

Rapid Communication

The intertidal wetlands of southern Jiangsu Province, China – globally important for Spoon-billed Sandpipers and other threatened waterbirds, but facing multiple serious threats

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Summary

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’ Spotted 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.

Introduction

The Yellow Sea coasts of China and the Korean peninsula have been recognized as one of the world’s most important regions for waterbirds, particularly for migratory shorebirds using the East Asian–Australasian Flyway (Barter 2002). These include the ‘Critically Endangered’ Spoon-billed Sandpiper *Calidris pygmaea* (BirdLife International 2016a). The East Asian–Australasian

Flyway is currently witnessing severe populations declines in many shorebird species (Amano *et al.* 2010, Clemens *et al.* 2016), resulting in a greater proportion of globally threatened waterbirds than any other major global flyway (Kirby 2010). These declines are particularly severe for species using intertidal mudflats in the Yellow Sea region as migration stopover sites (Amano 2010, Studds *et al.* in press). Serious and numerous threats are imperilling the survival of waterbirds and their intertidal wetland habitats in the Yellow Sea region (MacKinnon *et al.* 2012, Hua *et al.* 2015, Melville *et al.* 2016, Piersma *et al.* 2016). Large-scale loss of feeding habitat through land claim is the most serious and widespread threats in this region (Ma *et al.* 2014, Murray *et al.* 2014). The large land claim project at Saemangeum, Republic of Korea, in 2006 is associated with subsequent significant reductions in shorebird numbers, including Spoon-billed Sandpipers and particularly the 'Endangered' Great Knot *Calidris tenuirostris* (Moore *et al.* 2016). Therefore, the identification and effective protection of the most important sites for waterbirds in the flyway, and particularly in the Yellow Sea, is of huge conservation importance.

In recent years, the southern Jiangsu coast (Figure 1), in the south-west corner of the Yellow Sea, has become recognized as a key migration stop-over and moulting area for Spoon-billed Sandpipers, both in spring and autumn (Tong *et al.* 2012, Bai *et al.* 2015). Following the first documented record in 2008, increasing fieldwork effort produced more reports of Spoon-billed Sandpipers near the port of Yangkou, Rudong County; in 2010 reaching single day counts of 21 on 17 April, and 24 on 24 September (Li *et al.* 2011). Two birds were also reported from the coast adjacent to the nearby town of Jianggang, Dongtai county, in April 2010 (Li *et al.* 2011). As the global understanding of the importance of this area increased (Tong *et al.* 2012), international teams have visited annually since 2012 to support increasingly intensive survey efforts focused on coordinated counts to estimate the total number of Spoon-billed Sandpipers using the area. As a result, a minimum of 143 individuals was recorded along this stretch of coast in October 2013 (Tong *et al.* 2014). More recently, significant numbers of other globally threatened waterbirds have been recorded, particularly Spotted Greenshank *Tringa guttifer* (1,117 in October 2013; Bai *et al.* 2015), a count which is twice that of the most recent world population estimate for this species (Wetlands International 2016).

A wetland is considered internationally important if it regularly holds at least 1% of the individuals in the population of a waterbird species (Ramsar Convention Secretariat 2010). Bai *et al.* (2015) report records from the coast of China, for 2010–2013 inclusive, for counts of waterbird species that exceed 1% of the East Asian–Australasian flyway population. This paper takes the same approach and updates these data for three key sites so far identified in southern Jiangsu Province; emerging, collectively, as a critically important area for several globally threatened waterbird species.

Methods

Study area

The study area was a 120-km stretch of coastline, comprising extensive intertidal mud and sand flats, in southern Jiangsu Province, People's Republic of China, principally within the counties of Rudong and Dongtai (Figure 1). Over 100,000 shorebirds have been recorded along this coast during both the northward and southward migration periods (Bai *et al.* 2015). Within this coastline, three study sites were chosen, as those that had provided the majority of records of Spoon-billed Sandpipers from Jiangsu in recent preceding years: (1) the coast adjacent to the port of Yangkou (Rudong County, Nantong Prefecture), (2) Dongling (Rudong County, Nantong Prefecture; 50 km to the south-east of Yangkou), and (3) Tiaozini (Dongtai County, Yancheng Prefecture; 30 km to the northwest of Yangkou). For comparison, Bai *et al.* (2015) refer to the same three sites, respectively, as (1) Rudong coast (RD), (2) Dongling coast (DL), and (3) Dongtai coast (DT). These three sites, and indeed the whole southern Jiangsu coast, comprise open bare intertidal flats, or saltmarsh dominated by invasive Smooth Cord Grass *Spartina alterniflora*, adjacent to flat land claimed for aquaculture, industry or agriculture over recent decades (Cai *et al.* 2017). During the study period, the three study areas all retained significant areas of mudflat at relatively high

