

Results from Marking of Sandwich Terns (*Sterna sandvicensis*) with Colour Rings and Radio Transmitters at Pomorie Lake

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Abstract: The paper presents information on marking with colour rings of Sandwich terns (*Sterna sandvicensis*) in the area of Pomorie Lake. The ringed birds are from Sandwich tern colony nesting on artificial islands created by Green Balkans NGO. This is the first marking in Bulgaria of Sandwich terns with colour rings and it was done in the period 2010-2012. In total 7 adult (nesting) and 264 juvenile birds have been marked. Data on follow-up observations of the ringed birds in the area of Pomorie Lake and abroad are presented. Within the study at Pomorie Lake are registered observations of Sandwich terns, marked with colour rings in Italy – Comacchio salt pans, Po Delta, Emilia-Romagna region. The data on place and date of marking of the foreign individuals is summarized after feedback information by Italian scientists. Seven adult and one juvenile birds have been tagged with radio-transmitters that provide opportunity for distant study of the birds. Outputs of that study are limited but provide important experience in planning of future efforts on that type of studies.

Key words: Sandwich tern, colour rings, ring recovery

Introduction

Sandwich tern (*Sterna sandvicensis* Latham, 1787) is a seabird of the tern family Sternidae with 3 subspecies: *Sterna sandvicensis sandvicensis* Latham, 1787 found at the coasts of Western Europe, North-western Mediterranean sea, Black and Caspian sea; *Sterna sandvicensis acuflavida* Cabot, 1847 found along Eastern coast of USA and Caribbean islands, south to Bahamas, Cuba and Yucatan, occasionally in Western Palearctic; *Sterna sandvicensis eurygnatha* Saunders, 1876, found at the islands along Venezuela and coasts of Northern and Eastern South America south to Patagonia (CRAMP 1983).

European population is estimated at 120-140 000 breeding pairs with largest populations in Ukraine, United Kingdom and the Netherlands (TUCKER, HEATH 1994). For Black sea region highest number of breeding pairs are reported for Ukraine – Tuzlov Liman Complex (7400 pairs), Tendrivska

Bay (8300-28800 pairs) and Eastern Syvash (5103 pairs) in 1998-1999 (STOILOVSKY 2003).

In Bulgaria Sandwich tern was first recorded as a breeding species on 12. 06. 1984 at Atanasovsko Lake (SIMEONOV 1986). Maximum number of breeding pairs for Atanasovsko Lake is 1269 in 1994 (DIMITROV *et al.* 2005) but in last four years (2009-2012) no breeding is recorded there (KONSTANTIN POPOV, pers. comm.).

Number of breeding pairs at Pomorie Lake starts from 5 in 1998 (GRADEV 2003) and gradually increase through the years to 1500 in 2009 (GREEN BALKANS 2010) as a result of conservation measures for restoration of nesting habitat by Green Balkans NGO. In the period 2007-2012 the number of the breeding colony at Pomorie Lake are stable in the range of 1300-1500 pairs.

Study of birds through different ways of mark-

ing is a widespread technique and bird ringing (banding) is one of the oldest of these. This method was introduced in Bulgaria as early as 1928 (NANKINOV 1988; 1997). Bird ringing schemes in Bulgaria are coordinated by Bulgarian Ornithological Centre – separate department at Institute of Biodiversity and Ecosystem Research of Bulgarian Academy of Sciences. Standard ornithological rings are metal but inscribed text on these is not readable from distance even with high magnification optical equipment. To compensate that setback colour plastic rings can be used – either as a combination of several colours or with inscribed text or number code.

The pilot colour ringing scheme for marking of Sandwich terns in Bulgaria was started by Green Balkans NGO in 2010 at Pomorie Lake: the only breeding site in the country in past 5 years. The aim of the study was to collect information about dispersal of chicks from the Pomorie colony and to study migratory routes to wintering sites. Additionally return to natal colony of birds hatched at Pomorie Lake colony was investigated. Results are presented in current paper together with data from observations of Sandwich terns at Pomorie Lake in Bulgaria marked within Italian colour ringing scheme.

