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The Influence of the Creation of a Lagoon on Waterbird Diversity in Urdaibai, Spain

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Abstract.—Restoration and the creation of artificial wetlands can mitigate the loss and degradation of natural wetlands. The chief wetland areas in northern Iberia are the estuaries situated along the coast of the Bay of Biscay. These areas are tidal in nature and often small in size. These characteristics, together with high levels of human, disturbance can cause significant limits on the conservation of waterbirds. At the end of 2009, an old polder within the Urdaibai marshes in Spain was modified to create an artificial lagoon (Orueta Lagoon). The goal of this study was to evaluate the use of this lagoon by waterbirds, and its contribution to waterbird assemblage and richness at Urdaibai. Orueta Lagoon contributed 26.8% of total abundance, including 11 species not present in other zones of Urdaibai. Thus, it provided a new and attractive habitat for several waterbird species, especially ducks, coots and allies, shorebirds and grebes. Therefore, Orueta Lagoon plays a fundamental role in the enrichment of the waterbird assemblage at Urdaibai and hence is of great value from a conservation standpoint. *Received 16 September*, 2013 accepted 30 December 2013.

Key words.—coots, ducks, population trends, species richness, surveys, tidal marsh, Urdaibai, wetlands conservation.

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The estuaries along the coast of the Bay of Biscay in Spain are the primary natural wetland areas on the Atlantic facade of northern Iberia. The primary value of this region for waterbird conservation is its use by migrating and wintering birds as an emergency migratory stopover (Overdijk and Navedo 2012) or as a refuge during winter (Galarza and Domínguez 1989). Human disturbance in these areas, coupled with their frequently small size and tidal nature, often pose severe space limitations over long time periods (Navedo and Masero 2007; Navedo and Herrera 2012). The restoration and/or creation of new habitat can therefore result in an enrichment of the waterbird community by increasing the availability of foraging and roosting sites, allowing us to mitigate the loss and/or the degradation of natural wetland habitat (e.g., Fitzsimmons et al. 2012).

Urdaibai is one of the main tidal marshes along the coast of northern Iberia. With a surface area of 918 ha, it is a focal place for the conservation of waterbirds in Spain (Galarza and Domínguez 1989). The Urdaibai marshes are included in the Urdaibai Biosphere Reserve, designated in 1984, and the area was declared a Ramsar site in 1993 (Hidalgo and Del Villar 2004). However, waterbirds at Urdaibai are impacted by human disturbance arising from activities such as fishing, angling, walking, sailing, etc. These disturbances are the main reason why some migrant bird species of conservation interest, such as the Eurasian Spoonbill (scientific names are in Table 1), have reduced their stopover duration at Urdaibai (Garaita 2012).

During the 18th century part of the intertidal mudflats and the upper marsh at Urdaibai was converted into polders. Following the abandonment of agriculture in this area, by the mid-20th century, the exotic and invasive saltbush (*Baccharis halimifolia*) invaded many polders (Caño *et al.* 2013). A 13.1-ha polder (1.4% of Urdaibai) located in the upper marsh was excavated in 2009 to create an artificial lagoon (Orueta Lagoon) (Rozas and Álvarez 2011). This work was part of a larger project, which aimed to eradicate the saltbush from the Reserve.

The aim of this study was to evaluate the use of Orueta Lagoon (lagoon) at Urdaibai by documenting the number and species of waterbirds and their population sizes. Specifically, we wanted to see whether the Orueta Lagoon: 1) hosted a relevant fraction of the waterbird abundance at Urdaibai; and 2) hosted species scarce or inexistent in other areas of Urdaibai.

WATERBIRDS

Groups Common Name Scientific Name Presence Divers & Grebes Great Northern Diver Gavia inmer 2 3 Divers & Grebes Little Grebe Tachybaptus ruficollis 2 Divers & Grebes Great Crested Grebe Podiceps cristatus 23 P. nigricollis Phalacrocora Divers & Grebes Black-necked Grebe C c. + C 1

Table 1. Waterbirds observed at the Orueta Lagoon and the rest of Urdaibai in 2012. Presence: "1" = species pres-
ent at Orueta Lagoon only; "2" = species present at the rest of Urdaibai only; and "3" = species present at both
locations.

