Contrasting modes of reproduction by common shallow-water antarctic invertebrates

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High-latitude invertebrate faunas long have been characterized as having an unusually high proportion of species that brood their young and avoid pelagic larval stages (White 1984). Yet some shallow-water species in the Antarctic are not brooders but have planktotrophic larvae. Among the most abundant shallow-water echinoderms of the antarctic coast, for example, the sea urchin *Sterechinus neumayeri* and the sea star *Odontaster validus* have planktotrophic larvae that are nearly indistinguishable from the larvae of similar species on the California coast (Pearse 1969; Bosch et al. 1984; Pearse and Bosch in press). Our on-going research program is examining reproduction of the common shallow-water invertebrates in McMurdo Sound to ascertain which mode, if any, predominates there and to determine the factors that select for different modes.

We have focused on asteroids (sea stars) because they are conspicuous and diverse. Moreover, when ripe, animals often can be induced to spawn by injection of 1-methyladenine (Stevens 1970), and larvae can be reared in the laboratory following standard techniques (Strathmann 1971). We collected and examined 13 species of asteroids in 1984 – 1985 (table). Two of these species, *Diplasterias brucei* and *Notasterias armata* were known to brood embryos (Clark 1963); approximately 10 percent of the population of *D. brucei* were brooding in 1984 – 1985, and several of these were followed in the field until they released their young (about 5 months).

At least six other species are broadcast spawners and were seen to spawn gametes in the laboratory during 1984 – 1985. The planktotrophic larvae of one of these, *Odontaster validus*, had been described (Pearse 1969) and these larvae were reared through metamorphosis in 1984 – 1985 (5.5 months). Only one other species, *O. meridionalis*, was found to produce planktotrophic larvae.

Large (550 to 1,300 micrometer diameter) eggs were freely spawned into the water by four species. The eggs of *Porania* sp., a small (1- to 2-centimeter ray length) undescribed species, settled on the bottom of the culture dishes where they developed to the morula stage. The eggs of the other species were buoyant and floated to the surface when spawned. Those of *Acodontaster hodgsoni* developed into non-feeding swimming larvae that passed through a modified brachiolaria stage before metamorphosing in about 2.7 months.

The ovaries were dissected from five other species of asteroids. All contained large numbers of oocytes between about 450 and 1,200 micrometers in diameter, and similar to those of species that broadcast spawned and produced lecithotrophic larvae. Moreover, although frequently noted and collected by earlier workers, none of these species have ever been noted brooding their young; they almost certainly are broadcast spawners with lecithotrophic larvae.

Thus most species of shallow-water antarctic asteroids appear to have pelagic larvae (mainly lecithotrophic). However, asteroid larvae have rarely been collected from the plankton. Extensive sampling with diver-towed nets, stationary nets, and traps from September 1984 through June 1985 yielded only 14 larvae of *O. validus*, and no lecithotrophic larvae. The fate of these larvae therefore remains unclear. Because most of the lecithotrophic larvae are buoyant, they may float to the undersurface of the sea ice where they could develop within the platelet ice without being swept far away.

Reproductive characteristics of shallow-water asteroids in McMurdo Sound, Antarctica

Species	Egg diameter (in micrometers)	Embryo/larva nutrition
Brooders		
Diplasterias brucei[a]	2250–3150	Lecithotrophic
Notasterias armata	>2500	Lecithotrophic
Confirmed Broadcasters[b]		
Odontaster validus[a]	150–200	Planktotrophic
Odontaster meridionalis	150–200	Planktotrophic
Acodontaster hodgsoni[a]	550	Lecithotrophic
Porania sp.	550	Lecithotrophic
Bathybiaster loripes	950–1000	Lecithotrophic
Lophaster sp.	1300	Lecithotrophic
Probable Broadcasters		
Porania antarctica	>450	Lecithotrophic
Acodontaster conspicuus	>700	Lecithotrophic
Psilaster charcoti	>800	Lecithotrophic
Macroptychaster accressens	>1000	Lecithotrophic
Perknaster fuscus	>1200	Lecithotrophic

[a] Reared through metamorphosis.

