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

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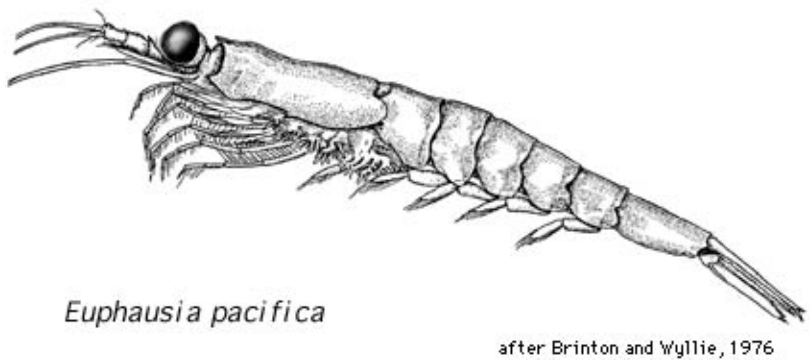
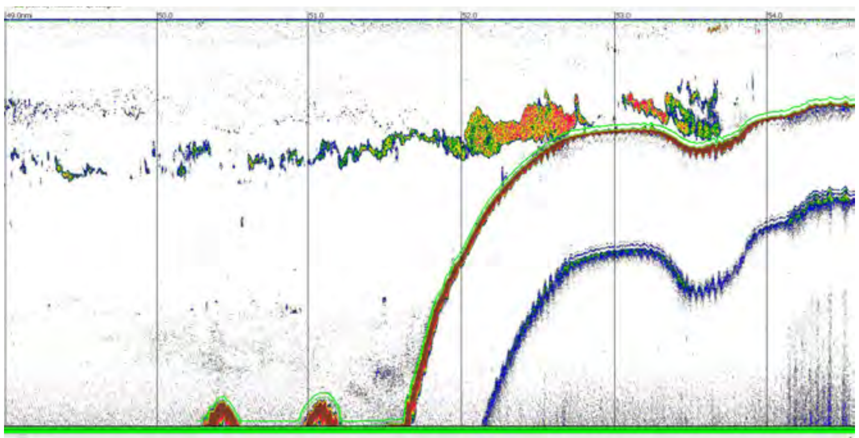
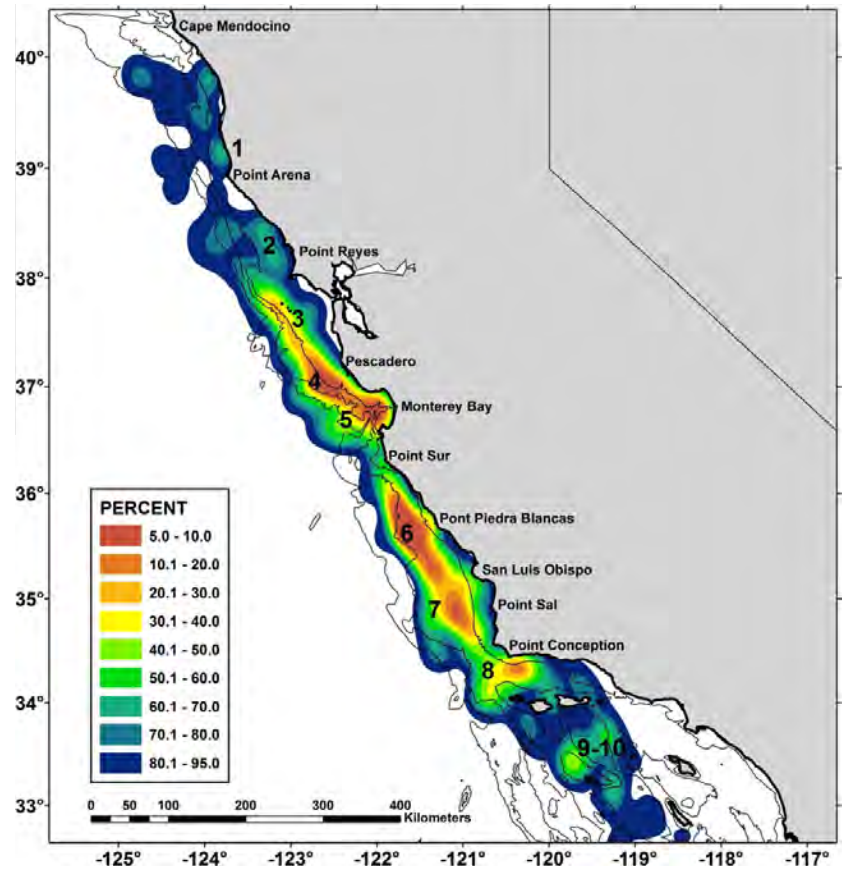
Acoustic Analysis of Krill May- June, 2004-2009