Material and Methods

Sandwich tern colony at Pomorie Lake, Bulgaria is occupying artificially created islets at a distance of 180 m off the Southern coast of the lagoon.

In Bulgaria Sandwich tern is protected species listed in Annexes II and III of Bulgarian Biodiversity Act and for trapping of the birds special permit was procured from Ministry of Environment and Water. All birds tagged within the study were trapped within conditions of Permit No 254 / 23.03.2010 issued by Ministry of Environment and Water. The colour ringing program for Sandwich terns in Bulgaria was consulted with national (Bulgarian Ornithological Centre - BOC) and European (EURING-European Union for Bird Ringing) coordinators for bird ringing. During the study three codes were used: green ring with a white 3 letter code; blue ring with a white 3 letter code and orange ring with a black 3 letter code. All letter codes start with letter 'C'. Format for ringing is: colour ring is attached on left leg and standard metal ring (size 3) is placed on right leg. Colour rings used within the study were supplied

by Polish producer INTERREX and had following sizes: inner diameter – 5.5 mm and height – 12.5 mm. During the three years of the current study totally 264 chicks and 7 adults were tagged with colour rings. Monitoring of ringed birds was done using Nikon Fieldscope ED 82 with zoom eye piece 25x-75x. Average distance for reading codes of colour rings was 150-200 m.

Trapping and ringing took place in the colony just before sunrise and was limited to 20 min to lower disturbance and abandoning of chicks by adults. The chicks were surrounded to stop them swim away from nesting islet and get drowned at deeper areas of the lagoon. Approximate age during ringing was 20 days – at that age tarsus has already reached the size of an adult. 29 chicks were tagged with green ring with white 3 letter code on left leg and standard metal ring on right leg on 23rd June 2010. The same format for marking was applied again on 6th July 2011 for 122 chicks and 26th June 2012 for 33 chicks. Different code was used for 80 chicks marked on 26th June 2012 - orange rings with black 3 letter code.

Different trapping method was used for adult birds: vertical mist nets at dusk plus decoys and sounds. On 2nd June 2011, 7 adult Sandwich terns were tagged with blue colour rings with 3 letter code on left leg and standard metal ring on right leg.

In parallel to colour ringing program pilot for Bulgaria radio-telemetry study of Sandwich terns was done. In total 8 individuals have been radio-tagged: 7 adults (blue rings with white 3 letter codes) and one chick (green ring with white code CFZ). Radio-tags we have used were produced by Biotrack Ltd (UK), model Pip Ag357 with silver-oxide battery and weight of 4.5 g. Frequencies were around 150 MHz and transmitter antenna had 20 cm length. Expected life span for the tags was up to 6 months. Selected attachment method was back-mounted glue-on similar to that recommended for Charadriiformes (WARNOCK, WARNOCK 1993). To achieve longer attachment life to the bird back the tag was stuck to gauze for larger gluing surface. Feathers were trimmed before gluing and the skin was degreased with alcohol. Cyanoacrylate Superglue plus Superglue activator was used. Radio-tracking was done by using 4 element Yagi antenna (Televilt Y-4FL) and radio-receivers (ICOM IC-R6).

Results and Discussion

19 (7.2%) of colour ringed Sandwich tern chicks at Pomorie Lake colony have been recovered dead in the proximity of the colony. The number of dead recoveries varied through the years. One dead chick was recovered from the 29 tagged in 2010: that is 3.45 % mortality rate. In 2011 the mortality rate of ringed chicks from the colony increased to 8.2 % (10 dead recoveries from 122 ringed chicks) but in 2012 it decreased to 7.08 % (8 dead recoveries from 113 tagged chicks). Two of the dead recoveries in 2011 have been found 14 days after ringing outside of the nesting islet. First one (green ring, white code CCT) was found at the Southern coast of Pomorie Lake at a distance of 470 m from hatching site. Second one (green ring, white code CLN) was recovered at even larger distance (1950 m) on one of the more distant internal dikes at Pomorie Lake. All other 17 chicks have been discovered at nesting islet in September same year of ringing during maintenance activities at the site.

