



Stopover Ecology of Spoon-billed Sandpipers and Nordmann's Greenshanks at the Yellow Sea

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Photo by Li Dongming at Yangkou, Rudong on August 12, 2015

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Executive summary

Abstract

The Yellow Sea region is of high global importance for waterbird populations, but recent systematic bird count data enabling identification of the most important sites are relatively sparse for some areas. Surveys of waterbirds at three sites on the coast of southern Jiangsu Province, China, in 2014 and 2015 produced peak counts of international importance for 24 species, including seven Globally Threatened and six Near-Threatened species. The area is of particular global importance for the Critically Endangered Spoon-billed Sandpiper *Calidris pygmaea* (peak count across all three study sites: 62 in spring [2015] and 225 in autumn [2014]) and Endangered Nordmann's Greenshank *Tringa guttifer* (peak count across all three study sites: 210 in spring [2014] and 1,110 in autumn [2015]). The southern Jiangsu coast is therefore currently the most important migratory stopover area in the world, in both spring and autumn, for both species.

Several serious and acute threats to waterbirds were recorded at these study sites. Paramount is the threat of large-scale land claim which would completely destroy intertidal mudflats of critical importance to waterbirds. Degradation of intertidal mudflat habitats through the spread of invasive *Spartina*, and mortality of waterbirds by entrapment in nets or deliberate poisoning are also real and present serious threats here. Collisions with, and displacement by, wind turbines and other structures, and industrial chemical pollution may represent additional potential threats. We recommend the rapid establishment of effective protected areas for waterbirds in the study area, maintaining large areas of open intertidal mudflat, and the urgent removal of all serious threats currently faced by waterbirds here.

The project team initiated a series of community programs, reach local fishermen, school and people in the nearby cities, including Shanghai. A significant number of people pay attention to the mudflat crisis and the three key mudflat have been listed as the ten most noteworthy mudflat in 2016.

1. Introduction

Migratory shorebirds rely heavily on coastal intertidal mudflats to refuel and complete their migration between breeding and non-breeding grounds. These intertidal habitats are often rich in food resources that are extremely important not only to migratory shorebirds, but also to the livelihood of humans (Reid et al. 2008). Unfortunately, more than one-third of the global human population lived within 100 km of the coast (Burke et al. 2001), imposing enormous pressure on the fragile coastal

intertidal mudflats. In fact, 65% of tidal flats were lost in the Yellow Sea, East Asia, in the last 50 years (Murray et al. 2014). Migratory shorebirds along the East Asian–Australasian Flyway (hereafter EAAF) are among the most poorly known of the different flyways (Stroud et al. 2006), with many species declining partly due to habitat loss (Amano *et al.* 2010; Gan *et al.* 2009; Murray *et al.* 2014; Rogers *et al.* 2011; Wilson *et al.* 2011). The Spoon-billed Sandpiper *Calidris pygmaea* (‘Critically Endangered’) and Nordmann’s Greenshank *Tringa guttifer* (‘Endangered’) along the EAAF are two of the most threatened shorebird species in the world, with a population estimate of 360–600 and 250–999 individuals, respectively (BirdLife International 2012, 2013).

Latest effort to conserve these species led to a recent discovery of a critically important stopping region — Rudong, along the Jiangsu coast in East China. A total of 143 Spoon-billed Sandpipers and 1,117 Nordmann’s Greenshanks were recorded in mid October 2013 (Tong et al. 2014), the largest numbers ever recorded for both species in any region. This indicated the importance of Rudong to these highly threatened bird species even though the site has not been listed as an important bird area nor protected area due to the very recent discovery (BirdLife International 2009). Moreover, little is known about why the two threatened species choose to stop at Rudong and what do they do during their stopover.

In this study, we aim to build on the latest discovery at Rudong to understand why this region has been attractive for Spoon-billed Sandpipers and Nordmann’s Greenshanks by studying their stopover ecology during southward migration. We conducted regular weekly counts, focal bird observations and macrobenthic sampling to quantify their passage dates, transiting population sizes and their dietary choice. This final report will provide the details of our major achievements of this project.

Project objectives

1. Improve the estimate of the total number of transiting Spoon-billed Sandpipers and Nordmann’s Greenshanks, as well as generate the first estimate of their passage dates.
2. Explore the potentially important food sources for Spoon-billed Sandpiper and Nordmann’s Greenshank in the study area.
3. Generate essential data before the end of this project for predicting quantitatively the effects of development on population sizes and demographic rates of the two shorebird species.

4. Ensure a significant increase in the proportion of local community members who are aware of the threats.

2. Methods

Study area

Rudong is located in the east of Jiangsu province and north of the Yangtze River delta. The north and east of Rudong borders the south Yellow sea and is in the southern most section of the Yellow sea (Figure 1). Rudong has a coastline of 106 kilometres with a mudflat of 70,000 hectares. Dongtai is located to the north of Rudong with a coastline of 85 kilometer and 100,000 hectares of mudflat. Dongsha Island is located 50 kilometers to the east of Dongtai coast, and is a sediment sandbank of the river mouth. No systematic shorebird survey was conducted in the region before 2010. In recent years, amateur bird surveyors have recorded a large number of shorebirds in northward and southward migrations. These observations include over 200 Spoon-billed Sandpipers and almost 1200 Nordmann's Greenshanks in a single survey (Zöckler et al. 2015). This region, hence, draws great attention globally.