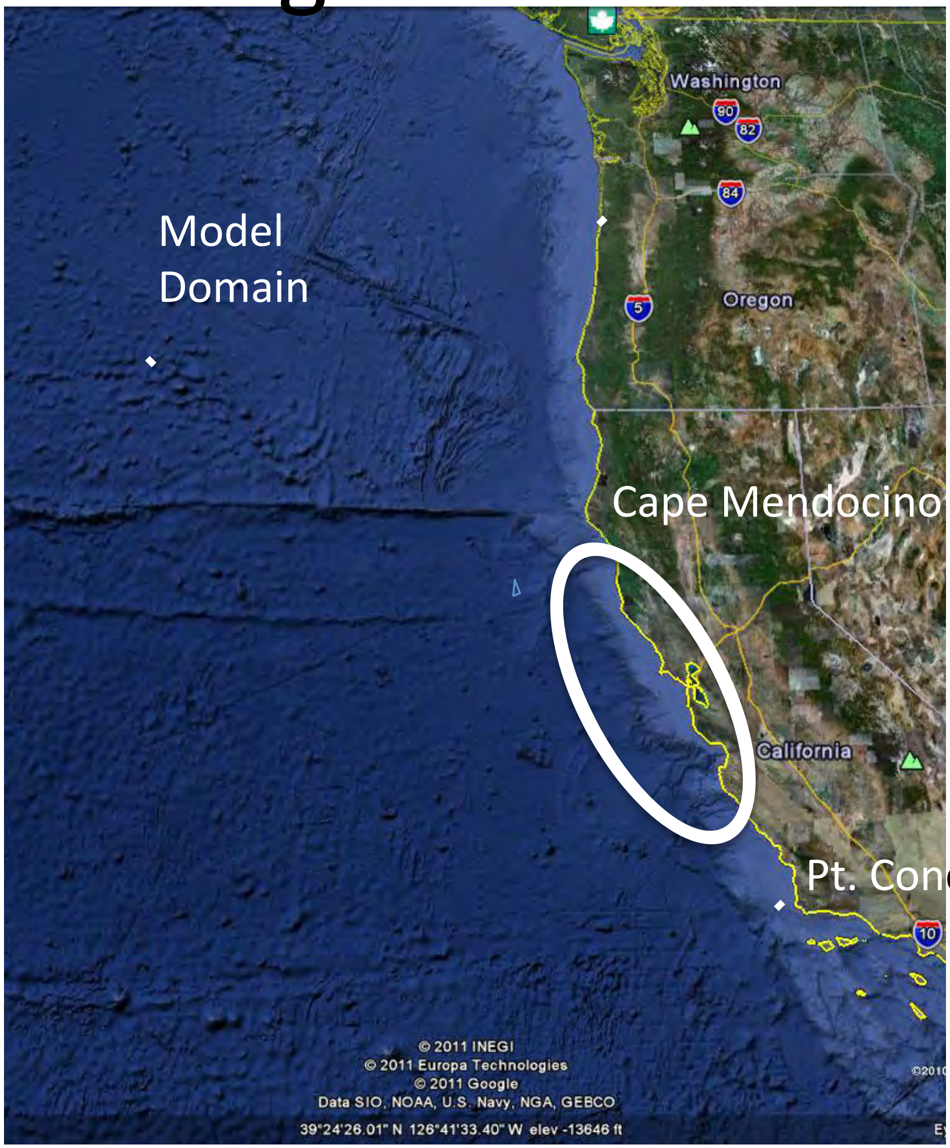


Santora et al. 2011, Progress in Oceanography

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)



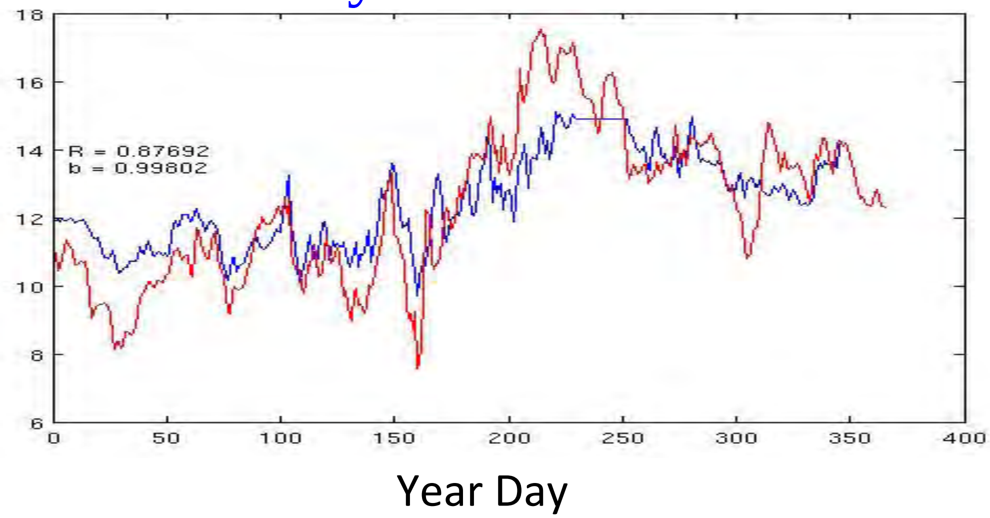
- Years Modeled 2000 – 2008
- NCEP-NARR Forcing (32 km)
  3-hourly
- SODA Boundary Conditions
  Monthly
- 3-6 km grid resolution

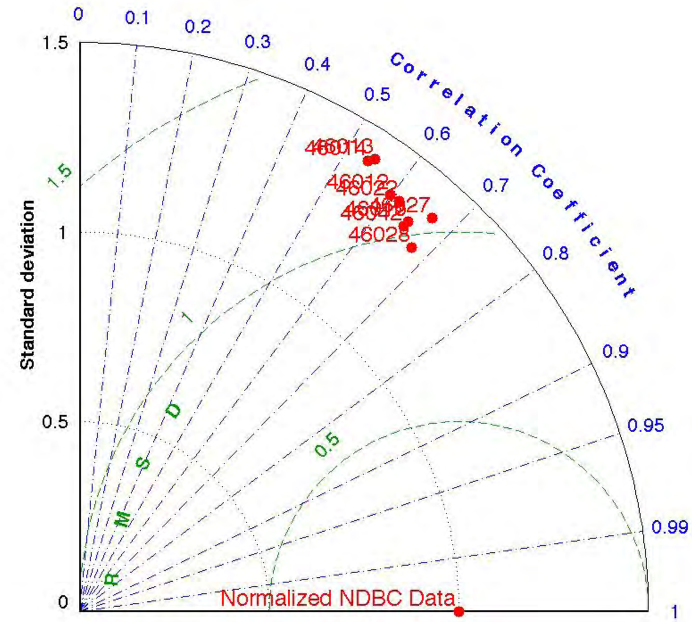
Bathymetry of ROMS Domain

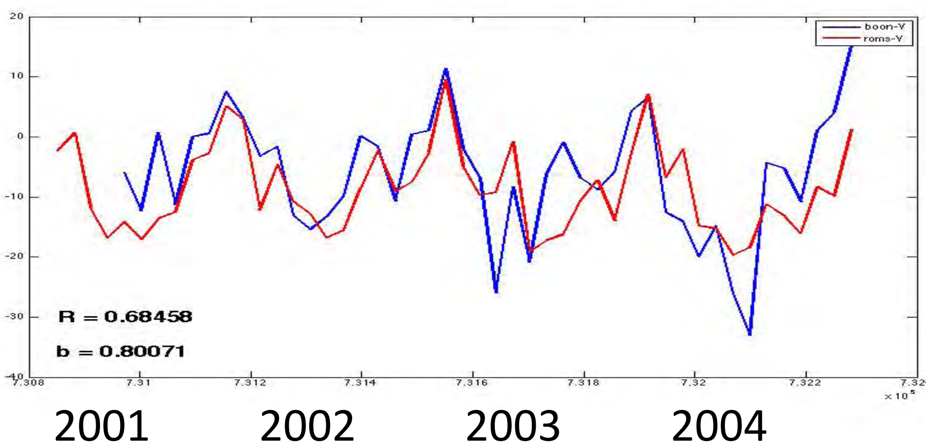
ROMS Results vs. Observation Data

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 - 4^{th} 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