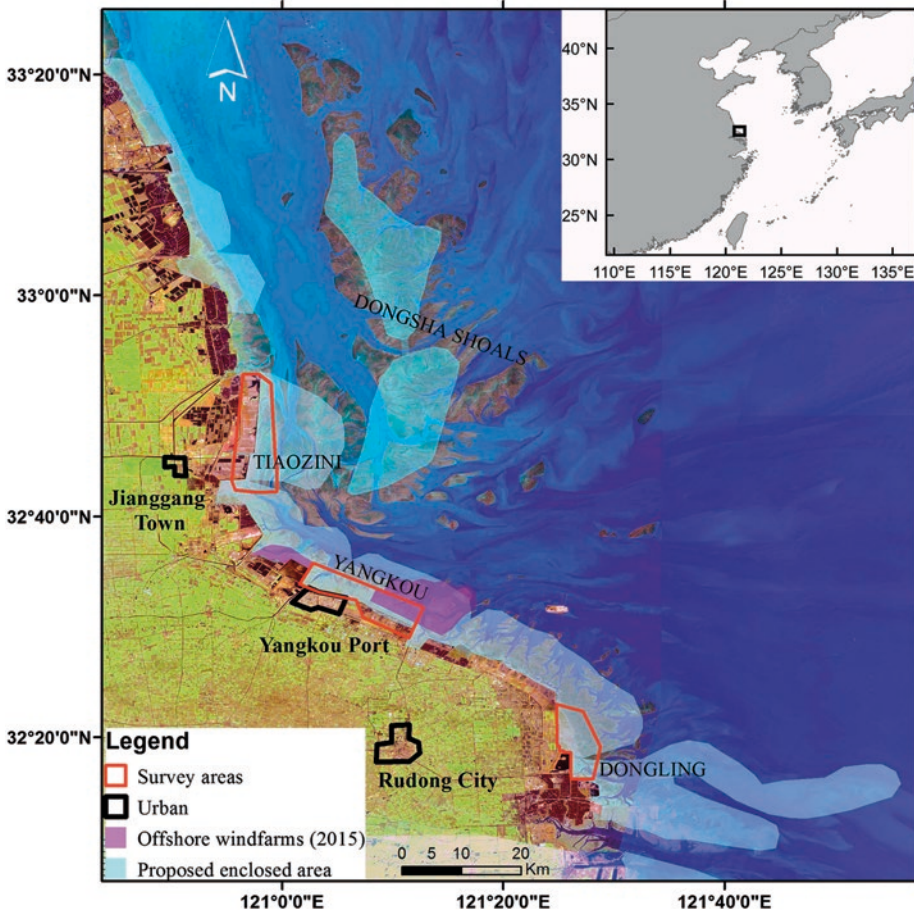


Figure 1. Map of the Jiangsu coast (China) showing study areas, where counts took place in 2014 and 2015. Red lines indicate the maximum limits of the areas surveyed: both areas of intertidal mudflats, where birds were observed foraging or roosting, and areas landward of the current seawall where birds were observed at high tides roosts. Pink shaded areas represent current off-shore wind farms, and pale blue shaded areas show the extent of proposed future land claim projects (Zhang *et al.* 2011).

elevations, which, during spring tide series, were last to be flooded on a rising tide and first to be uncovered on a falling tide, thus attracting large concentrations of waterbirds, especially shorebirds, around the high tide periods.

Areas of considerable potential importance to waterbirds, the Dongsha Shoals (Wang and Barter 1998) – extensive radial sandbanks located 50 km to the East and north-east of Tiaozini, administered by Dongtai County (Figure 1) – were not surveyed for waterbirds, due to logistical difficulties in accessing the area.

Survey methods

Counts of waterbirds (ducks, geese, swans, storks, spoonbills, ibis, herons, pelicans, shorebirds, gulls and terns) were made during 2014 and 2015, with fieldwork effort focused on the northward

and southward migration periods (boreal springs and autumns, respectively). The three study areas were surveyed at least once a month throughout the year, with multiple additional survey dates in each migration period. Within each migration period, the number of survey visits to each site varied according to several factors: suitable high tide height to bring birds close enough to the upper shore, weather conditions and access permissions.

Most surveys were carried out during series of spring tides and, on each day, around the high tide period, when waterbirds were restricted to feeding or roosting on limited areas of exposed intertidal mud, or on adjacent areas, on recently claimed land behind the current seawall. Around low tide, waterbirds, and especially shorebirds, became widely dispersed over the extensive remaining mudflats, and hence very difficult to count effectively.

All counts were conducted by experienced waterbird surveyors. Typically, multiple observers would collect data from the same site on the same day, surveying waterbirds 100–1000 m apart along a continuous shoreline. Maximum numbers of each species encountered were recorded by each observer. These data were then combined to minimise the risk of double counting by comparing known times and species composition of any flocks observed moving along the coast between areas covered by different observers. This collation of count data was carried out as soon as possible after a fieldwork period; usually later the same day. Within each migration period studied (March–May for northward migrations, July–November for southward migration), counts for all waterbird species were collated and the maximum single date count for each site identified. For a small number of species where peak recorded counts fell outside the main migration periods, records from January to May are presented here as northward (spring) migration, and June to December as southward (autumn) migration, for convenience. Count data are reported here if they met or exceeded the 1% flyway population threshold, derived from the world population estimates for waterbirds produced by Wetlands International (2016) or the species is listed as globally threatened or 'Near Threatened' (BirdLife International 2016b). The 1% flyway population threshold is used here for consistency of approach with previously published data from the same study sites (Bai *et al.* 2015).

To examine changes over recent years in the numbers of Spoon-billed Sandpipers recorded at the three study sites, the data presented here were combined with previous survey data (Bai *et al.* 2015, Spoon-billed Sandpiper Task force unpubl. data). During waterbird surveys, observers also recorded the presence of any human threats to waterbirds.

