HIGH DENSITIES OF THE FRENCH COASTAL ENDEMIC BLUETHROAT (*CYANECULA SVECICA NAMNETUM*) REVEALED IN INTERTIDAL REED BEDS AND CONSERVATION PERSPECTIVES TOWARDS SEA LEVEL RISE

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Résumé.— *Fortes densités de la Gorgebleue endémique du littoral français (*Cyanecula svecica namnetum*) révélées dans les roselières intertidales et perspectives de conservation au regard de l'élévation du niveau marin.*— Notre étude porte sur l'estimation de la densité au sein des roselières intertidales de l'estuaire de la Gironde (France) de la sous-espèce de Gorgebleue à miroir endémique du littoral atlantique français (*Cyanecula svecica namnetum*). Nous avons analysé des données de points d'écoute collectées durant le début de période de reproduction grâce à 94 stations distribuées sur 100 hectares. L'analyse des données intégrant la probabilité de détection des oiseaux en fonction de la distance de détection (distance sampling) nous a permis d'estimer une densité moyenne de 20,5 ± 3,7 mâles pour 10 hectares (14,4 – 29.5 dans l'IC à 95 %). Jusqu'à ce jour, de telles densités n'ont jamais été documentées pour ce taxon endémique au statut de conservation préoccupant compte-tenu de son relatif haut degré de spécialisation en termes de ressources trophiques exploitées, de son aire de répartition et de ses effectifs limités. Malgré leur singularité compte tenu de la taille limitée de la zone d'étude, nos résultats confirment l'importance des marais côtiers pour *C. s. namnetum*. Au vu des importantes altérations des habitats littoraux inhérentes à la montée du niveau marin déjà observées sur les zones de reproduction de *C. s. namnetum*, nos résultats mettent en lumière l'intérêt à développer des stratégies de conservation pour les habitats exploités par le taxon, intégrant les rôles-clés potentiels des zones arrière-littorales pour compenser les pertes d'habitats inhérentes aux effets des changements globaux en cours et à venir.

Summary.— Our study deals with density estimation in intertidal reed beds of the Gironde estuary (France) of the French endemic subspecies of Bluethroat breeding along the Atlantic coast (*Cyanecula svecica namnetum*). We analysed count point data collected during the beginning of the breeding period, with information gathered from 94 stations distributed over 100 hectares. Analysis of data integrating bird detection probability as a function of the detection distance (distance sampling) allowed us to estimate an average density of 20.5 ± 3.7 males for 10 hectares (14.4 – 29.5 within the 95 % CI). Up to now, no equivalent densities have been documented for this endemic taxa which is of conservation concern given its relatively high degree of specialization in terms of ecological resources exploited and its limited range and numbers. Despite their singularity given the limited size of the study area, our results confirm the particular importance of coastal marshes for *C. s. namnetum*. In view of strong alterations of coastal habitats due to the rise in sea level already observed in the breeding grounds of *C. s. namnetum*, our results highlight the interest in developing conservation strategies for habitats exploited by the taxa, integrating the potential key roles of back littoral areas in order to compensate losses of habitats due to the ongoing and forthcoming effects of global changes.

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The Bluethroat (*Cyanecula svecica*) is a Holarctic migratory songbird of conservation concern in Europe (Tucker & Heath, 2004). This widely distributed passerine is a complex polytypic species with 11 currently acknowledged subspecies distributed in Europe, Asia and Alaska (ten subspecies documented by Cramp, 1988 to which must be added *azuricollis*, Svensson, 1992; Peiro, 1997; Johnsen *et al.*, 2006; Arizaga & Alonso, 2015). Some populations of the species have been considered by several authors to be under high risk of extinction due to global changes (see Huntley *et al.*, 2007). One subspecies, *C. s. namnetum* (differing clearly from all other subspecies in microsatellite allele frequencies, see Johnsen *et al.*, 2006) is endemic to the Western Atlantic French coast with restricted range (see Fig. 1) and numbers (only 8,000 to 12,000 pairs, Caupenne *et al.*, 2015). In its breeding grounds, particularly along coastal areas or in grounds located near to the coast, *C. s. namnetum* mainly breeds in the bushes of saltpans slopes,