<u>Spring Model Runs</u>

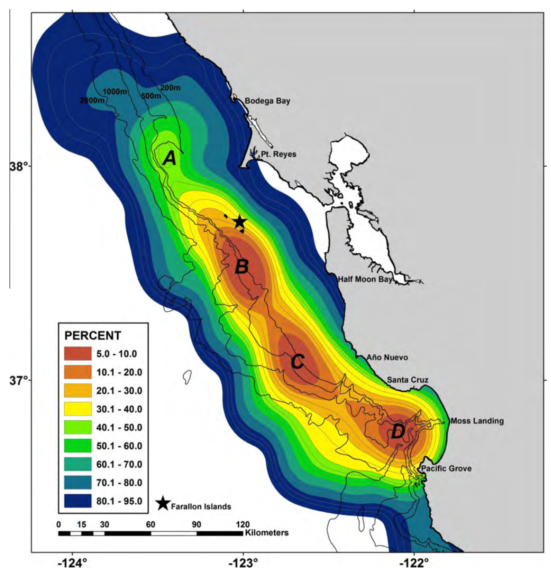
Start Date – Feb 15

40,000 Particles

Uniform Distribution

"How are these Hotspots Formed?"

May - June



Santora et al. 2011, Progress in Oceanography

<u>Summer Model Runs</u>

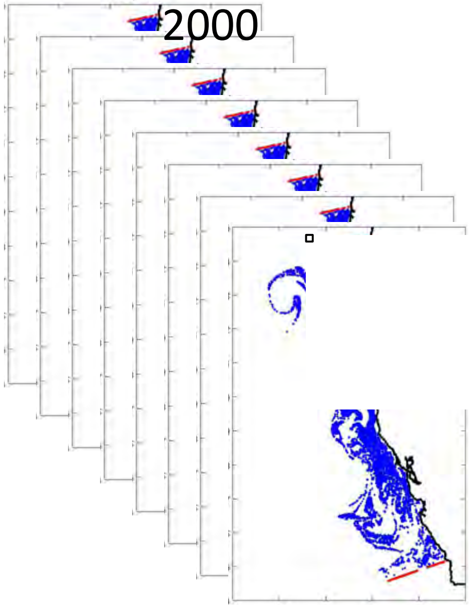
Start Date – May 15

40,000 Particles

Uniform Distribution

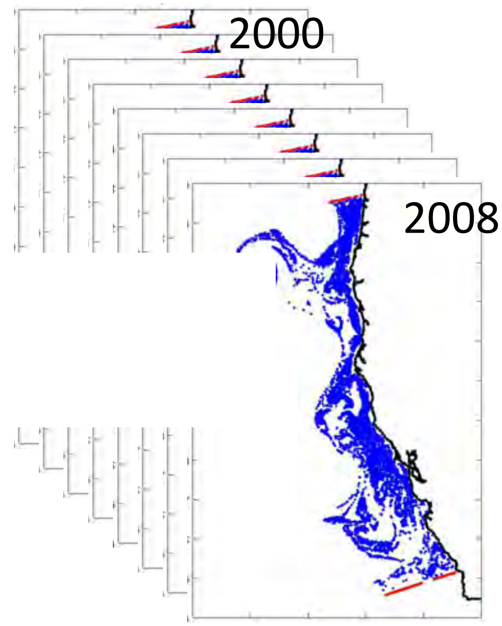
"Where do these Hotspots Go?"

