Influence of Currents, Topography and Behavior in Controlling Euphausiid Distributions in the Northern California Current

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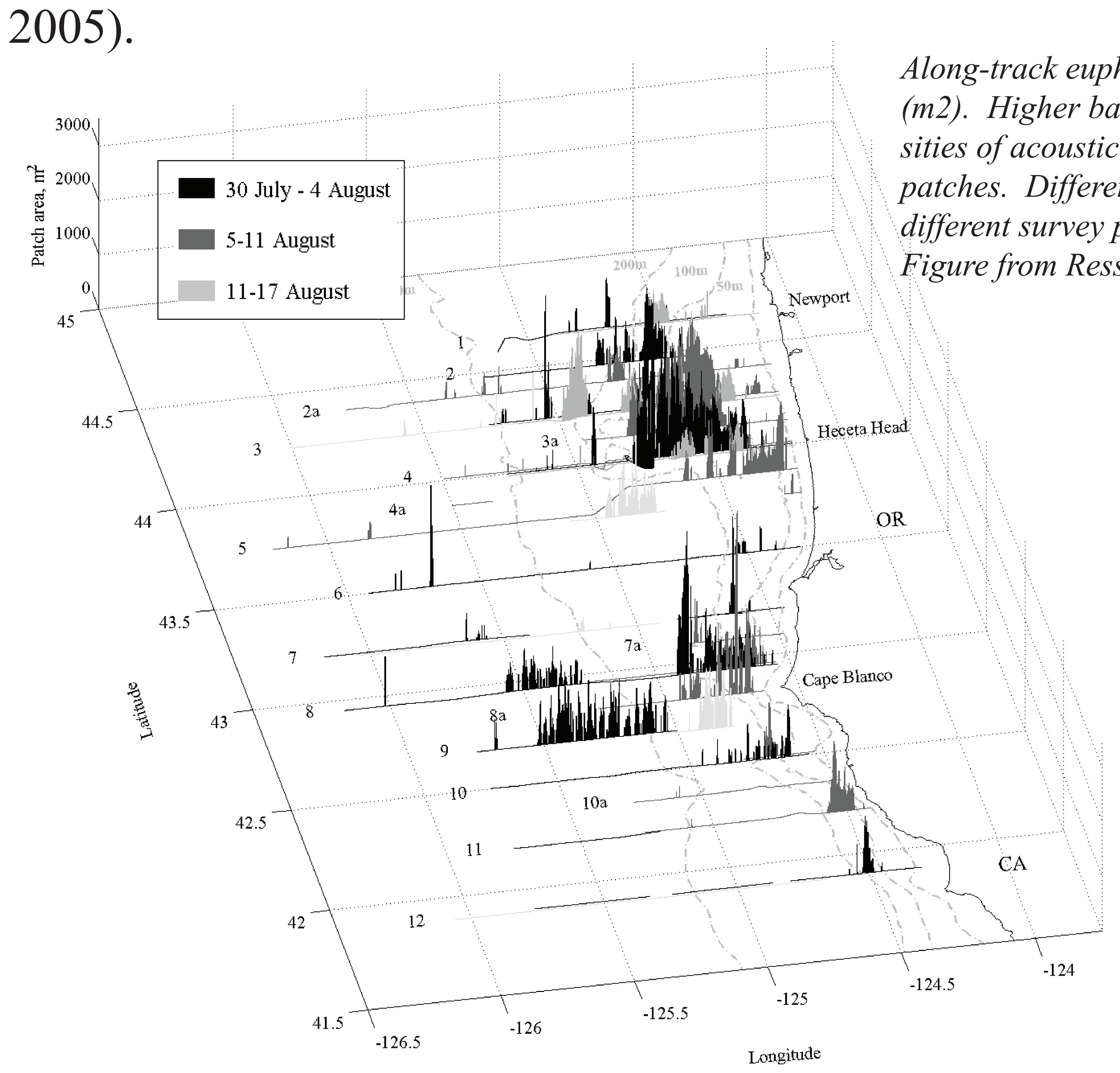
Observations from 2000 & Motivation