[b] Spawned in laboratory.

Other shallow-water animals in McMurdo Sound also have pelagic development. We found numerous small eggs (190 micrometers in diameter) in the abundant large nemertean *Parbarlasia corrugatus* from September to December; these were spawned in December and January. Many pilidium larvae were present from November at least through June. The common burrowing bivalve *Laternula elliptica*, mistakenly reported to brood (Burne 1920), spawned large numbers of small eggs (220 micrometers) in the laboratory and field in March 1985; embryos within fertilization membranes were abundant in the plankton and bottom sediments the following month until they hatched as tiny juvenile clams. On the basis of egg size in the ovaries, two other common bivalves, *Adamussium colbecki* and *Limatula hodgsoni* almost certainly are broadcast spawners also. The three most abundant large shallow-water gastropods, *Amauropsis grisea*, *Trophon longstaffi*, and *Neobuccinum eatoni*, were found to deposit eggs in capsules within which embryos develop into juveniles. Nevertheless, gastropod veligers of unknown origin were the most abundant meroplankters during the 1984 – 1985 season.

Our findings to date indicate that the predominate mode of reproduction among common shallow-water invertebrates in McMurdo Sound is pelagic lecithotrophy (about 60 percent of the asteroids), in theory a poor reproductive strategy (Vance 1973). Lecithotrophy indicates that food conditions for larvae are limiting, and the parents need to provide the embryos and larvae with large nutrient supplies. Only a few species in the Antarctic depend on plankton for larval food. On the other hand, relatively few species brood their embryos, and there does not seem to be unusual selection against species with pelagic larvae as previously assumed.

We thank Ronald Britton and Baldo Marinovic for assistance in the field, and Vicki Pearse, Rodney Simpson, and William Stockton for comments on the manuscript. This work was supported in part by National Science Foundation grant DPP 83-17082.

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Sinking rates of natural phytoplankton populations of the western Weddell Sea

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One potentially large loss of biogenic material from the euphotic zone is via sinking of particles. Data exist which imply that sinking may be particularly important in ice-edge systems and in the southern oceans in general. For example, large deposits of siliceous oozes occur on the continental shelfs of the southern oceans (DeMaster 1981). These deposits are diatomaceous and often appear to consist of whole, non-fragmented diatoms. In addition, antarctic diatoms are usually heavily silicified when compared to temperate and tropical forms; such ornamentation might be expected to increase the density of cells and increase the relative sinking rates. Finally, epontic algae have been reported to sink very rapidly when ice is melted (Sullivan personal communication), and because active ice-melt and ice algal release occur in marginal ice zones, losses of these species due to sinking might be expected to be large. However, an analysis of the total (dissolved plus particulate) silica distribution within an ice-edge bloom in the Ross Sea indicated that losses of siliceous material from the euphotic zone were low (Nelson and Smith in preparation); a corollary to this is that net sinking rates within the bloom were low (Smith and Nelson 1985). Determination of sinking rates could help us understand the temporal and spatial variations of phytoplankton biomass within the ice-edge system.

Measurements of particle sinking rates were conducted on the R/V *Melville* during November and December 1983 as part of AMERIEZ (Antarctic Marine Ecosystems Research at the Ice-Edge Zone). All determinations were made using settling chambers constructed using the recommendations of Bienfang (1981-a) (figure). The chambers were suspended on a gyro mount, placed on deck and maintained at *in situ* temperatures by circulating surface seawater through the water jacket. By conducting measurements on deck, experimental manipulations of the ambient-light regime could be performed. The method used to calculate sinking rates determines the change in phytoplankton biomass after a period of time in the chamber's lower portion; this increase can then be related to population sinking rate (see Bienfang 1981-a for theoretical treatment of the meth-