Global Flyway Network

The shorebird ecological demographics & conservation initiative

SHOREBIRD NORTHWARD MIGRATION THROUGH THE LUANNAN COAST, BOHAI BAY, CHINA, APRIL – JUNE 2023

Chris Hassell
Katherine Leung
and Theunis Piersma

Red Knots and other shorebirds on Nanpu mudflats, 11 May 2023

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Shorebirds flying above Nanpu mudflats, 8 May 2023. © Katherine Leung

Summary

This is the fourteenth year in a row for Global Flyway Network (GFN)'s fieldwork at the Luannan Coast, Bohai Bay, China. Katherine Leung and Yang Liu (Xiao Liu) carried out the fieldwork for 6 weeks, from 23 April to 3 June, 42 days in total.

GFN extend our thanks to Bobolink Foundation, Australian Wader Studies Group, Queensland Wader Studies Group, and Dr Weipan Lei from Beijing Normal University for supporting this year's expenditure.

The Luannan Coast referred to throughout this report encompasses our study sites shown in Figure 1 and the adjacent salt and aquaculture ponds.

The main findings from this year's fieldwork showed that in 2023, Red Knot *Calidris canutus* were present in the lowest number on the Luannan Coast since the start of our studies in 2010. The highest single count was only 3,660 on 28 May at Nanpu. This is a stark contrast to the counts of 17,000 to 48,630 individuals in 2015-2020, and significantly low even compared to the low numbers in recent years (9,000 in 2021 and 9,938 in 2022). As there was no report of significant declines in Red Knot numbers at the non-breeding areas in the 2022/23 non-breeding season, it is unlikely that there is a flyway-wide crash in Red Knot populations. It is most likely that Red Knot have changed their migration pattern and are not using the Luannan Coast as the major hub, possibly due to change in the availability of their favoured food, *Potamocorbula laevis*. There was also a drop in the overall shorebirds numbers this season.

We recorded 1,211 marked shorebirds of 11 species from 21 marking locations throughout the East Asian-Australasian Flyway (EAAF), as well as from India (usually regarded as a part of the Central Asian Flyway (CAF)). This year, 128 birds were individually recognisable from the GFN colour-banding project in Northwest Australia (NWA). As would be expected from the low number of Red Knots and other shorebirds present at the study site, numbers of marked and GFN colour-banded birds were much lower compared to previous years, although the fieldwork period was a little shorter too (Table 1 and Table 2). The GFN colour band totals were dominated, as always, by

Red Knots roosting at Nanpu salt pond, 31 May 2023. © Katherine Leung

Red Knot with 124 individuals identified, Great Knot *Calidris tenuirostris* with 1 and Bar-tailed Godwit *Limosa lapponica* with 3 (Table 3). Despite the low number of records this year, these records still once again reflect the vital importance of the Luannan Coast for Red Knots from NWA and throughout the EAAF.

A table of species recorded in internationally important numbers has been compiled from GFN and Beijing Normal University (BNU) studies over the previous fourteen northward migration seasons (2010–2023). It is an effective way to give an indication of the immense importance of the Luannan Coast shorebird site. In the period 2014-2019, fourteen species of migratory shorebirds and one migratory tern have been recorded in internationally significant numbers (Ramsar criteria of >1% of a population). Four species have an absolute minimum of 10% of their entire EAAF population passing through the Luannan Coast during northward migration (Table 4). Note that these are single peak counts and do not account for turnover rate: if that statistic was applied, the total number of birds assessed using the Luannan Coast during the northward migration season would be much greater (Lok *et al.* 2019). Even in this historically low year, the Luannan Coast is still of significant international importance to the EAAF's Red Knot with the highest count at Nanpu alone is still equivalent to more than 3% of the EAAF Red Knot population.

The intertidal mudflats are one of the most important habitat components of the Luannan Coast. The commencement of protection and management actions of the area as Provincial Wetland Park and potential World Heritage Site nomination have shed some lights on the conservation of this important habitat for shorebirds. However, despite direct destruction of the intertidal habitat having almost ceased in the past ten years, the pressures on the intertidal areas are still present with the development of industrial and residential areas adjacent to and on previously reclaimed mudflats. This includes a large steel works that will have a port developed on still existing intertidal mudflats. Multi-billion-yuan projects are still in the planning stages for development within the Luannan Coast area and the future of these critically important intertidal areas remain under threat.

At high tide, when the intertidal mudflats are inundated by the sea, the ponds within the salt works/aquaculture areas host all the migratory shorebirds, making the area a critical component of the Luannan Coast. These ponds also provide foraging and breeding habitats for many shorebirds and terns, and at the same time are an important contributing factor to the local economy and jobs. The importance of the vast area of commercial ponds adjacent to the intertidal area for shorebirds has been well documented from GFN's work and that of BNU researchers in previous years. A small proportion of these ponds are now protected as part of the Provincial Wetland Park and potential World Heritage Site nomination.

World Heritage Site nomination publicity signage on Nanpu seawall, 30 April 2023. © Katherine Leung

This year the use of ponds by shorebirds had much reduced. Many species still utilise the ponds, but almost all of the ponds that were explored had deep water in them consistently throughout the season - as has now been the situation for a few years. This deprives shorebirds of foraging opportunities. We are not certain if the loss of all these ponds as foraging habitats is one of the contributing factors to the lower numbers seen in recent years. And if the loss is detrimental to the shorebirds fattening up at the Luannan Coast to the extent that it deprives them of resources required to put on enough weight for successful migration and breeding. Have birds decided to change their migration pattern as they learnt that

this site doesn't offer the 'extra' food resources that were once available in the ponds?

Another pressure to the shorebirds this year was the untimely earth-moving works carried out along the seawall and at some sections of the ponds. Our observations saw shorebirds feeding on the intertidal mudflats frequently disturbed by large trucks running along the entire section of the Luannan Coast seawall from Zuidong to Beipu for transporting earth into the ponds. A large area of the ponds in Nanpu had also been fully drained since October with diggers and bulldozers working in them. Such earth-moving works are part of a 'wetland restoration' project costing hundreds million yuan to enhance the seawall, intertidal mudflats and pond habitats of the Provincial Wetland Park. It was a pity that poorly planned timing of this project with good conservation intentions has caused negative impacts to the shorebirds at this critical stage of life, before any benefits that can be brought when the project is completed. Strategic conservation management and consistent communications between decision makers and scientists are urgently needed.

Global Flyway Network aims to continue conducting research activities and follow-up analysis to document the futures of four shorebird species (Bar- and Black-tailed Godwit and Red and Great Knot) at their non-breeding sites in NWA and throughout the EAAF, with an emphasis on the Luannan Coast. A critical question is the interpretation of the variable use of the Luannan Coast by Red and Great Knots. What does this variability mean? Is it changes to, or loss of, habitats at the site and elsewhere? Or that the favoured food of Red Knots, *P. laevis* is not in regular or consistent abundance at all sites and Red Knots 'choose' the best sites year on year? Knowing this distinction is critical. The recent paper, "When a typical jumper skips: itineraries and staging habitats used by Red Knots (*Calidris canutus piersmai*) migrating between Northwest Australia and the New Siberian Islands" (Piersma *et al.* 2021) and the paper "Mollusc aquaculture homogenizes intertidal soft-sediment communities along the 18,400 km long coastline of China" (Peng *et al.* 2021) have shed some light on this.

Red Knot landing on the Nanpu mudflats, 28 Apr 2023. © Katherine Leung

Introduction

Most of the Yellow Sea intertidal mudflats are critical feeding areas for migratory shorebirds on their journeys to and from their breeding and non-breeding grounds. The areas used by migratory shorebirds are referred to as 'stop-over sites' (sites used mainly for a 'pit-stop', a rest) or 'staging sites' (sites used for more than a few days for serious refuelling). Birds spend from a few days to about six weeks at any one or several sites on their way north. The Luannan Coast is one such critical area and is particularly important to Red Knot (Piersma *et al.* 2016, Rogers *et al.* 2010). The ecology of the enigmatic long-distance migratory shorebird Red Knot, despite a lot of studies, still leaves much to be discovered in the EAAF. It is represented in this flyway by three subspecies: *piersmai, rogersi* and *roselaari* (the latter is not part of this study because it only breeds on Wrangel Island in the Russian Far East and migrates to the Americas). The subspecies *piersmai* and *rogersi* breed in different locations in the Siberian Arctic and share non-breeding locations in Australasia (Tomkovich 2001, Rogers *et al.* 2010), as well as South-east Asia.

Despite Red Knots having been one of the best researched shorebirds in the world for quite some time (see, for example, summary in Piersma *et al*. 1997), we only started to understand the northward and southward migration strategies of the two subspecies that use the Luannan Coast, and changes to these strategies, as a consequence of habitat change and loss within the EAAF (Piersma *et al.* 2021). Surveys of the Yellow Sea by Mark Barter and Chinese colleagues failed to find significant numbers of the species despite extensive searching in May 2000. During northward migration in 2002, they did record 14,277 in the north-west Bohai Bay region, now called the Luannan Coast (Barter *et al.* 2003). During a brief six-day visit in late April 2007, Chris Hassell from GFN counted a single flock of 10,650 Red Knot in the same region. In September 2007, Hongyan Yang, then a PhD graduate at BNU commenced a project on the food, foraging and staging ecology of Red Knots in the area. She had been conducting regular counts since 2003 during northward migration and her work showed that numbers of Red Knots in the Luannan Coast had increased over the years, presumably due to habitat destruction elsewhere and consequently birds moving into the study site (Yang *et al*. 2011).

It is well documented that migratory shorebirds can move from one area to another if one area becomes unsuitable. However, this is of course unsustainable if habitat destruction and degradation continues; eventually there will not be enough habitats with substantial quality to support the populations. It is equally well documented that there are negative survival consequences for birds moving to new sites (Burton *et al.* 2006). Until local and international decision makers accept that birds cannot continue to 'just move somewhere else' indefinitely (see arguments in Piersma *et al*. 2017), the populations of migratory shorebirds passing through the Yellow Sea and therefore returning to their various non-breeding locations in the southern areas of the EAAF are in grave danger of diminishing to dangerously low levels (Piersma *et al.* 2016, Studds *et al*. 2017).

It is clear from our current knowledge that the Luannan Coast is the single most important site for Red Knot on northward migration in the EAAF. The southward migration route and staging areas of Red Knot are gradually being revealed from geolocator and satellite transmitter studies (Tomkovich *et al*. 2013, Piersma *et al*. 2021).

Red Knots in the morning mist, 29 May 2023.
© Katherine Leung

In conjunction with the work by researchers from Beijing Normal University, Fudan University and the Center for East Asian-Australasian Flyway Studies, studies by GFN have continued during the northward migration seasons of 2010 to this year,

2023. These fieldwork studies have concentrated on searching for individually marked Red Knots and have been remarkably successful. In view of the many human-related threats to this area, it is the single most important staging area for two subspecies of Red Knot in the EAAF encompassing the vast majority of the populations wintering in Australia, New Zealand and South-east Asia, it seems of utmost importance to continue the survey work. The research effort in China builds on the research conducted in NWA funded from 2007 to 2013 by BirdLife-Netherlands. BirdLife-Netherlands and WWF-Netherlands have continued to financially support Theunis Piersma as the Rudi Drent Chair in Global Flyway Ecology at the University of Groningen through which the analytic and data-processing work in 2014-2016 by Dr Tamar Lok was made possible. From 2010 to 2018, Beijing Normal University funded the daily on-ground costs, notably accommodation and transport, through Prof. Zhengwang Zhang. From 2019 to 2022, the Centre for East Asian-Australian Flyway Studies at Beijing Forestry University, headed by Prof. Guangchun Lei, has covered the costs of this project. This 2023 season's work was made possible with financial support from Bobolink Foundation, Australasian Wader Studies Group, Queensland Wader Study Group and Dr Weipan Lei from Beijing Normal University. Here we report on what we have achieved in April – June 2023.