Cormorants	Great Cormorant	Phalacrocorax carbo	3
Cormorants	European Shag	P. aristotelis	2
Herons, Storks & Allies	Grey Heron	Ardea cinerea	3
Herons, Storks & Allies	Purple Heron	A. purpurea	1
Herons, Storks & Allies	Great White Egret	Egretta alba	3
Herons, Storks & Allies	Little Egret	E garzetta	3
Herons Storks & Allies	Cattle Egret	Bubulcus ih is	3
Herons, Storks & Allies	White Stork	Ciconia ciconia	2
Horona Storks & Allion	Closer Ibis	Blogg dis falsinglas	2
Lenone, Storks & Allies	Europian Snoonhill	Platalas Jaucineius	3
Herons, Storks & Allies	Eurasian Spoonbin	Flatalea leucoroaia	3
Ducks & Coots	Black Swan	Cygnus atratus	2
Ducks & Coots	Greylag Goose	Anser anser	3
Ducks & Coots	Common Shelduck	Tadorna tadorna	3
Ducks & Coots	Mandarin Duck	Aix galericulata	1
Ducks & Coots	Eurasian Wigeon	Anas penelope	3
Ducks & Coots	Gadwall	A. strepera	3
Ducks & Coots	Common Teal	A. crecca	3
Ducks & Coots	Mallard	A. platyrhynchos	3
Ducks & Coots	Northern Pintail	A. acuta	3
Ducks & Coots	Garganey	A. querquedula	1
Ducks & Coots	Northern Shoveler	A. clypeata	3
Ducks & Coots	Red-crested Pochard	Netta rufina	1
Ducks & Coots	Common Pochard	Aythya ferina	3
Ducks & Coots	Tufted Duck	A. fuligula	1
Ducks & Coots	Black Scoter	Melanitta nigra	2
Ducks & Coots	Red-breasted Merganser	Mergus servator	2
Ducks & Coots	Eurasian Coot	Fulica atra	1
Ducks & Coots	Common Moorhen	Gallinula chloropus	1
Diurnal Raptors	Osprev	Pandion haliaetus	9
Diurnal Raptors	Western Marsh-harrier	Circus geroginosus	3
Diurnal Raptors	Hen harrier	C companys	3
Shorebirds	Fursian Ovstercatcher	Haematopus ostralemus	9
Shorebirds	Black winged Stilt	Himantopus himantopus	2
Shorebinda	Diack-winged Stift	December of the second	9
Shorebirds	Field Avocet	Recurvirosira avoseita	2
Shorebirds	Eurasian Stone-curiew	Burninus oeaicnemus	Z
Shorebirds	Northern Lapwing	Vanellus vanellus	3
Shorebirds	Eurasian Golden Plover	Pluvialis apricaria	3
Shorebirds	Grey Plover	P. squatarola	2
Shorebirds	Common Ringed Plover	Charadrius hiaticula	3
Shorebirds	Little Ringed Plover	Charadrius dubius	3
Shorebirds	Kentish Plover	C. alexandrinus	2
Shorebirds	Common Snipe	Gallinago gallinago	3
Shorebirds	Black-tailed Godwit	Limosa limosa	3
Shorebirds	Bar-tailed Godwit	L. lapponica	2
Shorebirds	Whimbrel	Numenius phaeopus	2
Shorebirds	Eurasian Curlew	N. arquata	2
Shorebirds	Spotted Redshank	Tringa erythropus	1
Shorebirds	Common Redshank	T. totanus	3
			-