reed beds or sedge meadows (Marquet *et al.*, 2014; Caupenne *et al.*, 2015). Locally, and more particularly in inland areas where the taxa has tended to extend since the mid-1990s, *C. s. namnetum* can also breed in dry habitats of agricultural lands where it exploits in particular fields of rapeseed (De Cornulier *et al.*, 1997). Up to now, maximal densities documented for the subspecies concern exclusively coastal or huge back littoral marshes and range from 2.6 to 11.9 pairs for 10 hectares (2.9 – 11.9 pairs / 10 ha in the Guérande saltpans, Taillandier *et al.*, 1985; 5.4 – 6.6 pairs / 10 ha in the Brière marshes, Marchadour & Séchet, 2008; 3.4 pairs / 10 ha in the marais Poitevin, Joyeux *et al.*, 2010; 7.5 – 12 pairs / 10 ha in the region of the marshes of the "Pertuis charentais": Ré island, Oléron island and Moëze-Brouage marshes, Eybert & Questiau, 1999). Despite its recent extension, *C. s. namnetum* remains a Bluethroat subspecies breeding in a reduced distribution area, with a restricted population size and largely dependent on Atlantic coastal marshes for reproduction and for energy-demanding events such as migration (Arizaga *et al.*, 2015) or moult (Musseau *et al.*, 2017). Different works highlighted the major role of subspecies genetically distinct from the others for species conservation (Zink, 2004; Phillimore & Owens, 2006) illustrating the importance to develop conservation strategies for endemic subspecies such as *C. s. namnetum*. Currently, different coastal marshes of the Atlantic coast are facing severe damages due to global changes (rising water level and erosion dynamics, see Musseau *et al.*, 2017), making the future of these areas uncertain for the conservation of birds such as *C. s. namnetum*. Given these threats occurring in coastal wetlands, we decided to set up a monitoring plan in intertidal reed beds of the Gironde estuary in order to start documenting the importance of these habitats for the reproduction and the conservation of this taxa. We thus decided to organize a survey using a distance sampling method adapted to count points, allowing analysis of male densities taking into account bias detection of birds due to their distance from the observer.

MATERIAL AND METHODS

STUDY SITE

The study was carried out on the North bank of the Gironde estuary (France, 45°25'51.75"N, 00°46'9.30"W, see Fig. 1) in the heart of a long coastal ecocomplex of the mesohaline region which is subjected to tidal influences. This area which is the largest ecocomplex subjected to tidal influences of the estuary covers approximately 1,500 hectares and is over 25 kilometres in length, with a width ranging from a few tens metres to over a kilometre. This large area consists of mudflats, sub-halophilic meadows, reed beds and numerous flooded depressions created for waterfowl hunting. The site is mainly owned by the "Conservatoire du Littoral" and managed by the "Conservatoire Régional d'Espaces Naturels de Poitou-Charentes". We focused our study in the largest areas of these intertidal marshes, located between two municipalities (Chenac-Saint-Seurin-d'Uzet and Mortagne-sur-Gironde) in three different sites covering a total area of around 100 hectares. Sampled sites were characterized by an identical vegetative cover dominated by reed beds (*Phragmites australis*) including patches of Sea Couch meadows (*Elytrigia acuta*) and bordered along the coastline by a strip of Bulrush bed dominated by *Bolboschoenus maritimus*.

SAMPLING METHOD

Despite line transects tend to be generally more efficient than count points in distance sampling (see Buckland, 2006), count points have been used given the difficulties to circulate across dense reed beds. Count points were distributed systematically (from a start point randomly chosen) throughout the three sampled sites. Given the relatively small surface of each site, we decided to distribute count points following a 100 m grid as tested by Buckland (2006) in Scotland to estimate densities of different species of songbirds. We thus defined a total of 94 count points (31 each for two sites and 32 for the third site). Each count point has been sampled walking in the study site across patches of meadows distributed between the different patches of reed beds. Given the relative proximity of the different count points, some birds may have been detected from more than one point, but this is known to be of little consequence in distance sampling analyses as demonstrated by Buckland *et al.* (2001) and Buckland (2006). Count points were not equally sampled owing to the possible presence of water within the points. For each count point we then registered the sampling effort (proportion of the count point sampled) in order to weight the number of contacts by the proportion of the count points effectively sampled. For instance, in the case of count points bordering the estuary, half of the point corresponding to a surface of water, the sampled proportion for the point was 50 %. A sampling effort of 0.5 was thus recorded in the data set, allowing to product density