All the migratory birds mentioned in this report are covered by the China-Australia Migratory Bird Agreement (CAMBA). The data in this report confirm the importance of the Luannan Coast for migratory birds and the priority for both Australia and China to advance and build on their actions to protect this site for the future of migratory birds.

The Luannan Coast is important for both birds and people, 31 May 2023. © Katherine Leung

Study site

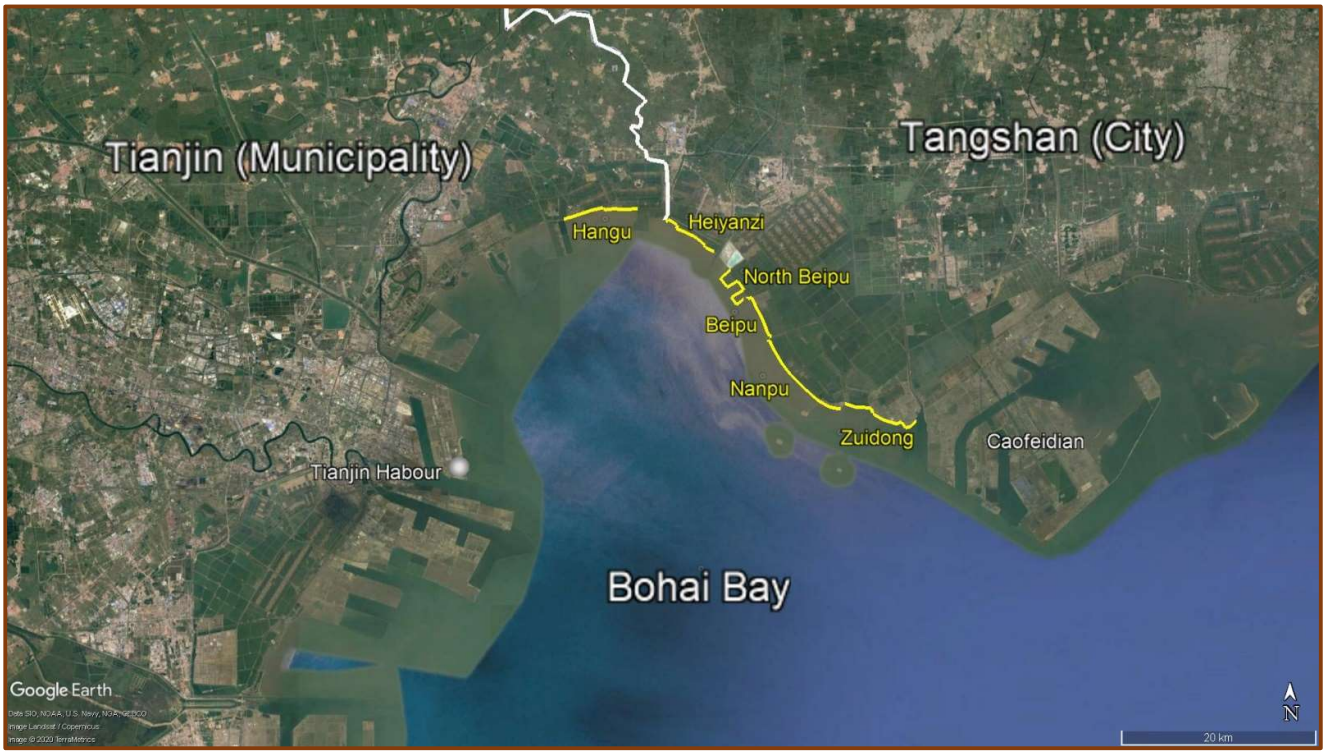


Figure 1. Interpreted satellite image of northern Bohai Bay, China with the coastal study sites marked in yellow.

The centre of the study site is situated at 39° 03' 35" N, 118° 12' 33" E. It is near Nanpu Development City, situated 190 km south-east of Beijing, China. Figure 1 shows the six coastal study sites and the Caofeidian Industrial Park. This enormous area covers 142 km^2 of previous intertidal mudflat and shallow sea. The mudflats of our six study sites cover 40 km in length and are 1-4 km wide (on the lowest tides). The total coastline of Bohai Bay is 1,294 km of which more than 95% is considered to be 'built environment'. This is mostly the huge port and industrial developments of Caofeidian, Tianjin and Huanghua (Sun *et al.* 2017).

The intertidal mudflats are separated by a man-made seawall from the Nanpu ponds complex. These are reputedly 'the largest salt works in Asia'. This ponds complex, adjacent to the mudflats, is also critical habitat for birds to forage and roost (Lei *et al.* 2018, Lei *et al.* 2021a), and for some species to nest (Lei *et al.* 2021b), but some of these areas have also been lost to industrial development. The area of ponds adjacent to the Luannan Coast is vast, stretching 10 km inland and across the entire 20 km, from south-east to north-west, of our four southerly study sites and therefore roosting opportunities are many and varied for migratory shorebirds and terns. There are also suitable ponds for roosting shorebirds and terns adjacent to the Hangu mudflats but almost zero roosting opportunities behind the seawall at Heiyanzi as this area is now highly industrialized.

The ponds are used for the production of salt (evaporation, storage and crystallization ponds), fish and shrimp for human consumption, brine shrimp *(Artemia)* that are fed to larger species of *Litopenaeus* shrimp to fatten them for harvest and sale for human consumption. Brine shrimp cysts (dormant eggs) are also collected and can be stored for long periods and hatched, on demand, to provide a convenient form of live feed for larval fish and are the most sought after of the *Artemia* products. Different water levels and salinities of the ponds are, more or less, suited to the different uses. For the purposes of this report, all and any pond, regardless of its use, is referred to as a 'pond'.

In previous years, the majority of shorebirds and terns have used the ponds for roosting and feeding. In 2013 when there were many and varied ponds available to birds, we had the amazing sight of 95,833 mixed shorebird species foraging in a single, shallow, large pond (2.6 km^2) on 16 May. On 29 May that year, we had a count of 34,200 Red Knot foraging in another shallow, large pond (3.4 km^2). Since 2016, it has been markedly different with very few shorebirds foraging at the ponds as most of them were too deep. Now the deep water provides few foraging opportunities particularly for the small and medium-sized shorebirds.

One of the very few ponds with low water level in this fieldwork season, 2 June 2023. © Katherine Leung

Marking of shorebirds

Shorebirds captured throughout the EAAF are mostly marked with plain coloured leg flags, engraved leg flags (ELF), or combinations of four colour-bands and one leg flag. Each bird also has a metal band placed on it supplied by the country's relevant banding scheme. Each capture location has its own colour flag combination and/or position of the flag on the birds' leg: http://eaaflyway.net/documents/Protocol_birds%20marking.pdf

'Scanning 'is systematically searching through feeding or roosting birds using telescopes to look specifically for flags and colour-bands on bird legs. Each marked bird is recorded, and the records are sent to each banding project at the end of our fieldwork season.

The focus of our study is the individually colour-banded birds marked at Roebuck Bay and Eighty Mile Beach, NWA, but we record every single marked bird we see during our fieldwork thereby documenting the importance of the Luannan Coast for various shorebird species from regions throughout the EAAF and CAF.

In addition to the data collected during our studies at the Luannan Coast, the GFN project is also getting tens of thousands of resightings at Roebuck Bay and Eighty Mile Beach. This huge dataset, with such a high number of records of individually marked birds, is very valuable for learning about survival and movements of these shorebirds (Piersma *et al.* 2016).

NWA colour-banded Red Knot (3RLLR) was marked at Eighty Mile Beach, Northwest Australia on 2 March 2011. This bird has been recorded at the Luannan Coast every spring since (except 2017). This image is from 1 May 2023.

© Katherine Leung

Fieldwork in 2023

The fieldwork program for 2023 started on 23 April and finished on 3 June, equating to forty-two consecutive days of field work with two observers in the field daily.

Due to limitations in observers, the first fieldwork day was some fourteen days later than usua. and this year fieldwork was almost solely focused on Red Knots at Nanpu and Hangu with much reduced visits to other sites.

Red Knot numbers fluctuated between 600 to 2,200 at Nanpu during the first month of fieldwork from 23 April to 23 May. Higher numbers were recorded on 24 May to 29 May, with the peak of 3,660 on 28 May. On the last few days of fieldwork, Red Knot numbers dropped from 1,602 on 30 May to 459 on 3 June.

All the totals should be considered absolute minimum totals for the area due to the fact that there are areas of mudflats and ponds inaccessible to us and we cannot count all sites used by shorebirds simultaneously.

Note: all counts throughout this document are minimum numbers

Katherine scanning on the Nanpu seawall, 25 May 2023. © Furong Bai

Table 1 documents the duration of our study periods at the Luannan Coast, Bohai Bay. We started with a preliminary visit in 2007, as our understanding of the importance of the site became clear to us, we started to cover the entire northward migration season of Red Knots, leading to the complete and continuous coverage of northward migration from 2010-2023. No observations were made during northward migration season 2008.

Table 1. Days of observation, total sightings of marked birds and resightings of individually recognisable colour-banded Red Knot from NWA at the Luannan Coast study site 2007-2023.

YEAR	DAYS OF OBSERVATION	TOTAL SIGHTINGS OF ALL MARKED BIRDS	COLOUR-BANDED RED KNOT FROM NWA
2007	7	49	0
2008	0	0	0
2009	19	859	76
2010	57	3133	106
2011	52	3354	170
2012	53	4496	279
2013	59	4613	269
2014	57	5014	345
2015	57	4147	387
2016	56	3554	261
2017	55	2765	265
2018	57	4116	313
2019	57	3452	336
2020	34	1169	189
2021	59	2087	208
2022	40	486	106
2023	42	1211	124
TOTAL	**761**	**44505**	**3434**

During the forty-two days of fieldwork, we made a total 1,211 sightings of marked birds of which 350 were 'known individuals', those able to be identified from unique engraved leg flags or colour-band combinations to an individual bird (Tables 1, 2 and 3). Total sightings of all marked birds for 2023 were low due to the low number of Red Knot and other shorebirds at the Luannan Coast this year, and the shorter fieldwork period. Also, this is possibly due to fewer birds being marked overall at the many banding locations throughout the EAAF as some banding activities have been disrupted due to COVID-19 in the past few years. The total number of Red Knot colour-band resightings for 2023 was 320, and the number of known individuals recorded was 124.

Xiao Liu scanning on the Nanpu seawall, 9 May 2023. © Katherine Leung

The scanning of foraging birds on the intertidal mudflats with the observers on the seawall occupied most of our time. All shorebirds that forage on the mudflats leave there at high tide as the tide reaches the seawall, and fly to roost or continue to forage in the ponds. Therefore, we also took some time to explore the ponds as we were hoping to find other scanning opportunities. Between 2016 and 2018, the water levels in most ponds in Nanpu have gradually become deeper due to increased management for aquaculture while still maintaining salt production. Subsequently there are fewer foraging opportunities for shorebirds. This was the same during this season.

