Modeling krill “hotspots” in the central California Current: results from variation in diel vertical migration schemes

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Acoustic Analysis of Krill
May- June, 2004-2009

Euphausia pacifica
after Brinton and Myhre, 1976

Santora et al. 2011, Progress in Oceanography
Roadmap

• Introduction to
  – Models (Physical and Biological)
  – Data Collection

• Results
  – Q1: Does our modeling efforts reproduce similar hotspots to what has been observed acoustically
  – Q2: Is the nature of these hotspots related to the physical environment (controls).
  – Q3: Can we learn anything about properties of these hotspots from the model
Physical Oceanographic Modeling Regional Ocean Modeling System (ROMS)

- Years Modeled 2000 – 2008
- NCEP-NARR Forcing (32 km) 3-hourly
- SODA Boundary Conditions Monthly
- 3-6 km grid resolution

Model Domain

Bathymetry of ROMS Domain
ROMS Results vs. Observation Data

Sea Surface Temperature (1-day)
NDBC Buoy 46012 vs. ROMS SST

Surface Currents (1 mo. avg.)
BOON CODAR vs. ROMS
Individual Based Model

- Particle Tracking with Saved ROMS Data (Runge-Kutta Advection - 4th order)
- No Biology, Other than Diel-Vertical Migration
- Downward Vertical Migration of organisms based on light-levels
- Upper Vertical Migration limit set at 5m, 20 meters, or 40 meters

Spring Model Runs
Start Date – Feb 15
40,000 Particles
Uniform Distribution

May - June

Summer Model Runs
Start Date – May 15
40,000 Particles
Uniform Distribution

“How are these Hotspots Formed?”

“Where do these Hotspots Go?”

Santora et al. 2011, Progress in Oceanography
Feb 15 Start – DVM = 5

Spring Runs

May 15 Start – DVM = 5

Summer Runs
Individual Based Model
Initial Conditions
40,000 Particles

Analysis - Getis Ord Statistic
- Spatial Statistic that highlights clusters of high local values in relation to overall values for the entire area.
Conversion of Acoustics to Getis-Ord

3. Results
3.1. Identification and location of krill hotspots
3.1.1. ‘Core’ area: Cordell Bank (38°N) to Monterey Bay (36.5°N)
Summer Runs 2000-2008
20m Upper Limit of DVM

Peaks in Acoustic and Model Data

Acoustic =  
Model =  

Number of Days Significantly “Hot”
1. Migrating Higher in the Water Column (5m) results in greater offshore displacement of Hotspots
2. Consistent Hotspots are found in the two of the three locations identified as hotspots by acoustics.
Hotspot Correlation with Alongshore Velocity

Spring DVM = 20m

Summer DVM = 20m
Hotspot Correlation with Alongshore Velocity

215,2000-2008 - DVM 20m - V-velocity vs. Avg HS Value at 20m

Alongshore Velocity (m sec^{-1})
1. Strong equatorward alongshore currents (i.e. Upwelling Events) are more likely to the North of Pt. Reyes compared with regions to the South.
2. These currents inhibit the formation of hotspots during these periods.
Hotspot Analysis Through Time

- Size
- Intensity
- Persistence
- Direction
- Starting Location
- Ending Location
- Evolution

Animation of Daily Hotspot Movement
Size of Hotspots - 2000-2008
20m Upper Limit of DVM

Size of Acoustic Hotspots
200 km²
575 km²
600 km²
800km²

Percentage of Sampled Area

Size (km²)
Conclusions and Future Directions

Conclusions
1. Vertical migration to surface waters results in a more offshore distribution of particle hotspots.
2. The model represents the two major hotspots observed in acoustic data.
3. Intense Ekman transport appears to inhibit hotspot formation to the North of Point Reyes but not in the region between San Francisco and Monterey Bay.
4. Size of model hotspots generally agree with the acoustic representations.

Future Directions
1. Analysis of Hotspots in a Lagrangian sense.
2. Comparison of Interannual variability in model and acoustics.

-Funding and Support
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-Model Development
ROMS Community, Hal Batchelder, Oregon State University
subroutine end_of_talk
! An attempt to introduce levity to a talk based entirely on modeled results and
! lacking a cool ending image of zooplankton nets being deployed from a ship at
! sunset.
    if ((QUESTIONS .eq. .TRUE.) .AND. (TIME .eq. TRUE)) then
      print *, ‘I would be happy to answer any questions.’
    else if ((QUESTIONS .eq. .TRUE.) .AND. (TIME .eq. .FALSE.)) then
      print *, ‘Please contact me at dorman@berkeley.edu.’
    else if (QUESTIONS .eq. .FALSE.) then
      print *, ‘Thanks for your attention and time.’
    end if
end subroutine end_of_talk