analyses weighted by this value. Each count point has been visited over three periods in 2013: from 3rd to 17th April (session 1), from 2nd to 9th May (session 2), and from 1st to 10th June (session 3). Observations were carried out from local time of sunrise, for four hours and in standard conditions (wind speed < 10 km/h and temperature felt > 10°C). At each count point, birds were counted using the « snapshot » method (see Buckland *et al.*, 2001) consisting in recording bird positions at a snapshot moment occurring precisely three minutes after the observer's arrival at the count point (the three minutes before the snapshot moment allowing to the observer to assess the potential number of birds around the point). All surveys were carried out by the same observer, rigorously trained in distance measurement in different vegetation configurations and identification of Bluethroat vocalisations. Given the nature of the vegetation (dense reed beds), we only recorded singing males in order to homogenize detection probabilities of birds (non-singing males being not detectable as singing males in dense vegetation areas).
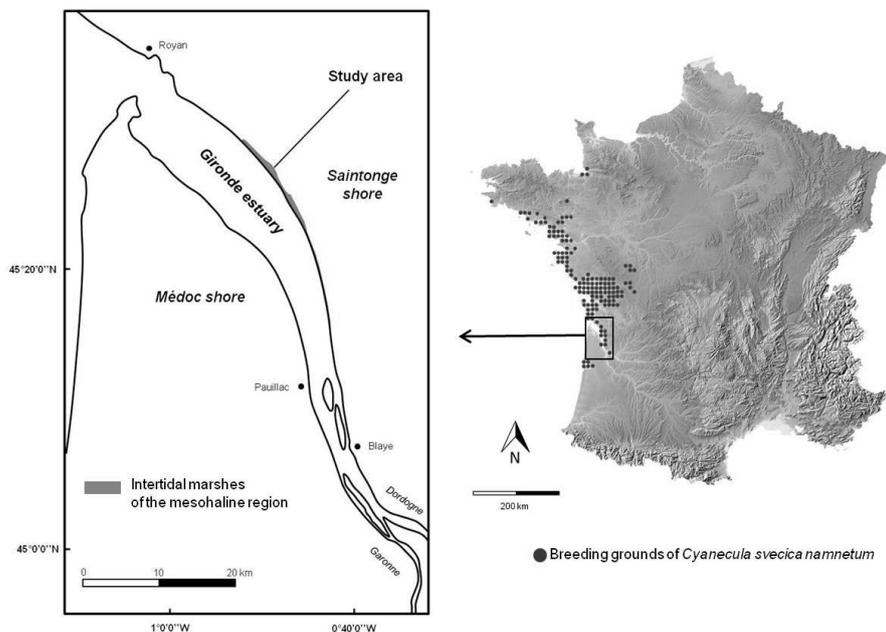

Figure 1.— Location of the study site and distribution of *Cyanecula svecica namnetum* (grey spots) during the breeding season (years 2005-2012, according to Issa & Muller, 2015).

STATISTICAL ANALYSES

Bird density was calculated using the DISTANCE program, version 6.0 (Thomas *et al.*, 2005). As recommended by Buckland *et al.* (2001), densities were assessed truncating distance intervals with detection biased. We then truncated low abnormal detection rate within the first metres of the sampled point and low detection rate among the longest distances (see details in "Results"). Densities were assessed using basic key functions and series expansion recommended by Buckland *et al.* (2001). The fit of models to data has been tested by the mean of a Chi-square goodness of fit test and model comparisons have been done using Akaike's information criterion (Akaike, 1974; Buckland *et al.*, 1997).

