Plover *Charadrius leschenaultii*(67 in May and 33 in June) and Eurasian Curlew *Numenius arquata* (27 in May). Sonadia Island is an important site in the East Asian – Australasian Flyway for at least five globally threatened shorebirds, as it supports significant numbers of adult birds in wintering, and small numbers of first-year juvenile birds in over-summering periods. Sonadia Island is declared nationally as an Ecological Critical Area (ECA) and to acquire further international focus and support, the island should be designated as Ramsar site and Important Bird Area since it fulfils the criteria for both.

Crossland, A. C., L. Lubis, S. A. Sinambela, A. S. Sitorus, A. W. Sitorus, and A. Muis. 2012. Observations of shorebirds along the Deli-Serdang Coast, North Sumatra Province, Indonesia: 1995–2006. *Stilt* **61**:37-44.

(Abstract)

This paper reports the presence of large populations of shorebirds on the Deli-Serdang coastline of North Sumatra Province, western Indonesia. We estimate that upwards of 22,000 shorebirds of 32 species (25 waders, six terns, one gull) occurred in this area during 1995 to 2006, including internationally significant concentrations of Lesser Sand Plover, Greater Sand Plover, Asian Dowitcher, Bar-tailed Godwit, Eurasian Curlew, Common Redshank, Terek Sandpiper and Curlew Sandpiper. This confirms the international importance of this area to shorebirds and, as the area is under threat from development and other human uses, it will benefit from increased international recognition.

Conklin JR, Battley PF. 2012. Carry-over effects and compensation: late arrival on non-breeding grounds affects wing moult but not plumage or schedules of departing bar-tailed godwits Limosa lapponica baueri. *Journal of Avian biology* **43,** 252-263

(Abstract)

In the annual cycle of migratory birds, temporal and energetic constraints can lead to carry-over effects, in which performance in one life history stage aff ects later stages. Bar-tailed godwits *Limosa lapponica baueri*, which achieve remarkably high pre-migratory fuel loads, undertake the longest non-stop migratory flights yet recorded, and breed during brief high-latitude summers, may be particularly vulnerable to persistent effects of disruptions to their rigidly-timed annual routines. Using three years of non-breeding data in New Zealand, we asked how arrival timing after a non-stop flight from Alaska (>11 000 km) affected an individual godwit's performance in subsequent flight feather moult, contour feather moults, and migratory departure. Late arrival led to later wing moult, but godwits partially compensated for delayed moult initiation by increasing moult rate and decreasing the total duration of moult. Delays in arrival and wing moult up to 34 – 37 d had no apparent effect on an individual's migratory departure or extent of breeding plumage at departure, both of which were extraordinarily consistent between years. Thus, 'errors' in timing early in the non-breeding season were essentially corrected in New Zealand prior to spring migration. Variation in migration timing also had no apparent effect on an individual's likelihood of returning the following season. The bar-tailed godwits' rigid maintenance of plumage and spring migration schedules, coupled with high annual survival, imply a surprising degree of flexibility to address unforeseen circumstances in the annual cycle.

Gosbell K, Minton CDT, Fox JW. 2012. Geolocators reveal incubation and re-nesting characteristics of Ruddy Turnstones Arenaria interpres and Eastern Curlews Numenius madagascariensis. *Wader Study Group Bulletin* **119,** 160–171.

(Abstract)

We report findings from geolocators on the breeding phenology and incubation of Ruddy Turnstones and Eastern Curlews. Output from 26 geolocators deployed and retrieved from Ruddy Turnstones in SE Australia during 2009–2011 showed that two birds failed to breed but the other 24 made one or two nesting attempts. Eight were apparently successful in hatching their first clutch having incubated for a full term; 16 lost their first clutch and seven of them did not attempt to re-nest; the other nine re-nested, and of those, four succeeded and five failed. The nine birds that re-nested lost their first clutches significantly earlier than the seven that did not attempt to re-nest. This study is the first to report re-nesting in arctic-breeding Ruddy Turnstones. In 2011, half the birds that nested successfully (4/8) did so because they re-nested suggesting that re-nesting might make a significant contribution to overall breeding productivity. For 12 Ruddy Turnstones that completed full-term incubation periods, there was no systematic difference between the sexes in the length of incubation bouts or in the aggregate time spent incubating per day. However, these parameters differed significantly between individual birds and some spent considerably more time incubating than others. Time spent incubating per day averaged 9.9 hours and showed no significant change across the incubation period. The length of incubation bouts showed a significant humped, quadratic relationship with the incubation period, increasing steeply over the first nine days and declining towards the end. Output from three geolocators deployed and retrieved from Eastern Curlews in SE Australia in 2011 showed that all three failed to nest successfully, with one bird possibly making an unsuccessful second nesting attempt. This study demonstrates the value of using geolocators to study the behaviour of arctic-breeding waders.

Vezina F, Williams TD, Piersma T, Morrison RIG. 2012. Phenotypic compromises in a long-distance migrant during the transition from migration to reproduction in the High Arctic. *Functional Ecology* **26**, 500–512.

(Abstract)

1. Seasonal carry-over effects may be important structuring components of avian life-history cycles. However, little is known on physiological transitions between stages and on phenotypic compromises that may be made at such time to improve fitness.

2. We studied postmigratory body remodelling in red knots (*Calidris canutus islandica*) arriving on the Arctic breeding grounds. Our objectives were to determine the effects of body

reconstruction and preparation for breeding on maintenance energy costs and to determine whether weather conditions can force compromises between functions required for postmigration recovery of body composition, thermoregulation and breeding.

3. During two consecutive springs at the northernmost land on Earth (Alert, Ellesmere Island, Canada, 82o30'N), we monitored changes in knots post-arrival body stores. Using ultrasonography, we also tracked changes in gizzard size, an indicator of gut size, and pectoral muscle thickness, not only an endogenous protein source but also a thermogenic organ. We measured basal metabolic rate (BMR) throughout reconstruction and compared it with BMR of nonbreeding red knots wintering in the Dutch Wadden Sea.

4. Arriving knots faced temperatures up to 13oC lower than during midwinter. Birds arrived with large body stores and pectoral muscles, which declined in size while they grew their gizzard and prepared for breeding. BMR at arrival was indistinguishable from winter BMR and increased linearly throughout reconstruction. BMR increased up to 69% faster in females than males, likely due to the development of their reproductive organs.

5. Birds had lower body stores but larger muscles in the colder year, and muscle loss was correlated with the warming of spring temperatures. Therefore, muscles would not only serve as a nutrient source, but their thermogenic function could also provide the flexibility to cope with high thermostatic costs in the spring. However, retaining muscles for shivering may limit protein recirculation and delay the onset of breeding.

6. Postmigratory recovery therefore involves significant energy costs and arriving birds likely have to make physiological compromises, depending on spring conditions, which may impact on fitness. Although this period is clearly critical in the life cycle of red knots, it is one of the least understood life-history stages in Arctic-breeding shorebirds.

VanDusen BM, Fegley SR, Peterson CH. 2012. Prey Distribution, Physical Habitat Features, and Guild Traits Interact to Produce Contrasting Shorebird Assemblages among Foraging Patches. *PLoS ONE* **7,** e52694.

