

Lunar Rhythms in the Deep Sea: Evidence from the Reproductive Periodicity of Several Marine Invertebrates

Annie Mercier,^{*1} Zhao Sun,^{*} Sandrine Baillon,^{*} and Jean-François Hamel[†]

^{*}*Ocean Sciences Centre (OSC), Memorial University, St. John's (Newfoundland and Labrador), Canada, and* [†]*Society for the Exploration and Valuing of the Environment (SEVE), Portugal Cove-St. Philips (Newfoundland and Labrador), Canada*

Abstract While lunar rhythms are commonly documented in plants and animals living in terrestrial and shallow-water environments, deep-sea organisms have essentially been overlooked in that respect. This report describes evidence of lunar periodicity in the reproduction of 6 deep-sea species belonging to 2 phyla. Occurrences of gamete release in free spawners and larval release in brooders exhibited significant peaks around the new and full moons, respectively. The exact nature of this lunar period (endogenous or exogenous rhythm) and its adaptive significance in the deep sea remain elusive. Current knowledge suggests that proxies of moon phases at depth may include fluxes in particulate matter deposition, cyclic currents, and moonlight for species living in the disphotic zone.

Key words lunar, reproduction, deep sea, marine invertebrates, corals, echinoderms

In environments directly exposed to moonlight or submitted to tidal regimes, biological rhythms synchronized with lunar phases have long been documented (Naylor, 1982). Lunar cycles of reproduction have most notably been demonstrated in reef corals (Richmond and Hunter, 1990) and fishes (Takemura et al., 2010). Spawning events attuned to the lunar cycle have also been recorded in shallow-water tropical or subtropical species of echinoderms (Mercier and Hamel, 2009a), mollusks (Counihan et al., 2001), and crustaceans (Skov et al., 2005). The existence of such cycles is less often reported in marine taxa from temperate-cold regions (Bentley et al., 2001; Mercier and Hamel, 2010). Deep-sea environments (>200 m),

which make up more than 66% our planet's surface, are virtually overlooked in this respect given difficulties in studying live organisms in situ and in the laboratory. Here we provide unprecedented evidence of the occurrence of lunar breeding cycles in 6 deep-sea taxa belonging to 2 phyla and exhibiting different reproductive strategies (brood protection and free spawning).

Indirect evidence of gamete release was gathered from preserved samples of *Phormosoma placenta* collected from the field in November and December 2006 (Table 1, Appendix). Spawning in both sexes clearly coincided with the new moon, as depicted by the sharp drop in gonad index (GI) and the shift between

1. To whom all correspondence should be addressed: Annie Mercier, Ocean Sciences Centre, Memorial University, St. John's, NL, A1C 5S7, Canada; e-mail: amercier@mun.ca.