RESULTS

For the 94 points sampled, we recorded 71 contacts during session 1 (3rd to 16th April), 33 during session 2 (2nd to 9th May) and 58 during session 3 (1st to 10th June). The number of contacts thus differed significantly between the 3 sampling periods, highlighting, as described by Merilä & Sorjonen (1994), a level of Bluethroats' vocalisations decreasing dramatically during females' egg-laying. To avoid downgrading analyses including sampling periods with a low detection probability of birds, we decided to focus analyses on the data collected during the first period,

corresponding to the best period to detect singing males (see Eybert *et al.*, 2004). Distances recorded of birds' contacts ranged from 7 to 140 m. The analysis of the contact frequency within 20 intervals of equal distance (Fig. 2) revealed an abnormally low detection rates below 20 m and a low stochastic detection rate beyond 65 m. Low detection rates below 20 m correspond to an evident discretion of birds close to the observer, generating bias detections that may dramatically impact distance sampling analyses. Low stochastic detection rates beyond 65 m correspond to 5 % of data that should be removed from analyses as recommended by Buckland *et al.* (2001). We thus ran analyses truncating data below 20 m and data beyond 65 m. Within the remaining distance intervals (20 – 65 m) we recorded a total of 59 contacts of males Bluethroat for the three sampled sites. Analysis with the DISTANCE program revealed four equiprobable models (delta AIC < 2, see Tab. I) to assess density. All models tested presented a *P* value of a Chi-square goodness of fit test > 0.05 (see Tab. I). For these four models we obtained average densities of Bluethroats ranging from 1.83 to 2.14 males / ha (see Tab. I). We used the model averaging method to generate average densities weighted by the AIC weight from each model with a delta AIC < 2. Results of the model averaging revealed a mean density of 2.05 ± 0.37 males / ha (1.44 – 2.95 within the 95 % CI).
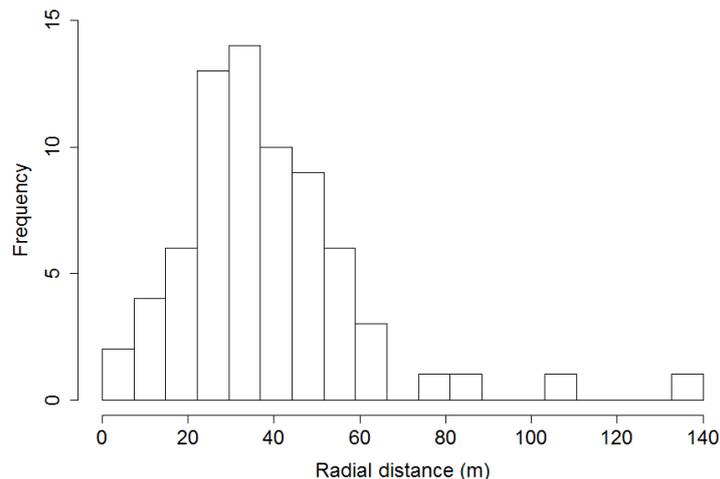

Figure 2.— Distribution of contact vocalizations in Bluethroat (*Cyanecula svecica namnetum*) according to distance in intertidal areas of the Gironde estuary (France).

TABLE I

*Models tested with program DISTANCE 6.0 to assess male densities of Bluethroat (*Cyanecula svecica namnetum*) in intertidal reed beds of the Gironde estuary (France) and estimated densities (males / ha)*

Key function + series expansion	Nb. Par.	AIC	Delta AIC	AIC weight	GOF Chi-*P*	Mean density	Estimates 95% CI
Uniform + cosine	1	441.51	0.00	0.2608	0.688	1.97 ± 0.22	1.58 - 2.45
Half-normal + cosine	1	441.60	0.09	0.2493	0.676	2.14 ± 0.46	1.40 - 3.28
Half-normal + hermite polynomial	1	441.60	0.09	0.2493	0.676	2.14 ± 0.46	1.40 - 3.28
Uniform + simple polynomial	2	443.46	1.95	0.0984	0.168	1.83 ± 0.31	1.31 - 2.56
Hazard rate + cosine	2	444.11	2.59	0.0711	0.685	1.85 ± 1.26	0.53 - 6.39
Hazard rate + simple polynomial	2	444.11	2.59	0.0711	0.685	1.85 ± 1.26	0.53 - 6.39