18 individuals from all 271 colour ringed Sandwich terns at Pomorie Lake have been observed alive representing 6.6% recovery rate. 16 of the live recoveries have been made at the site of ringing (Pomorie Lake) and 3 have been made abroad. One of the recovered birds was recorded both at Pomorie Lake and abroad. 16 of the recoveries were chicks hatched at Pomorie Lake and 2 were adults trapped at the same site. All live recoveries are presented in Table 1.

First observation of ringed bird from Pomorie was made in October 2010 when juvenile with the green ring CAD spent 7 days close to the natal colony after being tagged on 23 June same year. Most likely the bird has returned to natal colony before starting the autumn migration to wintering site after spending 2-3 months post fledgling dispersal period along Black sea coast. It was the only one marked in 2010 recovered in the same year. Sandwich tern with most numerous recoveries (green ring, white code CAS) had 5 records over 2 years close to nesting islet: 28th July 2011; 12th April 2012; 6th, 7th and 8th June 2012. Last three observations suggest nesting in the colony of origin with high probability. Two of adult birds ringed at Pomorie Lake in 2011 were observed at site of ringing in autumn 2012. Ringed bird from the study observed latest date in the year at Pomorie Lake was on 4th November 2011 when

chick ringed on 6th July 2011 was recorded (green ring, white code CCF; metal ring 3-08950).

Three of the chicks tagged in the study were observed abroad. One of the chicks ringed in 2010 (green ring, white code CBF; metal ring 3-11853) has been observed on Adriatic coast of Italy at Molfetta, Bari (coordinates: N41°12' E16°36') by Mr. Angelo Nitti on 6th May 2012. That was 683 days after been ringed as a hatchling at Pomorie colony. Second recovery of that same bird was registered almost 2 months later (4th July, 2012) at Pomorie in close proximity of the colony. The distance between Pomorie, Bulgaria and Molfetta, Bari in Italy is 925 km. There are two options for the observation in Italy – wintering site or passing during spring migration on its way back to site of origin at Pomorie.

Earliest international recovery of Sandwich tern from the current study was registered at Acre in Israel on Eastern coast of Mediterranean sea (coordinates: N36°22'23.88"; E31°11'57.41"). The bird was ringed in the nest at Pomorie Lake on 6th July 2011 (green ring, white code CKN; metal ring 3-16825) and observed 212 days later on 3rd February 2012 by Mr. Amir Ben Dov on the Israeli coast. The distance between two sites is 1253 km. The observation in Mediterranean sea in the beginning of February is most likely to be of a wintering bird confirming existing data about wintering sites of Black sea Sandwich terns (CRAMP 1983).

Last international recovery of birds tagged within the current study was made in September 2012. Chick marked at Pomorie on 26th June 2012 (orange ring, black code CPC; metal ring 3-11865) was observed twice on Western coast of Italy at Bocca di Serchio, Vecchiano, Pisa (coordinates: N43°47' E10°16'). Observations were made on 26th September, 2012 by Mr. M. Marcone and on 28th September, 2012 by Mr. A. Quaglierini. Distance between site of origin and observations is 1415 km and elapsed time is 90 days. This recovery is made at Liguria sea coast and it is the westernmost of all birds originating from Pomorie Lake colony. To compare diversity of movements another chick ringed at same site and day (orange ring, black code CAN; metal ring 3-18265) with approximately same age was observed at Pomorie Lake 7 days later (5th October 2012) after that one observed on Western Italian coast.

