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Circular pools in the seagrass beds of the Banc d'Arguin, Mauritania, and their possible origin

B.B.P.A. van der Laan, Wim J. Wolff *

Department of Marine Biology, University of Groningen, P.O. Box 14, 9750 AA Haren, The Netherlands

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Abstract

The tidal flats of the Banc d'Arguin, Mauritania, are covered by vast beds of *Zostera noltii*. At low tide these seagrass beds appear to be interspersed with partly vegetated, circular pools of 5–25 m diameter. Between February and May 2001 we described these pools and studied their possible origin. Several hypotheses regarding the origin have been developed. The first group of hypotheses assumes that the pools result from erosion activity. Since human disturbance of seagrass beds at the Banc d'Arguin is virtually non-existent, causes should be found in natural bed disturbances and/or tide or wave action. Therefore, small gaps, simulating holes dug by the crab *Callinectes marginatus*, were made to see if they would further erode by tidal currents or waves. The experiments showed no erosion. Neither we found support for other hypotheses assuming erosion to be the cause of circular pools. The alternative group of hypotheses stated that sedimentation on the flats would be responsible. We conclude that accretion of creek remnants is the most likely process behind the development of the pools; this conclusion is based on both mapping of the pattern of pools, the sediment profile in and around the pools and the distribution of seagrass biomass. Also the disturbance experiments showed bed accretion rather than bed erosion and support this hypothesis.

Keywords: Circular pools; Seagrass; *Zostera noltii*; *Cymodocea nodosa*; Banc d'Arguin; Mauritania

1. Introduction

A remarkable feature of the intertidal seagrass (*Zostera noltii* Hornemann) beds of the Banc d'Arguin, Mauritania (Fig. 1), is the presence of circular and semi-circular pools during low tide (Fig. 2). In most cases the bottom of these pools is covered, at least partly, by seagrasses. The only earlier reference to this phenomenon at the Banc d'Arguin is by Wolff and Smit (1990), who briefly stated: ''Most tidal flats covered with seagrass beds are interspersed with 0.2–1.0 m deep semi-circular pools with a diameter of 5–25 m.'' We are not aware of any other study describing similar pools elsewhere.

This study first aims to describe these circular pools and their occurrence at the Banc d'Arguin. Second we attempt to explain their origin. In the following paragraphs we develop, partly based on the literature, a number of alternative hypotheses for the formation of such pools. Subsequently, we use our field data to critically evaluate these hypotheses.

The hypotheses fall in two categories, viz.: (a) the pools are the result of accretion processes on tidal flats or (b) the pools are the result of erosion processes, either leading directly to the formation of pools, or starting from small disturbances gradually enlarging until they result in circular pools.

The accretion category leads to the formulation of two main hypotheses.

(1) The circular pools result from large-scale movements of sediment such as sandwaves travelling slowly over the tidal flats (Patriquin, 1975; Marbá and Duarte, 1995; Bell et al., 1999), or terrestrial sand dunes blown into the tidal flat area (Wolff, unpublished observations).
(2) The circular pools are the result of modification through accretion of existing non-circular depressions in the seagrass beds.

The erosion category of hypotheses necessarily starts with processes creating gaps in closed seagrass vegetation. Around the world many natural as well as anthropogenic causes have been found for such gaps. Large-scale, severe damage may result from storms and flooding (Poiner et al., 1989), disease

* Corresponding author. Tel.: +31 503632260.
E-mail address: w.j.wolff@rug.nl (W.J. Wolff).