Feb 15 Start – DVM = 5



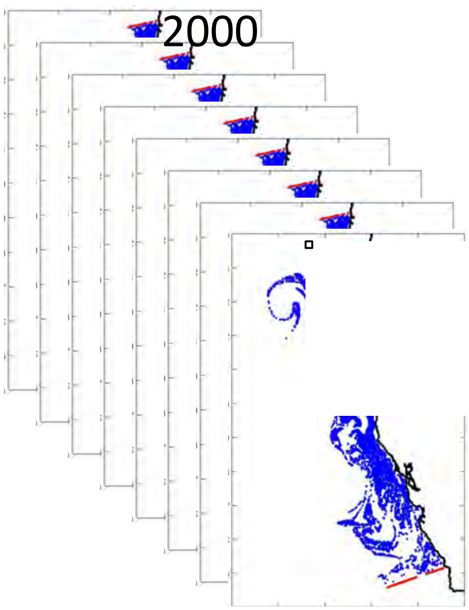
Feb 15 Start – DVM = 20

Feb 15 Start – DVM = 40

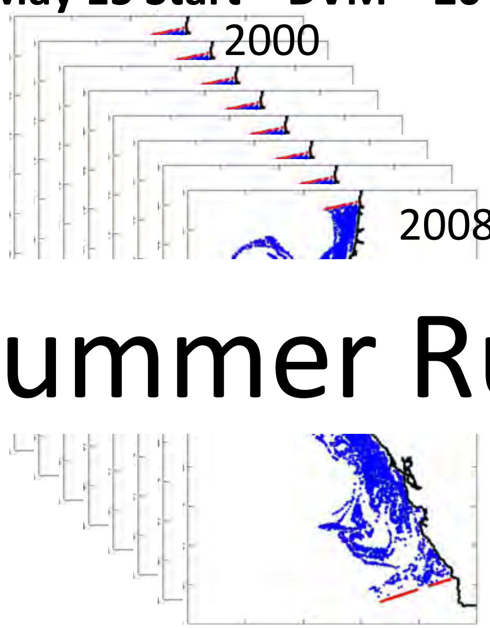


Spring Runs

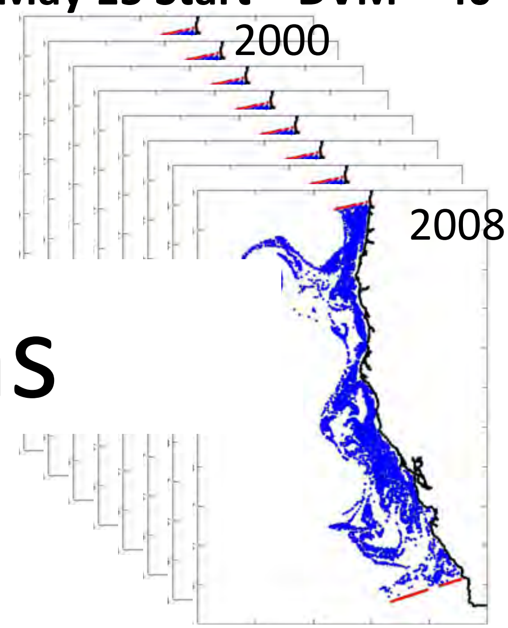
May 15 Start – DVM = 5



May 15 Start – DVM = 20

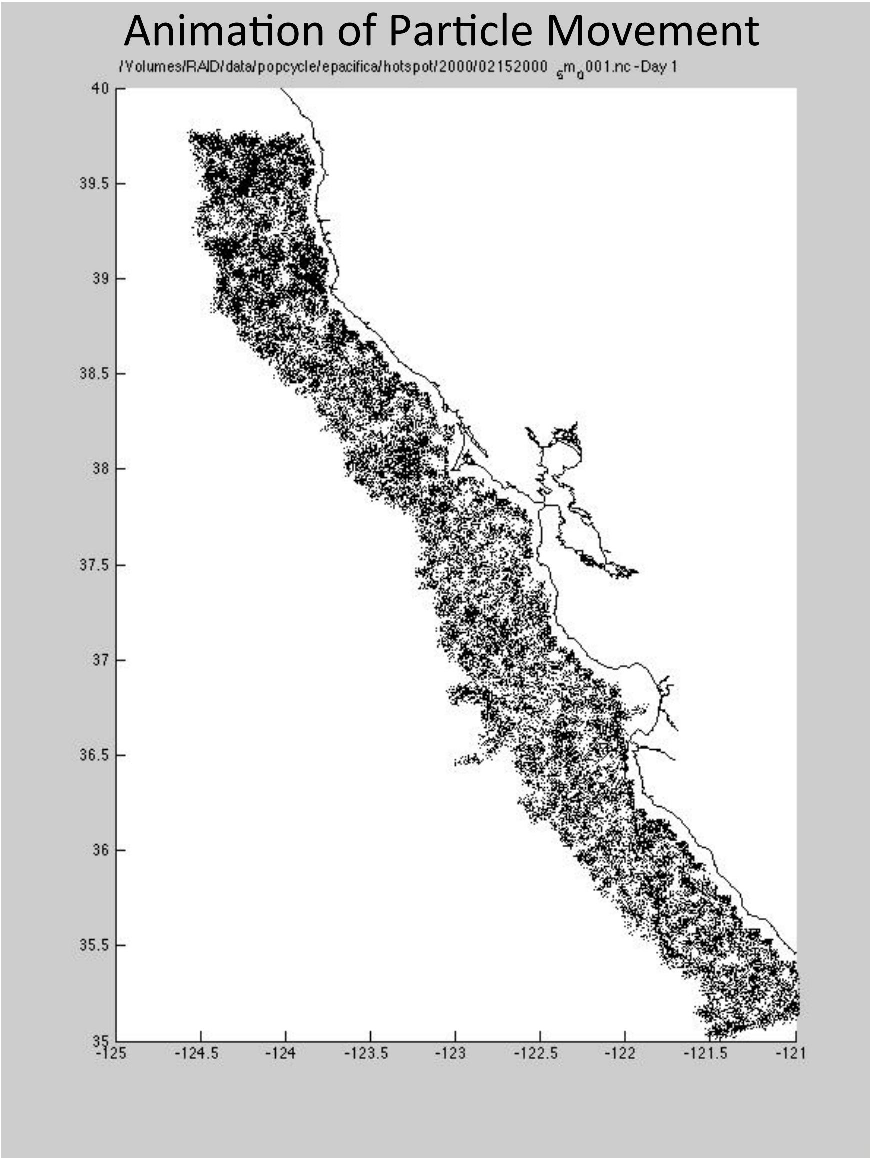


May 15 Start – DVM = 40