(Abstract)

Worldwide declines in shorebird populations, driven largely by habitat loss and degradation, motivate environmental managers to preserve and restore the critical coastal habitats on which these birds depend. Effective habitat management requires an understanding of the factors that determine habitat use and value to shorebirds, extending from individuals to the entire community. While investigating the factors that influenced shorebird foraging distributions among neighboring intertidal sand flats, we built upon species-level understandings of individual-based, small-scale foraging decisions to develop more comprehensive guild- and community-level insights. We found that densities and community composition of foraging shorebirds varied substantially among elevations within some tidal flats and among five flats despite their proximity (all located within a 400-m stretch of natural, unmodified inlet shoreline). Non-dimensional multivariate analyses revealed that the changing

composition of the shorebird community among flats and tidal elevations correlated significantly (rs = 0.56) with the spatial structure of the benthic invertebrate prey community. Sediment grain-sizes affected shorebird community spatial patterns indirectly by influencing benthic macroinvertebrate community compositions. Furthermore, combining sediment and macroinvertebrate information produced a 27% increase in correlation (rs = 0.71) with shorebird assemblage patterns over the correlation of the bird community with the macroinvertebrate community alone. Beyond its indirect effects acting through prey distributions, granulometry of the flats influenced shorebird foraging directly by modifying prey availability. Our study highlights the importance of habitat heterogeneity, showing that no single patch type was ideal for the entire shorebird community. Generally, shorebird density and diversity were greatest at lower elevations on flats when they became exposed; these areas are at risk from human intervention by inlet sand mining, construction of groins and jetties that divert sediments from flats, and installation of seawalls on inlet shorelines that induce erosion of flats.

Tulp I, Schekkerman H, de Leeuw J. 2012. Eggs in the Freezer: Energetic Consequences of Nest Site and Nest Design in Arctic Breeding Shorebirds. *PLoS ONE* **7**, e38041.

(Abstract)

Birds construct nests for several reasons. For species that breed in the Arctic, the insulative properties of nests are very important. Incubation is costly there and due to an increasing surface to volume ratio, more so in smaller species. Small species are therefore more likely to place their nests in thermally favourable microhabitats and/or to invest more in nest insulation than large species. To test this hypothesis, we examined characteristics of nests of six Arctic breeding shorebird species. All species chose thermally favourable nesting sites in a higher proportion than expected on the basis of habitat availability. Site choice did not differ between species. Depth to frozen ground, measured near the nests, decreased in the course of the season at similar non-species-specific speeds, but this depth increased with species size. Nest cup depth and nest scrape depth (nest cup without the lining) were unrelated to body mass (we applied an exponent of 0.73, to account for metabolic activity of the differently sized species). Cup depth divided by diameter2 was used as a measure of nest cup shape. Small species had narrow and deep nests, while large species had wide shallow nests. The thickness of nest lining varied between 0.1 cm and 7.6 cm, and decreased significantly with body mass. We reconstruct the combined effect of different nest properties on the egg cooling coefficient using previously published quantitative relationships. The predicted effect of nest cup depth and lining depth on heat loss to the frozen ground did not correlate with body mass, but the sheltering effect of nest cup diameter against wind and the effects of lining material on the cooling coefficient increased with body mass. Our results suggest that small arctic shorebirds invest more in the insulation of their nests than large species.

Gutierrez JS, Dietz MW, Masero JA, Gill Jr RE, Dekinga A, Battley PF, Sanchez-Guzman JM, Piersma T. 2012. Functional ecology of saltglands in shorebirds: flexible responses to variable environmental conditions. *Functional Ecology* **26**, 236–244.

(Abstract)

1. Birds of marine environments have specialized glands to excrete salt, the saltglands. Located on the skull between the eyes, the size of these organs is expected to reflect their demand, which will vary with water turnover rates as a function of environmental (heat load, salinity of prey and drinking water) and organismal (energy demand, physiological state) factors. On the basis of inter- and intraspecific comparisons of saltgland mass (msg) in 29 species of shorebird (suborder Charadrii) from saline, fresh and mixed water habitats, we assessed the relative roles of organism and environment in determining measured msg species.

2. The allometric exponent, scaling dry msg to shorebird total body mass (mb), was significantly higher for coastal marine species (0.88, N = 19) than for nonmarine species (0.43, N = 14). Within the marine species, those ingesting bivalves intact had significantly higher msg than species eating soft-bodied invertebrates, indicating that seawater contained within the shells added to the salt load.

3. In red knots (*Calidris canutus*), dry msg varied with monthly averaged ambient temperature in a U-shaped way, with the lowest mass at 12.5 oC. This probably reflects increased energy demand for thermoregulation at low temperatures and elevated respiratory water loss at high temperatures. In fuelling bar-tailed godwits (*Limosa lapponica*), dry msg was positively correlated with intestine mass, an indicator of relative food intake rates. These findings suggest once more that saltgland masses vary within species (and presumably individuals) in relation to salt load, that is a function of energy turnover (thermoregulation and fuelling) and evaporative water needs.

4. Our results support the notion that msg is strongly influenced by habitat salinity, and also by factors influencing salt load and demand for osmotically free water including ambient temperature, prey type and energy intake rates. Saltglands are evidently highly flexible organs. The small size of saltglands when demands are low suggests that any time costs of adjustment are lower than the costs of maintaining a larger size in this small but essential piece of metabolic machinery.

Kosztolányi A, Küpper C, Chastel O, Parenteau C, Yılmaz T, Miklósi Á, Székely T, Lendvai ÁZ. 2012. Prolactin stress response does not predict brood desertion in a polyandrous shorebird. *Hormones and Behavior* **61**, 734–740.

(Abstract)

One of the fundamental principles of the life-history theory is that parents need to balance their resources between current and future offspring. Deserting the dependent young is a radical life-history decision that saves resources for future reproduction but that may cause the current brood to fail. Despite the importance of desertion for reproductive success, and thus fitness, the neuroendocrine mechanisms of brood desertion are largely unknown. We investigated two candidate hormones that may influence brood desertion in the Kentish plover *Charadrius alexandrinus*: prolactin ('parental hormone') and corticosterone ('stress hormone'). Kentish plovers exhibit an unusually diverse mating and parental care system: brood desertion occurs naturally since either parent (the male or the female) may desert the brood after the chicks hatch and mate with a new partner shortly after. We measured the hormone levels of parents at hatching using the standard capture and restraint protocol. We subsequently followed the broods to determine whether a parent deserted the chicks. We found no evidence that either baseline or stress-induced prolactin levels of male or female parents predicted brood desertion. Although stress-induced corticosterone levels were generally higher in females compared with males, individual corticosterone levels did not explain the probability of brood desertion.We suggest that, in this species, low prolactin levels do not trigger brood desertion. In general, we propose that the prolactin stress response does not reflect overall parental investment in a species where different parts of the breeding cycle are characterized by contrasting individual investment strategies.

Escudero G, Navedo JG, Piersma T, De Goeij P, Edelaar P. 2012. Foraging conditions 'at the end of the world' in the context of long-distance migration and population declines in red knots. *Austral Ecology* **37,**355–364.

(Abstract)

The long-distance migrant red knot (*Calidris canutus* ssp. rufa – Scolopacidae) alternates between the northern and southern ends of the New World, one of the longest yearly migrations of any bird and paradoxically overflying apparently suitable habitat at lower latitudes.This subspecies is sharply declining, with a major mortality event following 2000, attributed to commercial overharvesting of food resources at its Delaware Bay (USA) stop-over site. A full understanding of this peculiar migrant requires an assessment of the foraging conditions at its southern hemisphere wintering sites. Here, for a major wintering site in Argentinean Tierra del Fuego (Río Grande), we describe and compare food abundance, diet and intake rates during January–February in 1995, 2000 and 2008. The two main prey types were the burrowing clam *Darina solenoides* and three species of epibenthic mussels Mytilidae. In the year 2000, food availability and intake rate were higher than those recorded at other sites used by knots anywhere else in the world, contributing to the explanation of why red knots carry out this impressive migration. Intake rate in 2008 on the two main prey types was dramatically reduced as a result of birds eating smaller prey and strongly increased human disturbance; the same year we also found a high prevalence of a digenean parasite in *Darina*. We suggest that during the strongly enhanced winter mortality in 2000, knots did not yet face ecological problems in their southernmost wintering area, consistent with the previous

evidence that problems at northern stop-overs negatively affected their numbers. However, in 2008 the ecological conditions at Río Grande were such that they would have facilitated a further decline, emphasizing the importance of a hemispheric approach to research and management.