In the years up to 2016 we spent about 25% of our scanning efforts in ponds, but from 2018 onwards that has reduced to under 5%. The birds still use the pond walls for roosting, but observing tightly packed roosts is relatively unproductive (results in fewer colour-band observations) and access to the ponds where the birds roost can be difficult. In the years before 2018, late in the season the birds utilise the mudflats less frequently and forage in the shallow ponds. During 2018-2020, we only found one or two accessible ponds with foraging Red Knot. In 2021, two large ponds 10 km from the Nanpu mudflats had suitable water levels for shorebirds foraging, for just three days at the end of April, when the majority of Red Knot had yet to arrive. In 2022 and this year, there were almost no feeding opportunities. Due to the deep ponds, the birds were still using the mudflats to forage, even late in the season.

The 10-ha area of salt ponds behind the seawall adjacent to Nanpu mudflats were the main scanning sites on the last few days of our fieldwork as was the case in 2020 and 2021. This is different from most years in the past when birds roost and do some foraging in these close ponds early in the season but then move further inland to the pond complex around mid-May. The roost areas in the ponds that we did access continued to be relatively undisturbed although pond workers do cause some occasional disturbance. The levels of disturbance do not appear to differ between roosts sites close to, or distant from, the mudflats. The myriad roosting opportunities available are a positive for the shorebirds, but the foraging opportunities within the ponds have diminished almost completely.

Xiao Liu scanning Red Knot at the roost in Nanpu salt pond, 31 May 2023 © Katherine Leung

Despite this change, it remains the case that both the ponds and the adjacent mudflats of the Luannan Coast are vital components of the area for shorebird conservation, even though the ponds are now predominately for their safe and relatively undisturbed roosting opportunities. The importance of the ponds for foraging could be augmented quite easily with different management. Any opportunities to engage with the owners and managers of the ponds should therefore be taken to explain the importance of the ponds to migratory shorebirds. As the water flows through the ponds system there may be opportunities to retain some shallow ponds without impacting on the commercial effectiveness of the ponds. Such an arrangement has yet to appear even with the establishment of the Provincial Wetland Park (see later section).

Table 2 below shows the totals of all marked migratory shorebirds recorded during all of our fieldwork seasons and the locations they were originally marked. The birds with plain flags just indicate the original marking location and cannot be identified to an individual bird. The colour-banded birds, the engraved leg-flagged birds (ELF) and some birds with unique positioning of flags on their legs can be attributed to individual birds when close views are obtained. As the team were seeing individually marked birds that were 'new' to the area late into the fieldwork period, it is not unreasonable to assume that plain-flagged birds were also still arriving while others will have moved through the site. So, while some will undoubtedly be multiple sightings, the numbers in the table are a good reflection of the numbers of flagged birds present during the study period. These records from 39 marking locations within the EAAF and CAF highlight the importance of the Luannan Coast, not only to birds from NWA, but from these two flyways.

Shorebirds at the Hangu Wind Farm Site mudflats, 18 May 2023. © Katherine Leung

Table 2. Totals of resightings of marked shorebirds, of all species, by banding area, recorded during fieldwork 2010-2023.

	MARKING LOCATION	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total 2010-23	KNOWN INDIVIDUALS 2023
1.	CHUKOTKA, RUSSIA	1	32	43	50	62	38	44	22	22	50	6	16	4	**14**	**404**	**3**
2.	KAMCHATKA, RUSSIA	1	3	4	1	0	6	7	20	37	65	11	25	23	**17**	**220**	**5**
3.	SAKHALIN, RUSSIA	0	4	5	48	52	44	43	33	36	21	3	1	1	**4**	**295**	**0**
4.	MONGOLIA	0	0	0	0	0	0	0	0	0	0	0	5	0	**1**	**6**	**0**
5.	HOKKAIDO, JAPAN	1	7	10	5	9	5	8	2	0	2	0	0	0	**0**	**49**	**0**
6.	NORTH-EAST COAST, JAPAN	0	0	0	0	0	4	1	0	0	0	0	0	0	**0**	**5**	**0**
7.	TOKYO BAY, JAPAN	0	0	0	0	0	0	0	0	1	7	0	1	0	**1**	**10**	**0**
8.	KYUSHU, JAPAN	0	0	0	0	0	0	2	0	0	0	0	0	0	**0**	**2**	**0**
9.	SOUTH KOREA	0	0	0	0	8	12	5	0	5	0	0	0	0	**0**	**30**	**0**
10.	LIAONING YALUJIANGKOU WETLAND NATIONAL NATURE RESERVE	0	0	0	1	3	3	0	0	0	0	0	5	0	**1**	**13**	**0**
11.	LIAONING LIAOHEKOU NATIONAL NATURE RESERVE (SAUNDERS'S GULL)	1	9	0	1	1	7	1	5	0	0	0	0	0	**0**	**25**	**0**
12.	HEBEI ZHANGJIAKOU (RELICT GULL)	0	0	0	0	0	0	0	0	0	2	0	0	1	**0**	**3**	**0**
13.	BOHAI BAY, LUANNAN & HANGU	122	96	129	125	108	55	162	78	126	77	16	43	2	**75**	**1227**	**16**
14.	BOHAI BAY, SOUTH										4	0	4	0	**5**		**1**
15.	JIANGSU, DONGTAI AND RUDONG	0	0	0	0	0	0	0	1	2	8	0	7	0	**3**	**21**	**0**
16.	SHANGHAI CHONGMING DONGTAN NATIONAL NATURE RESERVE	321	447	565	552	679	510	518	342	437	356	98	231	25	**86**	**5167**	**22**
17.	ZHEJIANG, HANGZHOU BAY	0	0	0	0	0	0	0	0	0	0	4	2	0	**6**	**12**	**0**
18.	GUANGDONG, LEIZHOU	0	0	0	0	0	0	0	0	0	0	0	2	0	**0**	**2**	**0**
19.	HONG KONG	5	23	19	44	39	20	20	6	18	9	4	24	10	**19**	**260**	**7**
20.	TAIWAN	4	0	2	3	2	4	1	0	1	7	0	6	0	**1**	**31**	**1**
21.	KINMEN ISLAND	0	0	0	0	0	0	0	2	0	0	0	0	0	**0**	**2**	**0**
22.	SINGAPORE	1	0	0	1	1	0	0	0	0	0	0	0	0	**0**	**3**	**0**
23.	INNER GULF OF THAILAND	31	18	34	96	153	92	125	75	113	118	47	82	1	**63**	**1048**	**3**
24.	PENINSULA, THAILAND	35	29	36	33	60	56	33	27	49	33	12	32	3	**11**	**449**	**0**
25.	OLANGO ISLAND, PHILIPPINES	0	0	0	1	1	0	0	0	0	0	0	0	0	**0**	**2**	**0**
26.	JAVA, INDONESIA	1	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**1**	**0**
27.	SUMATRA, INDONESIA	12	4	5	8	7	6	2	2	0	2	0	0	0	**0**	**48**	**0**
28.	NORTH-WEST AUSTRALIA (COLOUR-BANDS)	317	412	904	613	922	1221	671	680	1122	1095	446	535	177	**329**	**9444**	**128**
	NORTH-WEST AUSTRALIA (FLAGS)	912	812	1166	1053	1222	1036	964	916	1315	963	332	791	191	**405**	**12078**	**124**
29.	NORTHERN TERRITORY, AUSTRALIA	3	0	0	1	0	4	57	24	55	53	6	11	0	**9**	**223**	**3**
30.	QUEENSLAND, AUSTRALIA	7	7	8	27	12	4	14	3	1	13	1	8	0	**3**	**108**	**2**
31.	NEW SOUTH WALES	0	2	0	1	0	1	0	0	0	0	0	0	0	**0**	**4**	**0**
32.	SOUTH-WEST WESTERN AUSTRALIA	6	0	0	1	4	3	0	0	0	0	0	0	0	**0**	**14**	**0**
33.	SOUTH AUSTRALIA	12	35	62	73	54	31	40	20	20	26	15	12	1	**9**	**410**	**2**
34.	VICTORIA, AUSTRALIA	746	644	798	985	858	507	487	290	433	309	97	139	25	**76**	**6394**	**16**
35.	KING ISLAND, AUSTRALIA	3	2	4	0	1	5	2	4	1	0	0	1	0	**0**	**23**	**0**
36.	NORTH ISLAND, NEW ZEALAND	558	748	681	855	734	452	317	198	307	219	70	88	22	**61**	**5310**	**14**
37.	SOUTH ISLAND, NEW ZEALAND	32	20	21	35	22	17	18	5	2	7	1	7	0	**0**	**187**	**0**
38.	NORTH INDIA	0	0	0	0	0	0	5	5	5	4	0	7	0	**4**	**30**	**1**
39.	SOUTH INDIA	1	0	0	0	0	4	7	5	8	2	0	2	0	**8**	**37**	**2**
	TOTALS	**3133**	**3354**	**4496**	**4613**	**5014**	**4147**	**3554**	**2765**	**4116**	**3452**	**1169**	**2087**	**486**	**1211**	**43597**	**350**
	NUMBER OF SPECIES	**14**	**14**	**13**	**18**	**17**	**18**	**17**	**15**	**14**	**15**	**11**	**16**	**6**	**11**		

Shorebirds and human use of the mudflats and resighting coverage

The birds' use of the study site (Fig. 1) has changed since our first visit in 2007 and continues to vary each year as local conditions fluctuate and affect the suitability of different areas for the birds (particularly Red Knot, our focal species as it is a 'specialised feeder'). We have four major mudflat study sites (Nanpu, Zuidong, Beipu and Hangu) within the entire study area and the ponds. We have two areas that we only visit occasionally (North Beipu and Heiyanzi).

The Nanpu mudflat is the largest of the sub-sites that we study at 8 km long and 4 km wide, at the lowest tide, and it is often where most of the Red Knots congregate. This is presumably because, at present, this site has the most abundant and/or accessible prey. Due to the topography of the artificial seawall, it is also the last area of mudflat to be covered on an in-coming tide and the first to become exposed on an out-going tide. Consequently, this is where we obtain the best views of birds and is where most of our fieldwork is conducted.

Red and Great Knots on Nanpu mudflats, 26 April 2023.
© Katherine Leung

The Nanpu mudflats are undoubtedly the most important of the remaining mudflats in the area. There had been some dredging in 2006 for small-scale reclamation and artificial islands have been built close offshore for oil extraction, but the mudflats abutting the seawall are still important shorebird foraging grounds. The Nanpu mudflats and some of the adjacent ponds are now included in the Hebei Luannan Nanpu Zuidong Provincial Wetland Park established in 2020 (see later section). Mechanical shell-fishing operations are prohibited from 1 May to 30 September every year, in line with national guidelines. This is a very welcome policy and very sensible in that the fisherman will be permitted to return from 1 October when there will be less birds utilising the site. Shell-fishing by hand is allowed from 15 May onwards each year. Small groups of up to 15 people harvest shellfish daily on the mudflats. Each day they head out to the mudflats from designated locations on the seawall once the mudflats is exposed. Reasonable levels of fishing activity in past years did not appear to concern the birds, we would watch flocks of birds feeding close to people collecting shellfish.