US GLOBEC conducted an intensive summer of observations in 2000, including survey work using SeaSoar and acoustics to document the temporal and spatial variability of the Oregon coastal upwelling system. Aggregations of euphausiids (estimated with nets & acoustics) were observed near Heceta Bank and near Cape Blanco--locations where the generally alongshore equatorward upwelling jet was influenced by bathymetry and topography (Ressler et al. 2005).

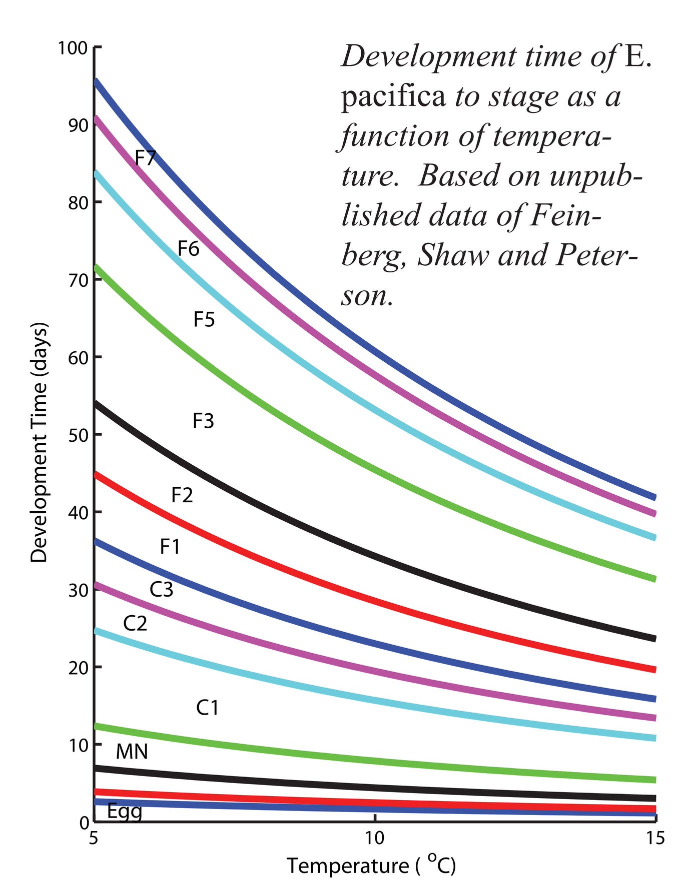
E. pacifica individuals migrate from near surface (5-10m) depths during the night to deeper depths during the day, with the amplitude of migration varying with life-stage, but generally shallow amplitude (to 35m) for younger stages to larger amplitude (to 125-225 m) for older lifestages.

Organisms in upwelling shelf ecosystems are subject to loss offshore (in surface waters) and significant alongshore transport. Batchelder et al. (2002) and others (Mart-Almeida et al. 2006; Peterson 1998; Shanks and Brink 2005) show that diel vertical migration of planktonic organisms in the vertically sheared flows of upwelling systems can strongly alter dispersion and transports. Our goal is to model processes that give rise to aggregations of euphausiids near Heceta Bank on the Oregon coast--such as those observed in August 2000. We hypothesize that the aggregations occur as a result of flow-behavior interactions (esp. vertical migration), and the aggregations are magnified in regions of complex topography.

Flow fields and hydrography are modeled using 3D Regional Ocean Modeling System (ROMS) with 4 km horiz resolution, using observed 2000 wind forcing and boundary conditions (Curchitser et al. 2005).



Along-track euphausiid patch area (m2). Higher bars indicate greater densities of acoustically determined patches. Different gray scales are from different survey periods in August 2000. Figure from Ressler et al. (2005).