Mendez V, Gill JA, Burton NHK, Austin GE, Petchey OL, Davies RG. 2012. Functional diversity across space and time: trends in wader communities on British estuaries. *Diversity and Distributions***18**, 356–365.

(Abstract)

Aim British estuarine ecosystems support large populations of protected migratory waders. Understanding how wader communities vary spatially and how they may be changing temporally can greatly improve the understanding of these dynamic ecosystems. Here, we explore the variation in functional diversity (using a range of morphological and ecological traits) in order to identify the processes shaping wader communities on British estuaries and how these processes may be changing. Location England, Wales and Scotland. Methods We use national survey data (Wetland Bird Survey) from 1980/1981 to 2006/2007 winter to calculate functional diversity (FD) – an index that measures trait dispersion – in wader communities on 100 estuaries. We test for evidence of non-random patterns of diversity and explore the relative importance of two key processes, environmental filtering and competition, in shaping these communities. Results The observed FD was significantly and positively associated with species richness and to a lesser extent estuary area, followed by longitude. An increase in observed FD was observed since 1980, supported by a small but significant slope. In the majority of cases, changes in FD were mirrored by changes in species richness. Observed FD was on average lower than expected by chance, as indicated by a negative value of observed minus expected FD. However, this difference became less negative over time, with observed minus expected FD values increasing slightly, but significantly, over the study period. Main conclusions Wader FD varies across British estuaries, and the relative influence of the processes by which communities are structured appears to be changing through time. We discuss the potential drivers underlying these patterns and the importance of identifying such drivers for the protection of wader communities.

Hong S-B, Lee I-S. 2012. Visitation Aspect of shorebirds (*Tringa* spp.) in the Nakdong Estuary, Busan.*Journal of Korean Nature* **5,** 267-272.

(Abstract)

This study was conducted at Nakdong Estuary in Busan Metropolitan City. The study aimed to monitor *Tringa* spp. at Nakdong Estuary through the comparative analysis of the long-term

findings between the early 1990s (May, 1989~April, 1993) and the mid-2000s (May, 2002~April, 2008). During the research period (May, 1989~April,1993, May, 2002~April, 2008: 10 years in total), the total of 116,761 birds representing 9 genera, 27 species were observed. Of them, the total number of *Tringa* genus of family *Scolopacidae* was 1,461 individuals (1.25%) representing 7 species, including 150 individuals of *Tringa erythropus*, 24 individuals of *Tringa totanus*, 28 individuals of *Tringa stagnatilis*, 1,223 individuals of *Tringa nebularia*, 9 individuals of *Tringa guttifer*, 24 individuals of *Tringa ochropus*, and 3 individuals of *Tringa glareola*. The monthly comparison of the visitation of the genera *Tringa* between two periods, there was no significant difference between the individual numbers in the early 1990s and the mid-2000s ($P<0.39$). There were more individuals observed in the early 1990s (Mean=163.00) than those in the mid-2000s (Mean=134.83). The results of monthly number of individuals in each year between the early 1990s and the mid-2000s (from May to April in following year) indicated that there was statistically significant mean difference in May ($P<0.01$). On the other hand, no statistical significance was found in the other months. The means of the individual numbers observed in the mid-2000s appear in Table 3 and Fig 3. As Table 3 indicates, the mean of individual number of five sites was 26.97: 57.33 individuals in Daema-deung (DMD), 11.83 individuals in Jangja and Shinja-Do (JJ & SJD), 7.33 individuals in Saja and Doyo-deung (SJ & DYD), 8.00 individuals in Lower Ulsuk-Do (LUD), 50.33 individuals in Ulsuk-Do (USD). There was statistically significant mean difference among these five sites ($P<0.01$).

Battley PF, Warnock N, Tibbitts TL, Gill Jr RE, Piersma T, Hassell CJ, Douglas DC, Mulcahy DM, Gartell BD, Schuckard R, Melville DS, Riegen AC. 2012. Contrasting extreme long-distance migration patterns in bar-tailed godwits *Limosa lapponica. Journal of Avian Biology* **43,** 21–32.

(Abstract)

Migrating birds make the longest non-stop endurance flights in the animal kingdom. Satellite technology is now providing direct evidence on the lengths and durations of these flights and associated staging episodes for individual birds. Using this technology, we compared the migration performance of two subspecies of bar-tailed godwit *Limosa lapponica* travelling between non-breeding grounds in New Zealand (subspecies *baueri*) and northwest Australia (subspecies *menzbieri*) and breeding grounds in Alaska and eastern Russia, respectively. Individuals of both subspecies made long, usually non-stop, flights from non-breeding grounds to coastal staging grounds in the Yellow Sea region of East Asia (average 10 060 +/- SD 290 km for *baueri*and 5860 +/- 240 km for *menzbieri*). After an average stay of 41.2+/- 4.8 d, *baueri* flew over the North Pacific Ocean before heading northeast to the Alaskan breeding grounds (6770 +/- 800 km). *Menzbieri* staged for 38.4 +/- 2.5 d, and flew over land and sea northeast to high arctic Russia (4170+/- 370 km). The post-breeding journey for *baueri*involved several weeks of staging in southwest Alaska followed by non-stop flights across the Pacific Ocean to New Zealand (11 690 km in a complete track) or stopovers on islands in the southwestern Pacific en route to New Zealand and eastern Australia. By contrast, *menzbieri* returned to Australia via stopovers in the New Siberian Islands, Russia,

and back at the Yellow Sea; birds travelled on average 4510 +/- 360 km from Russia to the Yellow Sea, staged there for 40.8 +/-5.6 d, and then flew another 5680–7180 km to Australia (10 820 +/- 300 km in total). Overall, the entire migration of the single *baueri* godwit with a fully completed return track totalled 29 280 km and involved 20 d of major migratory flight over a round-trip journey of 174 d. The entire migrations of *menzbieri* averaged 21 940 +/- 570 km, including 14 d of major migratory flights out of 154 d total. Godwits of both populations exhibit extreme flight performance, and *baueri* makes the longest (southbound) and second-longest (northbound) non-stop migratory flights documented for any bird. Both subspecies essentially make single stops when moving between non-breeding and breeding sites in opposite hemispheres. This reinforces the critical importance of the intertidal habitats used by fuelling godwits in Australasia, the Yellow Sea, and Alaska.

Soloviev MY, Tomkovich PS, Popovkina AB, Golovnyuk VV. 2012. Recent advances in understanding migration links of waders (Charadrii) breeding on Taimyr peninsula. *Zoologičeskij žurnal* **91,** 831-842.

(Abstract)

Information about ringing and long-distance recoveries of Taimyr waders accumulated after 1997 is analyzed; some their migration links are refined. Ringing effort on Taimyr decreased from the annual average of 558 waders in 1989—1997 to 417 waders in 1998—2011. Taimyr dunlins of the subspecies *Calidris alpina centralis* migrated to the Middle East and eastern Mediterranean, red-necked stints (C. *ruficollis*) spent winter in southeastern Australia, and little stints (C. *minuta*) flew to Africa. Records of ringed pectoral sandpipers (C. *melanotos*) from North America and Central America confirmed the migration link of Siberian birds of this species with the wintering area in South America. Grey plovers (*Pluvialis squatarola*) from the European non-breeding grounds appeared to migrate much farther to the east at Taimyr than it was known before. Additional data collected for the curlew sandpiper (*Calidris ferruginea*) and little stint indicated that their populations from different non-breeding grounds overlapped on Taimyr to a lesser extent than it was previously expected. During the previous analysis of migration links of Taimyr waders, most of the available data referred to wintering or staging sites in Western Europe, while the most interesting recent information (after 1997) was obtained for populations migrating across Eastern Europe, Middle East and Eastern Siberia. Future studies will strongly benefit from using modern advanced technologies, such as satellite tracking and geolocators. Nevertheless, for most of the wader species there is no alternative to traditional bird ringing and colour-marking.