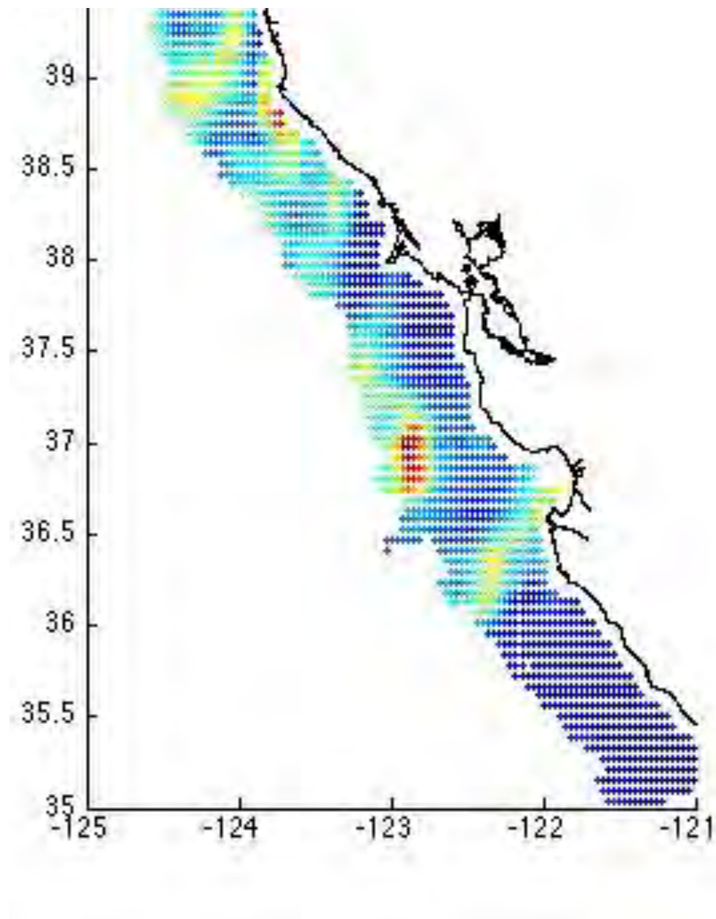
Summer Runs

Individual Based Model
Initial Conditions
40,000 Particles

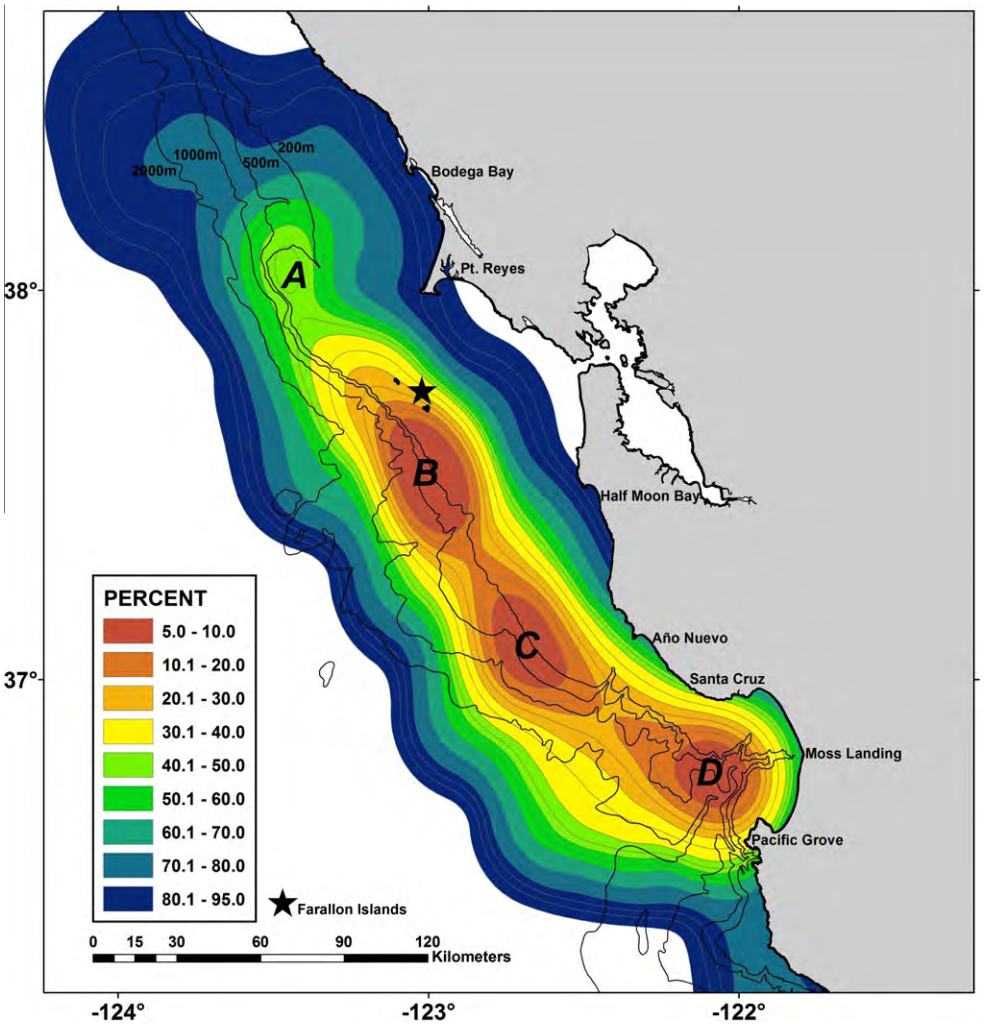


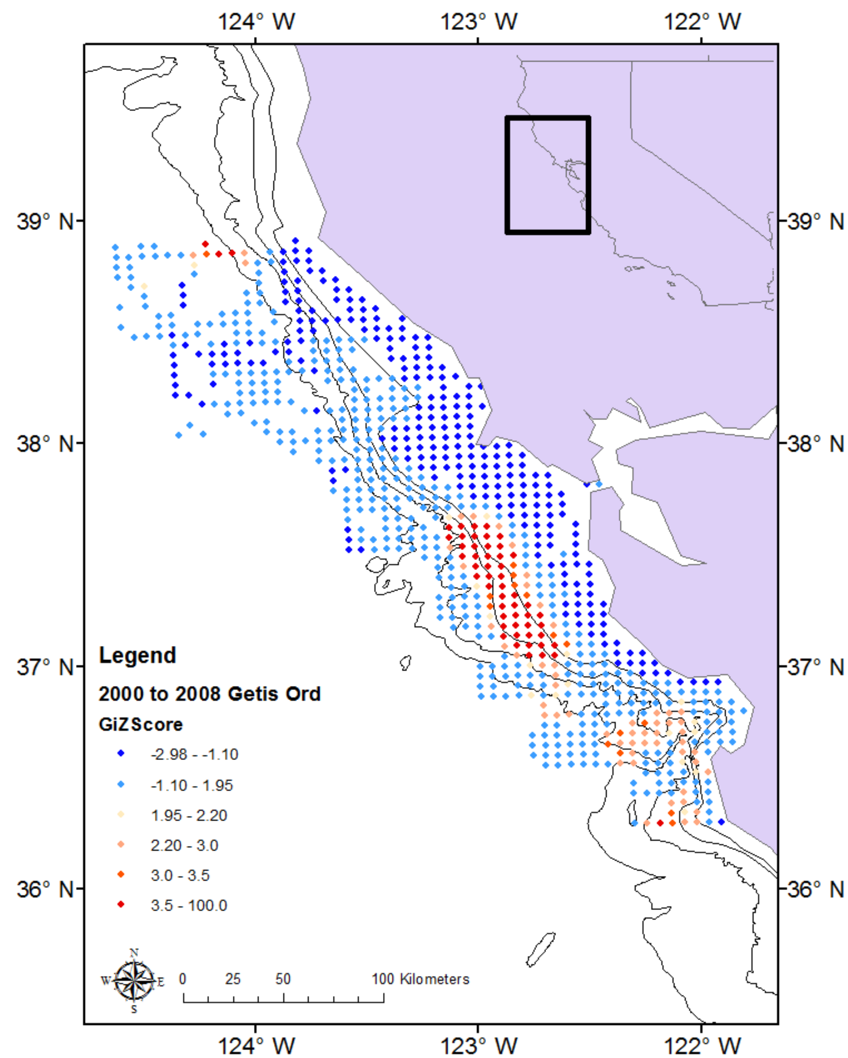
Analysis - Getis Ord Statistic

- Spatial Statistic that highlights clusters of high local values in relation to overall values for the entire area.