Within the current study seven birds tagged abroad have been observed at the target area of

Table 1. Alive recoveries of Sandwich terns tagged with colour rings at Pomorie Lake within the study

No	Ringing date	Colour ring	Metal ring	Recovery date	Place of recovery
1	23.6.2010	Green-CAA	3-11834	06.5.2012	Pomorie Lake
2	23.6.2010	Green-CAB	3-11835	07.06.2012; 05.07.2012	Pomorie Lake
3	23.6.2010	Green-CAD	3-11837	23-30.10.2010	Pomorie Lake
4	23.6.2010	Green-CAF	3-11838	28.07.2011; 04.08.2011	Pomorie Lake
5	23.6.2010	Green-CAJ	3-11840	14.06.2011; 05.07.2012	Pomorie Lake
6	23.6.2010	Green-CAS	3-11845	28.07.2011; 12.04.2012; 06,07,08.06.2012	Pomorie Lake
7	23.6.2010	Green-CBF	3-11853	06.5.2012	Molfetta, Bari, Italy
				04.7.2012	Pomorie Lake
8	23.6.2010	Green-CBJ	3-11854	25, 27.09.2012	Pomorie Lake
9	06.7.2011	Green-CCF	3-08950	04.11.2011	Pomorie Lake
10	06.7.2011	Green-CJJ	3-16807	06.9.2012	Pomorie Lake
11	06.7.2011	Green-CJS	3-16812	30.8.2011	Pomorie Lake
12	06.7.2011	Green-CKN	3-16825	03.2.2012	Acre, Israel
13	06.7.2011	Green-CLB	3-16832	05.8.2011	Pomorie Lake
14	06.7.2011	Green-CNT	3-16858	22, 23.09.2011	Pomorie Lake
15	02.6.2011	Blue-CAF	3-03825	06.9.2012	Pomorie Lake
16	02.6.2011	Blue-CAJ	3-03827	31.10.2012	Pomorie Lake
17	26.6.2012	Orange-CAN	3-18265	05.10.2012	Pomorie Lake
18	26.6.2012	Orange-CPC	3-11865	26, 28.09.2012	Bocca di Serchio, Vecchiano, Pisa, Italy

International recoveries of Sandwich terns from Pomorie Lake colony



Fig. 1. Map of international recoveries of Sandwich terns, hatched and ringed at Pomorie Lake in period of the study

the study: Pomorie Lake, Bulgaria. All the birds have been ringed at Western Adriatic coast by Mr. Adriano Talamelli who is running a colour ringing program at Salina di Comacchio at Po River Delta in Ferrara Province, Italy. On 20th April 2007 a Sandwich tern with a red ring and white code FJ was observed at Pomorie Lake. The feedback information provided kindly by BOC revealed it was trapped by Mr. Adriano Talamelli on 14th September 2004 at Salina di Comacchio, Ferrara, Italy (coordinates: N44°39'44.6" E12°11'54.38"). Distance between two sites is 1262 km and elapsed time between trapping and recovery at Pomorie - 947 days. That same bird has been observed twice before turning up at Pomorie: at Molfetta, Bari, Italy (coordinates: N41°12' E16°35') on 4th August 2006 and again at site of ringing in Salina di Comacchio, Ferrara, Italy on 27th September 2006. Last update on movements of this Sandwich tern showed it has traveled to Western Atlantic coast of Africa where it was observed on 23rd November 2007 at Embouchure Louerr in Morocco (coordinates: N28°10' E11°52'). From all observed birds within the current study this one was recorded at greatest distance. Other interesting fact is it has been observed at Molfetta, Bari in Italy – same site where bird originating from Pomorie was observed.

Second observation of Sandwich tern ringed at Salina di Comacchio in Italy was made on 6th April 2011 with repeated records at Pomorie Lake on 17th May 2011; 15th June 2011 and 7th June 2012. The bird was trapped and ringed with a blue ring, white code PZ on 27th March 2007 and estimated age was after 2nd year. More observations of that same individual were recorded in the period between ringing and recoveries at Pomorie. These were all at the Northern Adriatic Sea. On 19th October 2008 at Mirna River Mouth in Croatia (coordinates: N45°11'; E13°33') on Eastern Adriatic coast and twice at Isonzo River Mouth, Staranzano, Gorizia in Italy (coordinates: N45°43'55.78"; E13°33'47.88'): 23rd October 2009 and 28th September 2010. Records during breeding season at Pomorie Lake and observations in the colony suggest it was breeding there.

