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The importance of dredge islands for breeding waterbirds. A three-year study in the Venice Lagoon (Italy)

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ABSTRACT

Since 1989, intertidal dredge islands have been constructed in the Venice Lagoon using sediments originating from regular dredging of lagoon channels and inlets. Between 2005 and 2007, 75 dredge islands were surveyed in each year and the number of breeding pairs of seabirds and shorebirds estimated. The results showed that, of the 13 species that nested at least once, eight represented more than 1% of their total Italian population, sometimes even higher than 10%. Our results indicated that the majority of birds prefer site dimensions of between 10 and 30 ha, even if some species use small or very small (<1 ha) sites particularly heavily. Most of the other environmental variables we measured concurred in explaining species' occurrence and abundance. Redshank and Shelduck selected sites with high vegetation coverage, whereas sites with lower vegetation were preferred by Kentish Plover and Little Tern. More pairs than expected were observed at sites between 25 and 30 ha. These sites have a considerable wealth of habitat types, becoming suitable for species with contrasting nesting habitat requirements. Density of breeding pairs ranged between one and four pairs/10 ha; these values compare well with those observed in natural habitats existing in the Venice Lagoon, and support the opinion that dredge islands are a good alternative to natural sites. Along coastal sites where human pressure on beaches is particularly heavy, man-made habitats such as dredge islands may become a valuable alternative breeding site for those seabirds and waders of conservation concern. The results presented allow an assessment of the importance of dredge islands for breeding waterbirds over a short to medium period. They may also be used to estimate the expected richness and abundance of breeding birds that will use intertidal man-made sites, when these are built in a temperate coastal marsh.

1. Introduction

Beneficial use of dredged material at coastal sites includes the creation of tidal flats or salt marshes, with the aim of restoring previous areas, creating new substrate for halophytic vegetation and providing new feeding and nesting sites for birds, in particular waterbirds (Parnell et al., 1988; Streever et al., 1996; Streever, 2000; Zedler, 2000; Yozzo et al., 2004). Artificial islands created by the controlled disposal of sediments dredged from sea inlets, channels and lagoons have often been termed "dredge islands", and several studies have been published about their use by birds. A large majority of the studies found in scientific literature deals with sites in the USA (Soots and Parnell, 1975; Soots and Landin, 1978; Melvin and Webb, 1998; Mallach and Leberg, 1999; Delaney et al., 2000; Shafer and Streever, 2000; Zedler, 2000; Erwin et al., 2001, 2003; Perry et al., 2001; Neckles et al., 2002; Darnell and Smith, 2004; Spear et al., 2007; Golder et al., 2008; Emslie et al., 2009). On the other hand, very few data exist for sites in Europe, where these particular kinds of man-made site seem far less common and of very small size (ABP Southampton, 1998; de Jonge and de Jong, 2002; Atkinson, 2003; Bakker and Piersma, 2006; Gallego Fernández and García, 2007). Data reported in the previously quoted literature indicate that birds rapidly colonize dredge islands, and that nesting populations at these sites may reach levels of regional or national importance, at least for some species. Relationships between habitat characteristics (e.g. site dimension, vegetation coverage and type, extension of ponds and creeks) of these man-made islands and occurrence or abundance of birds have been the subject of detailed study outside Europe (see literature quoted above), but very little is known for European sites. In the Lagoon of Venice (NE

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Italy), the total area of salt marsh has fallen from approximately 12,000 ha to less than 4000 ha between 1900 and the present day, due to reclamation, erosion, and natural and man-induced subsidence (Cecconi, 2005; D'Alpaos et al., 2007; Tiezzi et al., 2010; Day et al., 2011). A large dredging program undertaken for the Italian Ministry of Public Works has been underway since 1984 to maintain channel depths for purposes of navigation and to increase tidal flushing in the inner lagoon. The resulting dredged material has been used to build artificial salt marshes (hereafter called dredge islands) and tidal flats (Cecconi, 2005; Tiezzi et al., 2010). In 2011 (last available data), about 100 dredge islands occurred, providing an extent of dredge island area of about 1100 ha and using a total volume of sediments in excess of 12 million cubic meters. These dredge islands host tens or even hundreds of pairs of breeding waterbirds, including species of relevant conservation value, i.e. that are included in Annex 1 of the European Community "Birds" Directive (EC/147/2009) or listed as Species of European Conservation Concern by BirdLife International (2004).

From 2005 until 2007, breeding bird surveys were performed each year at 55–75 dredge islands occurring in the Venice Lagoon. As far as we know, this is the first study in Europe that takes in account such a large number of man-made sites. The aims of this paper are to:

- assess the importance attained by dredge islands as nesting sites for waterbirds;
- explore relationships between the main morphological and vegetation characteristics and the occurrence of breeding species;
- suggest criteria for the optimal management of existing sites and the planning of new ones.