Results

Waterbird counts

Single-site counts of 24 waterbird species exceeded the 1% threshold of the East Asian–Australasian flyway population on at least one date within the survey period (Table 1). Of these, seven were globally threatened species and six were 'Near Threatened'. Counts of six species exceeded 10% of the total flyway population size; Eurasian ('Far Eastern') Oystercatcher *Haematopus ostralegus osculans* (Near Threatened), Kentish Plover *Charadrius alexandrinus*, Lesser Sand Plover *Charadrius mongolus*, Spoon-billed Sandpiper (Critically Endangered), Spotted 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, with 144 of those at Tiaozini. This represents around one third of the estimated global post-breeding population for this species in 2014 (661–718 individuals; Clark *et al.* 2016). A total of 1110 Spotted Greenshanks were recorded across all three study sites in autumn 2015, and 956 in autumn 2014; both very close to the figure of 1,117 from autumn 2013 (Bai *et al.* 2015). The great majority of these birds were recorded at Tiaozini, within a single roosting flock. These counts exceed the current global population estimate for this species (400–600 individuals; Wetlands International 2016). Four globally threatened and four 'Near Threatened' species, counts for which did not exceed the 1% flyway threshold criterion, were also recorded (Table 1).

Table 1. Maximum daily counts of waterbird species recorded during four recording periods: northward and southward migration 2014 and 2015, at the three southern Jiangsu study sites. Data are shown for all species where any survey maximum count exceeded 1% of the EAAF population (English species name in bold type) and/or species that are globally threatened or Near Threatened (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. *Some or all peak counts for these species occurred outside the main migration recording periods, and counts are correctly dated here.

Species	1% of EAAF population	Study Site	2014				2015			
			Spring (March-May)		Autumn (July-November)		Spring (March-May)		Autumn (July-November)	
Baer's Pochard <i>Aythya baeri</i> (CR)	5	Tiaozini	0		3 30 Oct + 8 Nov		0		0	
		Yangkou	0		0		0		0	
		Dongling	0		0		1	6 Mar	0	
Oriental Stork* <i>Ciconia boyciana</i> (EN)	30	Tiaozini	0		4* 6 Dec		0		0	
		Yangkou	0		0		0		0	
		Dongling	0		0		0		0	
Black-faced Spoonbill <i>Platalea minor</i> (EN)	20	Tiaozini	0		51	11 Oct	0		70	28 Sep
		Yangkou	3	28 Apr	3	10 Oct	1	11 May	0	
		Dongling	14	30 Apr	38	11 Oct	19	16 May	0	
Chinese Egret <i>Egretta eulophotes</i> (VU)	35	Tiaozini	1	2,15+21 May	0		4	6 May	2	27 Sep
		Yangkou	3	19 May	0		0		1	30 Sep
		Dongling	5	16 May	0		0		8	2 Oct
Dalmatian Pelican <i>Pelecanus crispus</i> (VU)	1	Tiaozini	0		24	11 Oct	0		30	12 Nov
		Yangkou	0		0		0		0	
		Dongling	0		0		0		0	
Eurasian Oystercatcher* <i>Haematopus ostralegus</i> (NT) [LC]	70	Tiaozini	30	4 May	1241*	6 Dec	32	8 Apr	690*	15 Dec
		Yangkou	11	29 Apr	48	11 Oct	8	11 May	0	
		Dongling	3700*	23 Jan	176	9 Nov	2100*	10 Feb	1670*	10 Dec
Pied Avocet <i>Recurvirostra avoetia</i>	1,000	Tiaozini	28	21 May	306	22 Sep	22	6 May	1,000	29 Sep
		Yangkou	22	20 May	33	24 Sep	9	3 May	0	
		Dongling	0		0		0		0	

Table 1. Continued.

Species	1% of EAAF population	Study Site	2014				2015			
			Spring (March-May)		Autumn (July-November)		Spring (March-May)		Autumn (July-November)	
Grey Plover <i>Pluvialis squatarola</i>	1,000	Tiaozini	9,000	1 May	4,100	9 Oct	3,000	6 May	1,700	13 Oct
		Yangkou	1,500	28 Apr	1,000	24 Sep	800	11 May	660	26 Sep
		Dongling	3,500	30 Apr	350	25 Sep	3,000	5 May	800	18 Oct
Kentish Plover <i>Charadrius alexandrinus</i>	1,000	Tiaozini	50	4 May	13,000	10+11 Oct	500	8 Apr	8,000	27 Sep
		Yangkou	570	12 Apr	8,050	11 Oct	600	9 Apr	5,100	30 Sep
		Dongling	150	30 Apr	6,500	9 Nov	500	7 Apr	4,500	15 Oct
Lesser Sand Plover <i>Charadrius mongolus</i>	390	Tiaozini	120	4 May	6,600	10 Oct	255	4 May	1,600	1 Oct
		Yangkou	1,810	29 Apr	3,500	24 Sep	375	7 May	3,942	13 Jul
		Dongling	2,000	12 May	4,500	25 Sep	1,600	5 May	2,000	28 Sep
Greater Sand Plover <i>Charadrius mongolus</i>	790	Tiaozini	16	1 May	40	21 Sep	6	7 May	863	16 Jul
		Yangkou	100	21 Apr	500	19 Aug	4	6 May	2,886	13 Jul
		Dongling	309	25 Apr	150	10 Oct	15	5 May	2,060	17 Jul
Northern Lapwing <i>Vanellus vanellus</i> (NT) [LC]	10,000	Tiaozini	0		0		0		2	1 Oct
		Yangkou	0		0		0		40	Nov
		Dongling	0		0		0		0	
Eurasian Curlew* <i>Numenius arquata</i> (NT)	1,000	Tiaozini	180	3 May	8,500	11 Oct	175	4 May	4000*	15 Dec
		Yangkou	750	12 Apr	960	24 Sep	63	11 May	1,300	26 Sep
		Dongling	75	30 Apr	800	25 Sep	300	18 Apr	2,060	10 Nov
Far Eastern Curlew <i>Numenius madagascariensis</i> (EN) [VU]	320	Tiaozini	50	4 May	18	22 Sep	50	8 Apr	120	16 Jul
		Yangkou	46	20 May	342	12 Jul	26	11 May	482	13 Jul
		Dongling	45	30 Apr	218	11 Jun	100	7 Apr	130	17 Jul
Bar-tailed Godwit <i>Limosa lapponica</i> (NT)	1,500	Tiaozini	4,000	1+4 May	103	21 Sep	6,500	6 May	550	12 Aug
		Yangkou	2,840	5 May	300	24 Sep	1,400	11 May	30	26 Sep
		Dongling	5,000	30 Apr	100	25 Sep	4,000	5 May	970	14 Aug
Black-tailed Godwit <i>Limosa limosa</i> (NT) [LC]	1,400	Tiaozini	2	1 May	0		50	6 May	2,232	16 Jul
		Yangkou	42	14 May	212	19 Aug	130	7 May	18	26 Sep
		Dongling	500	12 May	720	17 Aug	6	5 May	1,340	17 Jul