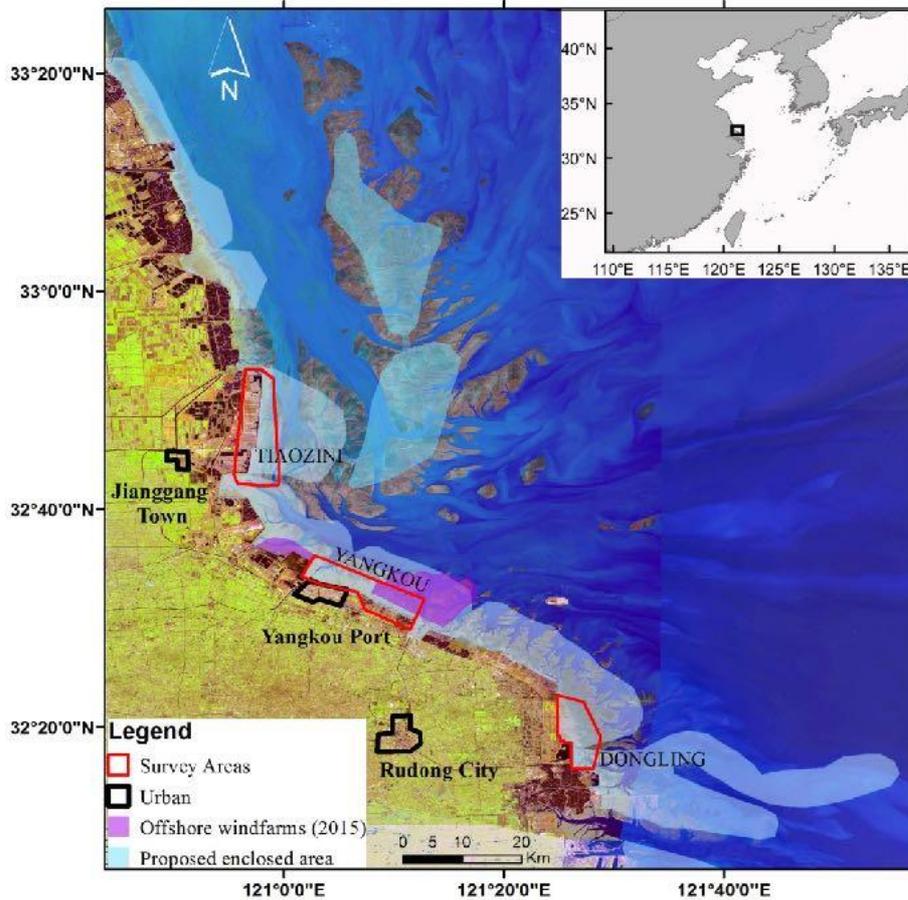


Figure 1. Rudong city and its surrounding intertidal flat during low tide, showing the exposed tidal flat and the proposed land claim areas.

Despite being crucial for Spoon-billed Sandpiper or similarly threatened shorebirds, the mudflat is threatened by land claim, some of the mudflat have disappeared in recent land claim projects. According to the *coastal 5-year propelling plan* by Jiangsu government in 2010, under the terms of *The first batch of important mudflat land claim project in Dongtai to implement million mudflat comprehensive development and the experiment region and Develop the argument for building a harbor in Dongtai coast*, Dongtai city government planned to start to claim the tidal wetland, build industry zones and a harbor from 2011 to 2015 (Jiangsu Provincial People's Government Office 2010). Now, in the north of Fangtang river mouth, Tiaozini at south of Liangduo river mouth, and Dongsha enclosed area, the project has been completed with 40,000 hectares of land claimed (in Figure 1). Currently, there are some wind farm, solar farm and fishery factories within the enclosed area, but most of the area remains undeveloped. In the region, there are some aquaculture ponds near the seawall. The Dongsha land claim project is in the layout with 66,700 hectares but has not started (in Figure 1). If all projects go ahead, there is going to be a catastrophic impact on shorebirds that depend heavily on this intertidal mudflat.

The invasive Smooth Cordgrass is also an issue. In Rudong, a large area of bare tidal flat has been invaded by Smooth Cordgrass and this has changed the ecological community (Zhang, pers. Obs.). In adjacent areas, the plant is spreading quickly on the mudflat. The Smooth Cordgrass could accelerate sediment accretion, elevate the mudflat height and create a new environment that may be difficult for native species to adapt. The spread of Smooth Cordgrass could reduce the amount of available habitat for shorebirds (Gan et al. 2009).

High tide shorebird counts

To achieve our first objective, we conducted regular high tide counts to model the number of birds transited in the region. Traditional approach using peak counts as the number of birds using an area and ignoring the different age-groups may underestimate the total number, because some individuals may have left the area before all has arrived, as illustrated by Great Knots in the Yalu Jiang coastal wetland (Figure 2). This example indicated that the total number of Great Knots transiting was almost twice as many as the highest count observed at any one time, as there were two peaks composed of different age-classes (Bai et al. 2012). Therefore, we used the Thompson's modelling approach to overcome the problem (Choi et al. 2016; Thompson 1993). During counts, we focused on the Spoon-billed Sandpipers and Nordmann's Greenshanks. We attempted to differentiate the age-classes of different individuals when possible (subsamples were taken if there were too many, e.g. 50 individuals in the right, 100 in the center, 50 in left). We also did flag searching / colour band reading of individually-marked birds, which revealed important information on where the individual came from and how its stopover duration if it was being sighted more than once.

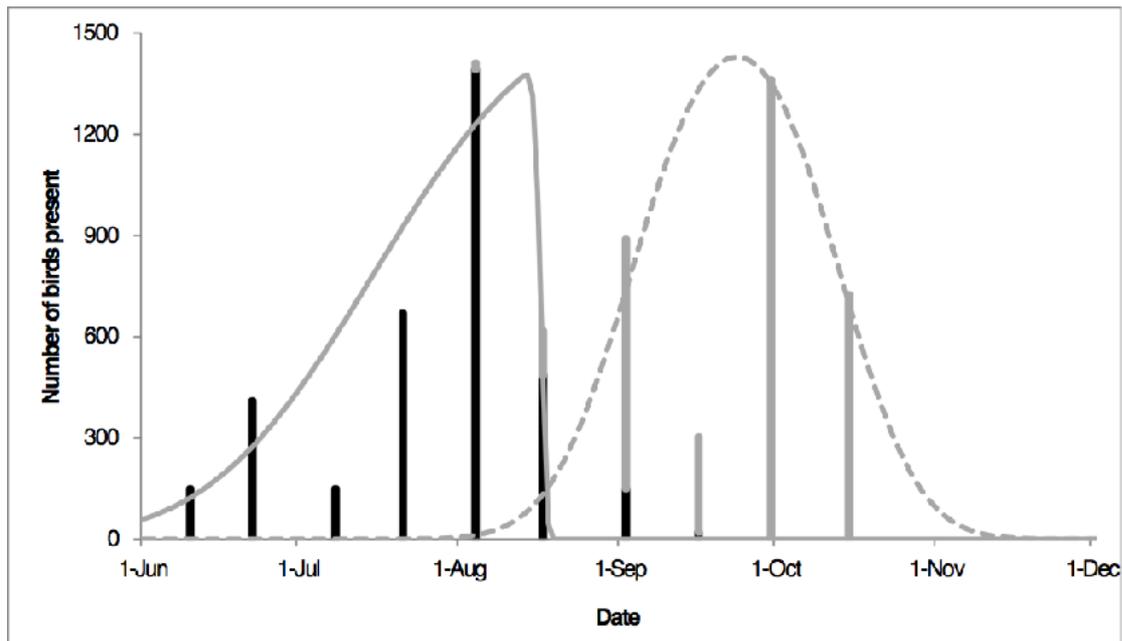


Figure 2. The number of Great Knots stopped over at the Chinese side of Yalu Jiang coastal wetland during southward migration in 2012. Black bars represent count data from surveys and the solid line the modelled estimate for adults while grey bars and dotted line for juvenile birds.

Low tide focal bird observation

To achieve our second and third objective, we conducted low tide focal bird observation and benthic sampling. During the low tide period, we followed the birds on the intertidal flat and recorded where the birds forage. When the condition was favourable (focal bird was within reasonable distance, with little heat haze), we conducted focal bird observation. Our target species for focal bird observation were Spoon-billed Sandpipers and Nordmann’s Greenshanks. We recorded their behaviour primarily using digital camera (i.e. video) and recorded what the focal individual bird do during the 5 – 10 mins observation bout. A focal bird was chosen randomly without bias towards foraging or resting individuals.

Primary moult

Recent studies indicated that field photography could be used for studying the primary moult of waterbirds and the moult data extracted could have a high within and between observer repeatability

(Conklin et al. 2012; Vieira et al. 2016). We therefore used the photos and videos taken in the field where the primary flight feathers could be seen and scored to obtain the moult data (**Figure 3**).