Lesku JA, Rattenborg NC, Valcu M, Vyssotski AL, Kuhn S, Kuemmeth F, Heidrich W, Kempenaers B. 2012. Adaptive Sleep Loss in Polygynous Pectoral Sandpipers. *Science* **337**, 1654-1658.

(Abstract)

The functions of sleep remain elusive. Extensive evidence suggests that sleep performs restorative processes that sustain waking brain performance. An alternative view proposes that sleep simply enforces adaptive inactivity to conserve energy when activity is unproductive. Under this hypothesis, animals may evolve the ability to dispense with sleep when ecological demands favor wakefulness. Here, we show that male pectoral sandpipers (*Calidris melanotos*), a polygynous Arctic breeding shorebird, are able to maintain high neurobehavioral performance despite greatly reducing their time spent sleeping during a 3-week period of intense male-male competition for access to fertile females. Males that slept the least sired the most offspring. Our results challenge the view that decreased performance is an inescapable outcome of sleep loss.

Cooper R, Clemens RS, Oliveira N, Chase A. 2012. Long-term declines in migratory shorebird abundance in north-east Tasmania. *Stilt* **61,** 19-29.

(Abstract)

Evidence of long-term declines in migratory shorebird populations is reported at two areas in north-east Tasmania. In north-east Tasmania, both George Town Reserve and Cape Portland have featured in National Wader Counts since 1981, although observations go back to the early 1970's. Compared with the extreme north-west of Tasmania and with many mainland study sites, wader numbers in north-east Tasmania are never large, which makes for relatively easier counting. At George Town, count data indicate long-term population declines from 1974 to 2011 in Eastern Curlew (*Numenius madagascariensis*), Ruddy Turnstone (*Arenaria interpres*), Curlew Sandpiper (*Calidris ferruginea*), and Bar-tailed Godwit (*Limosa lapponica*). George Town has also seen a decrease in the number of migratory shorebird species recorded each year, a drop on average from nine to seven, while Cape Portland has seen a larger drop in migratory shorebird species richness from eleven to six. Cape Portland has also experienced long-term declines from 1981 to 2011 in Ruddy Turnstone and Curlew Sandpiper. The reduction in species richness in both areas relates to historically uncommon species no longer being recorded such as Red Knot (*Calidris canutus*), Lesser Sand Plover (*Charadrius mongolus*), Greater Sand Plover (*Charadrius leschenaultia*), Grey-tailed Tattler (*Tringa brevipes*), Terek Sandpiper (*Xenus cinereus*) and Grey Plover (*Pluvialis squatarola*). Trends derived from these two north-east Tasmanian areas are similar to those being reported more widely in Australia, with growing numbers of migratory shorebirds showing evidence of long-term population declines. Threats to the foraging areas of both study sites, which have the potential to compromise their viability, are outlined. The volume of data available from these areas will allow for more detailed analyses in future.

Minton CDT, Dann P, Ewing A, Taylor S, Jessop RE, Anton P, Clemens RS. 2012. Trends of shorebirds in Corner Inlet, Victoria, 1982–2011. *Stilt* **61,** 3-18.

(Abstract)

Corner Inlet, Victoria, provides habitat for one of the largest and most diverse assemblages of shorebirds in southern Australia. Systematic counting commenced in 1981 and has continued, uninterrupted, to the present (2011). Standardised counts, along fixed boat routes, indicate that numbers in summer of all species combined have declined by 23% over the 30 year count period, from typically 35-40,000 in the earlier years to 25-30,000 in recent times. Ten species – Grey Plover *Pluvialis squatarola*, Ruddy Turnstone *Arenaria interpres*, Eastern Curlew *Numenius madagascariensis*, Red Knot *Calidris canutus*, Great Knot *Calidris tenuirostris*, Curlew Sandpiper *Calidris ferruginea*, Sharp-tailed Sandpiper *Calidus acuminata*, Common Greenshank *Tringa nebularia*, Greater Sand Plover *Charadrius leschenaulti*, and Lesser Sand Plover C. *mongolus*– have declined, while Sooty Oystercatcher *Haematopus fuliginosus*, has increased. Numbers of five other migratory species –Bar-tailed Godwit *Limosa lapponica*, Whimbrel *Numenius phaepus*, Red-necked Stint *Calidris ruficollis*, Sanderling C. alba and Double-banded Plover *Charadrius bicinctus* and one resident, species, Australian Pied Oystercatcher *Haematopus longirostris* – have not shown any significant change. Estimated declines in the abundance of individual species ranged from 47% to 95%. In contrast there was a significant increase in Sooty Oystercatchers of between 1.5 fold (winter) and 3.5 fold (summer). Numbers counted varied widely between years, most likely due to a combination of annual variation in demographic parameters, and possibly detection rates. The cause of longterm changes in abundance at Corner Inlet is not certain, but habitat destruction in staging areas, notably the Yellow Sea regions of China and Korea, is suggested as the main contributor with related changes in adult survival rates a more likely mechanism than changes in breeding success. Interestingly, declines in several species were most pronounced over one or two years. This study emphasises the benefit of using the same route and observers over long periods to identify trends in abundance.

Buchanan JB, Lyons JE, Salzer LJ, Carmona R, Arce N, Wiles GJ, Brady K, Hayes GE, Desimone SM, Schirato G, Michaelis W. 2012. Among-year site fidelity of Red Knots during migration in Washington. *Journal of Field Ornithology* **83,** 282-289.

(Abstract)

Many shorebirds exhibit within- and among-year site fidelity during their annual cycle. Little is known, however, about the migration ecology of Red Knots (*Calidris canutus)* that migrate along the Pacific Flyway and occur in Washington in numbers that exceed counts elsewhere on the flyway. At two large estuaries in coastal Washington, Grays Harbor and Willapa Bay, we searched for and recorded the locations of Red Knots (N= 547) that had been individually

marked with leg flags at their wintering grounds in Baja California Sur, Mexico, during the period from October 2006 to April 2009. In 2010, we resighted 43 Red Knots at Grays Harbor and Willapa Bay that had been observed at these sites in previous years, primarily in 2009. We found a high degree of site fidelity between years, with birds observed in 2010 more likely to return to the same stopover site used in 2009 than to switch stopover sites. For knots that did not switch estuaries between years, the median nearest distance between locations where individuals were observed between years was 1.4 km at Grays Harbor and 0.6 km at Willapa Bay. Our results provide the first evidence of stopover site fidelity by Red Knots of the roselaari subspecies. Fidelity occurred at three spatial scales: coastal Washington, the two estuaries where we conducted our study, and specific mudflat areas within the estuaries. Because our study sites support high populations of bivalves, Red Knots may be returning to the same areas in subsequent years to exploit what we suspect is a predictable food resource. The abundance of Red Knots and high degree of site fidelity suggest that our study sites in Grays Harbor and Willapa Bay are important for the conservation of this species on the Pacific Flyway.

Fernández G, Lank DB. 2012. Territorial behavior of Western Sandpipers on their nonbreeding grounds: effect of sex and foraging interference. *Journal of Field Ornithology* **83**, 272-281.