Table 1. Continued.

Species	1% of EAAF population	Study Site	2014				2015			
			Spring (March-May)		Autumn (July-November)		Spring (March-May)		Autumn (July-November)	
Ruddy Turnstone <i>Arenaria interpres</i>	290	Tiaozini	90	4 May	30	21 Sep	150	4 May	3	1 Oct
		Yangkou	50	5 May	135	19 Aug	115	11 May	101	12 Aug
		Dongling	400	16 May	50	17 Aug	350	5 May	172	14 Aug
Great Knot <i>Calidris tenuirostris</i> (EN) [VU]	2,900	Tiaozini	5,000	4 May	220	22 Sep	1,600	6 May	2,570	16 Jul
		Yangkou	55	29 Apr	790	12 Jul	15	7 May	200	30 Sep
		Dongling	400	18 May	1,400	11 Jul	1,000	7 Apr	6,820	17 Jul
Red Knot <i>Calidris canutus</i> (NT) [VU]	1,100	Tiaozini	123	15 May	1	21 Sep	150	4 May	2	13 Oct
		Yangkou	53	28 Apr	0		20	7 May	25	14 Oct
		Dongling	300	30 Apr	1,360	17 Aug	60	9 May	410	17 Jul
Broad-billed Sandpiper <i>Limicola falcinellus</i>	250	Tiaozini	40	13+15 May	100	22 Sep	30	4 May	250	16 Jul
		Yangkou	76	29 Apr	710	19 Aug	22	7 May	73	30 Sep
		Dongling	350	12 May	550	25 Sep	30	5 May	300	12 Oct
Curlew Sandpiper <i>Calidris ferruginea</i> (NT) [LC]	1,400	Tiaozini	40	1 May	43	21 Sep	125	4 May	1	13 Oct
		Yangkou	400	29 Apr	0		43	7 May	0	
		Dongling	60	12 May	1	25 Sep	37	9 May	3	12 Oct
Spoon-billed Sandpiper <i>Calidris pygmeus</i> (CR)	3	Tiaozini	25	1 May	144	26 Sep	47	10 May	101	16 Oct
		Yangkou	7	28 Apr	37	27 Sep	3	3 May	25	27 Sep
		Dongling	9	30 Apr	44	25 Sep	12	5 May	38	24 Sep
Red-necked Stint <i>Calidris ruficollis</i> (NT) [LC]	3,200	Tiaozini	11,100	20 May	1,137	21 Sep	5,000	10 May	2,000	25 Sep
		Yangkou	5,440	14 May	1,150	24 Sep	3,600	11 May	1,000	11 Sep
		Dongling	15,000	16 May	1,000	25 Sep	15,000	5 May	2,000	13 Sep
Sanderling <i>Calidris alba</i>	220	Tiaozini	810	21 May	430	22 Sep	1,300	8 May	500	25 Sep
		Yangkou	120	6 May	200	11 Oct	200	7 May	350	26 Sep
		Dongling	1,000	18 May	600	25 Sep	1,800	5 May	300	12 Oct
Dunlin <i>Calidris alpina</i>	10,000	Tiaozini	14,000	3 May	7,500	21 Sep	16,000	6 May	6,000	13 Oct
		Yangkou	8,800	29 Apr	4,500	24 Sep	3,040	11 May	3,000	11 Sep
		Dongling	25,000	16 May	4,500	25 Sep	10,000	5 May	8,000	13 Sep

Table 1. Continued.

