Study identifies bottlenecks in early seagrass growth

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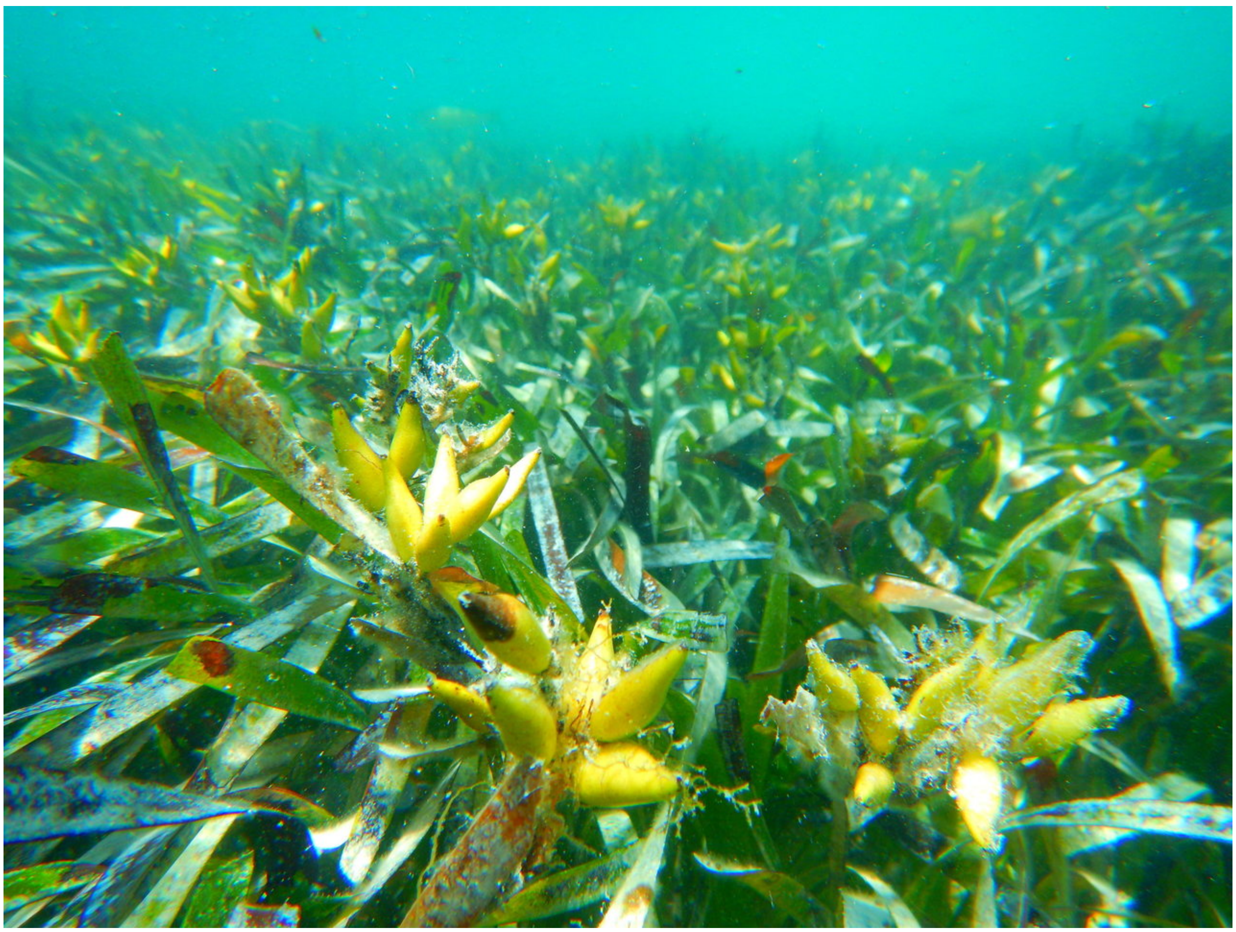


Fruits of the seagrass *Posidonia australis*. Credit: J. Statton/UWA.

Seagrass meadows, key nursery and feeding grounds for many kinds of marine life, are being lost worldwide to nutrient pollution, warming waters, and other ills. A new study by an international research team reveals bottlenecks in the growth of seagrass from seed to seedling, knowledge useful for improving seed-based restoration efforts.