DISCUSSION AND CONSERVATION IMPLICATIONS

We focused our analyses on data collected during a high song activity period of birds (ensuring high detection probability of males) after arrival from their wintering grounds and before clutch initiation (period during which song production of Bluethroat males dramatically decrease, see Merilä & Sorjonen, 1994). Nevertheless, given the short sampling period for each count point (three minutes) densities we assessed may be underestimated due to a probability potentially < 1 to have a song activity of all males present within the different points sampled. Despite this possible bias and a single monitoring year that may correspond to a singular year, the density of males assessed in our study is consistent with the number of males captured during ringing sessions organized in the study site all along the breeding seasons during spring 2016 and 2017 to fit geolocators on breeding males (number of captures close to 2 males / hectare of reed bed sampled, Musseau *et al.*, unpublished data). These results allow us to reject the possibility of a sampled year with unusual conditions explaining the high densities assessed.

The average density of 20.5 males for 10 hectares, highlighted in the present study, correspond to an important density of the French coastal endemic Bluethroat (*Cyanecula svecica namnetum*) that has never been documented before for this taxa. Given the particular method we used to assess the density, our results are difficult to compare with densities calculated within other parts of the distribution area of the bird. Nevertheless, these results (1) confirm the particular importance of coastal regions already highlighted for *C. s. namnetum* populations (maximal densities of these taxa have been discovered in coastal marshes: up to 11.9 pairs / 10 ha in the saltpans of Guérande marshes, Taillandier *et al.*, 1985; 7.5 to 12 pairs / 10 ha in the region of the marshes of the "Pertuis charentais": Ré island, Oléron island and Moëze-Brouage marshes, Eybert & Questiau, 1999); and (2) highlight the importance of intertidal reed beds for the taxa during the breeding period and the attention that should be paid to this habitats for the conservation of the populations belonging to this endemic bird.

The specific advantages that *C. s. namnetum* may benefit by exploiting intertidal grounds, particularly during energy-demanding events such as moult (feeding for instance on small crustaceans) have already been documented (see Musseau *et al.*, 2017). These different results thus confirm the key role of coastal marshes for the conservation of *C. s. namnetum* and suggest that similar studies to assess densities of this taxa within different sites of its breeding grounds may be interesting for a better knowledge of key habitats exploited by this bird during the breeding period. This appears particularly important given the uncertain future of several Atlantic intertidal marshes in the context of sea level rise. In response to sea level rise, 20 – 60 % of the world coastal wetlands are at risk of disappearing over the next hundred years (Titus, 1988; Nicholls *et al.*, 2007; Craft *et al.*, 2009). From 2000 to 2015, we highlighted an average retreat of the coastline exceeding 35 m in one third of the mesohaline region of the right bank of the estuary (see Musseau *et al.*, 2016; Musseau *et al.*, 2017). This situation is explained by an increasing influence of tides related to sea level rise in the Gironde estuary (between 2.2 and 2.8 mm / year measured between 1914 and 1996 see details in Eaucéa, 2008) and an increase of the dry season duration, affecting the level of fresh water in summer, these two phenomena affecting the location of the turbidity maximum zone of the estuary (Sottolichio *et. al.*, 2013). The coastline retreat observed on the considered sector has been accompanied by gentle shore gradients progressively turning into steep slopes, with the loss of about 50 % of the lowest intertidal vegetal formations exploited by species such as the Bluethroat (see Musseau *et. al.*, 2017). Today, in the Gironde estuary, two solutions to maintain intertidal habitats exploited by marshland passerines appear interesting to consider. They consist of (1) locally, the giving back of some reclaimed lands (depolderization) to compensate the losses of intertidal wetlands; (2) the creation of new wetlands behind dykes of agricultural polders at least partially subjected to tidal influences by means of water control structures. Such management solutions of back littoral areas developed since the year 2000 in the Gironde estuary

have already started to generate interesting results in terms of restoration of intertidal habitats and particularly intertidal reed beds (see for instance Hérault & Collet, 2010). These management solutions, interesting to consider in different coastal areas affected by sea level rise, reveal the key role of environmental and agricultural governance to develop trade-offs between conservation of agricultural practices and coastal habitats in the context of global changes.