Figure 3. The moulting individual Spoon-billed Sandpiper and Nordmann's Greenshank in Rudong

During the scoring process, we checked through successive photos and avoid scoring the same individual more than once. Ageing was not always possible but we did make an attempt when possible. This allowed us to exclude juvenile or second-calendar year individuals in our analysis. Moreover, in cases where the birds were too far to score, we noted down the number of individuals in active molt and the numbers not in active molt. We followed the British Trust for Ornithology standard to score each of the primary feather so the results can be comparable to other studies. The result of this process is a cumulative molt score for each individual ranging somewhere from 0 – 50.

0 = an old feather

1 = old feather missing or new feather completely in pin

2 = new feather just emerging from sheath (new feather visible), up to one third grown

3 = new feather between one and two thirds grown

4 = new feather more than two thirds grown, but waxy sheath still at its base (but not completely grown)

5 = new feather fully-grown with no trace of sheath at its base

We adopted the Underhill and Zucchini moult models to estimate the start date and duration of primary moult, using the *moult* package in R (Erni et al. 2013). Such an approach has four key assumptions, 1) a linear increase in the moult index overtime for each individual; 2) the duration of moult is

the same for every individual; 3) a normally distributed start date of moult in the population; 4) the individual observations are independent.

We transformed the moult scores into proportion of feather mass grown because the latter is more likely to be produced at a constant rate than the score itself and therefore, meeting the first key assumption of the UZ moult models (Summers et al. 1983). The feather mass of different species were obtained from published records and the nearest sized species were used if no data is available (Underhill et al. 1995). The proportion of feather mass grown was then used as the moult index. All moult-related analyses were performed with R v3.3.2 (R Core Team 2016).

Benthic sampling

We conducted benthic sampling in the middle of the shorebird migratory season (September 2015) to determine the potential food sources for Spoon-billed Sandpipers and Nordmann's Greenshanks. We collected samples from 3 subregions, 3 height bands in each of the subregion and 3 different treatments, namely those used by the Spoon-billed sandpipers, Nordmann's Greenshanks and those selected randomly. Sampling stations were determined from records of foraging spots used by these species while the random stations were selected randomly in ArcGIS. We collected 4 benthic core samples (replicates) randomly per sampling station, all within 12.5m to the center of foraging spot. A total of 264 samples were taken from the three subregions and the numbers for Nordmann's Greenshank were fewer than planned due to the lack of foraging spots found (27 Spoon-billed Sandpiper stations, 27 random stations and 12 Nordmann's Greenshank stations). Each benthic core sample (corer diameter 15.5 cm, 10 cm deep) was divided into top and bottom 5 cm and sieved separately. Benthic organisms remained in the sieve (0.5mm mesh size) were stored in seawater and took back to our field base. These were then transferred to 90% ethanol (every evening) for further measurement in the laboratory in November. At each of the sampling station, we also collected sediment samples (corer diameter 22mm) at 10 cm deep. This was stored in zipping bag and kept frozen.

Opportunistic collections were carried out to cover the entire size ranges of some common species for biomass estimation. These samples were washed carefully with freshwater to clear the sediments that may be stuck on the surface, before storing at -20deg celcius. The length of polychaete worm was measured before freezing.

Community work

To achieve our fourth objective, ensure a significant increase in the proportion of local community members who are aware of the threats, we have conducted four different programs to reach different audiences.

The first program was fishermen livelihood survey, the aim of the activity is to understand how much local fishermen know about the conservation status of mudflat and with the information we could design long term conservation programs to reach the fishermen effectively. In three mudflats, we interacted with fishermen in two ways. Face to face interview in fish market are the methods, secondly, we reach large mudflat renters who hire over 50% local fishermen. To encourage more people to provide feedback and understand the purpose of the project, we prepared small gifts with “CLP” logo on them and a simple brochure that explain the relationship of Spoon-billed sandpipers and



other migratory birds with mudflat.

Figure 4. Fishermen read Spoon-billed Sandpiper brochure Photo credit: Siyang Liu

The second program raised public awareness program by online and offline programs. Most Chinese are WeChat users and the project update the news weekly in the WeChat account of “Stay with Spoon-

billed sandpiper” . In project sites and other neighboring larger cities, we conducted talks, participated public event and hold field birding trips for general publics.



Figure 5. Dongtai School kids reading photo exhibition Photo credit: Siyang Liu

The third program is bird by-catch mediation in the mudflat. It was originally a side project in the field work by volunteers and has been put into a higher priority for future conservation programs. The by-

catch incidents are related to the food availability of local fishermen and the sustainable use of mudflat. The preliminary survey within this project is trying to understand how often fishermen set the fishnet and how many species of birds died on nets by counting the fishnet and body of dead birds.



The last program was to develop education outreach and Media programs. We have three different approaches, one is online video which is jointly completed by another fund by 2016 that introduce the unique mudflat and species of the project to people all over China; we then developed the physical souvenirs for supporting our offline activities; the third approach was to share our story in magazine, newspaper and other media channel.

Figure 6. Spoon-billed sandpiper killed on the fishnet Photo Credit: PETER CRIGHTON

3. Results and discussion

Migration shorebird numbers during southward

Compiling the count data collected in this study as well as other surveys during the southward migration in 2014 and 2015 (**Table 1**), we found 7 Globally Threatened and 6 Near-Threatened waterbird species in the study region (Peng et al. Submitted). The maximum single-date counts of seven species exceeded 10% of the total population size; Far Eastern Oystercatcher *Haematopus ostralegus osculans* (Near-Threatened), Eurasian Curlew *Numenius arquata* (Near-Threatened), Kentish Plover *Charadrius alexandrinus*, Lesser Sand Plover *Charadrius mongolus*, Spoon-billed Sandpiper (Critically Endangered), Nordmann's Greenshank (Endangered) and Saunders's Gull *Saundersilarus saundersi* (Vulnerable). A total of 225 Spoon-billed Sandpipers were recorded across all three study sites in autumn 2014. This represents around one third of the estimated global post-breeding population for this species in 2014 (661–718 individuals; Clark et al. 2016). Meanwhile, 1110 Nordmann's Greenshank were recorded in autumn 2015, and 956 in autumn 2014; both very close to the figure of 1,117 from autumn 2013 (Bai et al. 2015). These counts exceed the current global population estimate for this species (400–600 individuals; Wetlands International 2016).

Table 1. Maximum daily counts of waterbird species recorded during southward migration in 2014 and 2015 in the study region (Peng et al. Submitted). The conservation status of various species are provided in parentheses (IUCN, 2016: CR= Critically Endangered, EN=Endangered, VU=Vulnerable, NT=Near Threatened). Where threat status on the official Red List of China (Jiang 2016) differs, this is shown in square brackets (LC = Least Concern). Counts representing over 1% of the EAAF population are indicated by bold type and 10% of the EAAF population are indicated by bold type and underlined.