Groups	Common Name	Scientific Name	Presence
Shorebirds	Common Greenshank	T. nebularia	3
Shorebirds	Green Sandpiper	T. ochropus	3
Shorebirds	Wood Sandpiper	T. glareola	1
Shorebirds	Common Sandpiper	Actitis hypoleucos	3
Shorebirds	Ruddy Turnstone	Arenaria interpres	2
Shorebirds	Red Knot	Calidris canutus	2
Shorebirds	Sanderling	C. alba	2
Shorebirds	Little Stint	C. minuta	3
Shorebirds	Dunlin	C. alpina	3
Shorebirds	Ruff	Philomachus pugnax	1
Shorebirds	Red-necked Phalarope	Phalaropus lobatus	1
Gulls & Terns	Great Black-backed Gull	Larus marinus	2
Gulls & Terns	Yellow-legged Gull	L. michahellis	3
Gulls & Terns	Lesser Black-backed Gull	L. fuscus	3
Gulls & Terns	Common Black-headed Gull	L. ridibundus	3
Gulls & Terns	Mediterranean Gull	L. melanocephalus	2
Gulls & Terns	Caspian Tern	Hydroprogne caspia	2
Gulls & Terns	Sandwich Tern	Thalasseus sandvicensis	2
Gulls & Terns	Black Tern	Chlidonias niger	2
Others	Water Rail	Rallus aquaticus	3
Others	Common Kingfisher	Alcedo atthis	3

Table 1. (Continued) Waterbirds observed at the Orueta Lagoon and the rest of Urdaibai in 2012. Presence: "1" = species present at Orueta Lagoon only; "2" = species present at the rest of Urdaibai only; and "3" = species present at both locations.

Methods

Study Area and Data Collection

Urdaibai is situated in the Basque province of Biscay (northern Spain). It is 12 km in length and is surrounded by small mountains whose elevation is less than 800 m above sea level. Climatically, it is within the Atlantic region and the mean temperatures vary from 9 °C (winter) to 19 °C (summer). Precipitation levels are high (annual mean: 1,200 mm). Habitats surrounding the wetland are Holm oaks (Quercus ilex) forest, marine cliffs, riparian woodland, exotic plantations of Monterey pine (Pinus radiata) or eucalyptus (Eucalyptus spp.), and traditional Atlantic countryside (a mosaic of small rural areas, hedgerows, forest patches and meadows). The Orueta Lagoon is isolated from the rest of Urdaibai except for two overflow channels. These overflow channels, or spillways, allow water to enter the lagoon during spring tides. This control system created a permanent layer of water of < 1 m in depth, often no more than a few centimeters, dotted with islets covered with grass or sedge (Juncus spp.).

Waterbirds were surveyed using telescopes (visual detections only with no auditory cues) in all habitats associated with coastal tidal marshes. The surveys were carried out twice per month (one survey per 15-day interval) throughout 2012. We designed a unique survey protocol, counting waterbirds at 11 points (Fig. 1). The points were strategically selected to obtain an optimal view of Urdaibai. The size and form of Urdaibai pre-

vented us from considering a single survey point for the study. There was no overlap between the points to minimize the possibility of double counting. The survey areas formed polygons of irregular size and form (range: 3.8-119.5 ha). They were outlined on a map and subsequently corroborated in the field by the observers who participated in the survey.

Overall, we surveyed 573.3 ha (Orueta Lagoon: 13.1 ha; rest of Urdaibai: 560.2 ha) out of the 858.7 ha of marshes at Urdaibai. However, reed beds (Phragmites spp.) were not surveyed but made up a small portion of the actual survey area (37.2 ha, i.e., 6.5%). Surveys were carried out at intermediate tide, from 1.5 hr before to 1.5 hr after mid-tides, by two observers who surveyed points 00 to 06 (Urdaibai's east shore) and 08 to 10 (west shore) (Fig. 1). The observers did not move on from one point to the next until all birds were counted. Points were surveyed in the same order on each occasion. The survey points on the east shore were situated in elevated zones, which allowed us to observe large areas (mean ± SD survey area per point was 63.4 ± 39.0 ha; range: 17.8-119.5 ha). By contrast, the survey points on the west shore were situated at low elevations and therefore the areas of observation from such points were relatively small (mean survey area: 38.8 ± 41.2 ha; range: 3.8-84.2 ha). Orueta Lagoon was surveyed from point 07 (Fig. 1). With some exceptions, the same observers were used for the entire study period and they surveyed the same points each time. Overall, six observers were used for the survey. The survey (points 00 to 10) took from 1.3-4.4 hr to complete (mean: 2.2 ± 0.7 hr).



Figure 1. The Urdaibai estuary and the survey points (dots). The gray area corresponds to the survey zone; dark gray areas show main villages; fine black line: main roads; thick black lines: limits of the coast and the marsh area at Urdaibai. P07 corresponds to the Orueta Lagoon and the remaining survey points (P01-06, 08-10) correspond to the rest of Urdaibai.