(Abstract)

Nonbreeding shorebirds often alternate social structure between anonymous flocks and territorial behavior in response to different environmental factors. To evaluate specific drivers for one species, we studied the spacing behavior of wintering Western Sandpipers (*Calidris mauri*) at Bahía Santa María, northwestern Mexico, using behavioral observations. The density, population structure, and territorial behavior of Western Sandpipers differed among three habitat types. Cattail marshes supported 110 birds per ha, 49% males, and no territorial birds. Mangrove flats supported 288 birds per ha, 58% males, and 5% territorial birds. Brackish flats supported 365 birds per ha, 76% males, and 7% territorial birds. Territories consisted of rectangular strips (5–9 m long, N= 77). Territory length was not related to either bird density or number of territorial birds by plot, but was positively related to nearest bird distance. Aggression rate was inversely related to territory length, suggesting that territory length is set by the costs of defense. Foraging rate was independent of territory length, and prey densities in territories did not differ from those in areas used by nonterritorial birds. Males were more likely to be territorial and had a higher aggression rate than females, suggesting that males, which forage more on surface prey, were more affected by foraging interference. Our results suggest that the territorial behavior of Western Sandpipers in our study was an opportunistic strategy to reduce foraging interference. The variation in spacing behavior we documented provides evidence that interference competition affects the social structure of Western Sandpipers during the nonbreeding season.

Quinn JT, Hamilton DJ. 2012. Variation in diet of Semipalmated Sandpipers (*Calidris pusilla*) during stopover in the upper Bay of Fundy, Canada.*Canadian Journal of Zoology* **90,** 1181-1190.

(Abstract)

Semipalmated Sandpipers (*Calidris pusilla* (L., 1766)) use the upper Bay of Fundy, Canada, as a critical stopover site during their annual fall migration to wintering grounds in South America. While in the area, they feed extensively on mudflat invertebrates. Historically the amphipod *Corophium volutator* (Pallas, 1766) has been thought to make up the majority of their diet. However, we have recently observed flexibility in foraging behaviour and prey selection by sandpipers. The extent of this flexibility and the current diet composition is unknown. To address these knowledge gaps, we assessed Semipalmated Sandpiper diets using stable isotope analyses of blood plasma and available prey items. Data were collected in two arms of the Bay of Fundy during summer 2009 and 2010. Diets fluctuated between years and sites, but in all cases the diet was much more diverse than previously thought. Polychaetes and biofilm made substantial contributions, and C. *volutator* was still present in the diet, but at much reduced levels than previously noted. This previously unrecognized inclusion of biofilm in the diet is consistent with recent observations of other calidrid shorebirds. Based on measures of prey availability, there is little evidence of preference for C. *volutator.*

Küpper C, Edwards SV, Kosztolányi A, Alrashidi M, Burke T, Herrmann P, Argüelles-Tico A, Amat JA, Amezian M, Rocha A, Hötker H, Ivanov A, Chernicko J, Székely T. 2012. High gene flow on a continental scale in the polyandrous Kentish plover *Charadrius alexandrinus. Molecular Ecology* **21,** 5864–5879.

(Abstract)

Gene flow promotes genetic homogeneity of species in time and space. Gene flow can be modulated by sex-biased dispersal that links population genetics to mating systems. We investigated the phylogeography of the widely distributed Kentish plover *Charadrius alexandrinus.* This small shorebird has a large breeding range spanning from Western Europe to Japan and exhibits an unusually flexible mating system with high female breeding dispersal. We analysed genetic structure and gene flow using a 427-bp fragment of the mitochondrial (mtDNA) control region, 21 autosomal microsatellite markers and a Z microsatellite marker in 397 unrelated individuals from 21 locations. We found no structure or isolation-by-distance over the continental range. However, island populations had low genetic diversity and were moderately differentiated from mainland locations. Genetic differentiation based on autosomal markers was positively correlated with distance between mainland and each island. Comparisons of uniparentally and biparentally inherited markers were consistent with female-biased gene flow. Maternally inherited mtDNA was less structured, whereas the Z-chromosomal marker was more structured than autosomal microsatellites. Adult males were more related than females within genetic clusters. Taken together, our results suggest a

prominent role for polyandrous females in maintaining genetic homogeneity across large geographic distances.

Clemens RS, Kendall BE, Guillet J, Fuller RA. 2012. Review of Australian shorebird survey data, with notes on their suitability for comprehensive population trend analysis. *Stilt* **62,** 3-17.

(Abstract)

Shorebirds are one of the most well-monitored taxa in Australia. In this paper, we review the spatial and temporal coverage of the Australian shorebird monitoring count data currently administered by BirdLife Australia, and comment on the subset of those data likely to be of immediate use for comprehensive trend analysis. Of the 253 shorebird areas known in Australia, seventeen in the southern half of Australia had consistent survey coverage over the last 30 years, with summer counts available in over 80% of those years, and with each area holding nationally significant numbers of some shorebird species. Similarly consistent data were available for eight additional shorebird areas, but these generally held fewer birds. Another 21 shorebird areas with nationally important numbers of shorebirds had 15 to 30 years of data with some variation in spatial coverage or changes in methods over time. Our review suggests that Australian shorebird monitoring data are of sufficiently high quality and spatial coverage to permit robust analysis of shorebird population trends across much of Australia.

Leyrer J, Lok T, Brugge M, Dekinga A, Spaans B, van Gils JA, Sandercock BK, Piersma T. 2012. Small-scale demographic structure suggests preemptive behavior in a flocking shorebird. *Behavioral Ecology* **23,** 1226-1233.

(Abstract)

Under the ideal-free distribution, omniscient individuals with similar habitat requirements that are free to move should be distributed such that no individual can improve fitness by changing sites; deviations would indicate trade-offs and constraints on ranging behavior. We studied site occupancy and annual survival in red knots Calidris c. canutus at their main wintering area Banc d'Arguin, Mauritania. We collected mark-resighting data at 2 high-tide roosts (A and B) that were only 3 km apart and within sight. Birds were faithful to their roosts and foraged in nearby intertidal areas, with no overlap between birds from A and B. Shellfish-rich seagrass beds were of greater abundance for birds roosting at A than at B. During 8 winters, we found different sex ratios (48% and 58% males at A and B, respectively) and different proportion of juveniles (22% and 45%) at the 2 roosts. Adult annual survival was higher at A (0.830.01 standard error [SE]) than at B (0.810.03). Though rare, between winter season movements were 3 times more frequent from B to A than vice versa, indicating that knots can assess the differences in site quality: birds behaved as if they were ideal. As larger females and older

birds occurred more at A, differences in competitive ability might maintain the site occupancy pattern. As females return from the high Arctic breeding grounds first, and adults return before juveniles, priority of occupancy may also play a role. Such an advantage of arriving earlier would represent a seasonal carryover effect.

Ryan J. Stutzman. 2012. Stopover decisions of migratory shorebirds: An assessment of habitat use, food Availability, behavior and phenology. Masters Thesis University of Nebraska

(Abstract)

Habitat loss and alteration from land use change, species invasion, and more recently, climate change has reduced biodiversity and ecosystem function worldwide. Habitat decisions have important implications to individual fitness as well as population dynamics and community structure. Resource limitation, predation, competition, and unfavorable abiotic conditions all have the potential to influence survival and future reproductive potential. Understanding how changes to ecosystem structure and function impact species and populations of conservation concern is essential for conservation delivery to be effective. Similar to many migratory species, shorebird populations are declining worldwide and declines may be related to the loss of important stopover habitat in the form of mid-continental wetlands.