Species	1% of EAAF population	2014	2015
Baer's Pochard <i>Aythya baeri</i> (CR)	5	3	0
Oriental Stork* <i>Ciconia boyciana</i> (EN)	30	4	0
Black-faced Spoonbill <i>Platalea minor</i> (EN)	20	92	70
Chinese Egret <i>Egretta eulophotes</i> (VU)	35	0	11
Dalmatian Pelican <i>Pelecanus crispus</i> (VU)	1	24	30
Eurasian Oystercatcher <i>Haematopus ostralegus</i> (NT) [LC]	70	<u>1465</u>	<u>2360</u>
Pied Avocet <i>Recurvirostra avosetta</i>	1,000	339	1000

Grey Plover <i>Pluvialis squatarola</i>	1,000	5450	3160
Kentish Plover <i>Charadrius alexandrinus</i>	1,000	<u>27550</u>	<u>17600</u>
Lesser Sand Plover <i>Charadrius mongolus</i>	390	<u>14600</u>	<u>7542</u>
Greater Sand Plover <i>Charadrius mongolus</i>	790	690	5809
Northern Lapwing <i>Vanellus vanellus</i> (NT) [LC]	10,000	0	42
Eurasian Curlew <i>Numenius arquata</i> (NT)	1,000	<u>10260</u>	7360
Far Eastern Curlew <i>Numenius madagascariensis</i> (EN) [VU]	320	578	732
Bar-tailed Godwit <i>Limosa lapponica</i> (NT)	1,500	503	1550
Black-tailed Godwit <i>Limosa limosa</i> (NT) [LC]	1,400	932	3590
Ruddy Turnstone <i>Arenaria interpres</i>	290	215	276
Great Knot <i>Calidris tenuirostris</i> (EN) [VU]	2,900	2410	9590
Red Knot <i>Calidris canutus</i> (NT) [VU]	1,100	1361	437
Broad-billed Sandpiper <i>Limicola falcinellus</i>	250	1360	623
Curlew Sandpiper <i>Calidris ferruginea</i> (NT) [LC]	1,400	44	4
Spoon-billed Sandpiper <i>Calidris pygmeus</i> (CR)	3	<u>225</u>	<u>164</u>
Red-necked Stint <i>Calidris ruficollis</i> (NT) [LC]	3,200	3287	5000
Sanderling <i>Calidris alba</i>	220	1230	1150
Dunlin <i>Calidris alpina</i>	10,000	16500	17000
Asian Dowitcher <i>Limnodromus semipalmatus</i> (NT)	230	10	1
Terek Sandpiper <i>Xenus cinereus</i>	500	1375	790
Grey-tailed Tattler <i>Tringa brevipes</i> (NT) [LC]	440	31	2
Nordmann's Greenshank <i>Tringa guttifer</i> (EN)	5	<u>956</u>	<u>1110</u>
Saunders's Gull <i>Larus saundersi</i> (VU)	85	<u>4040</u>	<u>2240</u>
Relict Gull <i>Larus relictus</i> (VU) [EN]	120	14	38
Common Tern <i>Sterna hirundo longipennis</i>	460	635	410

Transiting numbers and passage dates

We completed 21 rounds of regular survey from July to November 2015, with each round covering at least two subregions (Dongling and Dongtai). The shorebirds generally move close to the seawall during high tide and sometimes may roost in the aquaculture ponds inside the seawall if the high tide inundates the entire tidal flat. Among these counts, the maximum number of Spoon-billed Sandpiper and Nordmann's Greenshank counted were 76 and 768, respectively. These were substantially higher than the modelled estimates using the Thompson's modelling approach (60 and 525, respectively). The varied number of observers, vast survey area relative to the number of observers and time available for counts, might have led to the lower modelled estimates in bird abundance.

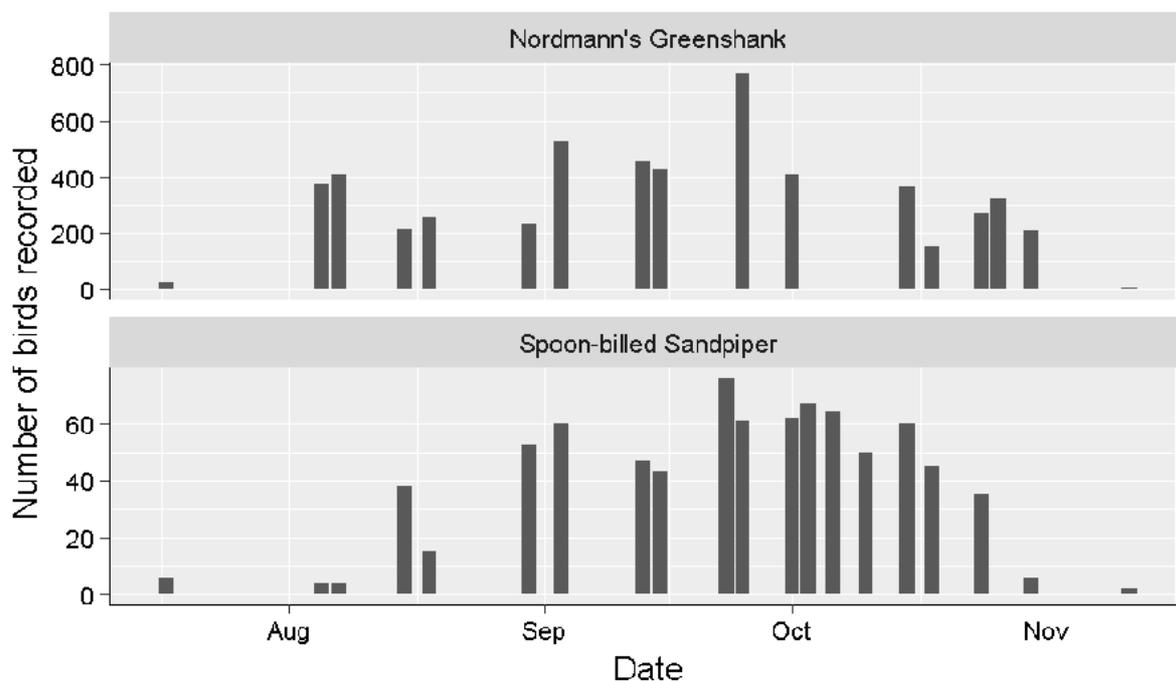


Figure 4. The number of Spoon-billed Sandpiper and Nordmann's Greenshank recorded from July to November 2015 in the south Jiangsu region.

The modeled average arrival dates for the Spoon-billed Sandpiper and Nordmann's Greenshank were 19-August (± 11 days) and 31-July (± 9 days), respectively, while the average departure dates were 24-October (± 6 days) and 23-October (± 16 days), respectively. These gave a stopover period of 66 and 84 days for the Spoon-billed Sandpiper and Nordmann's Greenshank, respectively, in the Dongtai-Rudong region (**Figure 4**). According to flag sighting records in the same period, preliminary estimation of stopover duration for Spoon-billed Sandpiper averaged 22 ± 17 days ($n = 16$). The longest stay was 58 days. More surveyors joined during the middle of our survey period, and 10 more Spoon-billed Sandpipers were flagged locally. This yielded more flag sighting records in a very short

time. These resighting records may involve individuals that arrived earlier or have been missed in earlier survey time due to lack of surveyors. In short, the stopover durations generated from Thompson's modelling approach are probably more accurate than that based on flag resighting records.

