

Early development, settlement, growth, and spatial distribution of the sea cucumber *Cucumaria frondosa* (Echinodermata: Holothuroidea)

Jean-François Hamel and Annie Mercier

Abstract: *Cucumaria frondosa* was studied in the field and in the laboratory to elucidate its development, growth, substrate selection, and migration patterns. In 1992 and 1993, spawnings in the laboratory and in the lower St. Lawrence Estuary occurred in mid-June. Males spawned first, followed shortly by females. The fertilized eggs and resulting embryos were buoyant. They developed into pentactula 9 d after fertilization. In the laboratory, embryonic development was fastest at 12°C, pH 8, and salinity 26 psu (practical salinity unit). The first contact of embryos with the substrate, made with the tentacles, occurred ca. 48 d after fertilization. Following a search period of 3–40 h, settlement was achieved using the ambulacral podia. Laboratory and field observations showed that gravel or rock were favored by larvae during settlement. After reaching ca. 2.8 mm in length, ca. 4–5 months later, young sea cucumbers moved to sheltered, illuminated areas of rocky substrate, and migrated from protected to exposed areas after they exceeded ca. 35 mm in length. Overall, the growth rates were maximal during the spring and summer phytoplanktonic blooms with rising temperature. Field observations showed a size-dependent migration from photic to aphotic depths (≥ 40 m depth), when the animals reached sexual maturity.

Résumé : Des études en laboratoire et dans le milieu naturel ont été réalisées pour comprendre le développement, la croissance, le choix d'un substrat et les migrations de *Cucumaria frondosa*. Les pontes de 1992 et 1993 se sont produites à la mi-juin, dans l'estuaire du Saint-Laurent et en laboratoire. Les mâles pondent un peu avant les femelles et leurs oeufs, comme leurs embryons, flottent près de la surface de l'eau. Neuf jours après la fécondation, ils atteignent le stade pentactula. Les meilleures conditions de culture en laboratoire ont été obtenues à une température de 12°C, un pH de 8 et une salinité de 26 psu. Les embryons contactent le substrat pour la première fois par l'intermédiaire des tentacules, 48 jours après la fécondation. La fixation finale à l'aide des podia ambulacraires est complétée après une période exploratoire de 3 à 40 h. Des expériences sur le terrain et en laboratoire montrent que les larves privilégient le gravier et les rochers pour se fixer. Ayant atteint une longueur de ca. 2,8 mm, 4–5 mois plus tard, les jeunes concombres de mer se déplacent vers les zones éclairées et protégées du substrat. Ils ne poursuivent leur migration vers des zones exposées qu'après avoir atteint la taille de ca. 35 mm. Le taux de croissance culmine au moment de la floraison estivale du phytoplancton lors de l'élévation de la température. Des observations effectuées dans la nature ont montré que la migration de la zone euphotique à la zone aphotique (≥ 40 m de profondeur) est reliée à la taille des individus parvenus à maturité sexuelle.

Introduction

The sea cucumber *Cucumaria frondosa* (Echinodermata: Holothuroidea) is one of the most abundant and widely distributed species of echinoderms along the east coast of Canada (Gosner 1979). It can be found throughout the St. Lawrence Estuary and Gulf from the lower tide limit to the deepest waters and in numerous other locations around the North Atlantic. Some aspects of its reproduction and ecology have been studied during the past 85 years (Arts 1910; Runnström 1918;

Runnström and Runnström 1919; Thorson 1946; Jordan 1972) but as yet, its life history has not been completely described.

The spawning and development of many other sea cucumber species have been detailed in studies by Chia and Buchanan (1969), Holland (1981), McEuen (1986, 1987), McEuen and Chia (1985, 1991), Cameron and Fankboner (1989), and Dolmatov and Yushin (1993). Still, except for some evidence from the work of Young and Chia (1982) on *Psolus chitonoides*, and that of Bulteel et al. (1992) on *Holothuria tubulosa*, little is known about the substrate selection, recruitment, and migration of young sea cucumbers after settling and about their juvenile life stages. In that regard, holothuroids remain poorly known compared with asteroids and echinoids (Birkeland et al. 1971; Barker 1977; Barker and Nichols 1983; Lucas 1984; Zann et al. 1987; Rowley 1989, 1990; Harrold et al. 1991; Keesing et al. 1993). The growth rates of very few species of sea cucumbers have been modelled (Buchanan 1967; Ebert 1978; Conand 1988) and Rutherford (1973) is the only person to have studied the growth of newly recruited *Cucumaria pseudocurata* over a year. Further, to our knowledge, no study has ever followed the growth rate of a sea

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J.-F. Hamel¹ and A. Mercier. Société d'exploration et de valorisation de l'environnement (SEVE), 90, Notre-Dame est, Rimouski, QC G5L 1Z6, Canada, and Département d'Océanographie, Université du Québec à Rimouski, 310, allée des Ursulines, Rimouski, QC G5L 3A1, Canada.

¹ Author to whom all correspondence should be sent at the first address.