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REFERENCES

AKAIKE, H. (1974).— A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19: 716-723.

ARIZAGA, J. & ALONSO, D. (2015).— Phenological parameters of a Bluethroat *Luscinia svecica azuricollis* population breeding at high altitude in Spain. *Ardeola*, 62: 173-178.

ARIZAGA, J., ALONSO, D., CORTÉS, J.A, EGGENHUIZEN, T., FOUCHER, J., FRANZ, D., GARCÍA, J., KONING, J., LECONTE, M., RGUIBI, H., VALKENBURG, T., VERA, P. & HOBSON, K.A. (2015).— Migratory connectivity in European bird populations: feather stable isotope values correlate with biometrics of breeding and wintering Bluethroats *Luscinia svecica*. *Ardeola*, 62: 255-267.

BUCKLAND, S.T. (2006).— Point-transect surveys for songbirds: robust methodologies. *Auk*, 123: 345-357.

BUCKLAND, S.T., ANDERSON, D.R., BURNHAM, K.P., LAAKE, J.L., BORCHERS, D L. & THOMAS, L. (2001).— *Introduction to distance sampling*. Oxford University Press. Oxford.

BUCKLAND, S.T., BURNHAM, K.P. & AUGUSTIN, N.H. (1997).— Model selection: an integral part of inference. *Biometrics*, 53: 603-618.

CANTY, A. & RIPLEY, B. (2015).— *Boot: Bootstrap R (S-Plus) functions*. R package version 1.

CAUPENNE, M., JIGUET, F. & NIDAL, I. (2015).— Gorgebleue à miroir *Luscina svecica*. Pp 942-945 *In* : N. Issa & Y. Muller (eds.). *Atlas des oiseaux de France métropolitaine, nidification et présence hivernale*. Vol. 2. LPO / SEOF / MNHN, Paris: Delachaux & Niestlé.

HÉRAULT, T. & COLLET, H. (2010).— Dépoldérisation, la reconquête du fleuve sur l'ancien polder de Mortagne-sur-Gironde. *Le Courrier de la Nature*, 255: 26-32.

CRAFT, C., CLOUGH, J., EHMAN, J., JOYE, S., PARK, R., PENNINGS, S., GUO, H. & MACHMULLER, M. (2009).— Forecasting the effects of accelerated sea level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment*, 7: 73-78.

CRAMP, S. (1988).— *The Birds of the Western Palearctic*. Vol. 5. Oxford: Oxford University Press.

DAVISON, A.C. & HINKLEY, D.V. (1997).— *Bootstrap methods and their applications*. Cambridge: Cambridge University Press.

DE CORNULIER, T., BERNARD, R., ARROYO, B. & BRETAGNOLLE, V. (1997).— Extension géographique et écologique de la Gorgebleue à miroir dans le Centre-Ouest de la France. *Alauda*, 65: 1-6.

EYBERT, M.C., BONNET, P., GESLIN, T. & QUESTIAU, S. (2004).— *La Gorgebleue*. Belin, Paris.

EYBERT, M.C., & QUESTIAU, S. (1999).— Gorgebleue à miroir blanc de Nantes *Luscinia svecica namnetum*. *In*: G. Rocamora & D Yeatman-Berthelot (eds.). *Oiseaux menacés et à surveiller en France. Listes rouges et recherche de priorités. Populations. Tendances, menaces, conservation*. Paris: S.E.O.F/L.P.O.

HUNTLEY, B., GREEN, R.E., COLLINGHAM, Y.C. & WILLIS, S.G. (2007).— *A climatic atlas of European breeding birds*. Lynx Edicions, Barcelona.

ISSA, N. & MULLER, Y. (eds.) (2015).—— *Atlas des oiseaux de France métropolitaine, nidification et présence hivernale*. LPO / SEOF / MNHN, Paris: Delachaux & Niestlé.