Species	1% of EAAF population	Study Site	2014				2015			
			Spring (March-May)		Autumn (July-November)		Spring (March-May)		Autumn (July-November)	
Asian Dowitcher <i>Limnodromus semipalmatus</i> (NT)	230	Tiaozini	5	1 May	10	24 Sep	19	4 May	1	27 Sep
		Yangkou	63	29 Apr	0		3	3 May	0	
		Dongling	7	30 Apr	0		0		0	
Terek Sandpiper <i>Xenus cinereus</i>	500	Tiaozini	525	1 May	570	21 Sep	450	8 May	135	16 Jul
		Yangkou	650	5 May	590	19 Aug	725	11 May	555	13 Jul
		Dongling	410	30 Apr	215	10 Oct	520	5 May	100	28 Sep
Grey-tailed Tattler <i>Tringa brevipes</i> (NT) [LC]	440	Tiaozini	30	13 May	9	21 Sep	35	6 May	1	1 Oct
		Yangkou	23	19 May	20	24 Sep	21	7 May	1	30 Sep
		Dongling	40	16 May	2	25 Sep	45	5 May	0	
Spotted Greenshank <i>Tringa guttifer</i> (EN)	5	Tiaozini	45	4 May	841	22 Sep	200	6 May	946	2 Oct
		Yangkou	2	19+20 May	35	11 Oct	0		22	30 Sep
		Dongling	19	16 May	80	25 Sep	10	9 May	142	18 Oct
Saunders's Gull <i>Larus saundersi</i> (VU)	85	Tiaozini	500	3+4 May	2,550	22 Sep	200	10 May	940	29 Oct
		Yangkou	200	7 May	370	11 Oct	500	11 May	300	26+30 Sep
		Dongling	220	12 May	1,120	10 Oct	80	16 May	1,000	12 Oct
Relict Gull <i>Larus relictus</i> (VU) [EN]	120	Tiaozini	0		4	28 Oct	0		1	1 Oct
		Yangkou	0		2	11 Oct	0		8	12 Oct
		Dongling	0		8	30 Oct	0		29	10 Feb
Common Tern* <i>Sterna hirundo longipennis</i>	460	Tiaozini	4,000	4 May	19	22 Sep	350	10 May	8	27 Sep
		Yangkou	250	29 Apr	551*	12 Jun	220	7 May	400*	12 Jun
		Dongling	0		65	11 Jun	80	5 May	2	2 Oct

Counts of 13 species at Yangkou exceeded the 1% flyway population level over the whole two-year study period: seven species in spring and all 13 in autumn. At Dongling, the equivalent figures were 19 species over the whole study, 13 in spring and 13 in autumn, whereas for Tiaozini; 21 species over the whole study, 12 in spring and 16 in autumn.

Species differed as to whether they were more numerous in spring or autumn. Spoon-billed Sandpipers were recorded in considerably greater numbers in autumn than in spring. Other species apparently more common in autumn than spring include: Kentish Plover (all sites), Lesser Sand Plover (at Tiaozini and Yangkou), Eurasian Curlew *Numenius arquata* (all sites), Spotted Greenshank (at Tiaozini and Yangkou) and Saunders’s Gull (at Tiaozini). Other species were more common in spring at all sites; Bar-tailed Godwit *Limosa lapponica*, Red Knot *Calidris canutus*, Ruddy Turnstone *Arenaria interpres*, Dunlin *Calidris alpina*, Red-necked Stint *Calidris ruficollis* and Common Tern *Sterna hirundo longipennis*. Peak numbers of only one species, Eurasian (‘Far Eastern’) Oystercatcher, regularly occurred outside the main migration periods, during the boreal winter. Four globally threatened waterbird species were recorded at all sites in all four survey periods (Far Eastern Curlew *Numenius madagascariensis*, Great Knot, Spoon-billed Sandpiper and Saunders’s Gull). A fifth, Spotted Greenshank, was recorded for all but one site-survey period combinations.

Most species reported on here that are listed as globally threatened or ‘Near Threatened’ by IUCN (2016) are also similarly categorised on the latest China official Red list (Jiang *et al.* 2016), but with differences in threat category in some cases (see Table 1 for details).

When compared with data from previous surveys (Bai *et al.* 2015, Spoon-billed Sandpiper Task Force unpubl. data), the maximum counts of Spoon-billed Sandpipers from 2014 and 2015 suggest declining recorded numbers at Yangkou for this species, stability at Dongling, but increasing importance of Tiaozini (Table 2).

Threats to waterbirds

Several confirmed or potential threats to waterbirds were recorded during the study:

1. Loss of intertidal wetlands by land claim. Extensive areas of mudflat have already been recently claimed in this region as evidenced by new seawalls enclosing land under early stages of conversion – either still as bare sediment or aquaculture ponds. Plans for future large scale land claim at Tiaozini were on public display at the site. Construction of new seawalls, apparently associated with port developments, was also observed at Yangkou in 2015.
2. Loss of intertidal open mudflats due to invasive non-native Smooth Cord Grass *Spartina alterniflora*. Dense *Spartina* swards were present on intertidal areas at both Yangkou and Dongling, and considerable spread at both sites was noted between spring 2014 and

Table 2. Changes over time in the peak single-day counts of spoon-billed sandpipers recorded at the three study sites. Data from 2010 to 2013 are from Bai *et al.* (2015) and Spoon-billed Sandpiper Task Force (unpubl. data). A dash indicates no systematic surveys for waterbirds were conducted at this site during this period.

Year	Tiaozini		Yangkou		Dongling	
	Northward (spring)	Southward (autumn)	Northward (spring)	Southward (autumn)	Northward (spring)	Southward (autumn)
2010	-	-	21	24	-	-
2011	-	-	15	103	-	-
2012	17	0	25	64	0	37
2013	0	44	0	59	10	40
2014	25	144	7	37	9	44
2015	47	101	3	25	12	38

autumn 2015. At Tiaozini, dense *Spartina* swards were restricted to the south-western corner of the site, however recent deliberate plantings on mudflats (regular parallel lines of young plants) were observed near the south-eastern corner of the seawall in April 2014. Although no extensive swards were present along the eastern edge of this site, considerable spread of small clumps of the plant, including the deliberately planted areas, was noted here between 2014 and 2015.

