

Reproductive periodicity, spawning and development of the deep-sea scleractinian coral *Flabellum angulare*

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Received: 16 July 2010 / Accepted: 12 October 2010 / Published online: 30 October 2010
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Abstract Increasing threats to deep-sea corals highlight the need to expand knowledge of these taxa so that conservation measures can be developed. The present study focused on the reproductive patterns of the deep-sea solitary coral *Flabellum angulare*. A series of samples ($n = 398$) collected in 2006–2008 in the northwest Atlantic at depths of 925–1,430 m revealed that gametogenesis was synchronous among males and females and fluctuated seasonally. Initiation of gamete synthesis was estimated to be in August–September and spawning in June. Further analysis and daily monitoring of 30–60 individuals maintained in a flow-through mesocosm showed that gamete release occurred in March–June with a peak in May. Release of oocytes coincided with rising seawater temperatures and high deposition rates indicative of elevated water column productivity. Oocytes (900–1,200 μm diameter) were released through the oral cavity, generally in bundles of 3–5 surrounded by mesenterial filaments and attached to a thread (30–50 mm long). As oocytes became free in the water column, ovulation occurred followed by fertilization. Eggs/embryos initially remained on the tentacles of the spawner before either falling onto the substratum or floating to the surface. The embryos developed into planula larvae measuring 2–3 mm in length within about 24 h. Together, these findings shed new light on the

strategies used by deep-sea corals to maximize their reproductive success.

Introduction

Flabellidae (Cnidaria: Scleractinia) are known from the Early Cretaceous and are widespread in today's oceans, from the surface to >5,000 m depth and from polar to tropical seas (Zibrowius 1980; Cairns 1982, 1989a). They are solitary and azooxanthellate, relying primarily on sexual reproduction, although some genera reproduce asexually (Cairns 1989b; Waller et al. 2002). In the North Atlantic, deep-sea flabellids are generally found on soft sediments in various slope and abyssal environments as well as on the mid-ocean ridge (Gass and Willison 2005; Waller 2005; Buhl-Mortensen et al. 2007; Wareham and Edinger 2007; Mortensen et al. 2008). Accounts do not always distinguish species of the genus *Flabellum* (*F. alabastrum*, *F. macandrewi* and *F. angulare*), and many only refer to the better known *F. alabastrum*.

Information on the reproduction of deep-sea flabellids and other deep-water solitary corals is limited, especially when compared to the numerous studies on shallow-water scleractinians (reviewed by Baird et al. 2009). The reproductive ecology of a cosmopolitan species, *Fungiacyathus marenzelleri*, was investigated through a series of samples in two locations. It was found to exhibit a “quasi-continuous” mode of reproduction both at 4,100 m in the northeast Pacific (Flint et al. 2007) and at 2,200 m in the northeast Atlantic (Waller et al. 2002), although the latter study also noted a non-significant trend towards synchronous spawning in June/July. Waller et al. (2008) examined fecundity and development in preserved specimens of three *Flabellum* species collected at 270–700 m on the continental shelf off

Communicated by J. P. Grassle.

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