The study authors are John Statton, Leonardo Montoya, and Gary Kendrick of the University of Western Australia, Robert Orth of William & Mary's Virginia Institute of Marine Science, and Kingsley Dixon of Curtin University in Perth. Their work appears in today's issue of *Scientific Reports*, an open-access journal from the publishers of Nature.

"The science behind seed-based restoration is very underdeveloped for most seagrass species and lags severely behind that for land plants," says Statton. One notable exception is the success of using seeds to restore eelgrass to Virginia's seaside bays; work pioneered by Orth during years of trial and error testing both seeds and transplanted shoots.

In the current study, the researchers sought to understand the journey from seed to seedling for the Australian seagrass Posidonia australis or ribbon-weed. This slow-growing species has experienced serious declines over much of its range, earning it a "near threatened" status on the IUCN Red List.

The team conducted their study by painstakingly monitoring the fate of more than 21,000 P. australis seeds hand-planted within experimental plots in Western Australia's Cockburn Sound. They sited the plots to test varying degrees of exposure to waves, seed grazers such as crabs, and "bioturbators," animals that inadvertently bury seeds during burrowing or other activities—often too deep for subsequent development.

VIMS professor Robert JJ Orth examines a bed of *Posidonia australis* seagrass within Cockburn Sound, Western Australia. This species has suffered substantial losses here and elsewhere due to nutrient pollution and industrial development of the coast. Credit: S. Manley/VIMS.

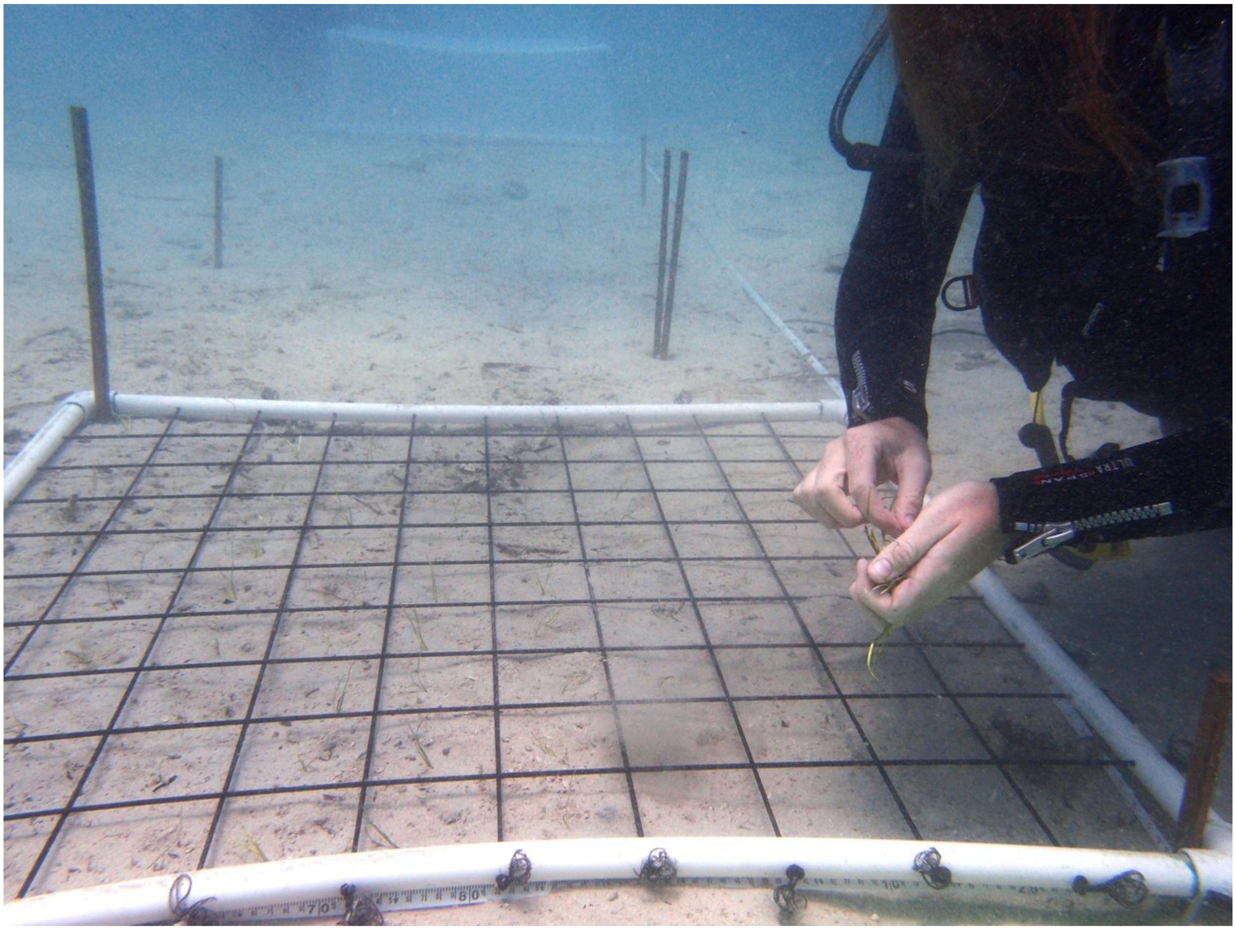
Unlike most other studies of seagrass growth, which have simply looked at the overall proportion of seeds that reach maturity as adult plants, Statton's team carefully followed the progress of their seeds at each step from germination to seed-dependent, seed-independent, and established seedlings.