3. Trapping of waterbirds in nets and traps. One apparently derelict and abandoned mist net (probably 2–3 m high when operational), containing the remains of several long-dead birds (unidentifiable due to range of observation; c.400 m), was observed on tidal flats at Dongling in April 2014. A greater threat to waterbirds during the study period came from fine mesh, multi-layer monofilament nylon 'trammel' fish nets; 1–1.5 m tall, set vertically between bamboo poles spaced 15–20 m apart, and in long lines (hundreds of metres). These nets were set at low tide on open mudflats, and primarily designed to catch fish on the rising tide, before being emptied during the following low tide period. Such nets were observed being used at Tiaozini in September 2014 and 2015 and were a threat to birds moving across the mudflats around high tides, particularly at night. A single line of nets, approximately 150 m long, set within 300 m of the seawall, was found on 29 September 2014 after just one nocturnal high tide, containing 35 dead small shorebirds (31 Kentish Plover, one Lesser Sand Plover, two Dunlin and one Sanderling), plus another Sanderling still alive but in poor condition. Multiple net lines were found at Tiaozini in September and October 2015, frequently containing dead shorebirds, or with dead birds found close to the nets, having been removed and discarded by the net operators. A single 100 m line of nets, within 200 m of the seawall at the southern end of the survey area (Figure 1) contained 71 dead shorebirds after one nocturnal high tide period, including one juvenile Spoon-billed Sandpiper. It is unclear whether or not such nets were ever used deliberately to catch birds, although their design and location suggests their primary use was to catch fish. Both live and dead small shorebirds were also occasionally found in lines of crab traps; made of coarse netting, and divided into low (c.50 cm high) rectangular sections, each with a funnel entrance.
4. Poisoning of waterbirds. Significant mortality of waterbirds (up to 1,000 dead and dying birds of over 40 species) and other birds, including migrant passerines, quails and doves, was recorded at Tiaozini in September and October 2014. Corpses and moribund birds were found along the shoreline and over an area of approximately 5 km² immediately behind the seawall – used as high tide roost site by shorebirds. Two dead Spoon-billed Sandpipers were found among the corpses. The cause of this mortality is currently unknown, but the number and concentration of corpses, not repeated at other sites, matches that expected from an acute poisoning incident. Deliberate use of poison baits, affecting both landbirds and some shorebirds, on a recently claimed patch of land close to Yangkou was also noted in May 2015.
5. Collision with, or displacement by, man-made structures. The Jiangsu coastline is highly industrialized and many man-made structures are present, including a particularly high density of large (> 50 m tall) wind turbines. Over 250 turbines were visible from many points along the current outer seawall close to Yangkou, with over 100 offshore on mudflats. Many turbines are also present along the current outer seawall at Dongling. Powerlines and other industrial structures are frequent along this coast and may also represent additional hazards to waterbirds. We recorded no direct evidence of collision mortality or displacement of waterbirds from potential foraging or roosting areas, however detailed studies into the possibility of these impacts were not undertaken. Shorebirds and other waterbirds were regularly seen flying close to wind turbines, particularly at Yangkou when moving between intertidal feeding areas and roosting sites inland of the current seawall. Large numbers of waders, including Spoon-billed Sandpipers, were frequently observed both feeding and roosting within 100–200 m of both off-shore and on-shore wind turbines at Yangkou.

6. Potential loss of roost sites through land development. During the 2014 and 2015 survey periods, at tides high enough to cover all open mudflats, shorebirds were observed roosting on claimed areas behind the current seawalls. This was particularly the case at Tiaozini and Yangkou, where consistent roost sites were used; either on open unvegetated flat sediment, or around aquaculture ponds. At Dongling, by contrast, most observed shorebird roosting took place in the remaining unvegetated areas of upper mudflats otherwise dominated by *Spartina*. Future industrial or agricultural development and further spread of *Spartina* may reduce the availability of suitable safe high tide roosting areas for waterbirds.
7. Environmental pollution from industrial or agricultural sources. The large industrial developments adjacent to this coastline have the potential to be the source of chemical pollutants that may impact on the intertidal ecosystem, ultimately affecting food supplies for waterbirds. No direct evidence of this was observed during our study but no specialized studies were conducted to determine the likelihood of this potential threat.

Discussion

Bird numbers recorded

The counts presented here confirm the southern Jiangsu coast as the most important region, and Tiaozini the most important single site, known in the world for both Spoon-billed Sandpiper and Spotted Greenshank. Only the Gulf of Mottoma in Myanmar has recorded similar numbers of (wintering) Spoon-billed Sandpipers in recent years (Zöckler *et al.* 2016). Furthermore, all three Jiangsu sites surveyed here consistently held internationally important numbers of many waterbird populations. The 21 species exceeding the 1% threshold recorded at Tiaozini puts this site alone into the top six for waterbirds on the Chinese coast, by this criterion (cf. Bai *et al.* 2015). The importance of all three sites is evident for both spring and autumn migration periods – the southern Jiangsu coast is clearly a critically important migration stop-over area for waterbirds on the East Asian–Australasian flyway.