Since October 2022, there were on-going 'wetland restoration' works along the seawall and at some sections of the ponds within the Provincial Wetland Park. Throughout the fieldwork season, we saw large trucks frequently transporting earth along the entire length of Nanpu seawall to the ponds where earth-moving works were being carried out. These trucks created high levels of disturbance to feeding shorebirds on the mudflat as well as to our scanning fieldwork. We often observed feeding bird flocks flushed as the trucks passed by. Those ponds which were being 'restored' were fully drained and not used by birds.

Chain of trucks on the Nanpu seawall, 13 May 2023.
© Katherine Leung

The mudflats at Beipu are 4.5 km long and approximately 4 km wide at the lowest tide. The mudflats here have undergone many changes

since our first visit in 2009. During our fieldwork in 2009 and 2010 we were regularly scanning at Beipu with thousands or tens of thousands of Red Knots frequenting the site. However, soon after our fieldwork season finished in 2010, development work started and was still going on during the 2011 field season. This involved many large industrial dredging ships pumping mud out of the mudflats and over the seawall into the adjacent salt ponds, damaging two shorebird habitats in one process. In the areas that were dredged, the mud was extracted up to a depth of 15m. This brings up anaerobic sediment and was pumped into the pond that was going to be filled. The heavy sediments settled and remained in the pond while the finer sediment and water run back out through sluice gates placed in the seawall for this purpose. As the fine black water and sediments run out back over the mudflats, they may smother the mudflats and cause the benthos to 'suffocate'. Just after this process there was a dramatic drop in shorebirds foraging at the affected area. We also saw this happen at our southern-most study site of Zuidong in 2009–2011.

The destruction of the mudflats at Beipu ceased prior to our 2012 season due to a dispute between the development companies and the pumping companies. This situation has not changed since, with no dredging or development work being done on the Beipu mudflats. The Beipu mudflats have had wildly fluctuating numbers of foraging Red Knots over the years, ranging from only a couple hundred to 25,000. Scanning effectively was more difficult at Beipu than it is at Nanpu, mainly due to logistics and the shorter time the birds are close enough to read flags and colour-bands. However, we know from our work and resighting histories that birds use all sites and so we are likely to encounter any birds that were using Beipu at either Nanpu or Hangu. We were not able to access Beipu this season as the seawall was blocked for 'restoration' works. Anyhow, the highest number of Red Knots observed on Beipu mudflats, by viewing at the western end of the seawall at Nanpu, was only 200 in this season and those were likely disturbed birds moved from Nanpu mudflats after the tide dropped. The suitability of the Beipu mudflats as a foraging site for migratory shorebirds has certainly not been consistent over the fourteen-year period of our study years. Detailed studies on the benthos of the site have not been undertaken, as the soft mudflats are difficult and indeed dangerous to access. Despite the mud being soft at Beipu, there are some fishing nets and manual shellfishing there. Small number of fishermen and shellfish collectors access the mudflat with 'mud scooters' daily.

Another issue at Beipu that highlights the lack of regulation on the coast is that in 2016, a 'resort' was built on the seawall. By 2017 it had already been abandoned, having never been used. Some of the buildings had toppled over the edge of the seawall. The decrepit development does not seem to be a major conservation issue in comparison to the huge losses of mudflats along the Yellow Sea coast, but it illustrates the unregulated nature of the human use of this very important site. Some of these 'resort' structures were still present at the site in 2022, but were all removed this year due to the seawall 'restoration' works.

Seawall 'restoration' works at Beipu, 7 May 2023.
© Katherine Leung

The North Beipu site has been worked by us less and less over the years and this season it was not visited at all given that access was blocked. As with colour-banded Red Knots seen on the Beipu mudflats, we know from previous years that individual birds seen at North Beipu are also recorded at Beipu and Nanpu mudflats in the same season. The mudflats there are incredibly soft and access is prohibited due to the chlor-alkali liquid waste facility located there. The ponds at North Beipu had, in the early years of our study been good roosting and foraging habitat. The pond walls are now built up by dredged mud from within the ponds. This has made the sides steep and the

water deep at the base of the walls and therefore unsuitable for foraging shorebirds. The top of the walls are rough and as the dredged mud dries out, they become very cracked and unsuitable for roosting birds. Access to Heiyanzi has also been blocked this season. Viewing at the western end of the seawall at Nanpu, we could see construction cranes and buildings behind the seawall there.

Far view of North Beipu and Heiyanzi from Nanpu seawall, 7 May 2023. © Katherine Leung

The Zuidong mudflats have 'improved' since the major pumping and seawall construction in 2009–2011. In the past few years, an area of Zuidong that we give the name 'Double Bridges' was seeded with the edible mollusc *Ruditapes philippinarum*, a major shell exploited for commercial harvesting. Small groups of up to 10 collectors accessed the Zuidong mudflats daily to harvest shellfish by hand. At the eastern area of Zuidong there is a visitor attraction where people can access the mudflat and collect shellfish recreationally. There may be over 200 people on the mudflat during the Labour Day Golden Week Holiday, but they stay in a relatively small area and their current use likely has little effect on the overall population of benthos available to shorebirds. A lot of industrial development continues on the reclaimed land adjacent to the remaining Zuidong mudflats. Zuidong is the main foraging site of Great Knot but currently without protection. It was proposed on the World Heritage Site nomination in 2017 and 2018, but was withdrawn from the Phase II application in 2021. Most of our scanning there is done out on the mudflats and not from the seawall. Because Zuidong mudflats are covered by the tide earlier than the Nanpu mudflats, birds from Zuidong would regularly move between these two sites. Due to the shorter fieldwork period this year, we have not been scanning at Zuidong.

Hangu Wind Farm site, situated in Tianjin, is now regarded as one of our study sites within the Luannan Coast study area. We first visited Hangu regularly in 2017 but it is evident that it is an important component of the Luannan Coast for shorebirds. However, we only made a few visits to Hangu this year. Similar to the situation at Nanpu and Beipu, there were ongoing 'wetland restoration' works along the Hangu coast throughout the season. Access to many sections of the seawall where we used to scan in the past years was blocked for the work. And another location where we made good observations in 2021 was 'overcrowded' with shellfish collectors on 'mud-scooter', as the mudflats at Hangu is incredibly soft and very difficult to walk on. The highest single count of Red Knot at Hangu this year was only 1,000. From our previous work we know, from checking individual birds resighting history, that a proportion of the birds using the Hangu Wind Farm site, are the same birds that use the Nanpu and Beipu sites.

Shellfish collectors with 'mud-scooters' at Hangu mudflats, 29 April 2023. © Katherine Leung

Regardless of the low number of birds recorded this year, retention of the remaining mudflats at Zuidong, Nanpu, Beipu and Hangu remains of great conservation importance. Retaining these mudflats in good ecological condition will enable the internationally significant number of migratory shorebirds and terns to continue using the area as a staging site. Thanks to the continuous effort and discussions between provincial and county governments, BNU and NGOs, the Nanpu mudflats and some of the adjacent ponds are protected within the Hebei Luannan Nanpu Zuidong Provincial Wetland Park since October 2020. However, a lesson needs to be learnt. As

mentioned above, the untimely 'wetland restoration' work being carried out during the critical bird migration period is a clear planning failure. Proper strategic conservation management with careful planning and engagement with shorebird experts from BNU is vital to enhance the status of this critical site. It is hoped that better communication can be set up between decision makers and scientists so that subsequent conservation management of the Wetland Park will ultimately be successful and therefore enable the Red Knot and many other waterbird species of the EAAF to maintain sustainable population levels.

Table 3 shows records of individually colour-banded birds marked in NWA recorded on the Luannan Coast for the years 2010 to 2023. The 128 individuals recorded this year is significantly lower than most standard years and reflects the low number of Red Knots using Luannan Coast this year. The totals were dominated by Red Knot with 124 individuals identified, then Bar-tailed Godwit with 3 and Great Knot with 1. Numerous Red Knots have been seen over many consecutive years with some in all fourteen years. One of the Bar-tailed Godwit has been seen in all years since 2010 (except 2022), and the bird is a minimum of 18 years old. Despite this individual being very faithful to Luannan, this area is not a major staging site for Bar-tailed Godwits.

Table 3. Totals of individually colour-banded birds from the GFN project marked in NWA resighted on the Luannan Coast 2010-2023. No marked Black-tailed Godwits from NWA have been recorded within the study site.

NWA COLOUR-BANDED INDIVIDUALS	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
BAR-TAILED GODWIT	3	2	4	3	5	6	3	4	4	3	1	5	0	3
GREAT KNOT	6	20	17	12	11	30	31	22	44	48	3	23	1	1
RED KNOT	106	170	287	272	329	387	261	269	313	336	189	208	106	124
TOTAL	**115**	**192**	**308**	**287**	**345**	**423**	**295**	**295**	**361**	**387**	**193**	**236**	**107**	**128**

Internationally important counts

During the fourteen years GFN have been visiting the Luannan Coast from 2010 to 2023, we have been conducting regular counts in conjunction with BNU. The importance of this site is not in any doubt. Table 4 below shows clearly the immense importance of these mudflats and ponds to shorebirds from throughout the EAAF. All counts are absolute minimum counts as the vast area can never be completely covered with our current resources and no turnover analysis is done. Note that there have been higher counts of some species in Table 4 prior to 2014 but with the renewed EAAF Waterbird Populations Portal (Wetlands International 2023), we have only used counts from the last ten years to more accurately reflect the current situation at the Luannan Coast. Most migratory shorebird populations in the EAAF are declining and it is no surprise that many species have also shown declines in peak numbers on the Luannan Coast.

During this 2023 season, the overall number of shorebirds at our study sites has dropped significantly and we did not record any higher count of any species compared to other years. Even in this historically low year the Luannan Coast is still of significant international importance to EAAF's Red Knot with the highest count at Nanpu mudflats alone equivalent to more than 3% of the EAAF Red Knot population.

Asian Dowitcher feeding on Nanpu mudflats, 11 May 2023. © Katherine Leung

Table 4. Internationally important counts at Luannan Coast 2014-2023.