JOHNSEN, A., ANDERSSON, S., FERNANDEZ, J.G., KEMPENAERS, B., PAVEL ,V., QUESTIAU, S., RAESS, M., RINDAL, E. & LIFJELD, J.T. (2006).— Molecular and phenotypic divergence in the Bluethroat (*Luscinia svecica*) subspecies complex. *Mol. Ecol.*, 15: 4033-4047.

JOYEUX, E., CORRE, F., MARQUIS, J., MERCIER, F., SUDRAUD, J., THOMAS, A., MEUNIER, F., YÉSOU, P. & TEXIER, A. (2010).— La Goregbleue à miroir blanc *Luscinia svecica mamnetum* en marais Poitevin. État des populations et habitats utilisés. *Alauda*, 78: 197-205.

MARCHADOUR, B. & SÉCHET, E. (coord.) (2008).— *Avifaune prioritaire des Pays de la Loire*. Coordination régionale LPO Pays de la Loire, Conseil Régional des Pays de la Loire.

MARQUET, M., MASCLAUX, H., CHAMPAGNON, J. & EYBERT, M.C. (2014).— Sélection de l'habitat, biologie de la reproduction et estimation de la population chez la Gorgebleue à miroir blanc de Nantes *Luscinia svecica namnetum* dans les marais briérons. *Alauda*, 82: 177-192.

MERILÄ, J. & SORJONEN, J. (1994).— Seasonal and diurnal patterns of singing and song-flight activity in Bluethroats (*Luscinia svecica*). *Auk*, 111: 556-562.

MUSSEAU, R., BESLIC, S. & HÉRAULT, T. (2016).— L'érosion des zones humides estuariennes. *L'estuarien*, 55: 9.

MUSSEAU, R., BESLIC, S. & KERBIRIOU, C. (2017).—— Importance of intertidal wetlands for the French coastal endemic Bluethroat (*Cyanecula svecica namnetum*) and conservation implications in the context of global changes. *Ardeola*, 64: 325-345.

NICHOLLS, R.J. *ET AL.* (2007).— Coastal systems and low lying areas. Pp. 315-356 *in:* M. L. Parry *et al.* (eds). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, U.K.

PEIRÓ, I.G. (1997).— A study of migrant and wintering Bluethroats *Luscinia svecica* in south-eastern Spain. *Ringing and Migration*, 18: 18-24.

PHILLIMORE, A. & OWENS, I.P.F. (2006).— Are subspecies useful in evolutionary and conservation biology? *Proc. R. Soc. B*, 273: 1049-1053.

SOTTOLICHIO, A., HANQUIEZ, V., PERINOTTO, H., SABOURAUD, L. & WEBER, O. (2013).— Evaluation of the recent morphological evolution of the Gironde estuary through the use of some preliminary synthetic indicators. *J. Coast. Res.*, S.I., 65: 1224-1229.

SVENSSON, L. (1992).— *Identification guide to European Passerines (4ᵗʰ edn)*.

THOMAS, L., LAAKE, J.L., REXSTAD, E., STRINDBERG, S., MARQUES, F.F.C., BUCKLAND, S.T., BORCHERS, D.L., ANDERSON, D.R., BURNHAM, K.P., BURT, M.L., HEDLEY, S.L., POLLARD, J.H., BISHOP, J.R.B. & MARQUES, T.A. (2009).— *Distance 6.0*. Research Unit for Wildlife Population Assessment. University of St. Andrews. UK. http://www.ruwpa.st-and.ac.uk/distance.

TITUS, J.G. (1988).— *Greenhouse effect, sea level rise, and coastal wetlands*. EPA Rep. 230-05-86-013, Environ. Prot. Agency, Washington, D. C.

TUCKER, G.M. & HEATH, M. (2004).— *Birds in Europe: Population estimates, trends and conservation status*. BirdLife International. Cambridge.

ZINK, R. (2004).— The role of subspecies in obscuring avian biological diversity and misleading conservation policy. *Proc. Biol. Sci.*, 271: 561-564.