Coral reef fish larvae: Patch size estimation and mixing in the plankton

Abstract—The daily pattern of settlement of larvae of the bluehead wrasse, *Thalassoma bifasciatum*, onto a number of coral reefs was reconstructed with the daily otolith increment aging technique. Larvae settled simultaneously onto reefs within an area of about 1,000 km². The planktonic patch size of bluehead wrasse larvae is inferred to be at least 46 km wide. Larvae settled onto a reef are a product of the same age, indicating that planktonic dispersal has not yet been obtained by direct sampling methods. It is, however, possible to extract detailed information about processes occurring in the plankton from individuals that have already settled by the use of the daily otolith increment technique. This aging method provides extremely precise estimates of the duration of the planktonic larval period and the date of settlement for each individual larva that has already settled by the use of the daily otolith increment technique. Victor 1982). I also calculated the number of days each one had spent as a planktonic larva (the number of daily increments between the center and the settlement mark plus two: Victor 1982).

Bluehead wrasse larvae settle in brief and sporadic events that have a major impact on the future population composition and size (Victor 1982), but the question of what is controlling the timing and magnitude of these settlement peaks remains unresolved. Since planktonic organisms usually occur in sporadic events, it may be that these episodes of settlement are the result of occasional dense patches of larvae passing over reefs. If bluehead wrasse larvae do occur in patches it would be possible to infer the planktonic patch size by documenting the concordance on a geographical scale of specific settlement peaks. In other words, if a patch of competent bluehead wrasse larvae moved inshore and settled on the reefs that they encountered, one would expect to see a peak of settlement on that particular day on only those reefs within the path of the patch. If the reefs are arrayed broadside to the prevailing current, the linear extent of reefs encountered would be a measure of the size of the patch. This approach presumes that peaks of settlement reflect peaks of availability of larvae in the plankton. Preliminary evidence (Victor in prep.) does indicate that in San Bias Islands of Panama peaks of bluehead wrasse settlement closely correspond to peaks of planktonic fish larval abundance and diversity at a night-fishing sampling station.

I used this method to estimate the patch size of bluehead wrasse larvae settling in the San Bias Islands, an archipelago of reefs extending along the Caribbean coast of Panama. I collected a sample of juvenile bluehead wrasses from 18 patch reefs in mid-1981 (Fig. 1). On each reef visited, I collected every juvenile I encountered during a several-hour survey. I calculated the date of settlement for each individual by subtracting the number of daily increments between the mark corresponding to settlement and the edge of the otolith from the date of capture (Victor 1982, 1983). I also calculated the number of days each one had spent as a planktonic larva (the number of daily increments between the center and the settlement mark plus two: Victor 1982).

Most juvenile bluehead wrasses, 88% of the 654 captured, had settled during the 2 weeks around the new moon (Fig. 2). The largest peak of settlement occurred on 6 July, 3 days after the new moon, when 20% of all the juveniles captured had settled. The second largest peak of settlement, 12% of the total, took place on 29 June, 2 days before the new moon, and the peak the next month, 5% of the total, occurred on the night after the new moon. Fewer than 1% of the total settled during the week around the full moon.
most reefs examined, the two highest peaks of settlement that month were on 29 June and 6 July, although which one was higher varied between reefs. With a single exception, all other reefs experienced peak settlement within a day of these two dates. For the exception only the second highest peak was on some other date. Since there is some small error associated with counting daily increments, it seems likely that larvae recruited were settling simultaneously on all of the reefs (an area 46 x 16 km, or 736 km²). Since the prevailing current comes from the north in this area of Panama, it can therefore be inferred that the patch width of bluehead wrasse larvae was at least 46 km.

Newly settled bluehead wrasses probably metamorphose in hiding for their first 5 days on the reef, as has been demonstrated for another coral reef wrasse, the slippery dick, Halichoeres hirtellus (Victor 1983). Therefore I sampled only some of the reefs late enough to capture juveniles that settled during the July-August lunar peak of settlement (reefs ABHJKNLO). During this period peak settlement occurred on 30 and 31 July on most of the reefs with large samples (i.e., not on reefs BEJKL). Since the easternmost reefs (PQR) were not sampled late enough to include this settlement, the minimum patch width estimate for this settlement is only 20 km.

Since peaks of settlement tended to occur on all reefs simultaneously, the most parsimonious explanation would be that bluehead wrasse larvae occur in patches at least as wide as the area surveyed. Smaller patches of larvae could conceivably have moved through the area and happened to pass over all the reefs each time. However, as the prospective patch size gets smaller, this coincidence becomes progressively more unlikely. Since the reefs surveyed are arrayed broadside to both the prevailing onshore current in the area and the current measured during these settlement peaks (Fig. 1), a large patch size is much more likely. The patch of larvae moving in on a particular day was internally heterogeneous, since the magnitude of settlement per day was not constant between nearby reefs; for example, reef G received its largest settlement on 29 June and its second largest on 6 July, which was less than half the size of the 29 June peak, while reef D, < 1 km away, received its largest settlement on 6 July and its second largest on 29 June, and the 29 June peak was only a third the size of the 6 July peak. It is possible that rather than being passively delivered to the reef by circulating water masses, bluehead wrasse larvae are able to choose actively when to move inshore, either by swimming or by maneuvering themselves into favorable onshore currents. If this is true, the cues for such behavior must operate over an area of at least the size surveyed. This would suggest a different form of patch, as would the possibility of passive delivery by a front rather than a patch (for example by episodic internal wave trains: Shanks 1983), but both of these phenomena would still involve the simultaneous presence of larvae on a front at least as wide as the area surveyed. There is some lunar influence either on these cues or on passive delivery of patches of larvae, for the likelihood of any settlement during the week around full moon was very low. It is not, however, under precise celestial control, as days of settlement did not consistently fall on certain days of the lunar month. Gross weather and water conditions did not appear to trigger settlements, since peak settlements occurred on both clear and rainy days and generally at normal turbidity readings.

The bluehead wrasse larvae settling on any particular day were not of the same age. Therefore I sampled only some of the reefs during the July-August lunar peak of settlement. As a result, the juveniles that settle together are probably not closely related.

This is the first demonstration that planktonic dispersion of eggs does indeed mix cohorts of larvae before settlement and has important ecological ramifications. If larvae are settling simultaneously over very large areas, then the cues for settlement cannot be localized to a single reef. The notion that individuals settle from a pool of super-abundant larvae onto reefs in response to local changes in the supply of food or space (Smith and Tyler 1973; Sale 1978) is therefore inconsistent with my findings.

Benjamin C. Victor

Department of Biological Sciences and Marine Science Institute University of California Santa Barbara 93106

References


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