Analyses

Surveys were combined into months, the time unit for the analyses, allowing us to minimize any bias associated with particular survey days. Comparisons were made between Orueta Lagoon and the rest of Urdaibai. The parameters analyzed were waterbirds (species) richness, diversity and abundance.

We considered whether the species richness at Orueta Lagoon differed from that obtained for the rest of Urdaibai. Observed values of richness were not used for this comparison because not all species are detected with the same probability, and, additionally, this can vary over time (Boulinier et al. 1998). Thus, rather than directly considering the observed richness, we assessed it by applying a jackknife resampling procedure (Magurran and McGill 2011), assuming that detection functions vary between species. We used this methodological approach to compare richness between Orueta and the rest of Urdaibai for the entire sampling period. Jackknife values were calculated with EstimateS 8 software (Colwell 2006). This resampling provided an estimate (mean ± SE) of richness for each zone and month. Thereafter, we used a paired *t*-test (n = 12) to assess whether the species richness differed between Orueta and the rest of Urdaibai.

We also calculated an index of diversity for each study site. We used the Shannon index, which takes into account the number of species and their abundance (Magurran and McGill 2011). Differences between the two study sites were compared with a *t*-test using PAST software (Hammer *et al.* 2001). The *t*-test used to compare diversity indices was obtained from PAST.

We made comparisons to determine if abundances varied between groups (Table 1) at the two sampling zones. We used a Chi-square test for this analysis. Standardized residual values from this test were used to identify significant biases from a distribution assuming the same proportion of counts between zones and group. Standardized residual values > 3 indicate significant differences (Agresti 2002).

RESULTS

Waterbird Richness

During a complete survey year (2012), we counted 73 species of waterbirds at Urdaibai [Orueta Lagoon: observed, 49; richness estimation, 56.7 ± 3.0 (SD); rest of Urdaibai: ob-

served, 62; richness estimation, 76.4 \pm 4.6]. Thus, overall, more species were detected in the rest of Urdaibai than at the Orueta Lagoon. Using month as the time unit revealed a similar richness for the Orueta Lagoon and the rest of Urdaibai (paired *t* test: *t* = 0.864, df = 11, *P* = 0.406). Overall, the richness varied between months (Fig. 2), with a peak in February and March and another one around the autumn migration period. The lowest richness values were detected from late-spring to mid-summer.

Most waterbirds (n = 38) were common to both Orueta and the rest of Urdaibai, whereas 11 species were found only at the Orueta Lagoon and 24 were found only outside this lagoon (Fig. 3). Six of the 11 waterbirds recorded only at Orueta belonged to the ducks and allies: Garganey, Tufted Duck, Eurasian Coot, Red-crested Pochard, Common Moorhen and Mandarin Duck (Table 1). The remaining waterbirds, detected at Orueta only, belonged to the storks and allies (Purple Heron) and shorebirds (Spotted Redshank, Ruff, Wood Sandpiper and Red-necked Phalarope).

Waterbird Abundance

Quantitatively, we counted a total of 28,194 birds. The five most abundant waterbirds at Orueta were ducks and allies (Fig. 4). Outside this zone, however, a large fraction (45.5%) of the abundance was due to a single species, the Yellow-legged Gull (Fig. 4). Consequently, the diversity was higher at Orueta (Shannon index: 2.64 ± 0.00) compared with the rest of Urdaibai (2.02 ± 0.00 , t = 37.9, df = 17.737, P < 0.001).

Abundance varied between months at each study site (Orueta: $\chi^2 = 2,765.17$, df = 11, P < 0.001; rest of Urdaibai: $\chi^2 = 4,663.72$, df = 11, P < 0.001; Fig. 5), with one peak at the end of winter (Orueta: February; rest of Urdaibai: March), a second, weaker peak during autumn migration (Orueta: November; rest of Urdaibai: September), and very low numbers of waterbirds in late spring and summer (Fig. 6). Abundance distribution patterns throughout the year were biased from the distribution expected if the variation of abundance followed a similar pattern for the two study sites ($\chi^2 = 1,197.27$, df = 11, P < 0.001) (Fig. 6).