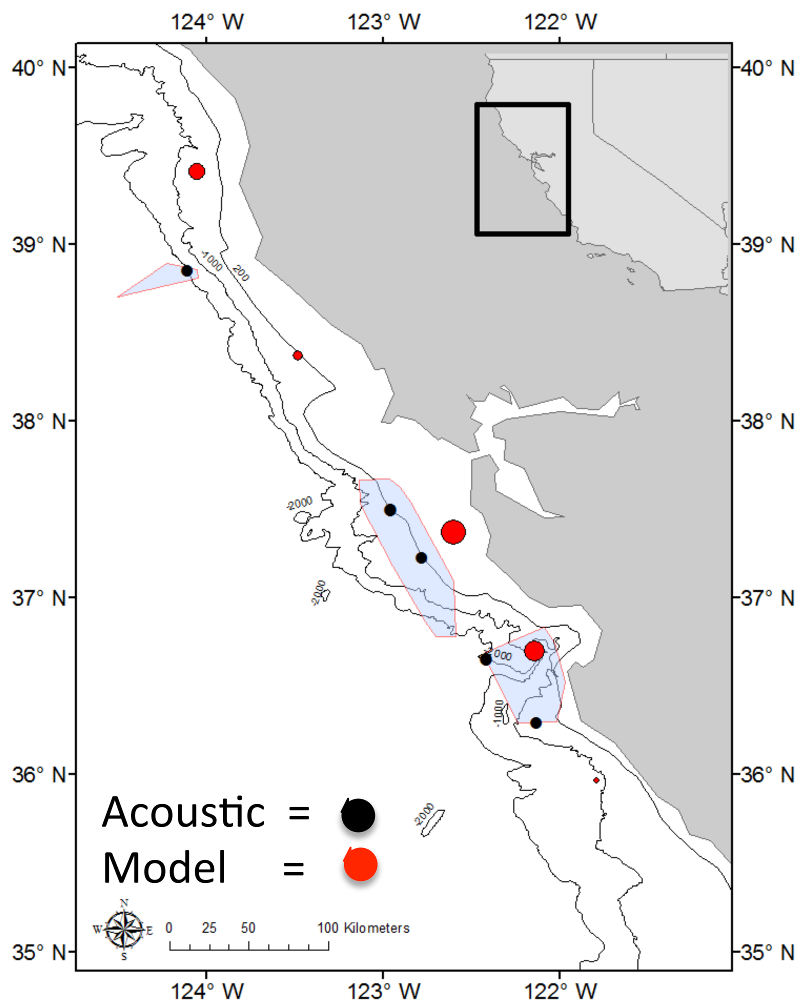


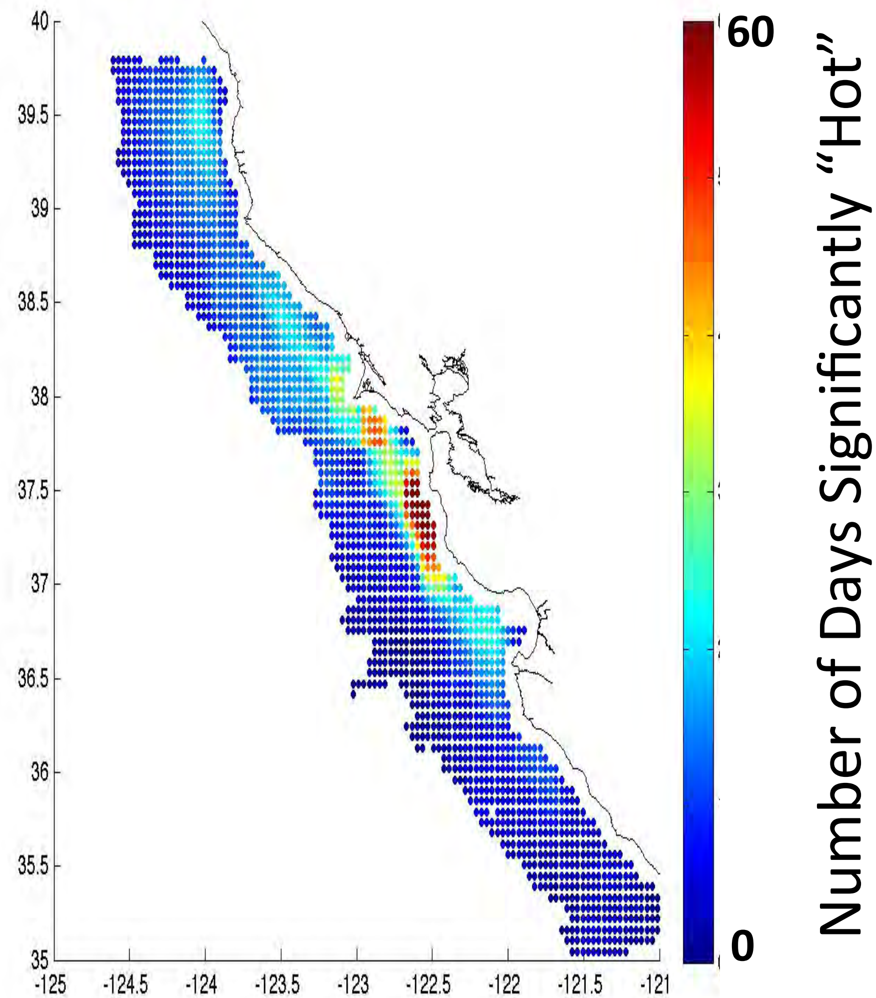
Conversion of Acoustics to Getis-Ord





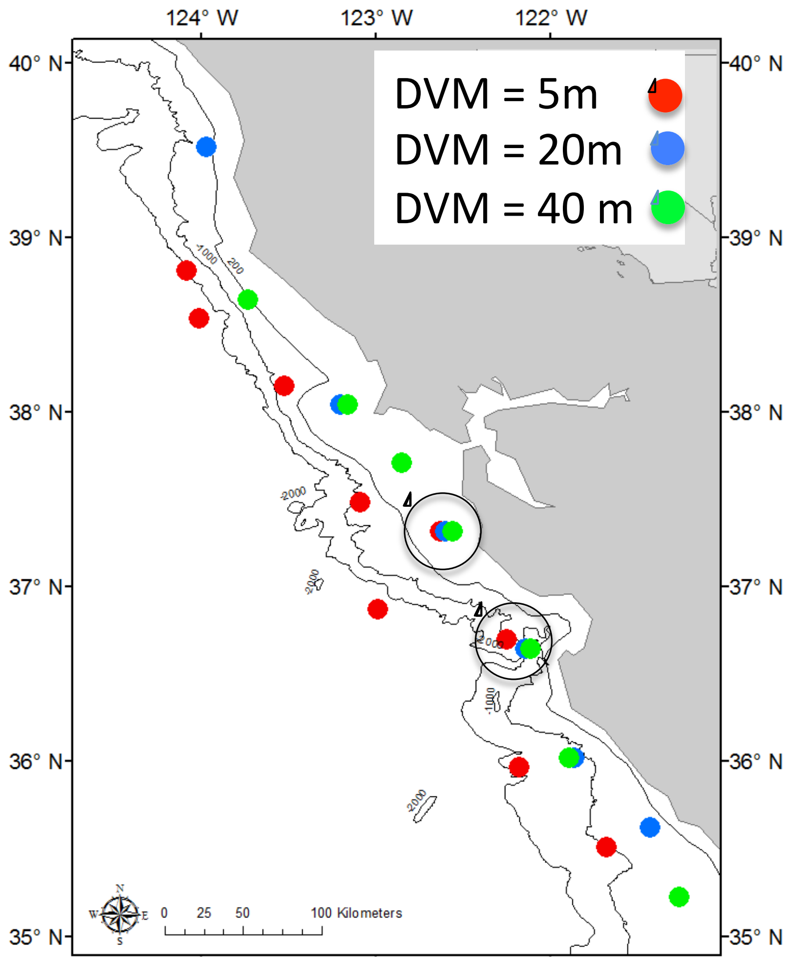
Summer Runs 2000-2008
20m Upper Limit of DVM