Since we are interested in sites comparable in origin and extent with ours, we will not include here comparisons to small islands, some tens or hundreds of square meters in size, that have often been created at European sites to provide nesting, roosting or feeding sites for waterfowl. For these reasons, we will define dredge islands as "those constructed from the sediments displaced as navigation channels are built and maintained by dredging", according to the definition given by Turner and Strever (2002).

2. Study area

The Venice Lagoon is a large (550 km^2) shallow coastal lagoon, located on the north-western coast of the Adriatic Sea, 45°26′N, 12°19′E (Fig. 1). Two barrier islands, each one about 10 km long, separate the lagoon from the sea. Most of the lagoon consists of an open water body (about 400 km^2). The mean depth of the lagoon is 1.1 m and the tidal range during spring tides is about 1 m, with a mean tidal range of 0.6 m, one of the highest observed in the whole Mediterranean (Cecconi, 2005). There are extensive intertidal natural salt marshes in the lagoon, regularly flooded during high tides since they have a mean elevation of only 0.20–0.30 m above mean sea level. Hundreds of these islets, covered with halophytes, are common in the south-western and northern corners of the lagoon. The Venice Lagoon is of particular importance for waterbirds, both as a wintering site and as a breeding site (Scarton and Valle, 1999; Scarton, 2005, 2010; Scarton et al., 2009; Scarton and Bon, 2009). Due to its importance for birds, the whole Venice Lagoon has been recognized since 2007 as a Special Protection Area, according to the European Community Birds Directive.

Between 1985 and 2011 about 100 dredge islands were built in the lagoon, with a total area of almost 1100 ha. Each dredge island consists of a containment cell formed using piles of woody material along the exterior. These areas of shallow waters are then filled with sediments originating from the regular dredging of lagoon channels or inlets (Cecconi, 2005). Sediments discharged into dredge islands are thus confined by a row of posts, with a sheet of geotextile along the inner side or by two or three rows of gabions, filled with stones. At some dredge islands posts or gabions were removed along selected sectors, in order to promote tidal creek formation.

After sediment compaction, these islands reach a mean elevation above sea level of between 0.5 and 1 m. For this reason the area flooded by normal high tides is variable, ranging from most of the site surface for dredge islands with the lowest elevation, to less than 30% for the highest elevated sites. Despite their very low elevation, the topography of dredge islands is not completely flat; small mounds and depressions coexist, producing an array of microhabitats. Soil composition and elevation above sea level of dredge islands drive the processes of vegetation colonization and succession. Throughout the years, remarkable modifications occur to the vegetation coverage and structure of dredge islands. From almost a bare surface, with the occurrence of just a few annual species mostly of the genus *Salicornia*, several phases lead to an almost continuous coverage of halophytes (*Sarcocornia fruticosa*, *Aster tripolium*, *Limonium narbonense*, *Puccinellia palustris*) or, less commonly, ruderal and nitrophilous species (genus *Elymus*, *Oenothera*, *Atriplex*). Bushes or small trees (*Tamarix gallica* and *Populus alba*) are extremely rare, occurring only at a few sites that have higher elevations.

The 75 dredge islands (i.e. all those existing in the lagoon between the years 2005 and 2007) considered in this study ranged in size from 0.09 to 51.37 ha, had a mean surface area of 11.3 ha (1 SD = ±10.7 ha) and a total combined area of 846 ha. Most of the sites (44; 59%) were smaller than 10 ha, whereas only five sites (7%) were larger than 30 ha. In 2007 the mean age of the sites (i.e., time elapsed from the end of construction work or, for some sites, from disposal of fresh sediments over most or all of the area) was 8.2 years (1 SD = ±5.1), ranging from one to 19 years. Human disturbance at most of the sites was very low or absent; only a few sites were irregularly used by professional fishermen, bait collectors or occasional visitors.

3. Methods

Field data were gathered between spring 2005 and summer 2007. Since new dredge islands were built each year, the number of study sites increased accordingly. In the first year 55 sites were visited, 74 in 2006 and 75 in 2007. Area, perimeter and extent of tidal flats (within a radius of 1 km) were calculated for each site, through the use of recent aerial or satellite pictures and GIS software. Vegetation mapping at a scale of 1:2000 was carried out for 65 sites (10 sites were not mapped in the field for logistical constraints) in the years 2005–2006, between June and October, with the aid of aerial photos taken in the same years. For the remaining 10 sites, soil coverage categories were estimated only with the use of aerial or satellite pictures taken in 2007. Digitization took place using ArcGis 9.3 (ESRI, Redlands, California, USA); vegetation was classified according to the dominant species. We used the following classes: (1) *Salicornia* sp. dominated area, (2) *Sarcocornia* dominated area, (3) other halophytes, (4) other non halophytes. Other typologies of soil coverage were: (1) ponds + creeks, (2) bare ground, and (3) bare, marginal surfaces exposed only during low tides and originating from erosion processes occurring along the inner side of the containment dike. Discriminating between the two last categories in the field was not easy, and a subjective approach had to be followed. Tidal flat extent, i.e. the area of shallow bottoms with elevation between +0.05 m and −0.30 m around and