Age structure

During the survey period, an average of 4.4% of the aged Spoon-billed Sandpipers were juvenile while that figure fell to 0.2% in Nordmann's Greenshank (average weighted by the number individuals scanned). The first juvenile was recorded on 4-Sep in the Spoon-billed Sandpiper while it was substantially earlier in the Nordmann's Greenshank (11-Aug) (**Figure 5**), probably due to the late nest initiation in the Spoon-billed Sandpiper, which breeds further north in the arctic compare to the Nordmann's Greenshank (BirdLife International 2016). The passage time of juveniles was in accordance with the published records (**Van et al. 2017**).

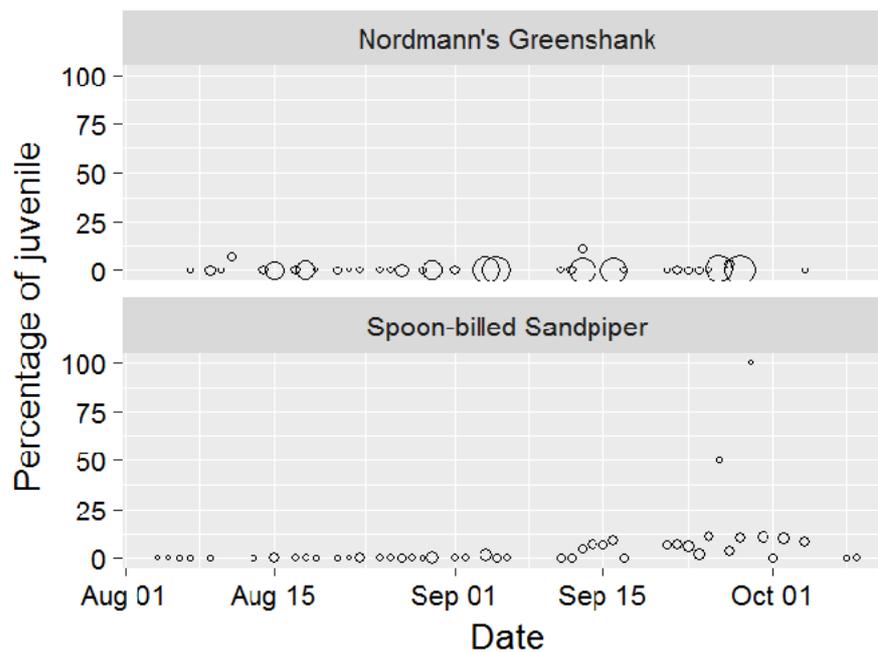


Figure 5. The percentage of juvenile Spoon-billed Sandpipers and Nordmann's Greenshanks recorded from August to October 2015 in the south Jiangsu region. The size of the symbol correspond to the number of birds aged, the larger the circle, the more birds were aged.

Primary moult

The analysis of photos and videos collected opportunistically during the study indicated that at least 22 shorebird species undergo some of the primary moult in the Rudong region (**Table 2**). Among species with a decent sample size, there was always a high percentage of Eurasian Curlew (78%), Far Eastern Oystercatcher (83%), Greater Sand Plover (67%), Nordmann's Greenshank (85%) and Spoon-billed Sandpiper (79%) undergoing primary moult (**Figure 6**). On the other hand, there were often some Bar-tailed Godwits (35%), Great Knots (37%) and Terek Sandpipers (53%) in active primary moult, but these are generally less common than those species mentioned above. Dunlin and Kentish Plover showed a different trend with many individuals in active primary moult at the start of southward migration while completing by the middle and late southward migration season or the population was being overtaken by an influx of moulted individuals (**Figure 6**).

Table 2. The number of birds in active primary moult or not moulting based on the examination of photos and videos taken during southward migration in the south Jiangsu region in 2015.

Species	In active moult	Not moulting
Bar-tailed Godwit	117	221
Broad-billed Sandpiper	3	1
Black-tailed Godwit	2	8
Common Greenshank	20	3
Common Redshank	1	7
Common Sandpiper	0	1
Common Snipe	0	2
Common Tern	0	1
Curlew Sandpiper	2	3
Dunlin	88	264
Eurasian Curlew	881	243
Far Eastern Curlew	0	3
Far Eastern Oystercatcher	158	32
Great Knot	53	91
Grey Plover	218	17
Greater Sand Plover	472	232
Grey-tailed Tattler	0	6
Kentish Plover	29	171

Little Ringed Plover	0	1
Lesser Sand Plover	42	35
Marsh Sandpiper	2	0
Nordmann's Greenshank	160	28
Pied Avocet	0	2
Red Knot	0	15
Red-necked Stint	4	121
Ruddy Turnstone	1	16
Sanderling	4	46
Saunders's Gull	0	2
Spoon-billed Sandpiper	27	7
Sharp-tailed Sandpiper	1	0
Terek Sandpiper	37	33
Whimbrel	0	5

