

Near-Shore Small-Scale Processes during Upwelling Relaxations along Northern California and Oregon and their Implications on Larvae Settlement: a Remote Sensing Approach.

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Presented at AGU's 2002 Ocean Sciences Meeting, Honolulu Hawaii, 11-15 Feb., 2002

Several previous studies have shown a link between upwelling relaxations in the California Current System (CCS) and increased near-shore settlement of various invertebrate larvae. It has also been postulated that the frequency and timing of the relaxation episodes play a dominant role in regional recruitment of the species' stocks. We utilized data series from AVHRR thermal and Synthetic Aperture Radar (SAR) satellite sensors over the past 10 years to detect changes within 30km of the coast associated with spring and summer upwelling relaxations in the northern CCS region between Pt. Arena, CA and Cape Lookout, OR.

The most commonly described physical phenomenon characterizing an upwelling relaxation along Northern California and Oregon is the reversal of nearshore current from offshore and equatorward to inshore and poleward. Some researchers have also suggested that the advection of offshore waters shoreward during relaxation events brings concentrations of pelagic larvae to the coast, thus facilitating increased settlement in favorable habitats.

Our findings show that two different regimes are encountered north and south of Cape Blanco, CA. South of C. Blanco an initial dominant coastal effect in many summertime relaxation episodes is the nearshore retainment of river runoff which rapidly increases surface temperatures, decreases salinity and most likely increases vertical stratification within 5 km of the coast. This is especially prominent in a large "upwelling shadow" region south of C. Mendocino, but commonly affects coastal sections north of the Cape as well. Although the expected shoreward and/or poleward flow is usually observed in satellite image series during relaxations lasting longer than 4-5 days, the offshore waters do not commonly reach the very nearshore habitats, as some previous investigators have surmised. Instead, throughout each episode, many regions offering adequately shallow larvae settlement habitats are mainly influenced by the runoff mixture which spreads longshore with the reversed currents. SAR data revealed that this runoff-affected inner zone is often characterized by greatly increased concentrations of surfactants forming large surface slicks.

The region north of C. Blanco was found to exhibit much reduced retention of river runoff during relaxations, and the runoff thermal and surfactant signatures rarely spread more than a few kilometers past the river mouths. An upwelling relaxation in the northern region is primarily characterized by inshore movement of the main "upwelling front". SAR data reveal high aggregations of surfactants inshore of the advancing front.

In both regions, the nearshore surfactant aggregations and river runoff retention are absent during active upwelling conditions.

Past studies have shown surface slicks to be associated with increased aggregations of fish and invertebrate larvae, and to possibly act as shoreward transport mechanisms in conjunction with internal waves. We examined a decade of bi-weekly purple urchin (*S. purpuratus*) larval settlement records at Ft. Bragg and Pt. Cabrillo in relation to the occurrence of the satellite-sensed runoff and surfactant patterns in that region. A strong correlation was found between the formation of those upwelling relaxation characteristics and larval settlement rates. In addition, the ENSO years of 1992 -1993, and 1997 - 1998 corresponded to especially strong periods of the inshore warm, surfactant-laden runoff retainment zone, as well as unusually high larval settlement rates.

Our findings suggest that retained river runoff spread by nearshore poleward currents during upwelling relaxations along northern California forms an important component of the very-nearshore zone that contains shallow habitats. Satellite data show that during most events offshore waters do not reach into this zone and are thus unlikely to significantly contribute to the increase of available settling larvae populations. The close temporal and spatial correspondence of surfactant accumulations with high urchin larvae settlement rates at Ft. Bragg/Pt. Cabrillo suggests that SAR-sensed distributions of surface slicks may be useful in studying both regional recruitment patterns and shoreward transport mechanisms of the pelagic larva stages of various organisms.