Species	Scientific name	Date recorded	Count	% of EAAF population present	Waterbird Populations Portal*	Total for 1% Ramsar criteria^
Pied Avocet	*Recurvirostra avosetta*	26 04 2019	1,149	1.1	100,000	1,000
Grey Plover	*Pluvialis squatarola*	26 04 2019	3,220	4	80,000	800
Eurasian Curlew (NT)	*Numenius arquata*	26 04 2019	2,722	2.7	100,000	1,000
Black-tailed Godwit (NT)	*Limosa limosa*	13 04 2019	17,937	11.2	160,000	1,600
Great Knot (EN)	*Calidris tenuirostris*	08 05 2019	12,971	3.1	425,000	4,250
Red Knot (NT)	*Calidris canutus*	16 05 2018	48,630	43.8	110,000	1,100
Broad-billed Sandpiper	*Calidris falcinellus*	27 05 2015	2,460	8.2	30,000	300
Sharp-tailed Sandpiper (VU)	*Calidris acuminata*	04 05 2014	4,000	4.7	85,000	850
Curlew Sandpiper (NT)	*Calidris ferruginea*	04 05 2014	24,500	27.2	90,000	900
Spoon-billed Sandpiper (CR)	*Calidris pygmaea*	25 05 2016	1	0.1	800	8
Red-necked Stint (NT)	*Calidris ruficollis*	08 05 2016	4,747	0.99	475,000	4,800
Sanderling	*Calidris alba*	29 05 2016	4,321	14.4	30,000	300
Dunlin	*Calidris alpina*	07 05 2017	40,000	1.6	2,460,900#	24,609
Asian Dowitcher (NT)	*Limnodromus semipalmatus*	08 05 2017	1,754	6.26	28,400	280
Spotted Redshank	*Tringa erythropus*	15 05 2016	592	2.6	25,000	250
Nordmann's Greenshank (EN)	*Tringa guttifer*	08 05 2016	7	0.7	1,200	10
Marsh Sandpiper	*Tringa stagnatilis*	27 04 2016	8,785	6.8	130,000	1,300
White-winged Tern	*Chlidonias leucopterus*	14 05 2014	40,000e	4	1,000,000	10,000

* - Wetlands International (2023). # - Uncertainty of distribution of all subspecies in EAAF.
e - Estimate

^ - The 1% Ramsar criteria refers to Criterion 6 of the Ramsar Convention: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Red Knot numbers

The focus of our studies on the Luannan Coast is the Red Knot. This year the number of Red Knot came to an historical low with the biggest day count being only 3,660 on 28 May at Nanpu mudflats. This was significantly low even when compared to the low counts in recent years (9,000 in 2021 and 9,938 in 2022). From our knowledge of the study sites in recently years, we are confident that there were not thousands of Red Knots at any of our regular study sites that we missed. None of the non-breeding areas of the EAAF have had dramatic changes in the numbers of Red Knots utilising them in the 2022/23 season. We do not think there is a flyway-wide crash in Red Knot numbers. It seems clear that the number of Red Knot using the Luannan Coast varies a lot from year to year. The 2018 (48,630) and 2019 (47,537) counts were our highest since 2015 (Table 5). We believe that the migration pattern of Red Knot during northward migration has changed in recent years. Preliminary results of the benthic sampling at Nanpu in recent years show that food shortage might be the main reason, and could have impacted other shorebird species as well (see later section). Based on communication with birdwatchers and surveyors along coastal China, there had not been any report of big number of Red Knots elsewhere along coastal China during northward migration period this year except around 2,000 individuals were counted at Lianyungang, northern Jiangsu in early May (Leung pers. comms.). It seems clear that the Red Knot were not concentrating at other sites when they were not present at the Luannan Coast. Nevertheless, it is getting even more important to keep monitoring the Luannan Coast in the coming years to record these changes properly. A programme of repeated satellite tracking would give us more answers but requires deep and long-term funding.

Table 5. Peak counts of Red Knots at Luannan Coast from 2015-2023.

2015	2016	2017	2018	2019	2020	2021	2022	2023
29,956	20,000	17,000	48,630	47,537	20,000	9,000	9,938 (BNU's data)	3,660

The presence of *rogersi* and *piersmai* Red Knot subspecies

The subspecies *piersmai* and *rogersi* Red Knot both use the Luannan Coast as a staging site. We get fabulous data each year on the individually marked birds from the project.

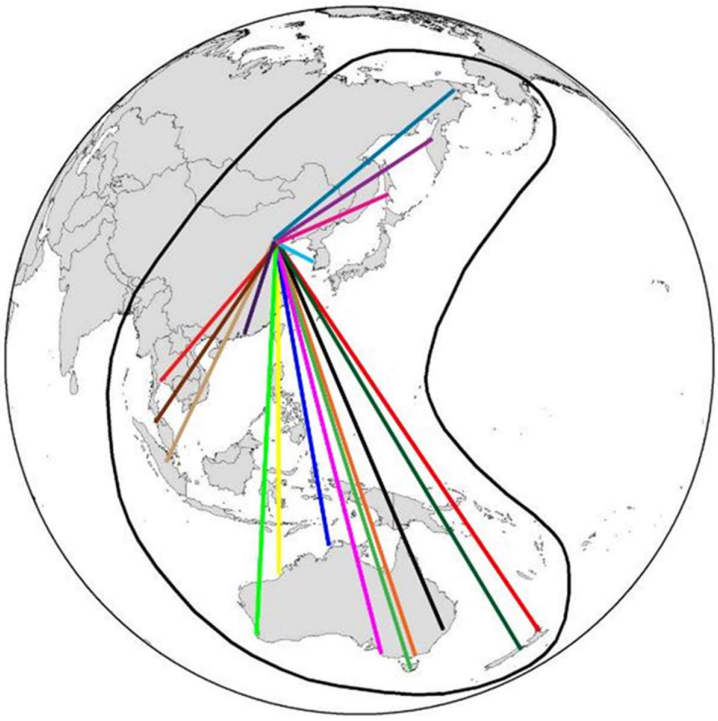


Figure 2. Between 2010 and 2023 we have recorded Red Knot from 23 different banding locations throughout the EAAF. The map below is a representation of some of these sites.

The majority of the two subspecies of Red Knot using the EAAF can be distinguished, when in fresh, full or near-full breeding plumage by the colour and pattern of that breeding plumage (Tomkovich 2001, Hassell *et al.* 2011). This is particularly noticeable when the two subspecies are side by side as is usually the case in our study site.

The *rogersi* birds, predominately from south-east Australia and New Zealand non-breeding grounds, generally arrive first and leave for their eastern Siberian breeding grounds earlier than the *piersmai* birds. The *piersmai* birds, predominately from NW Australia non-breeding grounds, breed in more northerly latitudes on the New Siberian Islands.

In relation to Red Knot marked in Roebuck Bay and Eighty Mile Beach, NWA, for both the total number of resightings and the individuals that those sightings represent, it needs to be taken into account that approximately 20% of Red Knots marked in NWA may be the *rogersi* subspecies. These *rogersi* birds may or may not move to New Zealand after marking in NWA and then use New Zealand as their permanent non-breeding area. From New Zealand they may migrate to the Luannan Coast under different schedules than *rogersi* that use NWA as their non-breeding location. Interestingly both *rogersi* and *piersmai* depart NWA at the same time (late April) despite the difference in breeding locations (Verhoeven *et al*. 2016).

A 'typical' *piersmai* AP 4 (left) and 'typical *rogersi* AP 3 (right). © Adrian Boyle

In our experience it appeared that birds which arrive at the Luannan Coast early in the season, before 1 May, are predominately *rogersi* and stay for up to a month. Birds that arrive late in the season, mid-May onwards, are predominately *piersmai* that only stay for a short time, in some cases, a week or less. This was confirmed by a sophisticated scientific paper showing the *piersmai* subspecies stay for 5-9 days at the Luannan Coast (Lok *et al.* 2019).

To evaluate the proportions of the two subspecies we conduct regular, random scans of flocks and assign a subspecies to each individual bird on the basis of plumage characteristics. The number of flocks and birds scanned had been very similar over the years. No scan was carried out in 2020 and 2022 (Table 6).

Table 6. Number of Red Knot flocks and birds scanned for subspecies at Luannan Coast 2015-2023.

YEAR	Number of scans	Number of Red Knots assessed
2015	225	39,925
2016	221	38,364
2017	218	38,866
2018	231	39,164
2019	257	52,186
2020	0	0
2021	212	34,184
2022	0	0
2023	176	39,830

Figure 3 shows the 'flow' of the *rogersi* and *piersmai* subspecies through the Luannan Coast over the northward migration period. In the past years, *rogersi* arrives and leaves earlier, *piersmai* later (Figure 3a). The breeding grounds of *rogersi* in Chukotka become snow free from about mid-May while the New Siberian breeding grounds of *piersmai* are not snow free until early-June. This year's flow was very different from previous years (Figure 3b). The percentage of *piersmai* birds remained fairly constant since the end of April, and only increased slightly at the end of May. This year's flow indicates that the migration pattern has changed, with *rogersi* staying longer and/or the number of *piersmai* did not build as they have in previous years.

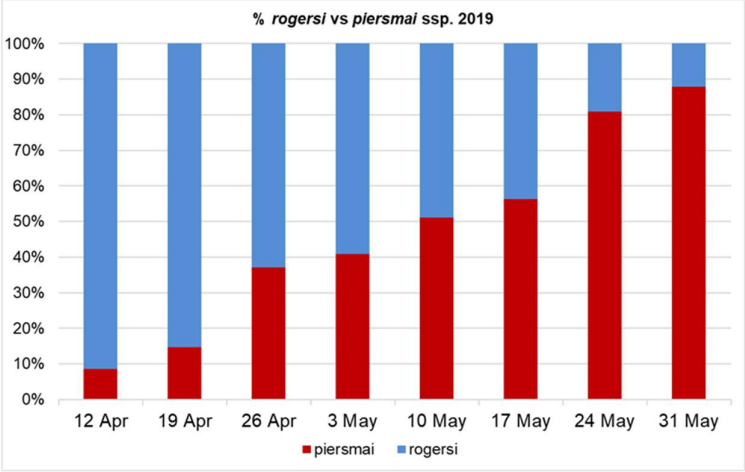


Figure 3a. Percentage *rogersi* vs *piersmai* subspecies over time 2019.

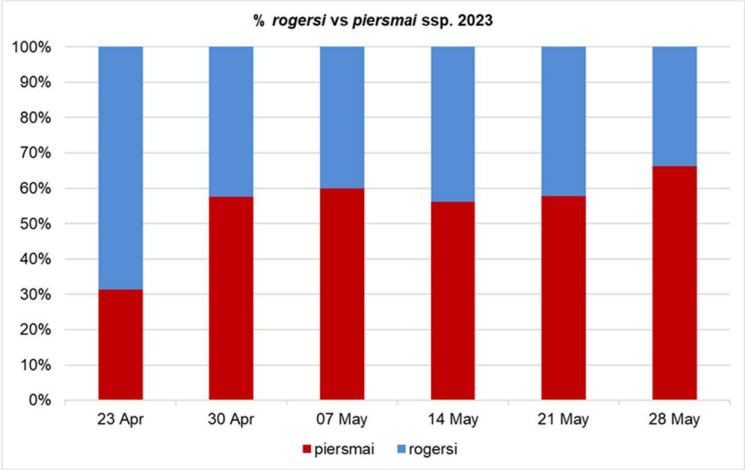


Figure 3b. Percentage *rogersi* vs *piersmai* subspecies over time 2023.

Abdominal profiles

As we are not catching Red Knots at the Luannan Coast, there is an absence of year-to-year body mass data (but see Hua *et al*. 2013 for data on the first study years), however it is possible to score the abdominal profile (AP) of birds visually in the field from telescope observations (Wiersma & Piersma 1995). This is a suitable alternative way to assess the fat stores and weight gain of birds**.** We record abdominal profile on all flagged and colour-banded Red Knot when we get a suitable view. A side-on view of the bird is needed for an accurate assessment. A factor the observer must consider is if the bird is 'fluffed-up' due to cold weather. This can mislead the observer into thinking the bird is 'fatter' than it really is. This can certainly be a problem, but the experienced observers of GFN are aware of this and so all observers are scoring under the same criteria. The scores range from AP 1- very thin to AP 5 - obese. A bird scored as 1 looks unhealthy and a bird scored at 5 is very fat.

Both subspecies and most individuals are arriving at our Luannan Coast study site in good body condition, whilst no birds are arriving in very poor condition (AP 1). This likely means that they are staging somewhere between their Australian and New Zealand non-breeding sites and the Luannan Coast. Colour-band and flag resightings show this and it is further supported from geolocator tracks and satellite tracking data confirming birds stop at many sites south of the Luannan Coast including Hong Kong, Taiwan, southern China and north east Borneo (GFN, AWSG unpublished data, Piersma *et al*. 2021). This northward migration strategy is, however, one piece of the Red Knot life-cycle question that we are still attempting to answer more fully.