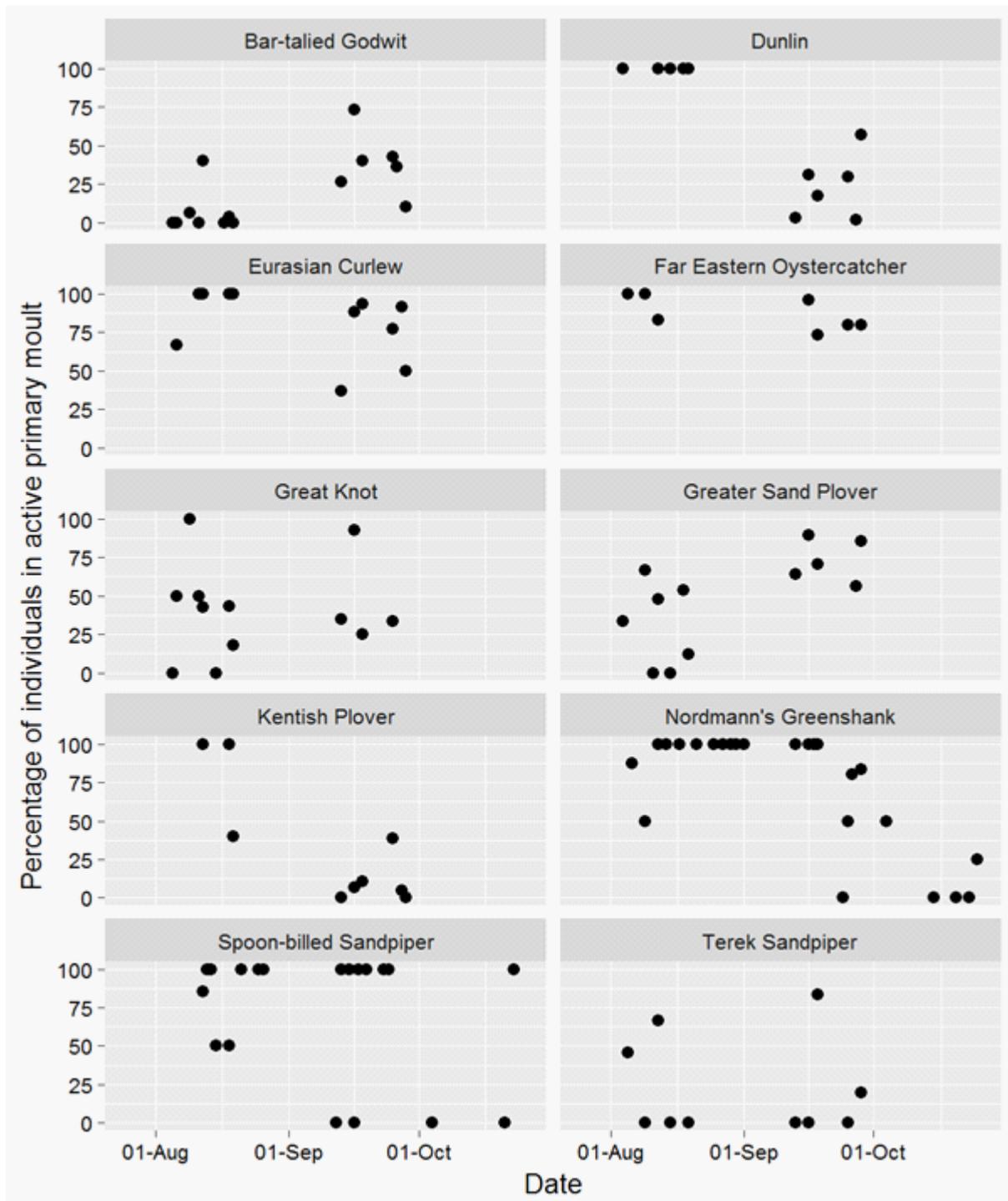


Figure 6. The percentage of individual in active primary moult for 10 shorebird species in the south Jianguo region during southward migration in 2015.

Detailed primary moult analysis on 6 species with primary moult score recorded on at least 10 different days, indicated that the Spoon-billed Sandpiper and Nordmann's Greenshank completed their primary moult during their stopover in the region (**Figure 7**). The Eurasian Curlew and Greater Sand Plover could also complete their primary moult during their stay but require further evidence due to

the lack of data in October. Some Bar-tailed Godwits and Great Knots also underwent primary moult but it was unclear if they could complete their moult before continuing their migration.

We found that the Spoon-billed Sandpiper and Nordmann's Greenshank took about 67 and 65 days, respectively, to complete their primary moult. The Nordmann's Greenshank started the primary moult on 27th July \pm 8.38 days, about 10 days earlier than the Spoon-billed Sandpiper, which started on 7th August \pm 13.52 days (**Table 3**). These estimated durations for primary moult were similar or shorter than the estimated stopover durations, allowing most Spoon-billed Sandpiper and Nordmann's Greenshank to complete their primary moult before migrating further south.

The primary moult duration estimated for Spoon-billed Sandpiper (67 days) and Nordmann's Greenshank (65 days) are shorter than other Calidrid sandpipers such as Long-toed Stint, Red-necked Stint and Curlew Sandpiper, need 70, 110 and 129 days, respectively (Barshep et al. 2011; Round et al. 2012; Thomas et al. 1971). The estimates for Great Knot and Bar-tailed Godwit are also substantially shorter than those reported in Australia and New Zealand (godwit range = 96–128; Conklin et al. 2012). The shorter durations found in this study are in accordance to the finding of shorter primary moult duration in shorebirds moulting further north than those in further south (Dietz et al. 2015). The Great Knot and Bar-tailed Godwit that underwent primary moult in south Jiangsu might be young individuals in their first migration or partial migrants with different primary moult speeds. It is important to note that the Underhill and Zucchini moult models adopted in this study can be sensitive to situations where individuals vary substantially in their timing of primary moult. The presence of individuals that have not initiated primary moult or have completed primary moult throughout the season may also confound the results (Erni et al. 2013). We minimised that by excluding individuals in their second-calendar year, which tend to initiate primary moult earlier, and those were not in active moult. More comprehensive study with an improved temporal coverage is recommended to improve the moult-related parameter estimates for shorebirds in south Jiangsu.

In short, the prebasic moult requires a substantial amount of time and energy to complete. We thereby believe that Dongtai-Rudong mudflat used to, or currently, have abundant food resources for Spoon-billed Sandpipers and Nordmann's Greenshanks, as well as a few other shorebird species, to undergo primary moult and refuel for their next migratory flight. The extensive moult in the highly threatened Spoon-billed Sandpiper and Nordmann's Greenshank is a new and important discovery, which provides the first quantitative evidence on the role of south Jiangsu wetland as the main moulting ground to these species during the southward migration. This also mean that conservation man-

agers need to ensure the habitat quality, in terms of both benthic prey resources and human disturbance, are monitored closely as these endangered shorebirds need to spend a large amount of time (around 70 days) in the region to complete the moult and prepare for the next migration flight.