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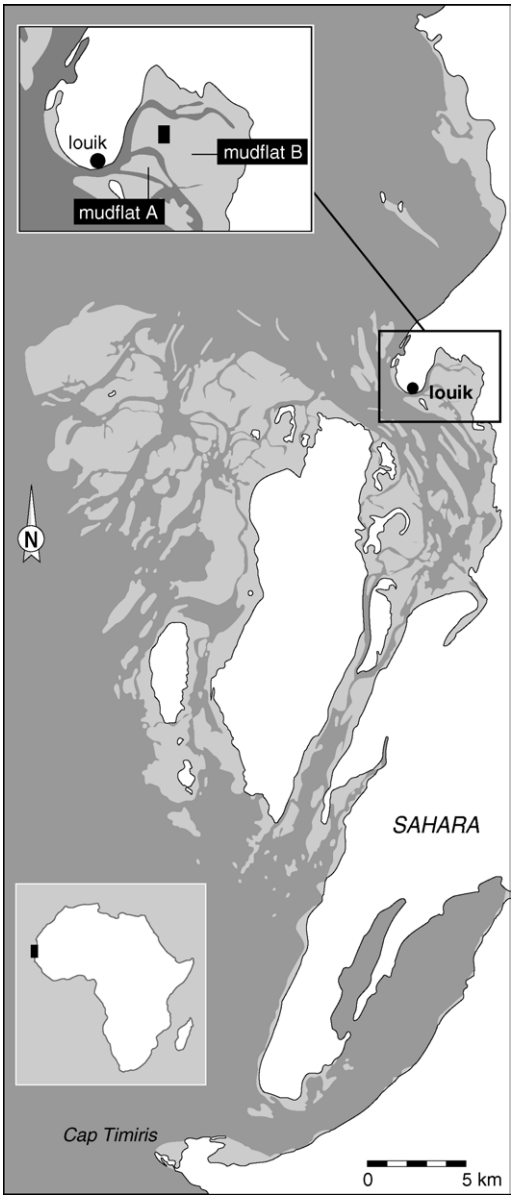

Fig. 1. The area of the Banc d'Arguin, Mauritania, showing the occurrence of tidal flats (light grey). The upper inset shows the Baie d'Aouatif with mudflats A and B; the black rectangle in the upper inset shows the position of the map in Fig. 4.

(Short, 1987), agricultural run off (Preen et al., 1995), industrial run off (Shepherd et al., 1989), oil spills (Jackson et al., 1989) and dredging (Pringle, 1989). It is, however, hard to imagine how such large-scale processes may result in the formation of pools of 5–25 m diameter in otherwise healthy seagrass beds. Hence, we do not consider these potential causes any further.

Small-scale damage to seagrass beds has been demonstrated to be caused by grazing birds, turtles (Thayer et al., 1984; Bjørndal, 1997; Williams, 1988a) or manatees (Preen, 1995), by demersal fish (Orth, 1975) and crustaceans (Suchanek, 1983), erosion by wind and wave action (Patriquin, 1975; Shepherd et al., 1989), as well as propeller (Zieman, 1976) and anchor (Williams, 1988a) damage from boats. Patchy deposition of mats of drifting macroalgae (Cowper, 1977; Holmquist, 1997) or drifting seagrass leaves (Hemminga and Nieuwenhuize, 1991) could result in die-off of the seagrass vegetation and subsequent erosion. Die-off also could result from strong insolation during low tide (Dr. J.E. Vermaat, personal communication). Another possibility is escape of natural gas from the sediment resulting in die-off of seagrasses and subsequent erosion (Prof. P.L. de Boer, personal communication). The relationship between seagrass cover on the one hand and wave exposure and current speed on the other hand (Fonseca and Bell, 1998; Frederiksen et al., 2004) points to the possibility that wind and wave action may cause small disturbances. Such small-scale damage could directly lead to pool formation, or be the starting point for erosion due to waves and currents leading gradually to pool formation.

Fig. 2. Photograph (courtesy Dr Jean Worms) of circular pools in a seagrass bed in the Baie d'Aouatif at the Banc d'Arguin, Mauritania.

Based on the literature, our general knowledge of the Banc d'Arguin environment and common sense we have considered the following hypotheses.

(3) The pools directly result from human activity (e.g. digging for shellfish, bomb craters).
(4) The pools directly result from the activity of large animals (e.g. whales, sharks; Hall et al., 1992).
(5) The pools are started as small disturbances of the seagrass vegetation and are gradually enlarged by erosion due to currents or waves. Causes of small disturbances could be (Hall et al., 1992) damage by waves or strong currents, escaping gas, strong insolation, deposited mats of drifting macroalgae or seagrass leaves, animals digging holes in the sediment, damage caused by feeding animals (e.g. manatees, birds, turtles, fish), and boats.

2. Area, materials and methods

2.1. Study sites

The Banc d'Arguin (Fig. 1) is situated on the west coast of Mauritania between the Sahara desert and the Atlantic Ocean. Due to a tidal range of 1.5–2 m it comprises vast areas of intertidal flats. The greater part of these usually very muddy flats is covered with seagrass (*Zostera noltii*) meadows.