During 2010-2011, I examined how long-distance migratory shorebirds have responded to extensive, agriculturally-driven, alterations to wetland habitats. I focused on a suite of ecological conditions that are expected to influence migrant fitness including habitat preference, resource availability and behavior. Additionally, because land use change is expected to act in conjunction with climate change to alter wetland habitats, I examined a number of phenologic variables and made predictions on how migrants might be affected in the future. Migrant shorebirds were more likely to use highly-altered, agricultural wetlands than wetlands embedded in native grasslands and did so in greater numbers. Preference for altered habitat was unexpected because these habitats had lower food availability, but preference may be explained by the role of mud flat as an influential cue, which would increase the attractiveness of agricultural wetlands. Such a scenario can be indicative of an ecological trap, where individuals prefer lower quality habitat. However, behavioral analysis indicates that migrants have adapted to using novel habitats through increased foraging efficiency. Despite their apparent adaptability to changing conditions, migrant shorebirds may be susceptible to further population decline as a result of changes in phenology brought about by climate change. Results show that peak migration is correlated with the availability of food resources. Given that shorebirds already prefer habitat with lower resource availability, any changes to invertebrate or migration phenology that is not congruent in magnitude and direction to the other could affect migrant populations.

Rogers, D. I., C. J. Hassell, A. Boyle, K. Gosbell, C. D. T. Minton, K. G. Rogers, and R. H. Clarke. 2011. Shorebirds of the Kimberley Coast – Populations, key sites, trends and threats. *Journal of the Royal Society of Western Australia* **94**: 377-391.

(Abstract)

The tidal flats of the Kimberley coast support the largest populations of migratory shorebirds in Australia. In this paper we review and discuss population sizes of all 41 shorebird species occurring on the Kimberley coastlines, and summarise the importance of the region in an international context. The Kimberley coastline is used by c. 3.7 million shorebirds, including c. 635,000 migrants from the northern hemisphere and c. 16,000 Australian-bred resident shorebirds which forage on the tidal flats of the Kimberley coast. A further c. 3.06 million migratory shorebirds from near-coastal grasslands (Oriental Plover, Little Curlew and Oriental Pratincoles) use roosts on the Kimberley coast at times. Most coast-dependent shorebirds of the Kimberley are concentrated in a small number of sites. Eighty-mile Beach and Roebuck Bay are the most important two sites; they have the highest numbers of birds, and the greatest diversity of species occurring in internationally significant numbers. Internationally important numbers of several species occur on some offshore islands (Adele Island, Ashmore Reef and the Lacepedes), including several species (e.g. Lesser Sand Plover, Grey Plover, Grey-tailed Tattler and Ruddy Turnstone) which are disproportionately abundant on offshore islands when compared to the mainland. Although most of the key shorebird sites on the Kimberley coast are remote and have not been greatly affected by humans, there are indications that populations of many migratory species on the Kimberley coast are declining, probably because of habitat loss in the east Asian areas where they stage on migration. Continued and enhanced monitoring of shorebirds in the Kimberley that contributes strategically to the conservation management of this group is strongly recommended.

Conklin JR, Battley PF. 2011. Contour-feather moult of Bar-tailed Godwits (*Limosa lapponica baueri*) in New Zealand and the northern hemisphere reveals multiple strategies by sex and breeding region. *Emu* **111,** 330–340.

(Abstract)

The extreme long-distance migration of Alaskan breeding Bar-tailed Godwits (*Limosa lapponica baueri*) may present severe constraints on annual moult, and high individual variation in plumage and migration timing suggests that multiple strategies by sex and breeding region may exist. We used digital photography of free-living Bar-tailed Godwits to describe the timing and extent of pre-basic and pre-breeding contour-feather moults in New Zealand, and used plumage of breeding birds in Alaska to infer the proportion of moults occurring in Alaska and Asia. These data demonstrated that:(1) Godwits conducted overlapping pre-alternate and pre-supplemental moults;(2) pre-basic and pre-breeding moults

were scheduled differently in relation to southbound and northbound migration respectively;(3) northern and southern Alaskan breeding Godwits of each sex were distinguishable by plumage differences throughout the non-breeding season; and(4) males and northern breeders achieved more extensive breeding plumage by spending longer in pre-breeding moult in New Zealand, rather than through faster moult rates or greater investment in moult during migratory stopover in Asia. The existence of a ventral pre-supplemental moult implies that contemporary selection for red breeding plumage overrides older selection for barred alternate plumage. Our use of individual-based data revealed a continuum of annual moult strategies within the population, which may reflect individual differences in any combination of sex, size, migration distance or breeding location. Even within the highly constrained annual cycle of extreme long-distance migrants, differential selection influences how individuals manage trade-offs among non-breeding activities such as moult, fuelling and migration.

Conklin JR, Battley PF, Potter MA, Ruthrauff DR. 2011. Geographic variation in morphology of Alaska-breeding Bar-tailed Godwits (*Limosa lapponica*) is not maintained on their nonbreeding grounds in New Zealand. *The Auk* **128**, 363−373

(Abstract)

Among scolopacid shorebirds, Bar-tailed Godwits (*Limosa lapponica*) have unusually high intra- and intersexual differences in size and breeding plumage. Despite historical evidence for population structure among Alaska-breeding Bar-tailed Godwits (*L. l. baueri*), no thorough analysis, or comparison with the population's nonbreeding distribution, has been undertaken. We used live captures, field photography, museum specimens, and individuals tracked from New Zealand to describe geographic variation in size and plumage within the Alaska breeding range. We found a north–south cline in body size in Alaska, in which the smallest individuals of each sex occurred at the highest latitudes. Extent of male breeding plumage (proportion of nonbreeding contour feathers replaced) also increased with latitude, but female breeding plumage was most extensive at mid-latitudes. This population structure was not maintained in the nonbreeding season: morphometrics of captured birds and timing of migratory departures indicated that individuals from a wide range of breeding latitudes occur in each region and site in New Zealand. Links among morphology, phenology, and breeding location suggest the possibility of distinct Alaska breeding populations that mix freely in the nonbreeding season, and also imply that the strongest selection for size occurs in the breeding season.

Conklin JR, Battley PF. 2011. Impacts of wind on individual migration schedules of New Zealand bar-tailed godwits. *Behavioral Ecology* **22**,854-861.

(Abstract)

Despite clear links between wind conditions and timing of migration at the population level, no study has examined the contribution of winds to annual variation in the migration timing of individual birds. At a single nonbreeding site in New Zealand, we closely monitored 3 years of departures of bar-tailed godwits (*Limosa lapponica baueri*), long-distance migrants with remarkable annual consistency in individual migration schedules. Although individual godwits showed very little variation in departure date and generally experienced favorable departure conditions, most off-schedule departures were explained by maximizing initial wind assistance for the nonstop flight to Asia. Surprisingly, early departures attributable to wind were more common and of greater magnitude than wind-related departure delays, and prolonged weather-related departure lulls did not always result in late-departing individuals. Thus, our results show that knowledge of individual departure decisions with regard to wind can strongly influence interpretation of population patterns. Early departures associated with winds, previously only demonstrated theoretically, may reflect conservative timing and extent of premigratory fueling, a possible adaptation for extreme long-distance migration in variable conditions.

McGowan CP, Hines JE, Nichols JD, Lyons JE, Smith DR, Kalasz KS, Niles LJ, Dey AD, Clark NA, Atkinson PW, Minton CDT, Kendall W. 2011. Demographic consequences of migratory stopover: linking red knot survival to horseshoe crab spawning abundance. *Ecosphere* **2**, art69.