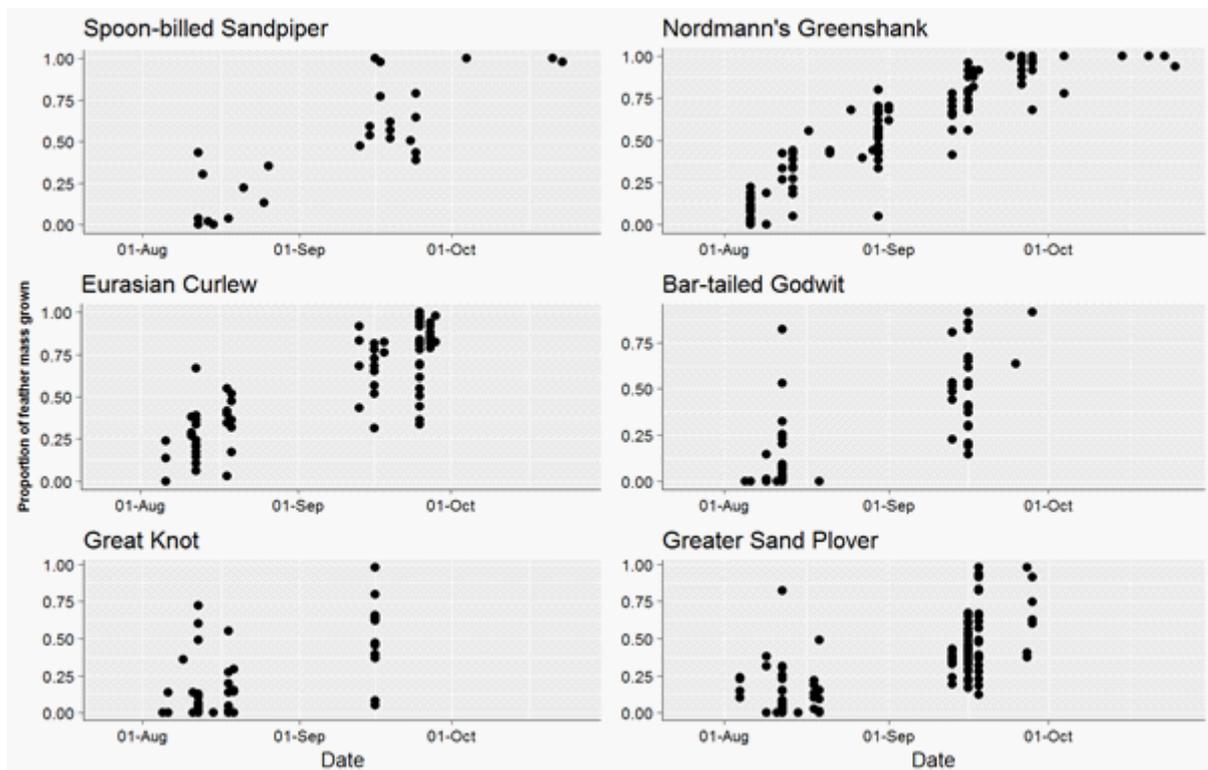


Figure 7. The progress of primary moult based on the proportion of feather mass grown in 6 shorebird species in the south Jiangsu region during southward migration in 2015. The feather mass data for Spoon-billed Sandpiper, Nordmann’s Greenshank, Eurasian Curlew, Great Knot and Greater Sand Plover were obtained from similar-sized species, namely the Little Stint *Calidris minuta*, Common Greenshank *Tringa nebularia*, Whimbrel *Numenius phaeopus*, Red Knot *Calidris canutus* and Chestnut banded Plover *Charadrius pallidus*, respectively (Underhill et al. 1995).

Table 3. The mean start date of primary moult and duration of six shorebird species during their stop-over in the south Jiangsu region during southward migration in 2015.

Species	Moult Duration	Mean start date of primary moult	Standard deviation	LOSS function
Spoon-billed Sandpiper	67.11	7-Aug-15	13.52	-74.48
Nordmann’s Greenshank	65.07	27-Jul-15	8.38	-398.7

Bar-tailed Godwit	57.77	17-Aug-15	12.41	-232.6
Eurasian Curlew	65.46	28-Jul-15	13.1	-281.3
Great Knot	56.05	16-Aug-15	16.06	-151.3
Greater Sand Plover	75.62	12-Aug-15	15.67	-351.8

Benthic organisms

We successfully collected 264 benthic samples in the field and processed all of these. Sampling locations were either in places where Spoon-billed Sandpipers were seen foraging, or Nordmann's Greenshanks seen foraging, or randomly selected (**Figure 8**). The overall benthic community was numerically dominated by polychaetes and bivalves, with more than 100 individuals occurring in every meter square (**Table 4**). Samples collected from stations where Spoon-billed Sandpipers were seen foraging had a substantially higher amphipod density than that in randomly selected stations, such a difference could potentially indicate that the Spoon-billed Sandpipers were foraging on amphipods. Further robust statistical analysis is needed to disentangle the effect of subregion and height band factors on the relationship between shorebird distribution and food availability.

In addition, we have taken hundreds of foraging videos to understand the diet of Spoon-billed Sandpipers and Nordmann's Greenshanks. These videos and the benthic samples could reveal the diet of these birds and potentially provide the essential data for making quantitative prediction of development impact in the future (objective 3).

Table 4. The numerical density (individual per meter square) of macrobenthic organisms collected from stations either randomly chosen (n = 26), or where Spoon-billed Sandpiper (n = 27), Nordmann's Greenshank were seen foraging (n = 11). Four replicates were taken from each station.

Station type	Amphipoda	Bivalvia	Crab	Gastropoda	Lingulidae	Polychaeta
Spoon-billed Sandpiper	7.36 ± 13.6	145.74 ± 167.01	11.29 ± 16.2	35.33 ± 74.22	9.32 ± 30.57	162.91 ± 115.33
Nordmann's Greenshank	1.2 ± 3.99	43.36 ± 39.34	6.02 ± 9.11	13.25 ± 23.7	2.41 ± 5.36	143.33 ± 70.31
Random	1.53 ± 4.32	138.61 ± 256.4	6.11 ± 9.35	35.16 ± 76.34	10.19 ± 24.94	173.77 ± 143.84
Overall	3.93 ± 9.64	125.25 ± 197.93	8.28 ± 12.6	31.47 ± 68.4	8.49 ± 25.13	163.96 ± 120.01

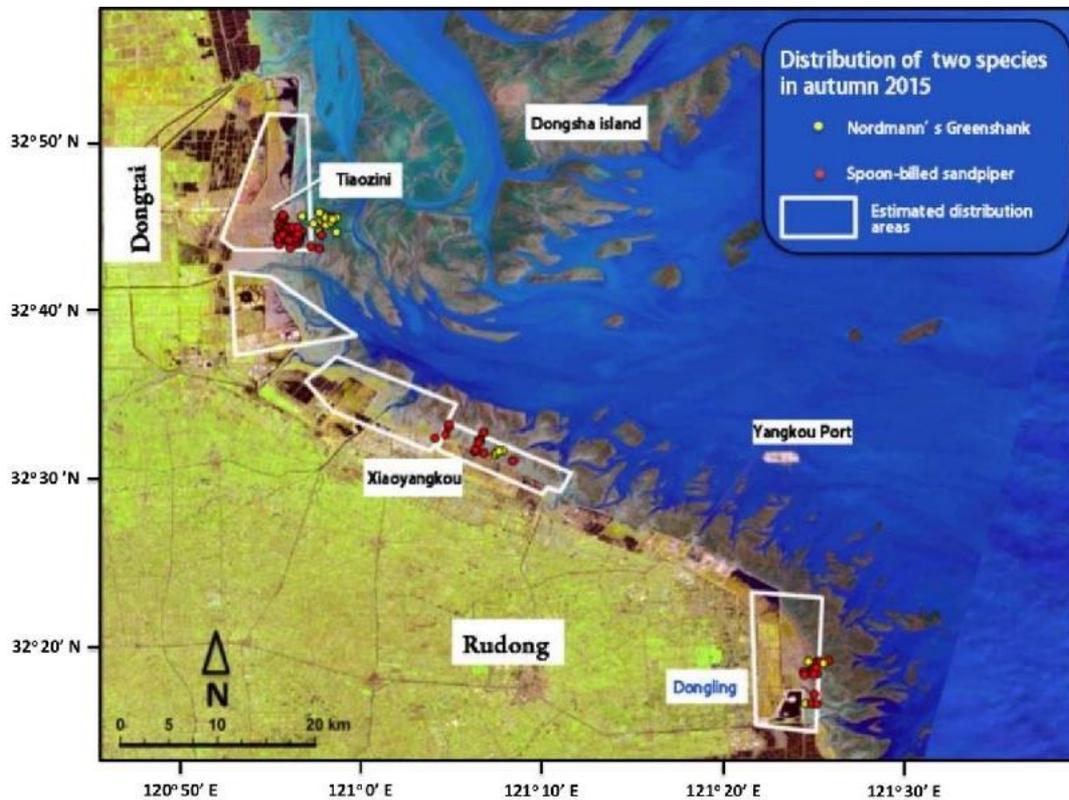


Figure 8. Dongtai-Rudong map and the main distribution area of Spoon-billed Sandpiper and Nordmann's Greenshank in autumn 2015

Community work

We achieved the fourth objectives with the results in the four programs.