"By identifying the exact early life-stage transitions that limit seagrass recruitment, we think we can improve our ability to target the processes most responsive to management," says Statton. "These bottlenecks may be unique for each seagrass species and even a particular location," adds Orth.

The team's results showed clear differences in seed success among the various life-stages. In the shallower, more-sheltered sites, few if any seeds survived grazing and bioturbation to complete the initial life-stage transition—the first month of growth when a germinated seedling still relies on its seed for energy. Seeds deployed in deeper sites survived for another four to six months, before almost all the now-independent seedlings were uprooted by waves from winter storms. As a result of these challenges, overall seed survival was vanishingly low—with fewer than 1 in 1,000 seeds reaching the juvenile stage—a probability of just 0.1 percent.

The researchers then used models to estimate the seeding density needed to overcome these severe bottlenecks, calculating success at seeding densities 2- to 40-times higher than their field studies. Here their results suggest the more seeds the better, although they note additional fieldwork is needed to test for diminishing returns in growth due to overcrowding of seeds and competition for limited resources.

Although the bottlenecks to growth observed in the Australian study might seem overwhelming, Orth notes they are actually in line with findings from other studies of both seagrasses and land plants. "In our restoration efforts in the seaside bays of Virginia's Eastern Shore," he says, "the probability of seed survival is only about one to five percent."



A researcher hand-plants *P. australis* seeds in one of the team's experimental plots. Credit: J. Statton/UWA.

Despite this, repeated seeding by VIMS researchers has led to restoration success. "In 1997 there was just a small patch of eelgrass in South Bay," says Orth. "Now, 71 million seeds later, there are more than 7,000 acres, and the grass is spreading naturally."

A similar approach might thus work in Australia and other areas worldwide where seagrasses have succumbed to cloudy waters and coastal development. "Our results indicate that seeding may be an appropriate strategy for restoring P. australis," says Statton. "But," he adds, "we would need to do so annually for a decade or more to escape both the summer bottlenecks associated with bioturbators and grazers, and the winter bottlenecks associated with storm waves."

"This approach would allow us to benefit from windows of opportunity," he explains, "benign years when winter storms were relatively weak or came from directions where landmasses blocked most waves. These conditions would allow seagrass seeds to take root and survive."

The team's field and modeling results suggest a number of other strategies to maximize restoration success. For wave-sheltered sites, these include relocating or excluding the crabs and other invertebrates that currently dislodge or eat most seeds and incipient seedlings. "In wave-exposed locations," says Statton, "we might introduce mixtures of seeds and seedlings from species adapted for turbulent conditions, thus providing some seafloor stability for the survival of P. australis."

More information: John Statton et al, Identifying critical recruitment bottlenecks limiting seedling establishment in a degraded seagrass ecosystem, *Scientific Reports* (2017). DOI: 10.1038/s41598-017-13833-y

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