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Comparative study of reproductive synchrony at various scales in deep-sea echinoderms

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ABSTRACT

This study examined the influence of temporal and spatial factors on the determination of reproductive cycles in selected deep-water echinoderms. The prevalence of inter-individual synchrony in the gametogenesis of three ubiquitous species, *Phormosoma placenta* (Echinoidea), *Hippasteria phrygiana* (Asteroidea) and *Mesothuria lactea* (Holothuroidea) collected off the coast of Newfoundland and Labrador (eastern Canada), was determined. Analyses revealed diverse degrees of gametogenic asynchrony at the scales examined (within trawls, between trawls over similar or different periods, as well as among depths and locations over the same period). Taken as a whole, samples did not show any annual or seasonal patterns, whereas some sets of samples, taken over a particular time period in the same area and at the same depth, revealed well synchronized maturing and/or spawning periods in *P. placenta* and *H. phrygiana*. This study presents evidence that determination of reproductive cycles in many deep-sea species may be affected by low sampling resolution inherent to most deep-sea studies. More accurate assessments of reproductive patterns and periodicities may require much tighter collection designs as several species are likely to rely on long-term or transient pairing and aggregation to synchronize their breeding activities.

1. Introduction

Large-scale environmental factors are considered major mediators of reproductive cycles in numerous species of marine invertebrates, including echinoderms (see reviews by Giese et al., 1991; Himmelman, 1999; Mercier and Hamel, 2009). They do so by providing a reference in time for the coordination of gamete development and release. However, since environmental factors such as photoperiod, temperature and phytoplankton levels exhibit temporal patterns that may vary over relatively small spatial scales, significant heterogeneity is expected to occur between distant and even fairly close populations.

Early ideas about the deep sea suggested temporal and spatial homogeneity, i.e. little or no fluctuation in temperature, salinity and other physico-chemical factors (Menzies, 1965). The traditional view was therefore that environmental factors were unlikely to drive cyclic reproductive activities in the deep ocean (Young, 1994, 2003). However, studies conducted over the last 30 years have revealed the heterogeneity of this environment (Billett et al., 1983; Tyler, 1988; Gage and Tyler, 1991; Smith, 1994; Gooday, 2002; Thistle, 2003). Among other things, seasonal pulses of phytodetritus were proposed to mediate periodic reproductive cycles in deep-sea echinoids (Tyler and Gage, 1984; Campos-Creasey et al., 1994), asteroids (Benítez-Villalobos et al., 2007) and ophiuroids (Gage et al., 2004). Depth-related patterns have also been reported that reflect adaptations to local conditions. For instance, deep-sea echinoderms from the bathyal zone exhibit seasonal reproductive cycles more often than deeper abyssal species, which tend to be predominantly aperiodic (Young, 2003; Mercier and Hamel, 2009). In the bathyal sea star *Henricia lisa*, marked differences in the life history were found between individuals from ~1300 and ~600 m (Mercier and Hamel, 2008). The former had a male biased sex ratio and an aperiodic reproductive cycle, whereas the latter displayed an equal sex ratio and a biannual breeding pattern. Laboratory trials showed that temperature variations played a major role in the biannual aggregation and spawning of *H. lisa* from ~600 m (Mercier and Hamel, 2008). Conversely, other eurybathic echinoderms do not exhibit any depth-related reproductive patterns. For example, Ferrand et al. (1988) observed comparable trends in populations of the echinoid *Brissopsis lyrifera* from 60 to 930 m in the Mediterranean Sea.

These variable trends suggest that sampling limitations may impact the reliability of data on the reproductive cycles of deep-sea species. Opportunities for sampling deep-sea organisms are

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