The results in 2010-2019 have been very similar with both subspecies' abdominal profile score increasing gradually throughout the season. Since 2020, there are some changes to the results. In 2020, birds appeared to reach AP 5 scores earlier in the season from around 20-May rather than at the very end of May. In 2021, some birds with AP 5 scores appeared as early as mid-April, and majority of the birds were in AP 3 scores throughout the course of May. Regardless of the changes comparing to previous years, most birds appeared to be able to feed effectively enough to gain suitable condition for the leg of their migration to the breeding grounds at the end of the season. No abdominal profile score was assessed in 2022.

During the 2023 fieldwork season, 886 Red Knot of both subspecies were assessed and given an abdominal profile score during a single sighting. This year's graph shows that the abdominal profile score of *rogersi* remained very stable since the start of our fieldwork season, while a very gradual increase in abdominal profile score was observed on *piersmai*. However, at the end of the season, both subspecies have only reached AP 4 rather than AP 5 as in all past years (Figure 4). Comment from Hebo Peng regarding the abundance of *P. laevis* is that they are in the lowest density since 2015 (see next section). Given the historical lowest number of Red Knots at the site than any previous years, it seems that the Red Knots have assessed *P. laevis* abundance based on their experience in the previous year and move to other sites.

Red Knots and Curlew Sandpiper feeding on Nanpu mudflat, 3 May 2023. © Katherine Leung

Potamocorbula laevis density

P. laevis is the key food for Red Knot at the Luannan Coast (Yang *et al.* 2013). Understanding the availability of food for Red Knots would help to interpret variations in the number of Red Knot using the Luannan Coast from year to year. Our colleague Hebo Peng conducted benthic sampling on mudflats along the China coast to monitor the variation of shorebirds' food (Peng *et al.* 2021). His

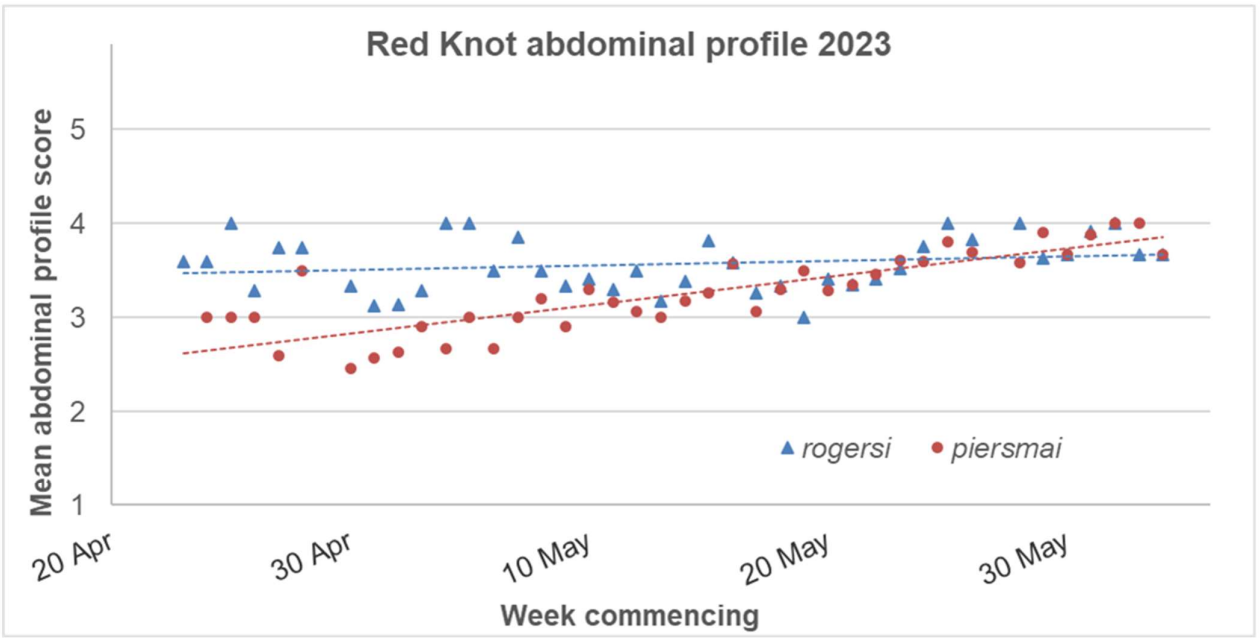


Figure 4. The graph shows the change in abdominal profile, over time, for the two subspecies of Red Knot in 2023 using 886 records.

team visited the Luannan Coast twice to survey the macrobenthos in both early and late May. Three transects were set out on the Nanpu mudflats and four on the Zuidong mudflats.

During the sampling, each 20 cm deep core of sediment from the mudflats is divided into two parts, the top 5 cm and the bottom 15 cm, to understand the availability and food density for different size shorebirds, small and medium-sized species e.g., Curlew Sandpipers and Red Knots and large-sized shorebirds, e.g., godwits. The sediment samples were washed through 0.5 mm sieves and all macrobenthos were identified and counted. All *P. laevis* are in the top 5 cm of the mudflats and therefore easy to access by foraging Red Knots. From 2010-2019, *P. laevis* showed stable levels at a high density, which provided abundant, high-quality food for Red Knots and other shorebirds. These high densities even became a 'fall-back' for shorebirds during the years when habitats in Tianjin, Cangzhou were negatively affected during land claim operations (Yang et al. 2011).

Preliminary results show that the density of *P. laevis* was low in Nanpu again this year with no 'hot spot' found along any of the three transects. We are yet to come up with a conclusion about the cause of this decline, it could be a periodic food fluctuation, pollution or some other aspect of the local habitat which we are as yet unable to identify. It doesn't seem to be a coincidence that both Red Knot numbers and *P. laevis* densities declined at the Luannan Coast in the past 4 years. But we are not clear yet how the availability of food at a particular site is affecting Red Knot distribution along the Yellow Sea coast during northward migration. Continuation of the benthic sampling work along the Chinese coast together with our field work at the Luannan Coast should eventually give us more insights.

P. laevis next to a Chinse one yuan coin
© Jan van de Kam

Breeding shorebirds and terns

In addition to the migratory shorebirds and terns passing through the Luannan Coast, there are nine species we have recorded breeding within the study site from 2010 to 2023. Pied Avocet is the most common species we recorded and is the focus of continued study by Professor Zhengwang Zhang's College of Life Sciences at BNU (see Lei *et al*. 2018, Lei *et al*. 2021b). Pied Avocets breed on the bare banks of ponds, on open areas of dry mud in unused or recently reclaimed ponds and on small islands within the ponds. Many of these banks are impossible to access so an accurate estimation of the total nesting population is difficult but there are between 1,000 and 2,000 pairs in the Luannan pond complex (Weipan Lei *pers. comm*.). In recent years they have had lower breeding success due to unstable water levels in the ponds. Sudden rises in water level by severe weather or for the purpose of pond management often lead to direct loss of eggs or chicks. Feral animals also pose threats to the breeding shorebirds and terns. We have observed feral dogs chasing and eventually catching an adult Pied Avocet in the past. Feral cats were found by infra-red camera to consume eggs in nests (Yang Wu *pers. comm.*). Black-winged Stilt *Himantopus himantopus* and Kentish Plover *Charadrius alexandrinus* breed in the same locations as Pied Avocet, both were recorded breeding in 2023 and presumably face similar threats.

Common Tern *Sterna hirundo* breed in scattered colonies numbering from a few to a few hundred pairs. Little Terns *Sternula albifrons*, Gull-billed Terns *Gelochelidon nilotica* and Whiskered Terns *Childonias hybrida* were all recorded carrying food from the mudflats to the ponds, so we believed they were also nesting in the area.

Pied Avocet feeding at Nanpu mudflats, 28 May 2023.
© Katherine Leung

Wetland Park

After years of discussion and hard work from BNU, the Paulson Institute (PI), WWF and the Luannan County Government, the Hebei Luannan Nanpu Zuidong Provincial Wetland Park (the Wetland Park) was officially established on 26 October 2020. The Wetland Park covers an area of 5,791.6 ha, including nearly 3,000 ha of shallow sea habitat and 2,177 ha of intertidal mudflat along the whole 8 km shore of Nanpu, plus 690 ha of salt and aquaculture ponds behind the Nanpu seawall at the north-west corner near Beipu. The initial intention in 2018 was that the Nanpu site should be designated as a nature reserve. However, the proposal for a lower grade protected area as a wetland park was preferred as it can safeguard both the biodiversity and, importantly, the livelihood of the local communities. In June 2021, a workshop was held in Luannan with all the major stakeholders, including government officials, BNU, PI, WWF, local representatives from Nanpu and Beipu villages, salt pond operators, and experts on sustainable aquaculture to share their view of the future management for the Wetland Park. The Wetland Park area is included in the application for "The Coast of the Bohai Gulf and the Yellow Sea of China World Heritage Site" Phase II nomination.

This year, the Wetland Park is still not yet open for public visitors. We saw a new visitor center has been constructed at the entrance near the salt pond area of the Wetland Park and more education signages have been set up along the visitor route along the seawall and the salt ponds. As mentioned above, a hundreds-million yuan "wetland restoration" project was being carried out at the Wetland Park since October 2022. Our

observations saw shorebirds feeding on the intertidal mudflats frequently disturbed by large trucks running along the seawall to transport earth into the ponds for building large and tall artificial islands which were not designed properly for waterbird roosting and nesting. It was a pity that improper management of a project with good conservation intentions has caused negative impacts to the shorebirds at their critical stage of life.

New visitor center of the Wetland Park, 30 May 2023. © Katherine Leung

Over the past years we have also seen some other improper management of the area including a completely unnecessary viewing platform built. Great views of the birds can be obtained from the path and the platform does not get people any closer to the birds. The only outcome from people climbing on to the platform will be disturbing the birds. When the birds first return from the salt pond roosts, they land close to the wall, start to feed, sometimes bathe, and sleep, people high on a platform will only disturb birds. Before the start of our field season in 2021, a line of *Tamarix* sp. tree seedlings was planted on the first 2.7 km section of the south-east end of the Nanpu seawall, making it hard work for scanning between tree branches. Although this line of trees might provide some screening effect to minimise disturbance to birds from vehicles along the road, tall trees will discourage waterbirds from feeding or landing close to the seawall in future due to nervousness of surprise attacks from raptors that can use the trees as cover (Rogers *et al.* 2006).

It goes without saying that GFN is supportive of the protection of the Luannan Coast as a Wetland Park. However, it is clear that proper strategic conservation management is as equally important as the protection status of a site. It is hoped that better communication can be set up between decision makers and scientists so that subsequent conservation management of the Wetland Park will ultimately be successful.

Large and tall artificial islands in the Wetland Park salt pond, 26 April 2023. © Katherine Leung

Human use of the mudflats and ponds

Shellfishing of mollusc is carried out at both Zuidong and Nanpu mudflats by the local fishing communities of Nanpu and Beipu villages from March to September each year. As mentioned previously, there is an annual ban on mechanical shellfishing between 1 May and 30 September, so only low-level shellfishing by hand on the mudflats is observed during our field season. Locals mentioned that summer harvesting (July to August) of *P. laevis* could be beneficial to their harvest in the following year. This theory has been argued by Yang *et al.* (2016) that the very intense fishing practices for *P. laevis* in the late-summer may even benefit shorebirds staging in the spring because it would allow an increase in the settlement of new recruits in the subsequent spring. Our colleague Hebo Peng's benthic sampling on the Luannan Coast mudflat show that there has been a decrease of density of *P. laevis* over the past few years. With the establishment of the Wetland Park, and the potential World Heritage Site nomination, there is hopefully room to explore regulated aquaculture and harvesting of *P. laevis*, which might maximise the benefit to both shorebirds, especially Red Knot, and local communities.

