Alan Shanks, Oregon Institute of Marine Biology, Size and Spacing Presentation on propagule duration and dispersal distance

The distance and time that propagules, or larvae of organisms, spend in the planktonic stage is an important factor for the size and spacing of marine reserves. Knowledge of larval dispersal distances can help estimate an optimal size for reserves as well as the distance between marine reserves. This will allow propagules with short pelagic durations (PLD) to sustain populations within a reserve and larvae with longer PLD's from one marine reserve to disperse and settle in another marine reserve.

Propagules spend from seconds to months in the plankton. The length of time larvae spend in the plankton is related to distance traveled. The longer larvae spend in the plankton, the further they can go. Additionally, larvae are not passively distributed, as was once believed. For example, some stay close to the bottom where currents are slower and they are therefore more likely to be retained in close proximity of their starting point.

There is a gap in dispersal distance between 1 and 25 km and no matter how many data points have been collected; the gap is not being filled in (Figure 1). As more species are studied and added to this plot, that gap may be filled. However, the lack of species with propagule dispersal distances of 1-25 km may reveal a strategy for species to stay close (within 1 km) or go very far (beyond 25 km) from where they were born.

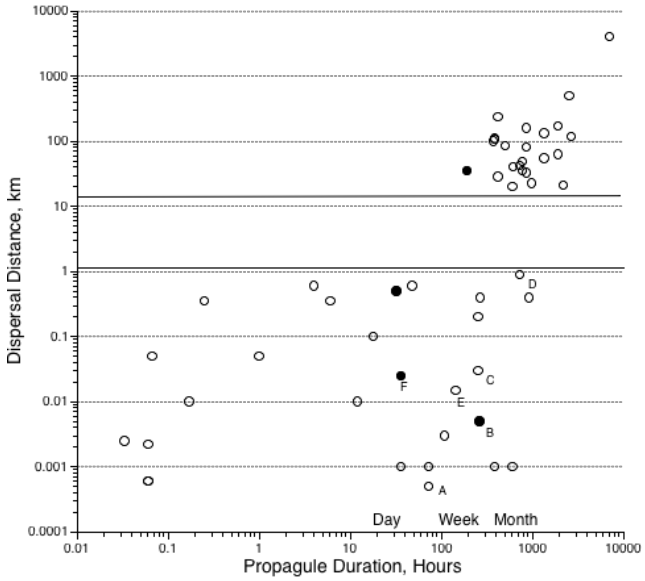
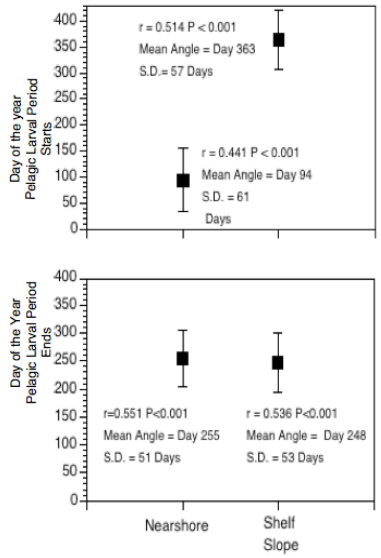


Figure 1. Graph of larval dispersal distances showing a gap between 1 and 25 km. Modified from Shanks, Grantham and Carr (2003).

A marine reserve could be designed to maintain populations of organisms whose larvae disperse short distances (< 1 km); a reserve 5 to 10 km in diameter should be adequate to allow populations to be sustained. A marine reserve would not, however, be designed to retain larvae that disperse over 25 km. The larger values could be used to estimate how closely reserves should be spaced. A minimum spacing of about 25 km, or 25-50 km might be appropriate based on the current data.

There are differences in the patterns of reproduction and dispersal of larvae of nearshore species and shelf/slope species. Nearshore fish larvae start their pelagic period around April 1 and end around mid-September, whereas shelf/slope fish larvae begin their pelagic period near the end of December and end around the beginning of September (Figure 2). The implications of these differences are important. Larvae of nearshore species are in the water only during the upwelling season whereas larvae of shelf/slope species are in the water during both the Davidson Current season and the upwelling season. The timing of reproduction by some shelf/slope species suggests that the currents are moving the larvae north and then south along the shelf, with possibly little net movement along the coast (Figure 3).

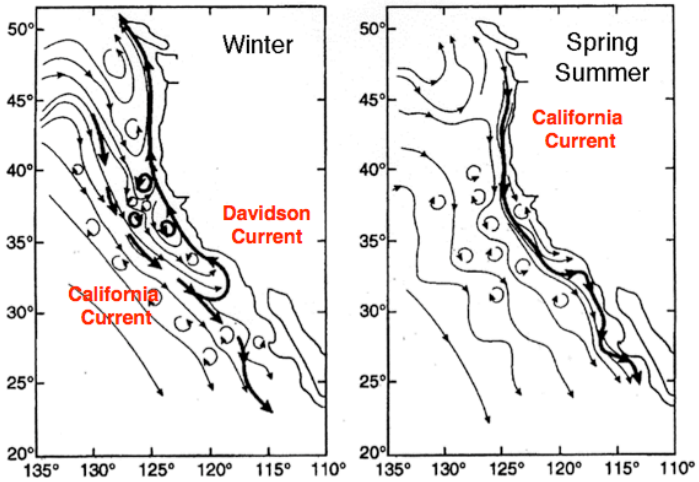


1. Nearshore fish larvae start their pelagic period around 1 April and end it around mid-September.

In Contrast

2. Shelf/slope fish larvae start their pelagic period near the end of December and are pelagic till the beginning of September.

Figure 2. Graphs showing the difference in nearshore and shelf/slope fish species with respect to time of year larvae are dispersed (Shanks and Eckert, 2005).



Current speeds in the Davidson Current range from 10 to 45 cm/sec. During a month in the plankton, larvae maybe transported 650 km to the north.

Current speeds in the California Current Range from 10 to 50 cm/sec. In a month, larvae may be transported from 258 to 1290 km to the south.

Figure 3. Diagrams illustrating the differences between the winter and spring/summer seasons in regards to the California and Davidson currents with implications for larvae dispersion.

Other research has been conducted to help confirm travel distances of larvae and juvenile fish. Studies of black rockfish otoliths (ear bones of fish which can show chemical changes, water conditions and other environmental factors as well as age of a fish) suggest a maximum dispersal distance of only 120 km dispersal—a smaller distance than previously thought (Miller and Shanks, 2004).

The overall conclusions indicate two main concepts:

1. For species with short dispersal distances (< 1km), a reserve one to a few miles in diameter may support self-sustaining populations. Enough larvae spawned in the reserve will recruit back into the reserve to sustain the populations in the reserve.
2. For species with larval with longer dispersal distances (e.g., > 25 km), larvae may be dispersed along the coast over distances from 10-20 or even several hundred miles. Larvae spawned in a reserve will settle over a broad area of the coast contributing to populations both inside and outside of a network of reserves. Given the variability in ocean currents, it is possible that some of these larvae will actually settle near where they were spawned.