(Abstract)

Understanding how events during one period of the annual cycle carry over to affect survival and other fitness components in other periods is essential to understanding migratory bird demography and conservation needs. Previous research has suggested that western Atlantic red knot (*Calidris canutus rufa*) populations are greatly affected by horseshoe crab (Limulus polyphemus) egg availability at Delaware Bay stopover sites during their spring northward migration. We present a mass-based multistate, capture-recapture/ resighting model linking (1) red knot stopover mass gain to horseshoe crab spawning abundance and (2) subsequent apparent annual survival to mass state at the time of departure from the Delaware Bay stopover area. The model and analysis use capture-recapture/resighting data with over 16,000 individual captures and 13,000 resightings collected in Delaware Bay over a 12-year period from 1997–2008, and the results are used to evaluate the central management hypothesis that red knot populations can be influenced by horseshoe crab harvest regulations as part of a larger adaptive management effort. Model selection statistics showed support for a positive relationship between horseshoe crab spawning abundance during the stopover and the probability of red knots gaining mass (parameter coefficient from the top model b=1.71, SE=0.46). Our analyses also supported the link between red knot mass and apparent annual survival, although average estimates for the two mass classes differed only slightly. The addition of arctic snow depth as a covariate influencing apparent survival improved the fit of the data to the models (parameter coefficient from the top model b=0.50, SE=0.08). Our

results indicate that managing horseshoe crab resources in the Delaware Bay has the potential to improve red knot population status.

Lindström Å, Gill Jr RE, Jamieson SE, McCaffery B, Wennerberg L, Wikelski M, Klaassen M. 2011. A Puzzling Migratory Detour: Are Fueling Conditions in Alaska Driving the Movement of Juvenile Sharp-Tailed Sandpipers? *The Condor* **113** 129-139.

(Abstract)

Making a detour can be advantageous to a migrating bird if fuel-deposition rates at stopover sites along the detour are considerably higher than at stopover sites along a more direct route. One example of an extensive migratory detour is that of the Sharp-tailed Sandpiper (*Calidris acuminata*), of which large numbers of juveniles are found during fall migration in western Alaska. These birds take a detour of 1500–3400 km from the most direct route between their natal range in northeastern Siberia and nonbreeding areas in Australia. We studied the autumnal fueling rates and fuel loads of 357 Sharp-tailed Sandpipers captured in western Alaska. In early September the birds increased in mass at a rate of only 0.5% of lean body mass day−1. Later in September, the rate of mass increase was about 6% of lean body mass day−1, among the highest values found among similar-sized shorebirds around the world. Some individuals more than doubled their body mass because of fuel deposition, allowing nonstop flight of between 7100 and 9800 km, presumably including a trans-oceanic flight to the southern hemisphere. Our observations indicated that predator attacks were rare in our study area, adding another potential benefit of the detour. We conclude that the most likely reason for the Alaskan detour is that it allows juvenile Sharp-tailed Sandpipers to put on large fuel stores at exceptionally high rates.

Glover HK, Weston MA, Maguire GS, Miller KK, Christie BA. 2011. Towards ecologically meaningful and socially acceptable buffers: Response distances of shorebirds in Victoria, Australia, to human disturbance. *Landscape and Urban Planning* **103**, 326–334.

(Abstract)

Buffers are often used to separate threatening stimuli, such as humans, from wildlife but with few exceptions buffer widths are based on little empirical information. We measured the distance at which a response (i.e., flight initiation distance [FID]) occurred among 28 of Australia's 36 regularly occurring shorebird species when presented with an approaching human (n = 760 approaches in Victoria, south eastern Australia). Species differed in their FID, with species with higher body masses having longer FIDs ($F_{1,26} = 36.830$, $p < 0.001$; $R2 = 0.586$). Mean FIDs for species were 18.6–126.1 m (n = 370 approaches by a walker). Depending on the species, FID was significantly influenced by the starting distance of the

human approach, flock size, previous exposure to humans and stimulus type (walker, jogger, walker with dog). The FIDs reported suggest that current buffer designations will reduce disturbance to many but not all shorebird species tested. We also surveyed 295 residents and users of shorebird habitat, who reported an overall positive attitude to shorebird conservation, and generally regarded buffers as an appropriate way of managing disturbance to shorebirds (except for walkers, the commonest recreational activity). By overlaying the buffer widths nominated by respondents as appropriate for shorebirds with the FIDs exhibited by shorebirds, we present the efficacy of buffers from both social and ecological perspectives.

Minton CDT, Gosbell K, Johns P, Christie M, Klaassen M, Hassell C, Boyle A, Jessop RE, Fox JW. 2011. Geolocator studies on Ruddy Turnstones *Arenaria interpres* and Greater Sandplovers *Charadrius leschenaultii* in the East Asian–Australasia Flyway reveal widely different migration strategies. *Wader Study Group Bulletin* **118**, 87–96.

(Abstract)

In 2010, following successful trials with geolocators on Ruddy Turnstones in 2009, a total of 105 units, of four different models, were deployed at five locations on Ruddy Turnstones and Greater Sandplovers. Geolocator retrieval rates were 44% on Ruddy Turnstone and 27% on Greater Sandplover. Complete (59%) and partial (15%) technical failure rates on geolocators were high and were mostly the result of wear and saltwater corrosion. All 30 units from the Swiss Ornithological Institute failed. Only half of the Mk10 and Mk12 units from the British Antarctic Survey produced full migration histories. The northward migration of Ruddy Turnstones was on a narrow path with many birds completing an initial non-stop flight of 7,600 km to Taiwan. Later, most made a stopover in the Yellow Sea. Median migration duration was 39.5 days and average migration speed of the first major leg of the journey (assuming the birds followed the great circle route between stopovers) was 63.4 kph. Southward migration paths showed a much wider spread, ranging from Mongolia to the central Pacific. The latter involved the same bird that had been tracked along this route the previous year. It has now been logged on similar 27,000 km round trips in two successive years. The median duration of southward migration (78 days) was nearly twice that of northward migration and data on average migration speed for just two migration legs indicated that it might be lower, 30 and 40 kph being the values recorded. Greater Sandplovers were only tracked on northward migration but seemed to follow a similar migration strategy with a large initial non-stop flight followed by shorter flights and more regular stopovers. Plans are outlined for further analyses and future deployments of geolocators.

Arakida H, Mitsuhashi H, Kamada M, Koyama K. 2011. Mapping the potential distribution of shorebirds in Japan: the importance of landscape-level coastal geomorphology. *Aquatic Conservation: Marine and Freshwater Ecosystems* **21,**553-563.

(Abstract)

1. Several recent studies have predicted potential habitats along coastal areas using large-scale physical environmental variables. However, no indices or methodologies for predicting tidal-flat habitats at a large spatial scale have been developed. Tidal flats housing large populations of shorebirds have been identified in semi-enclosed seas. Thus, bays are probably important topographic units for evaluating the locations of shorebirds' non-breeding habitats.

2. We developed a GIS-based methodology to extract "bay units" at any scale from coastline data. Using three environment variables: the area of the bay units at three spatial scales, the percentage of shallow water area in each bay unit, and the spring-tide range, we were able to predict tidal-flat habitats for six shorebird species with high accuracy (AUC>0.95, the sensitivity >90%).

3. Our results showed that the percentage of shallow water area in small- and medium-scale bays was the best predictor of tidal-flat habitats, followed by the area of bays at a large spatial scale. This indicates that the size (scale) of a bay and the percentage of shallow water present are highly related to the presence of tidal-flat habitats.

4. The prediction maps for individual species clearly showed differences in the distribution patterns of species. These maps were overlaid to identify potentially species-rich areas. This determined that tidal flats located in principal bays in Japan were likely to harbour shorebird habitats. Thus, it is imperative to pursue the conservation and restoration of the tidal flats in these bays.

5. Our model, which uses simple coastal data, is a useful, resource-efficient method for identifying target conservation and restoration areas across broad scales.