Development time of E. pacifica *to stage as a function of temperature. Based on unpublished data of Feinberg, Shaw and Peterson.*

References

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Particle Tracking

Particle tracking simulations considered advective transport, but not diffusion (future work). Particle depth was fixed at a single depth (5m, 35m, 50m, 65m, 95m) or allowed to sinusoidally vary (deepest at noon). Backward-in-Time Trajectory (BITT) simulations provided trajectories or probability densities of particle locations at earlier periods. Daily snapshots of physical conditions from the ROMS were used to integrate particles through space and time.

500 particles were initialized into a small region including part of Heceta Bank and adjacent slope waters. Locations were reseeded every 10 days. For BITT, simulations began on day 243 (1 Sept) and continued until day 153 (1 June). Particles from fixed 95m depth simulations that were initially deeper than the bottom were grounded and did not advect.

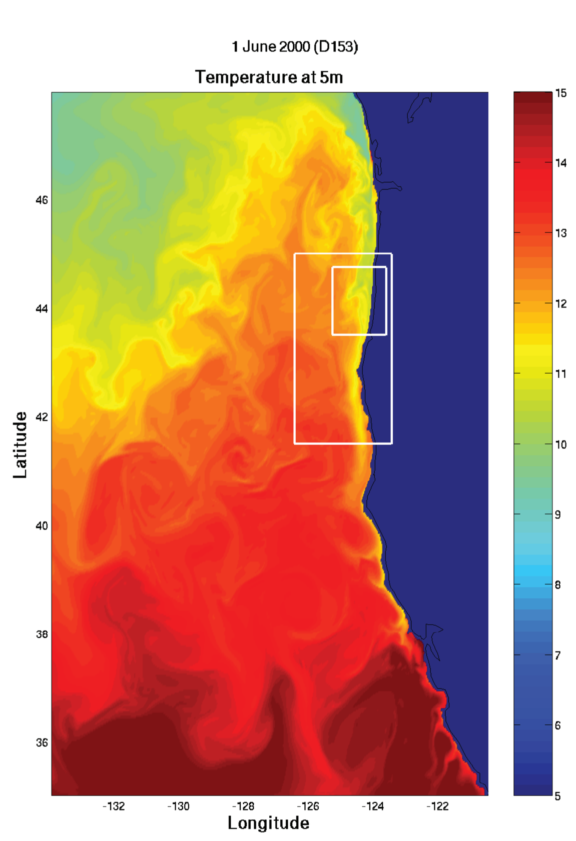
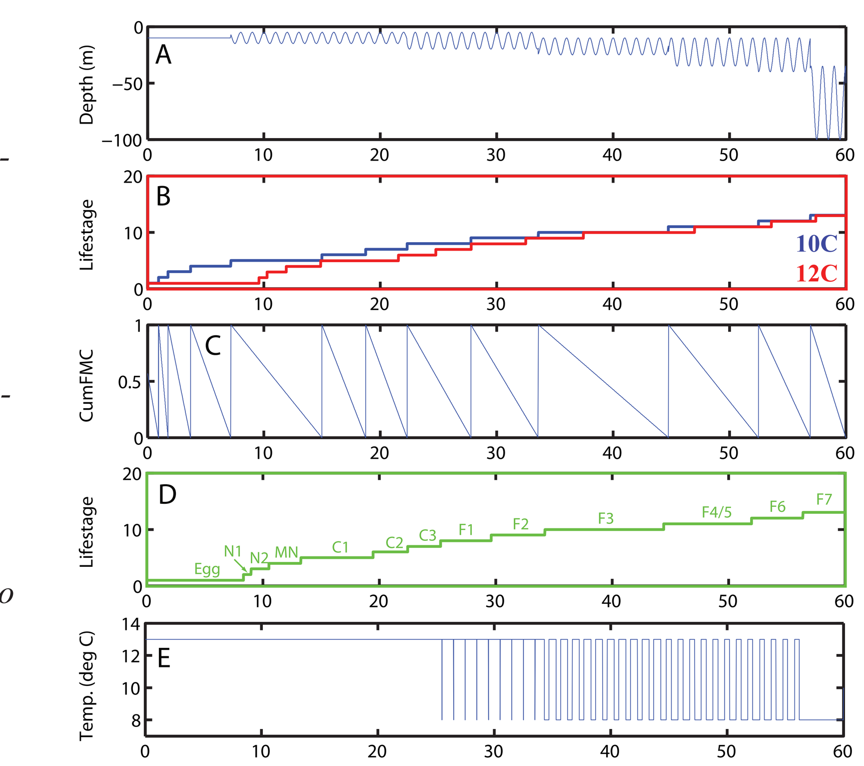
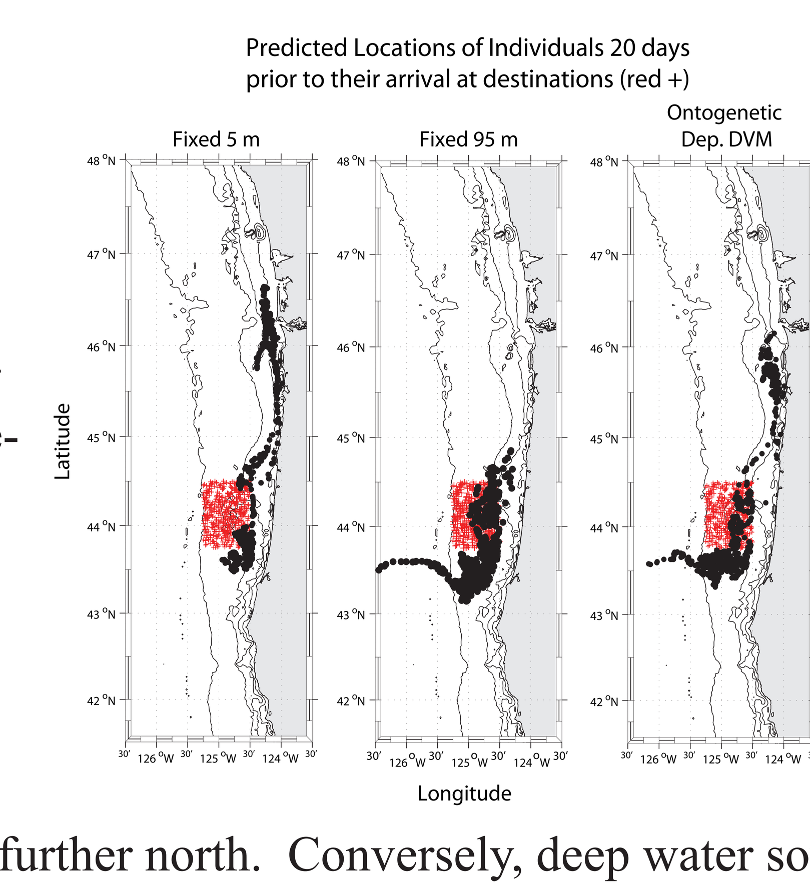