Third Sandwich tern was tagged at Salina di Comacchio on 11th September 2007 at an approximate age of 1st calendar year with yellow ring, black code IBD. That individual was observed 4 times at Pomorie Lake including during the breeding season: 16th April 2011; 18th April 2011; 14th June 2011

and 6th May 2012. Dates of observations and time and age of trapping in Italy suggest that it is possible that the Sandwich tern is originating from Pomorie and was trapped at Salina di Comacchio during its autumn migration to wintering site.

Fourth individual was ringed at Salina di Comacchio on 14th April 2010 at an age more than second calendar year with yellow ring, black code IZP. It was observed 5 times at Pomorie Lake: 4 times in 2011 (28th July and 1st, 2nd, 3rd August) and once in 2012 on 7th June. Last observation suggests the bird was breeding at Pomorie Lake colony. Additional recoveries of that individual were recorded by Mr. Marco Basso at two other sites both on coast of Venice lagoon: Malamoco (coordinates: N45°21' E12°20') on 14th October 2011 and Pellestrina (coordinates: N45°16' E 12°18') on 3rd November 2011. All records confirm the importance as staging site of the Western Adriatic coastal lagoons for Black sea populations of Sandwich terns.

Fifth individual was a Sandwich tern marked at Salina di Comacchio on 29th April 2009 at an age more than second calendar year with yellow ring, black code ITP. It was observed once at Pomorie Lake colony in 2012 on 7th June suggesting its breeding at the target area. In the period between its marking and recovery at Pomorie Lake colony this bird was recorded 5 times at Mouth of Isonzo River in Italian province of Gorizia (coordinates: N45°43'55.78"; E13°33'47.88') during autumn migration on 23rd October 2009, 5th, 12th and 28th September 2010, and 4th October 2010 by Mr. S. Candotto.

Sixth colour-ringed Sandwich tern marked at Salina di Comacchio on 20th September 2006 with blue ring, white two letter code HN at an age of more than first calendar year. Two recoveries of that individual were recorded in Italy: at Salina di Comacchio on 29th September 2006 and at Molfetta, Bari (coordinates: N41°11' E16°35') on 20th August 2008. On 7th June 2012 this bird was observed at Pomorie Lake colony together with other three individuals marked at Salina di Comacchio: yellow rings with black three letter code ITP and IZP and blue ring with white two letter code PZ.

The longest living of all Sandwich terns from the study was an individual found dead at Pomorie Lake on 29th April 2012 with a metal ring U-64902, ringed at Salina di Comacchio in Italy on 4th April 2006 in its 1st calendar year. The bird was found dead with a cut in the chest but its origin was not

identified. At the time of the finding the approximate age of the bird was more than 6 years.

In 2011 a pilot radio telemetry study of Sandwich terns in Bulgaria was held. 7 adults and 1 chick from Pomorie Lake colony have been tagged with radio transmitters. Radio signals have not been detected regularly despite every day efforts. Only single bearings have been detected and none triangulations thus the quality of the detections was low. Given the short range of signal recorded detections brought information mainly for presence/absence in the colony. Most of the telemetry effort was made from Southern coast at an altitude of about 5 m. Longest duration of signal detected from radio transmitters was 42 days for 2 adult Sandwich terns (blue rings CAB and CAC). Shortest time of detection was 5 days of a chick from the colony (green ring CFZ). The signal was lost after the 5th day and most probable reason was leaving of nesting site by the chick. Numerous obstacles have been faced during the study limiting significantly the obtained results. These were following:

Dynamics of Sandwich terns during feeding – Sandwich terns can travel up to 54 km from colony during foraging trips (PERROW 2011). During our

study we have attempted detection only from the ground and not from boat or air plane.