Shellfish collectors and foraging Red Knots close-by on Nanpu mudflat, 30 May 2023. © Katherine Leung

The Zuidong mudflats are currently not within the Wetland Park boundary nor the World Heritage Site nomination. At the eastern area of Zuidong there is a visitor attraction where people access the mudflat and collect shellfish recreationally. Locals have previously expressed their wish to keep operating the attraction and expand public access to other areas of the Zuidong mudflats. Acceptance of such a proposal would increase the disturbance to the main foraging area of Great Knot and potentially impact the overall population of benthos available to shorebirds. It is hoped that the World Heritage Site nomination can be extended to protect the Zuidong mudflat with no expansion of the recreational shellfishing. However, regulated eco-tourism from which the local community could benefit is possible with careful planning and relevant ongoing management.

Salt, fish, *Litopenaeus* shrimp, *Artemia* brine shrimp (adult and cysts) are the major products from the ponds adjacent to the Luannan Coast. In recently years, most ponds in Nanpu had gradually become deeper due to increased management for aquaculture and their use by shorebirds as foraging habitat, had reduced greatly. Through habitat management of the Wetland Park, there is potential to regulate water levels in some of the ponds to benefit shorebirds. On the other hand, a sustainable aquaculture accreditation system is being investigated for the pond products so there is hope that a win-win situation could be found for both shorebirds and locals.

While GFN are conducting our work on the Luannan Coast, we always try to engage the local shellfish collectors, pond and oil rig workers, we share our binoculars with them and show them the birds through our telescopes. BNU has some information brochures, developed by their students, and printed in Chinese which we hand out to people who approach us to ask what we are doing. Over the years our drivers Mr. Liu and Xiao Liu have developed great interested in the migratory birds and in our studies. They chat to various people who we encounter during our work and also ask local fishermen or shellfish collectors about situation of the mudflats. Since 2020, the GFN team has been comprised of Chinese language speakers and not predominately English speakers, this has given even more scope for engagement.

Habitat threats and management actions

Many huge industrial projects are underway around the Yellow Sea coast and our study area is no exception. A massive steel works has been built on reclaimed land at Heiyanzi, one of our less frequented study sites between Beipu and Hangu Wind Farm. This is an area we have seldom visited due to the difficulty of access to the mudflats and limited opportunities for scanning. Over the years, we have done some exploration of the ponds (now reclaimed) in that area but we know little about shorebird use of the adjacent mudflats. A classic case of losing habitat before the biological importance of the area has been documented.

The area is now called the "Hebei Fengnan By-port Economic Zone". The new zone has an enormous steel works. It has amalgamated five steel companies, each moved from their former locations within or near urban areas which is expected to bring an economic upturn to the area with additional jobs and investments. The project started in August 2017 and the steel works industrial zone has been completed in 2021. The total investment will be around the equivalent of $4 billion (Australian). The land on which the steel works has been built was reclaimed many years ago and used as aquaculture ponds, before being filled in for this project. In addition to the steelworks, a port will be developed. This will, from our understanding of the 'information boards' at the site, cover some 54 km^2 of mudflats and shallow sea and become an imposing feature of the coast. Another large chunk of mudflat set to disappear!

The Luannan Coast is very important for oil production and China National Petroleum Corporation (CNPC) operate there and have done so for many years. Generally, this industry does not cause too much of a conservation threat to the migratory bird populations. There is the loss of some habitat for drill rigs and infrastructure, but much of the exploration and infrastructure is offshore and away from the mudflats. However, some serious risks are associated with large scale oil production. An oil spill would be serious for the Luannan Coast mudflats, the associated benthos and birds. If that oil spill were to coincide with the spring migration season, the effects on migratory populations could be catastrophic. If an accident were to occur outside of peak bird use of the area

Shorebirds on Nanpu mudflats, with the oil production island in background, 26 April 2023. © Katherine Leung

it would still be a very serious as the benthos would be affected and diminish the areas biodiversity, suitability for shorebirds and shellfish harvest for the local people. A MOU has been signed between CNPC and the Luannan County in 2020 to maintain CNPC's right on oil production without compromising protection of the site for EAAF migratory waterbirds. It is hoped that the future Wetland Park authority will be in close communication with CNPC. The shared use of the area for on-going profitable oil production and keeping the area safe for foraging migratory shorebirds is quite possible with good will from both sides.

Smooth Cordgrass *Spartina alterniflora* is a highly invasive, non-native species and has caused huge problems in important shorebird sites in the Yellow Sea. In the past years, this invasive plant has established on the mudflats adjacent to the seawall at Zuidong and Nanpu. In June 2018, it was very pleasing to see that the issue was addressed at Nanpu in a project led by WWF-China with a spraying program to control the spread of the Spartina, following the success at Shanghai Chongming Dongtan National Nature Reserve. The Spartina at Nanpu was sprayed three times from July to September in 2018 with about 85% success rate. In June and July 2019, WWF once again organised for two sprays of the Spartina with drones. This follow up procedure was highly effective and has all but eliminated Spartina from the south-east corner of the Nanpu mudflats abutting the oil island causeway. The spraying programme was very successful with only small green spouts of new growth observed during the 2020 field season. A similar spraying project was also initiated by the Paulson Institute at Zuidong mudflats in 2019.

Before the start of our fieldwork season in 2021, an ecological restoration project was carried out by the Luannan County Government, which involves the removal of Spartina by cutting and digging the plants up to a depth of 40 cm over a total area of 18.3 ha at the Nanpu and Zuidong mudflats. The work was carried out during the winter in late 2020/early 2021. We are uncertain whether such mechanical digging would cause any impact on the mudflat habitat, but a digger would bring greater and longer disturbance to birds when comparing to using drones to spray and treat the Spartina. Nevertheless, it is good to see the Luannan County Government's good intention in addressing the issue.

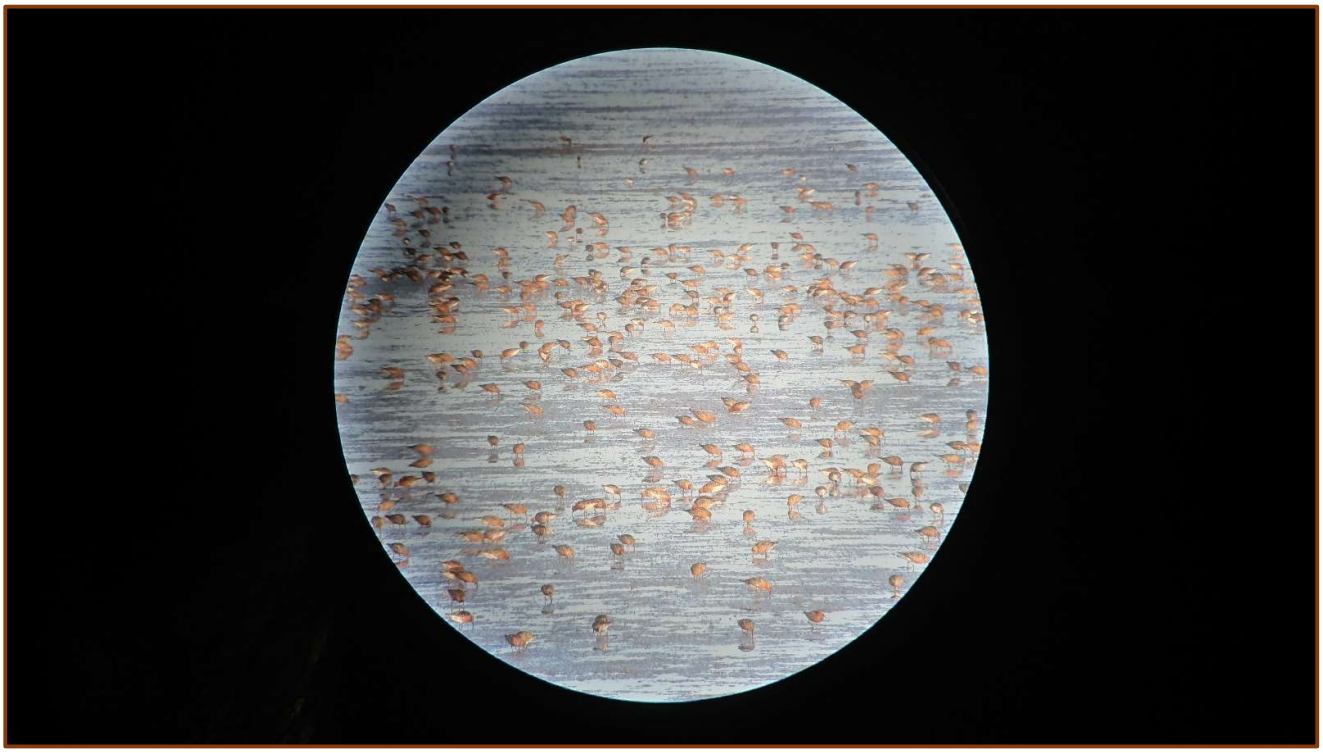
Persistent efforts over the past few years have been a success in eradicating Spartina. Almost zero regrowth was observed at both sites. In early 2023, the Chinese Central Government has set a target to eliminate at least 90% of the invasive Spartina along China coast by 2025. Monitoring and control of this invasive species ought to be continued in future years at the Wetland Park. This year we also saw similar effort on control of Spartina has been carried out on the Hangu mudflats.

Nanpu mudflats once invaded by *Spartina*, late May 2018 (left). © Adrian Boyle
Nanpu mudflats without *Spartina*, 3 May 2023 (right). © Katherine Leung

Future research

GFN continues to document the fate of four shorebird species from their non-breeding sites in NWA by applying individual colour-band combinations and conducting intensive resighting scans for the marked birds. A comprehensive database of sightings from the marking sites in NWA and throughout the flyway is being maintained. With the work in Bohai Bay and sightings from other shorebird colleagues throughout the flyway we will be able to assess the effects of human-induced habitat change on survival rates of the populations and a variety of demographic parameters.

GFN will continue conservation efforts at Bohai Bay in conjunction with Beijing Normal University, WWF China, Wetlands International, the Paulson Institute, Department of Conservation New Zealand and any provincial and local government agencies that we can engage with. Dr Ying-Chi Chan, a PhD graduate at the University of Groningen and the Royal Netherlands Institute for Sea Research (NIOZ) with Theunis Piersma, has completed her PhD with a number of the chapters having data from the Luannan Coast in them. Papers contained within her thesis have used mark-resighting data presented in GFN reports, as well as other methods such as satellite telemetry and benthic sampling. Hebo Peng, also a PhD student with Theunis Piersma is studying the benthic resources for migratory shorebirds along the entire coastline of China, including fieldwork on the Luannan Coast (see earlier section). All this work is made possible under the Rudi Drent Chair in Global Flyway Ecology at the University of Groningen, with past support from WWF Netherlands, WWF-China and BirdLife-Netherlands, with the in-kind support of the NIOZ, and in close cooperation with Beijing Normal University.