The count data presented here will almost certainly underestimate the true numbers of individuals of each recorded species that actually use the study areas on migration, due to turnover. This is likely to be especially marked during spring northward migration when stopover duration for most species is typically shorter than in autumn. In autumn many species of shorebird remain in the Yellow Sea area for longer to complete their annual moult, before continuing south along the flyway (Bai *et al.* 2012, Choi *et al.* 2016, Peng *et al.* 2016). Safe locations with adequate food supplies to allow the successful completion of an annual moult is a key requirement of all waterbirds. Better understanding of stopover durations from studies of marked birds and the role of the southern Jiangsu coast for moulting birds in autumn will further improve our understanding of the full importance of this region to the East Asian–Australasian Flyway's waterbird populations.

The extensive offshore radial sandbanks to the East of Tiaozini; the Dongsha Shoals (see Figure 1), could potentially be of very high importance for waterbirds in Jiangsu, both as feeding and roosting sites (Wang and Barter 1998). No systematic waterbird surveys of these large areas have been conducted recently, primarily due to the logistical difficulty of accessing the area. Bird surveys and habitat assessment here and an understanding of how these areas of intertidal habitat are used by waterbirds in combination with the coastal sites reported on here are high priority research needs.

The relatively short history of systematic bird surveys at these study sites, and the rapidly changing coastline through successive land claims makes temporal comparisons of count data somewhat difficult to interpret currently. Peak recorded numbers of Spoon-billed Sandpipers appear to have increased at Tiaozini and declined at Yangkou between 2010 and 2015. Changes in global population size, bird distribution (potentially driven by changes in hydrological and sediment structure changes resulting from previous land claim), survey effort or detectability (perhaps from better understanding of Spoon-billed Sandpiper behaviour) are all potential factors contributing to these changes in recorded numbers, but their relative importance is, currently, unknown. What is clear is

that the coastline of southern Jiangsu is – as a whole – of global importance for Spoon-billed Sandpipers, and many other waterbirds of conservation concern, with Tiaozini being the most important single site currently.

Threats to waterbirds

Loss of intertidal habitat through land claim

The intertidal zone of the Yellow Sea faces the threat of large-scale habitat loss from land claim. Over half of China's coastal wetlands have been lost in the last 50 years and the rate of land claim of intertidal mudflats along the Chinese coast is very high, and has increased dramatically over the last 25 years (Murray *et al.* 2014, Ma *et al.* 2014). Loss of intertidal mudflat represents a loss of foraging opportunity for waterbirds. Both direct loss of food resources (Baker *et al.* 2004) and loss of foraging habitats (Burton *et al.* 2006) are known to cause increased mortality in shorebirds. The population declines of migratory shorebirds in the East Asian-Australasian Flyway are closely correlated with the habitat loss from intertidal land claim in the Yellow Sea region (Amano *et al.* 2010, Piersma *et al.* 2016, Conklin *et al.* 2016). Pre- and post- construction data from the Saemangeum seawall and land claim project in the Republic of Korea clearly showed an overall reduction in the number of Spoon-billed Sandpipers recorded in the region on spring passage (Moores *et al.* 2016).

The southern Jiangsu coast is no exception to this pattern found elsewhere in the Yellow Sea; the entire coastline studied here is bounded by concrete and earth seawalls; all the outer boundary of recent land claims. Claimed areas typically remain as bare sediment for a few years, often while ground levels are raised by pumping sediment from adjacent intertidal areas, then rapidly developed into aquaculture ponds, industrial zones, wind and solar farms or harbours, depending on location. The intertidal areas at all three study sites are included within planned future claims of 1,800 km² of intertidal mud and sand flats between 2010 and 2020 (Zhang *et al.* 2011; Figure 1). Of the three sites studied, Tiaozini currently appears to be under the greatest immediate threat of further habitat loss, with a proposed claim of 670 km², including the entire Tiaozini coastal flats, and the Dongsha Shoals, forming an early part of the larger provincial plan for land claim (Jiangsu Provincial Government 2011). Indeed, the first phase of this has already been completed, claiming 70 km² of land and creating the new seawall present at Tiaozini in 2014. The planned second phase would include the total loss of the mudflats for which count data are presented here, including where the count of 144 individual Spoon-billed Sandpipers was made on 26 September 2014. If realised, these planned land claims will eliminate a globally important waterbird migration and moulting area, and are highly likely to result in further flyway population declines for many of the species reported on here. For several species, particularly Spoon-billed Sandpiper and Spotted Greenshank, significant declines of their global populations are likely to result. Large-scale land claim is currently the most serious long-term threat to waterbird populations, particularly shorebirds, in Jiangsu.

Loss of intertidal mudflat due to invasive *Spartina*

Invasive non-native Smooth Cord Grass *Spartina alterniflora* has covered large areas of intertidal mudflat in China, particularly in Jiangsu Province (Zuo *et al.* 2009). This plant can spread rapidly and accrete large volumes of sediment around its root and shoot systems. Although declared a 'pest' species by the Chinese Ministry of Environmental Protection (Melville *et al.* 2016) deliberate plantings continue to take place, as recorded in this study. Spread of this plant effectively speeds up the process of converting mudflat to dry land through raised sediment levels, it alters plant and benthic invertebrate communities (Li *et al.* 2009), and represents loss of suitable habitat for most waterbird species (Gan *et al.* 2009), including all of those listed in Table 1. It has previously been identified as a significant threat to waterbirds on the Jiangsu coast (Tong *et al.* 2012). If left unchecked, the observed rapid rate of spread of *Spartina* is likely to remove open mudflat habitat from a significant proportion of the intertidal area surveyed during this study, at all three study sites, over the

next few years. There is an extensive literature on the spread and control of invasive *Spartina* (summarised by Brown and Raal, 2013), and methods developed elsewhere to eradicate this invasive non-native plant should be implemented rapidly at all key waterbird sites along the southern Jiangsu coast to prevent the otherwise inevitable loss of crucially important habitats.