Short range of signal from radio transmitter - maximum range of used radio-transmitters was 1-2 km.

Aggression of Sandwich terns towards radio-transmitters – Sandwich terns are known to be quite persistent in attempting to remove foreign objects from themselves. Attachment of tag outside of reach of tern's beak is of great importance to lower the chance for its removal by the bird.

Dropping of radio-transmitter – Sandwich terns are catching their prey (fish) by diving in the water. To sustain that pressure strong attachment of the tag to the tern's back is needed and thus cyanoacrylate glue is used though this can break off, too. Alternatively 2 component epoxy glue can be used as it is more elastic than cyanoacrylate.

Conclusions

The data from colour ringing study reveals a close relation between Adriatic and Black sea populations of Sandwich terns. Importance of saline coastal lagoons as breeding site and staging area during mi-



Fig. 2. Map of international recoveries of Sandwich terns ringed at Salina di Comacchio, Italy observed at Pomorie Lake

Table 2. List of Sandwich terns tagged with radio transmitters

No	Colour ring	Metal ring	Frequency	Date of tagging	Last signal
1	CAA - Blue	3-03821	150.677	02.6.2011	11.6.2011
2	CAB - Blue	3-03822	150.629	02.6.2011	14.7.2011
3	CAC - Blue	3-03823	150.616	02.6.2011	14.7.2011
4	CAD - Blue	3-03824	150.245	02.6.2011	11.7.2011
5	CAF - Blue	3-03825	150.597	02.6.2011	11.6.2011
6	CAH - Blue	3-03826	150.572	02.6.2011	11.6.2011
7	CAJ - Blue	3-03827	150.552	02.6.2011	11.6.2011
8	CFZ - Green	3-16878	150.530	06.7.2011	11.7.2011

gration is confirmed by multiple records at Pomorie Lake, Bulgaria and Salina di Comacchio, Italy. 88.89 % (16 out of 18 individuals) of recoveries of colour ringed Sandwich terns from Pomorie Lake colony have been made at natal site. 68.75 % (11 out of 16 individuals) of Sandwich terns tagged at Pomorie Lake were observed at site of ringing during autumn migration in the period August-November. Probable reason for such high percent of recoveries during that season might be lower number of Sandwich terns in these months thus providing better opportunity for detailed observation of individuals. International recoveries of terns from Pomorie were from different sites of Mediterranean sea suggesting diversity of wintering sites. All birds marked abroad and observed at Pomorie Lake during the study have been ringed at Salina di Comacchio. None of these were with confirmed origin in Italy as these were ringed at an age more than 1 year. It would be highly advisable some chicks originating from colonies at Salina di Comacchio in Italy to be tagged with colour rings in order to study interconnections of both sites. Sandwich terns are coastal birds and all observations of marked birds were on sea shores. More intensive monitoring is needed at other Balkan countries coasts (Greece, Turkey, Albania, Montenegro, Croatia and Slovenia) to verify migratory routes along Balkan Peninsular sea coast and special attention should be paid at river mouths and coastal lagoons. River mouths are important feeding sites especially during migration confirmed by data from observations at river mouths of Mirna, Croatia; Izonzo and Serchio,

Italy; and Lourre, Morocco. Largest distance covered by bird observed at Pomorie is 3920 km (individual FJ, ringed in Italy and observed at Pomorie Lake and Lourre, Morocco) in 213 days.

In future radio-telemetry studies of Sandwich terns it is highly recommendable tracking in the sea to be planned either by boat or plane. Terrain around Pomorie Lake is low and there are very few higher posts where greater range of detection can be achieved. Small allowed weight of the radio-transmitters leads to low power source that significantly limits the range of signal. Detection effort should be with as high as possible regularity especially in first days after tagging. Irregular observation in 2012 made by boat showed that Sandwich terns can feed as far as 28 km (Ropotamo River mouth) from nesting site at Pomorie Lake (POPOV pers. comm.).

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