Telescope view of Red Knots on Nanpu mudflats, 22 May 2023. © Katherine Leung

Key points from 2023

- It is clear from our current knowledge that the Luannan Coast is the single most important staging site for two subspecies of Red Knot in the EAAF encompassing the vast majority of Red Knots wintering in Australia and New Zealand. Between 2010 and 2023, we have recorded Red Knot from 23 different banding locations throughout the EAAF.
- We recorded 1,211 marked shorebirds of 11 species from throughout the EAAF, as well as from India (usually regarded as a part of the CAF), highlighting the importance of the Luannan Coast for these 2 flyways.
- This year, 128 birds were individually recognisable from the GFN colour-banding project in Northwest Australia (NWA), dominated by Red Knot with 124 individuals identified.
- In the period 2014-2019, fourteen species of migratory shorebirds and one migratory tern have been recorded in internationally significant numbers, including four species with an absolute minimum of 10% of their entire EAAF population passing through the Luannan Coast during northward migration.
- In addition, there are nine species of shorebirds and terns we have recorded breeding within the study site from 2010 to 2023.
- On the Luannan Coast in 2023, Red Knot were present in the lowest number on the Luannan Coast since the start of our studies in 2010. The highest single count was only 3,660 on 28 May at Nanpu. The low numbers tally with the low densities of their preferred bivalve prey *Potamocorbula laevis* (Peng pers. comm.). Even in this historical low year, the site still supports more than 3% of the EAAF Red Knot population.
- Both the mudflats and the adjacent ponds of the Luannan Coast are vital components of the area for shorebird conservation, and an important contributing factor to the local economy and jobs.
- As in recent years, due to the water levels in the pond habitat being deep, Red Knots did very little feeding there. The loss of shallow ponds is depriving shorebirds of foraging opportunities.

Recommendations

- Support Universities and Global Flyway Network's aims to continue conducting research activities and follow-up analysis to document the futures of four shorebird species (Bar- and Black-tailed Godwit and Red and Great Knot) at their non-breeding sites in NWA and throughout the EAAF, with an emphasis on the Luannan Coast, Bohai Bay. With the work in Bohai Bay and marked-bird sightings from other shorebird colleagues throughout the flyway we will be able to assess the effects of human-induced habitat change on survival rates of the populations and a variety of demographic parameters.
- The retention of the remaining mudflats at Zuidong, Nanpu, Beipu and Hangu remains of great conservation importance. Retaining these mudflats in good ecological condition will enable the huge numbers of migratory shorebirds and terns to continue using the area as a staging site.
- Following the establishment of the Hebei Luannan Nanpu Zuidong Provincial Wetland Park, and the potential World Heritage Site nomination, explore the possibilities for the sustainable harvesting of shellfish on the mudflat and the sustainable aquaculture accreditation system with an optimal water level management regime in the ponds, which could maximise the benefit to both local communities and shorebirds for foraging and breeding.
- Establish strategic conservation management and consistent communications between decision makers and scientists for the Wetland Park.

Red Knots foraging on Nanpu mudflats, 22 May 2023.
© Katherine Leung

Non-shorebird migration

Although the migratory shorebirds were the focus of our work, whenever there was an opportunity, we were looking for anything with wings. The passerine migration through the area is marked by high species diversity despite the paucity of any substantial wooded habitat.

Appendix 1 has a complete list of all the 165 birds seen during the fieldwork period.

Yellow-rumped Flycatcher *Ficedula zanthopygia*, 23 May 2023. © Katherine Leung

Little Owl Athene noctua, 16 May 2023. © Katherine Leung

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Sunset on the Nanpu mudflats, 3 June 2023. © Katherine Leung

Collaborative partners

- Australasian Wader Studies Group (AWSG), Australia
- Beijing Normal University, Beijing, China
- BirdEyes, Centre for Global Ecological Change at the University of Groningen, Groningen, The Netherlands
- Broome Bird Observatory, Broome, Australia
- Broome Community Volunteers, Broome, Australia
- Center for East Asian-Australasian Flyway Studies, Beijing Forestry University, Beijing, China
- Fudan University, Shanghai, China
- NIOZ Netherlands Institute for Sea Research, Texel, The Netherlands
- Rudi Drent Chair in Global Flyway Ecology, University of Groningen, The Netherlands
- WWF China, Shanghai/Beijing, China
- WWF Netherlands, Zeist, The Netherlands

More information of GFN, see https://www.globalflywaynetwork.org/.

Contact Chris Hassell turnstone@wn.com.au

Early morning on the Nanpu seawall, 23 April 2023. © Katherine Leung

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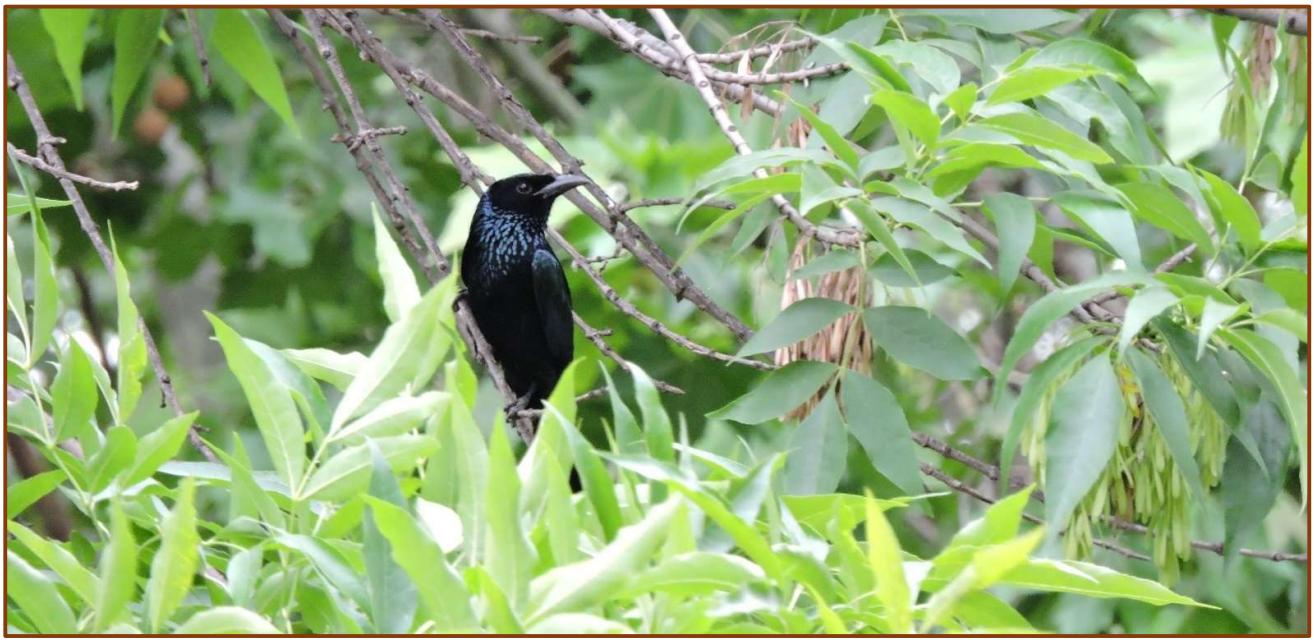
Appendix 1. Bird list

The full list of the 165 species recorded 23 April to 3 June 2023.

Greylag Goose
Common Shelduck
Mandarin Duck
Eastern Spot-billed Duck
Mallard
Eurasian Teal
Common Pheasant
Little Grebe
Great Crested Grebe
Rock Dove
Oriental Turtle Dove
Eurasian Collared Dove
Spotted Dove
Asian Koel
Large Hawk-Cuckoo
Indian Cuckoo
Common Cuckoo
Common Swift
Pacific Swift
Common Moorhen
Black-winged Stilt
Pied Avocet
Eurasian Oystercatcher
Grey Plover
Pacific Golden Plover
Grey-headed Lapwing
Lesser Sand Plover
Greater Sand Plover
Kentish Plover
Eurasian Whimbrel
Far Eastern Curlew
Eurasian Curlew
Bar-tailed Godwit
Black-tailed Godwit
Ruddy Turnstone
Great Knot
Red Knot
Ruff
Broad-billed Sandpiper
Sharp-tailed Sandpiper
Curlew Sandpiper
Red-necked Stint
Sanderling
Dunlin
Little Stint
Asian Dowitcher
Terek Sandpiper
Common Sandpiper
Grey-tailed Tattler
Spotted Redshank
Common Greenshank
Nordmann's Greenshank
Marsh Sandpiper
Wood Sandpiper
Common Redshank
Oriental Pratincole
Saunders's Gull
Black-headed Gull
Relict Gull
Black-tailed Gull
Common Gull
Vega Gull
Little Tern
Gull-billed Tern
Caspian Tern
White-winged Tern
Whiskered Tern
Common Tern
Oriental Stork
Great Cormorant
Yellow Bittern
Grey Heron
Great Egret
Chinese Egret
Little Egret
Eastern Cattle Egret
Chinese Pond Heron
Striated Heron
Black-crowned Night Heron

Grey Plover *Pluvialis squatarola*, 14 May 2023. © Katherine Leung

Black-winged Kite
Crested Honey Buzzard
Grey-faced Buzzard
Eastern Marsh Harrier
Pied Harrier
Little Owl
Eurasian Hoopoe
Common Kingfisher
Oriental Dollarbird
Rufous-bellied Woodpecker
Great Spotted Woodpecker
Common Kestrel
Amur Falcon
Eurasian Hobby
Peregrine Falcon
Ashy Minivet
Black-naped Oriole
Black Drongo
Hair-crested Drongo
Brown Shrike
Azure-winged Magpie
Oriental Magpie
Yellow-bellied Tit
Chinese Penduline Tit
Asian Short-toed Lark
Eurasian Skylark
Zitting Cisticola
Thick-billed Warbler
Black-browed Reed Warbler
Oriental Reed Warbler
Barn Swallow
Red-rumped Swallow
Light-vented Bulbul
Yellow-browed Warbler
Pallas's Leaf Warbler
Radde's Warbler
Dusky Warbler
Eastern Crowned Warbler
Pale-legged Leaf Warbler
Arctic Warbler
Chestnut-crowned Warbler
Asian Stubtail
Manchurian Bush Warbler
Reed Parrotbill
Vinous-throated Parrotbill
Chestnut-flanked White-eye
Swinhoe's White-eye
White-cheeked Starling
Crested Myna
White's Thrush
Siberian Thrush
Chinese Thrush
Chinese Blackbird
Eyebrowed Thrush
Grey-streaked Flycatcher
Dark-sided Flycatcher
Asian Brown Flycatcher
Rufous-tailed Robin
Siberian Blue Robin
Siberian Rubythroat
Red-flanked Bluetail
Yellow-rumped Flycatcher
Mugimaki Flycatcher
Taiga Flycatcher
Daurian Redstart
White-throated Rock Thrush
Blue Rock Thrush
Amur Stonechat
Eurasian Tree Sparrow
Forest Wagtail
Eastern Yellow Wagtail
White Wagtail
Olive-backed Pipit
Brambling
Chinese Grosbeak
Japanese Grosbeak
Common Rosefinch
Eurasian Siskin
Chestnut-eared Bunting
Yellow-throated Bunting
Pallas's Reed Bunting
Little Bunting
Black-faced Bunting
Chestnut Bunting
Yellow-browed Bunting
Tristram's Bunting



Hair-crested Drongo *Dicrurus hottentottus*, 24 May 2023. © Katherine Leung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