In the fishermen livelihood survey part, we visited two main sites of the three, Yangkou fish harbor and Dongling fish harbor. In Yangkou, we sent the questionnaire to the two largest mudflat renters and they helped to send the paper to workers for three months; in Dongling, we had two interview sections in the fish market for one-on-one talking. Total we sent 1000 copies and 200 valid copies returned. We had two main conclusions from the survey, first, fishermen are highly depend on the

mudflat for economic income for shared ocean resources of birds; secondly, fishermen hold relative neutral attitude for migratory birds on the mudflat, they were not competing relationship and one third could name at least one species of endangered waterbirds.

In this section, there is still a lot of knowledge gap. We have little information of artificial fishpond use and how this related to birds and local people, furthermore, there are extensive seaweed farming in the mudflat, we know little how this will affect the whole food availability for birds. This has been considered to be a potential part of our CLP follow up project application.

In the public awareness, we had two types of programs; one is online program, a Wechat account, which we updated weekly with the latest conservation news, till December 2016, we released around 150 posts, among which 40 are original articles, 12 translated video programs and 12 field report about the CLP and other funded projects. In 2015-2016, we hold 20 talks in 5 cities in schools, community and companies; there are 20 outdoor birding activities in the same period, in total, there were over 8,000 people attend either talks or our birding programs. As we reach more audiences, some have become volunteers later. The volunteers live not only in the project area but also in other three provinces in China with total number reached 50.

Field work volunteers initiated the by catch mediation program. In the field work part, volunteers counted the number of fishnets, and the dead birds in number and species. We also did simple interviews with some fishnet owners and trying to understand the incentive for the fishnet and brief them the mortality status for migratory birds, especially in peak time for Spoon-billed sandpiper and other bird on migration.

In the 7 x 4.4 km study area a total of five nets were found. Nets were located on open intertidal mudflat at a distance varying from 100 m to 1.6 km seaward of the seawall. All nets were 1 m high; individual net length varied from 80 to 300 m. Construction was of fine transparent monofilament net with a mesh size of 20 x 20 mm sandwiched between two coarser monofilament nets 200 x 200 mm, stretched between bamboo poles approximately 10 m apart. A total of 149 birds of 17 species were found trapped; 132 dead birds were extracted and 17 live birds released.

Fishermen set the fishnet only to get sea food and the place of the fishnet was randomly selected or depends on how much they could get. It is still questionable part for future project.

The last program was outreach and media. In total, we published two kinds of brochures, one is focus on spoon-billed sandpiper and mudflat conservation, the other is providing overall bird description for new birders with 110 pictures of local bird species. The brochure reached more than 4000 audiences

and more than 20 schools in Jiangsu province and Shanghai. We developed a serial of printing products, including calendar, postcards, posters and notebook. We also developed spoon-billed sandpiper stuffed toys, Spoon-billed themes cotton bags and outdoor shirt for public sale and fund raising. In 2016, we attend the three public fair to promote the mudflat conservation and reaches another 1200 people. The team member also wrote 3 articles and 3 paper in local and international magazines.

Key achievements

- two provincial nature reserves in the study area are set to be established by the end of 2016 (our overall goal). This is a significant step towards a complete protection of the shorebird habitat within the study region and our CLP team has played a significant role before and during the current project, by conducting regular counts over 6 years and bringing public's, as well as media's and government's attention on the importance of the study area to migratory waterbirds. All the three mudflat has been listed in the ten most noteworthy wetland in 2016. The team was invited into the judging panel and will work with the leading local conservation foundation for future on ground actions.
- we have published a popular science article in the Chinese National Geography magazine about the importance of tidal flats in Rudong for the Spoon-billed Sandpiper (Li 2016) ; submitted a scientific article to the Chinese journal of zoology on the distribution and threats of Spoon-billed Sandpiper in China (Peng et al. 2017 submitted); submitted a scientific article to the Bird Conservation International on the importance of our study area to migratory waterbirds (Peng et al. 2017 submitted); we have completed a status report that will be submitted to the BirdLife International to provide an overview of Spoon-billed Sandpiper records in China (Wang et al. 2016) ; worked with two collaborators and published an article that reported the results from our fishermen survey (Jackson. 2016) while another documented the issue of fishnets on the intertidal flat (Crighton 2016).
- we invited more than 200 fishermen or mudflat dependent local people for the first-ever questionnaire to reveal how they used the mudflat, with an estimates of their annual income. The

preliminary results will help to initiate more local conservation projects that takes the livelihood of local people into account.

- the most important, the CLP team, including 26 volunteers from 8 countries and local supports formed a great team for both fieldwork and local conservation project. This is a great encouragement for further scientific work and conservation project in the region and along coastal mudflat
- the CLP team helped the first shorebird banding expedition in south Jiangsu during our fieldwork, with excellent fieldwork experience and team spirit. The banding data will also be part of the project output

Attachment

- I. Spoon-billed Sandpiper and mudflat facts brochure
- II. 100 bird of Yellow Sea
- III. Questionnaire (Translated in English for reference)
- IV. Gifts for questionnaires programs: hats and cups
- V. Spoon-billed Sandpiper stuffed toys for public programs
- VI. video link Spoon-billed sandpiper and Jiangsu mudflat
- VII. offline activities list in 2015~ 2016
- VIII. Top five posts (English abstract only) in Wechat account

Acknowledgement

We thank for Conservation Leadership Programme provide fund and training for this project. Jiangsu Nantong Juvenile Social Practice Center has been providing accommodation for project team member and many volunteers. SEE foundation has support the team and the project for extensive publicity. Jiangsu Rudong Juegang Primary school has great initiatives and support for all school programs. Jiangsu Links Spa Hotel support the team for promote birding activities locally.

We also appreciate Spoon-billed Sandpiper Task force for all volunteers in field work.

We thank for Dr. Wenliang Liu and his lab for provide the lab service and accommodation of our project.

Ho-fai Cheung, David Melville, Chung yu Chiang, and colleague, Katherine Leung, Ben Lagasse, Peter Crighton, Tom Clarke, Richard Mundy, Andrew Baksh, Micha Jackson, Jingwei Hu, Wei Zhang, Wei Liu, Tengyi Chen, Chen Yu, Vladmir Morozov, Driver Tang, Le Xiang and Tong Mu have kindly provided valuable suggestion for this project, we appreciate a lot for their long term support for the conservation of Spoon-billed Sandpiper and the team.

It was great to have all the team members continuous effort during the project, they are Jimmy Cho, Xiaojing Gan, Lin Zhang, Jun Zhang, Jin Guo, Meiling Dong and you make the project fruitful.

Last and most important, we thank for Zhijun Ma, Wenliang Liu and Danny Rogers for equipment and advice. Their experience in research and conservation was invaluable for the project.

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