Shorebirds 2010 and earlier

2010

Kraan, C., J. A. van Gils, B. Spaans, A. Dekinga, and T. Piersma. 2010. Why Afro-Siberian Red Knots *Calidris canutus Canutus* have Stopped Staging in the Western Dutch Wadden Sea During Southward Migration. *Ardea* **98**:155-160.

(Abstract)

Afro-Siberian Red Knots *Calidris canutus canutus* use the western Dutch Wadden Sea as a refuelling area during southward migration from Taimyr to West Africa. Here we document the decline of their food stocks in this area, based on a yearly large-scale benthic mapping effort,

from 1996 to 2005. For each benthic sampling position, intake rate (mg/s, ash-free dry mass) was predicted by an optimal diet model based on digestive rate maximization. Over the ten years, when accounting for a threshold value to meet energetic fuelling demands, subspecies *canutus* lost 86% of its suitable foraging area. Over this period, the proportion of probable *canutus* in mist-net catches in July–August declined relative to overwintering *islandica* Knots. This suggests that *canutus* dropped even more in numbers than *islandica*, for which we showed earlier a food-explained decline in numbers. We discuss the possible causality between a decline in the quality of intertidal mudflats in the Dutch Wadden Sea and population declines of Knots in the West-African wintering quarters.

Tomkovich PS. 2010. Assessment of the Anadyr Lowland subspecies of Bar-tailed Godwit Limosa lapponica anadyrensis. *Bulletin of the British Ornithological Club* **130**:88-95.

(Abstract)

New specimens of breeding Bar-tailed Godwits *Limosa lapponica* in the Zoological Museum of Moscow State University have permitted a revision of the doubtful subspecific status of the isolated population that breeds in the Anadyr River basin, Chukotka, Russia. It is demonstrated that in spite of some intermediate characters between westerly *L. l. menzbieri* and the easterly *L. l. baueri*, birds of the Anadyr population should not be treated as a cline. Birds of this population differ significantly from one or both neighbouring populations in their back pattern, axillaries barring, number of bars on the axillaries, contrast of lines on the underwing-coverts and, in males, absence of a whitish patch on the bent wings formed by the upper greater secondary-coverts. Thus, the Anadyr population should be treated as a separate subspecies, *L. l. anadyrensis* Engelmoer & Roselaar, 1998.

2009

Gill, R. E. J., T. L. Tibbitts, D. C. Douglas, C. M. Handel, D. M. Mulcahy, J. C. Gottschalck, N. Warnock, B. J. McCaffery, P. F. Battley, and T. Piersma. 2009. Extreme endurance flights by landbirds crossing the Pacific Ocean: ecological corridor rather than barrier? *Proceedings of the Royal Society of London B: Biological Sciences* **276**:447–457.

(Abstract)

Mountain ranges, deserts, ice fields and oceans generally act as barriers to the movement of land-dependent animals, often profoundly shaping migration routes. We used satellite telemetry to track the southward flights of bar-tailed godwits (*Limosa lapponica bauera*), shorebirds whose breeding and nonbreeding areas are separated by the vast central Pacific Ocean. Seven females with surgically implanted transmitters flew non-stop 8117–11 680 km (10 153+/-1043 s.d.) directly across the Pacific Ocean; two males with external transmitters flew non-stop along the same corridor for 7008–7390 km. Flight duration ranged from 6.0 to 9.4 days (7.8+/-1.3 s.d.) for birds with implants and 5.0 to 6.6 days for birds with externally

attached transmitters. These extraordinary non-stop flights establish new extremes for avian flight performance, have profound implications for understanding the physiological capabilities of vertebrates and how birds navigate, and challenge current physiological paradigms on topics such as sleep, dehydration and phenotypic flexibility. Predicted changes in climatic systems may affect survival rates if weather conditions at their departure hub or along the migration corridor should change. We propose that this transoceanic route may function as an ecological corridor rather than a barrier, providing a wind-assisted passage relatively free of pathogens and predators.

Choi, C., X. Gan, Q. Ma, K. Zhang, J. Chen, and Z. Ma. 2009. Body condition and fuel deposition patterns of calidrid sandpipers during migratory stopover. *Ardea* **97**:61-70.

(Abstract)

We compared seasonal variations in body condition and fuel deposition patterns of five calidrid sandpipers at Chongming Dongtan (eastern China), a stopover site in the East Asian–Australasian Flyway. We tested the hypothesis that long-distance migrants show different body condition and fuel deposition patterns relative to those undertaking short-distance flights. Results indicated that the body condition and fuel deposition patterns of the sandpipers varied between the northward and southward migration seasons and between ageclasses. Great Knots *Calidris tenuirostris* and Red Knots *Calidris canutus* migrate southwards on a long-distance nonstop flight from Chongming Dongtan to northwest Australia, while covering on the return flight a relatively short-distance between Chongming Dongtan and the north Yellow Sea region. Both species attained a significantly higher body condition at Chongming Dongtan during the southward than northward migration. Moreover, they showed a significant increase in body condition at Chongming Dongtan during northward migration stopover, which we see as a recovery from the long flight from Australia. In contrast, Red-necked Stints *Calidris ruficollis* and Long-toed Stints *Calidris subminuta*, employing series of relatively short-distance flights during migration, indicated no significant difference in departure body condition at Chongming Dongtan between seasons, nor significant increase in body condition during either migration stopover. Dunlins *Calidris alpina* on the other hand, showed a significantly higher body condition during northward than southward migration stopover, most likely in anticipation of the longer travelling distance after leaving Chongming Dongtan during northward migration. This study confirms that the body condition and fuel deposition patterns among shorebird species that undertake long-distance nonstop flights are different from those that undertake series of short-distance flights, suggesting that the comparison of body condition and fuel deposition patterns of calidrid sandpipers can be an important tool to understand their migration strategies.

Riegen, A. C., D. Lawrie, T. Habraken, R. T. Gun, and C. J. Hyok. 2009. Report of the first shorebird survey at Mundok, North Korea by Miranda Naturalists' Trust and Korean Natural Environment Conservation Fund. 26–29 April 2009. *Stilt* **56**:32–36.

(No abstract available)

2004

Ma, Z., B. Li, B. Zhao, K. Jing, S. Tang, and J. Chen. 2004. Are artificial wetlands good alternatives to natural wetlands for waterbirds? – A case study on Chongming Island, China. *Biodiversity and Conservation* **13**:333–350.

(Abstract)

Loss of natural wetlands is a global phenomenon that has been a serious threat to the wildlife. A common practice is to construct artificial wetlands to compensate for the loss of natural wetlands. To test whether artificial wetlands as habitats for waterbirds are good alternatives to natural wetlands, we compared species richness, abundance, and seasonal dynamics of waterbird communities of natural (here tidelands) and artificial wetlands (here aquacultural ponds) on Chongming Island, China. Our results indicate that habitat preference of waterbirds showed seasonal difference: most of the shorebirds were found on tidelands in spring, whereas most of the natatorial birds were recorded in aquacultural ponds in winter. Waterbirds preferred the tidelands rather than aquacultural ponds in both spring and autumn, whereas they showed no preference for either the tidelands or the ponds in summer and winter. It is concluded that natural wetlands are better habitats for waterbirds than artificial wetlands on Chongming Island, while the artificial ones are also suitable habitats for waterbirds in winter. The waterbirds might use artificial wetlands only when natural wetlands are unavailable or of poor quality. An over-emphasis that artificial wetlands are suitable habitats for waterbirds might encourage land managers to convert natural wetlands into the artificial ones, resulting in considerable loss of bird diversity. Therefore, for the purpose of bird conservation, it would be a better practice to conserve natural wetlands rather than to construct artificial ones after destruction of natural wetlands.