From the Nearshore and Back Again – Biological Implications of Coastal Mixing
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Settlement Processes: Filaments, Meanders and a Coastal Jet

How do we predict larval settlement from remote sensing data? Understanding nearshore ocean dynamics helps us make predictions and hindcasts of what to look for. In this system the upwelling jet exerts strong control over the timing, pattern and abundance of settlement.

Figure 4. Meandering coastal jet and settlement. A releases (black), mature larvae (blue), and settle (green). Larvae travel equatorward within an upwelling jet while filament, coastal eddies and meanders propagate poleward.

Conclusion: Settlement is controlled by the jet and not by filaments reattaching.

How Well Mixed are Larvae in the Coastal Ocean?

Well-mixed days (117, dashed lines) have less σ vs. x. Here 0.25 + 0.5 sin(−w sin y + 0.05 cos(x−w sin y)) where w = 0.94. In this simple model larvae are swept up along the attracting LCS and deposited back to the nearshore coincident with a repelling LCS. However, we will see that the dynamics in the more realistic model are not this straightforward.

Figure 5. Mixing through time. Here 0–1 = 0, where x is the normalized standard deviation from the average concentration. Mixing changes in time as coastal material is driven into filaments.

Conclusion: The coastal ocean is not well mixed (diffusional regime).

LCS and Upwelling Filaments

Background: Lagrangian coherent structures (LCS) are transport barriers that move with the fluid [1,2,3]. Attracting LCS (blue below) separate waters that were recently far apart, and waters straddling repelling LCS (red) will soon separate. Here we test how LCS correlate to the filamentation process of coastal released larvae.

Figure 6. Concentration of larvae on more (Day 117) and less (Day 179) mixed days. Instead of mixing and distributing, extended upwelling concentrates larvae into filaments (Day 179). Note density (particles/m³) is in log scale to emphasize lower concentrations. Model larval distributions in no way resemble a diffusive regime.

Conclusion: Coastal larvae are dense in larvae and coincide with attracting LCS and thus high SST gradients (not diffusive).

Discussion

• Frontal instability causes locally high vertical velocities along (but off) LCS, which could explain production and predation at fronts offshore.

• Model is idealized, but shows similar dynamics to straight coastlines in Oregon/Washington and other Eastern boundary currents [4]. In situ measurements of barnacle larval recruitment suggest results are consistent [5].

• In situ measurements show concentration of rockfish larvae in upwelling filaments [6], suggesting that larvae maintain their vertical position, and either horizontal swimming is not important, or larvae swim towards filaments.

• What effect does the dense spatial concentration of larvae have on their life histories? Are they more subject to predation or food limitation? How does this affect recruitment?

References

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