Figure 2. Intra-year variation of estimated (mean \pm 95% CI) waterbirds species richness at the Orueta Lagoon and the rest of Urdaibai, Spain, in 2012.

WATERBIRDS



Figure 3. Number of species counted only at the Orueta Lagoon (white), only outside this Lagoon (i.e., rest of Urdaibai, in gray) and at both sites (black). Note that black bars are symmetrical because these species were detected at both sites (Orueta and rest of Urdaibai).

Bird numbers differed between zones and groups ($\chi^2 = 12,324.67$, df = 7, P < 0.001; Fig. 5). Significantly fewer birds (individuals) were detected at Orueta compared with the rest of Urdaibai, except for two groups,



Figure 4. Relative abundance (in percentage) of the 10 most abundant waterbirds at each sampling zone.



Figure 5. Contribution of each zone to the abundance of waterbirds at Urdaibai. Abundance in each group sums 100%. The symbol (*) indicates significant differences between the two zones in relation to an expected pattern similar for all groups.

which were ducks and allies and grebes (Fig. 6), for which the majority of birds were found at Orueta.

DISCUSSION

The Orueta Lagoon contributed 11 species not detected in other zones of Urdaibai. Most of them were ducks and coots (i.e., waterbirds strongly associated with open waters). Along with this result, the majority (72.1%) of the ducks and allies seen at Urdaibai were observed at the Orueta Lagoon. Therefore, the Orueta Lagoon was important for this group of birds, contributing to the enrichment of the waterbird community at Urdaibai. Another group found to be proportionally more abundant at the Orueta Lagoon, compared with the rest of Urdaibai, was grebes and allies. This result was due to the Little Grebe, since the other species of grebes and divers were absent from the Orueta Lagoon.

Four shorebirds were also detected only at Orueta. Although not newly observed at Urdaibai (Galarza and Domínguez 1989), this result suggested a preference for the Orueta Lagoon rather than the rest of Urdaibai. These shorebirds were relatively scarce throughout Urdaibai, and have been reported to be less dependent on tidal flats for foraging than other shorebirds (Cramp *et al.*

□ Orueta ■ Rest of Urdaibai



Figure 6. Monthly variation in waterbird abundance at the two study sites (Orueta and the rest of Urdaibai) at Urdaibai estuary, Spain. The symbol (*) indicates significant differences between the two zones in relation to an expected annual distribution pattern similar for both zones.

1985). Examples were the Ruff and the Rednecked Phalarope, which feed on small invertebrates found in wet grassland and soft mud, and at the bottom of open waters, respectively (Cramp *et al.* 1985). Other shorebirds, detected at both sites were also more abundant at Orueta than in the rest of Urdaibai, except for the Wood Sandpiper and Northern Lapwing. Coinciding with the attractiveness of this new site for a number of shorebirds, we found the Black-winged Stilt breeding here in 2011, being the first record for this species breeding at Urdaibai (Arizaga *et al.* 2012).

The Orueta Lagoon also hosted 80% of the Eurasian Spoonbill population recorded at Urdaibai during our survey, becoming the main site in the area for this species of concern (Tucker and Heath 2004). Furthermore, Eurasian Spoonbills were observed in the lagoon not only during the migration period, but also during the summer and winter (J. Arizaga, unpubl. data), a behavior that is new for Urdaibai (Del Villar *et al.* 2007). Eurasian Spoonbills at Orueta were observed stopping over for several days, whereas outside this area they do not remain for longer than a few hours, owing to human disturbance (Del Villar *et al.* 2007). This suggests that some waterbirds may have selected Orueta to avoid human disturbances. The Orueta Lagoon did not constitute a true ecological restoration, but rather a new, artificial habitat that would not exist in Urdaibai under natural circumstances.

The new Orueta Lagoon at Urdaibai provided an attractive habitat for several waterbird species, especially for ducks, coots and allies, which until 2010 were very scarce at Urdaibai, and also for other birds, such as shorebirds, grebes and spoonbills. Therefore, it can be considered a hot spot for waterbirds in this region and hence is of great value from a conservation standpoint.

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