Trapping and poisoning of waterbirds

During this study, significant threats to waterbirds were posed by fine-mesh trammel fish nets, and by the apparent deliberate use of poison baits. Both appear to have been responsible for the deaths of Spoon-billed Sandpipers, but the total numbers of birds killed in the study area in a single year are unknown. Other incidents of deliberate poisoning of shorebirds, apparently for human consumption, have been recorded at Dongling in October 2012 (Tong *et al.* 2012), using poisoned shrimps or mealworms as bait, and, subsequent to this study, at Yangkou in April 2016 involving 20 poisoned Little Curlew (Townshend 2016). A further three Spoon-billed Sandpipers (one juvenile, two adults) were found dead in fishnets in September 2015 (Crighton 2016).

The concentration of Spoon-billed Sandpipers and Spotted Greenshank at these study sites, particularly Tiaozini, and the indiscriminate nature of poisoning and trapping (whether intentional or not) mean that the death of a significant proportion of the world population of either species could easily result from just one incident of either of these threats. Action to remove the threat of deliberate poisoning of birds anywhere near these key waterbirds sites, and to remove the threat of dangerous types of net are therefore also both urgent conservation priorities. Methods of redesigning, modifying, or replacing types of fishing nets that are dangerous to birds should be urgently investigated, implemented and enforced. Greater enforcement of provincial laws banning the hunting of protected bird species is required.

We recorded only limited use of tall mist nets clearly aimed at *deliberate* trapping of waterbirds during the study. However, one serious incident of illegal mist-netting, involving 'several kilometres of net on the upper foreshore' was observed at Yangkou, in an area supposedly protected for Spoon-billed Sandpipers, in October 2013 (Thomas 2014). In addition, an old, apparently abandoned, tall mist net containing 30 dead birds was recorded at Tiaozini in 2013 (Tong *et al.* 2014). Large-scale use of mist nets for bird hunting has been reported as widespread in other coastal regions of China (Barter 2002, Martinez and Lewthwaite 2013) and is a potential risk in southern Jiangsu that should be monitored and guarded against.

Collision with, or displacement by, man-made structures

Although we recorded no direct evidence of collision with or displacement by wind turbines or other industrial structures, the potential for these impacts should be considered and investigated with future research. The regularly observed proximity of shorebirds to turbines at Yangkou suggests that displacement may not be the biggest threat these birds currently face on this coast.

Environmental pollution

The east coast is the most economically developed area of China, and highly industrialized. Chemical discharges (deliberate or accidental) can pollute the coastal environment (Melville 2015) and may kill benthic organisms (Li and Daler 2004), thereby potentially affecting availability of food for waterbirds. Chemical pollutants may also be directly toxic to birds and may bioaccumulate through the food chain (Smith *et al.* 2009). Although there is currently no evidence of a direct impact of environmental pollution on waterbirds in Jiangsu, waste water discharged from the Xiao Yangkou chemical industry complex in Rudong County is reported to have led to a decrease in benthic organisms on the adjacent intertidal flats (Qing and Song 2015). Thus, the potential impact of pollution on waterbirds, and the intertidal benthic organisms on which they feed, should be further investigated in Jiangsu.

Conservation recommendations

Retaining and maintaining open intertidal mudflat habitat along the southern Jiangsu coast is the clear conservation priority here, with Tiaozini being the single most important site to consider. Currently none of the coastal habitat studied is under any formal protection. The Yancheng National Nature Reserve does include intertidal habitat to the north of Tiaozini but currently does not include any of the key intertidal mudflats surveyed, and which are of critical importance to the globally important populations of waterbirds described, here. We urge the Provincial Government of Jiangsu to immediately reassesses the land claim and development plan of the Dongtai, Rudong and Dongsha tidal flats (Zhang *et al.* 2011), in the light of evidence for the global importance of these areas for threatened waterbird conservation. Future environmental impact assessment of any proposed land claim project in this region should consider the potential detrimental impacts of development on Spoon-billed Sandpiper, Spotted Greenshank and all other threatened species recorded. Environmental impact assessment should also consider the likely massive changes in hydrology and sediment dynamics, and their ecological consequences, that will occur in the surrounding region after any further large-scale land claim. Instead of further land claim projects, we urge the establishment of one or more new, effective and enforced protected areas for waterbirds along the southern Jiangsu coast as a conservation imperative. The protected status needs to result in the provision of large areas of open mudflat for foraging, safe roosting areas behind the current seawalls, and the removal and future prevention of all the serious direct threats to waterbirds identified here (trapping, poisoning, industrial pollution, spread of *Spartina*). The entire area surveyed at Tiaozini should be a priority for inclusion in such a protected area. These are extremely high conservation priorities not just for Jiangsu and China, but for the entire East Asian-Australasian flyway, and have been recognized as such called for by international conservation organisations (Price *et al.* 2016).

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