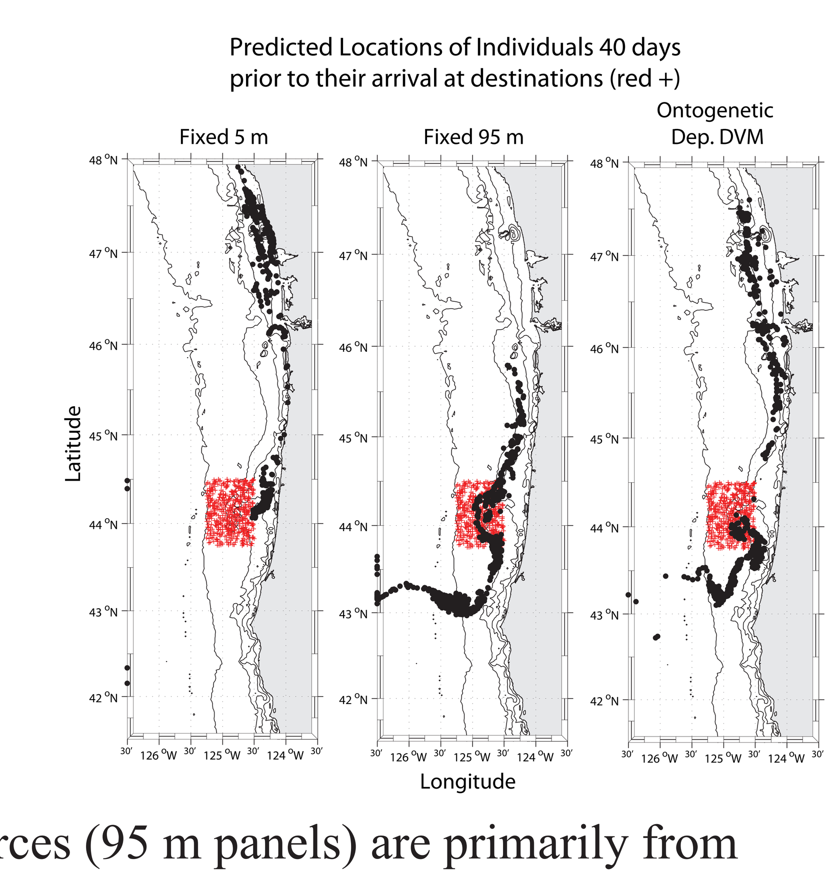
Figure LEFT: Temperature at 5 m for 1 June 2000 from the ROMS CCS simulation. Larger white box locates GLOBEC CCS study region; smaller white box identifies Heceta Bank region. Since this was early during upwelling season, the signature of upwelling (cold water near shore) is not yet strong (but still clearly present).

Figure RIGHT: Panels A-C show depth, Lifestage, and Cumulative Fraction of Molt Cycle completed (CumFMC) for constant 10C temperature (blue curves). Red curve on Panel B shows lifestage progression for 12C. Panels D-E show lifestage progression and experienced temperature for a 2-layer system (13C in upper 20 m; 8C deeper. Simulation is BITT, so time proceeds from later (60 days) to earlier (bottom axis), with individuals beginning simulation as Furcilia7 lifestage (stage 13). In panel B note that E. pacifica reach C1 stage nearly 10 days earlier at 12C than at 10C.



Positions of particles 20 (near-right) and 40 (far-right) days prior to arrival at locations indicated by red plus symbols (+). During summer upwelling, surface flow is predominantly alongshore from north to south (fixed 5 m), with smaller offshore transport; particles "captured" on Heceta Bank came from a broad range of latitudes, but most came from shelf waters further north. Conversely, deep water sources (95 m panels) are primarily from south and offshore of Heceta Bank (deep water inflow off Cape Blanco), with some shelf sources north of Heceta Bank (40d; 95 m). Source locations when vertical position is controlled by temperature-dependent progression through the life cycle shows a mix of southern and northern sources. After 20 days, most particles are south, but near, Heceta Bank. During this period, when the individuals are older furcilia (F4-F7), DVM places the individuals part of the day in deep waters (coming from the south) and part in shallow waters (coming from the north). The net displacement is relatively small. The positions of particles 40 days prior to "capture" at Heceta Bank, are more broadly distributed, with a greater fraction being on the outer shelf to the north. This results from the animals being smaller and more restricted to near-surface depths, which are predominantly from the north.





Sources and trajectories of organisms are sensitive to the depth of the particle in coastal systems with strong horizontal and vertical transport gradients. This is magnified by interactions of temperature (or food) on developmental progression through the life cycle in organisms that have ontogenetically controlled DVM behaviors.