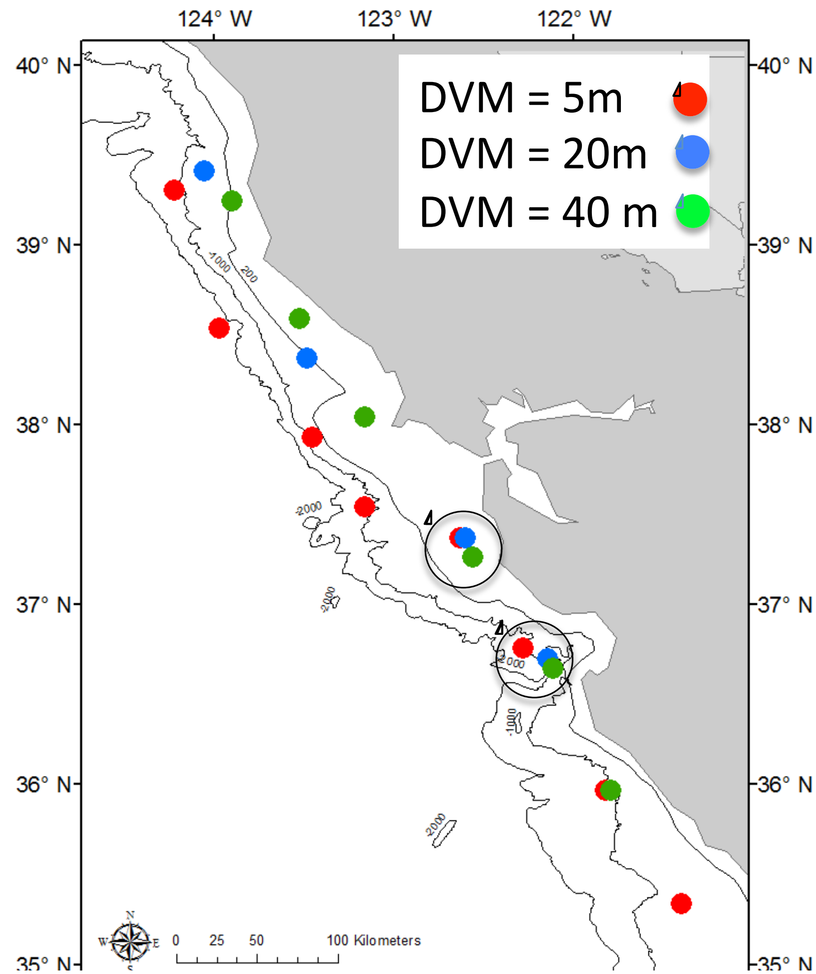


Peaks in Acoustic and Model Data

Spring Runs 2000-2008

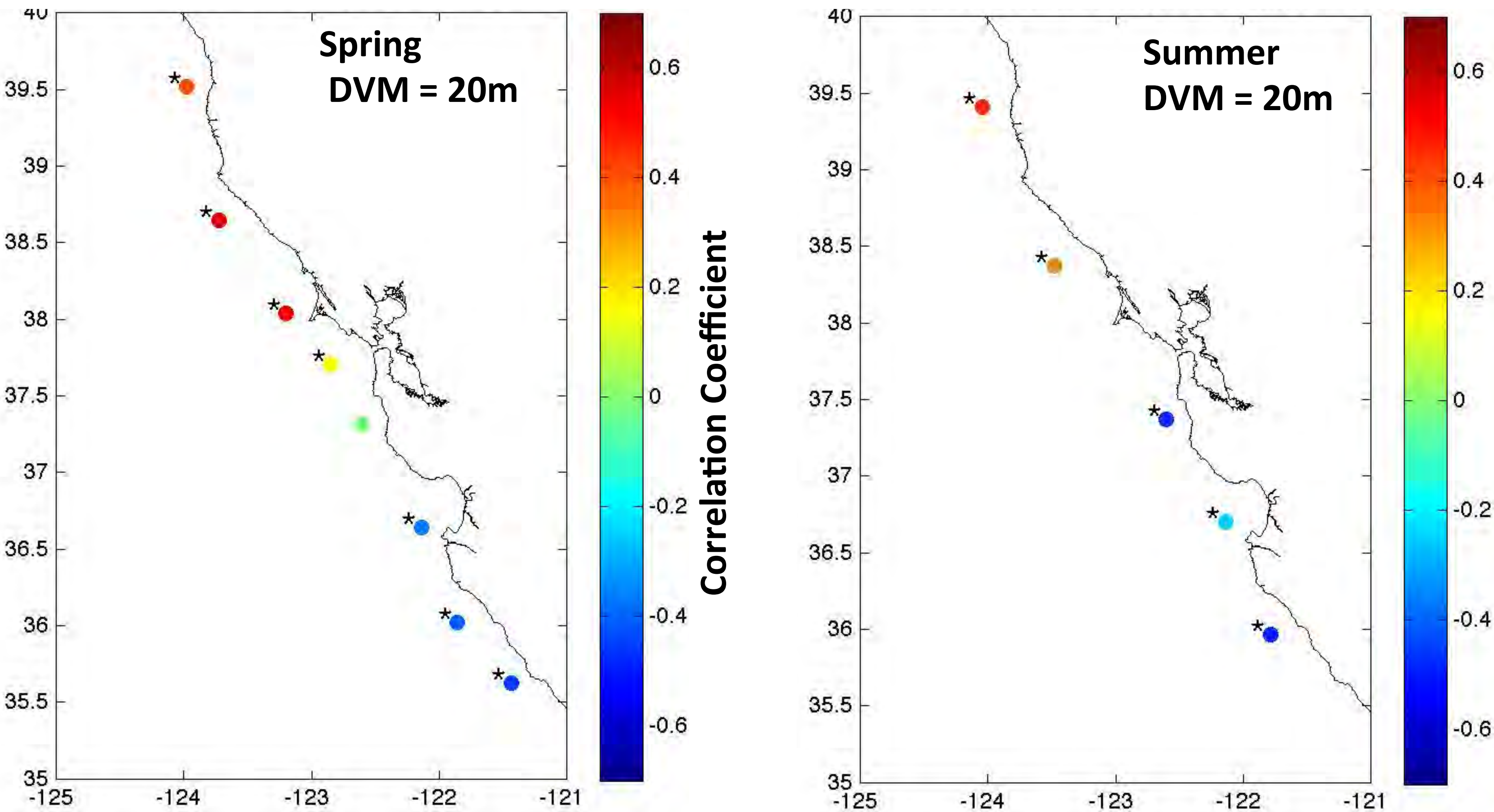


Summer Runs 2000-2008

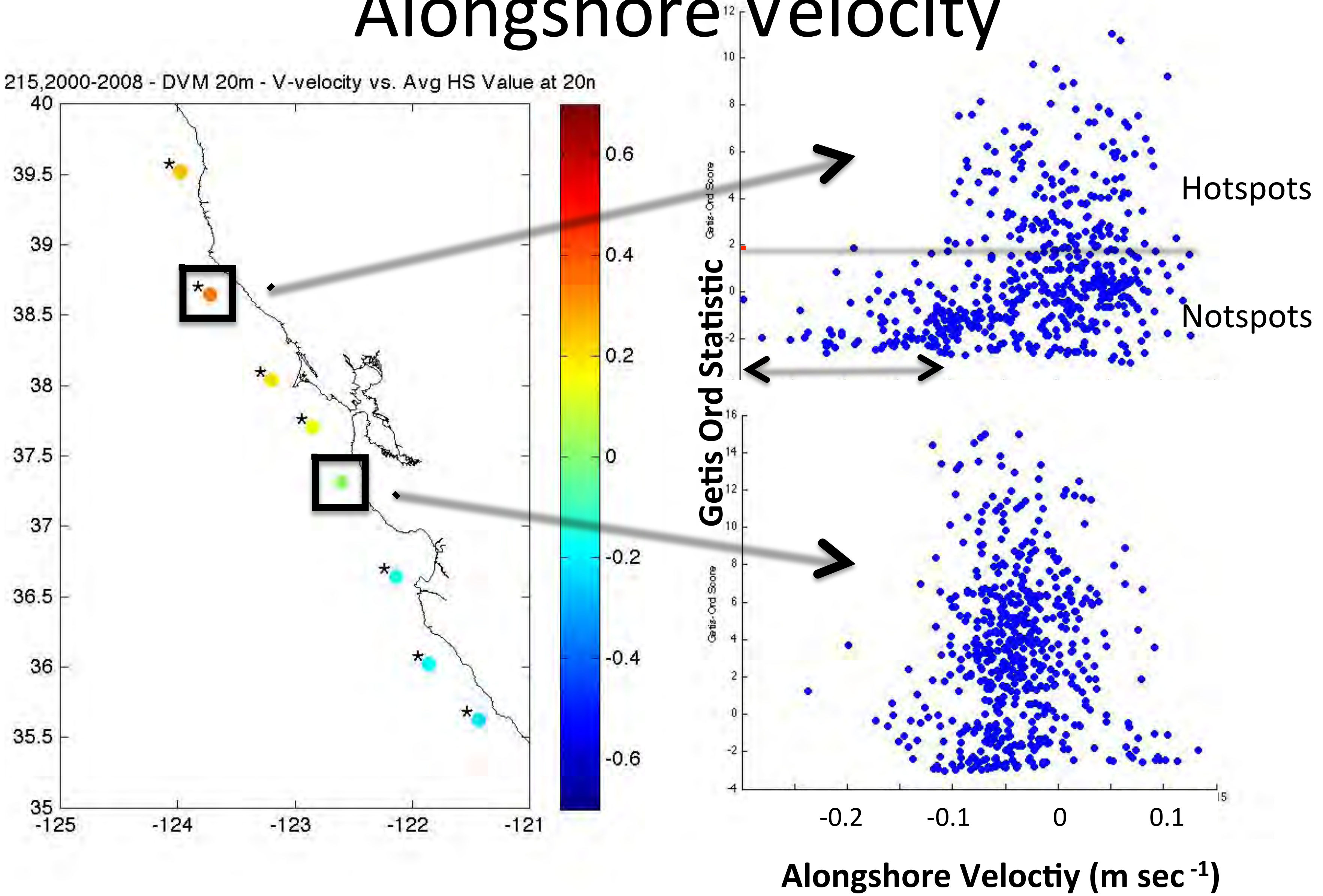


1. Migrating Higher in the Water Column (5m) results in greater offshore displacement of Hotspots
2. Consistent Hotspots are found in the two of the three locations identified as hotspots by acoustics.

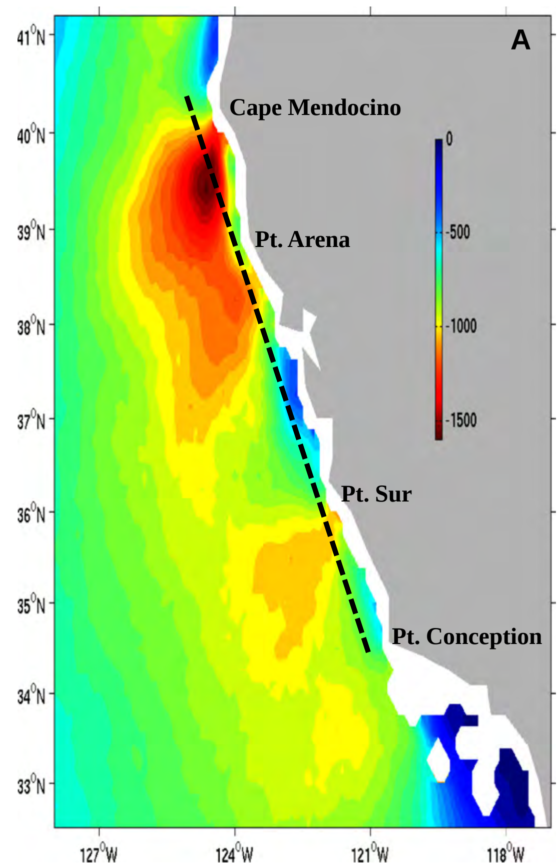
Hotspot Correlation with Alongshore Velocity

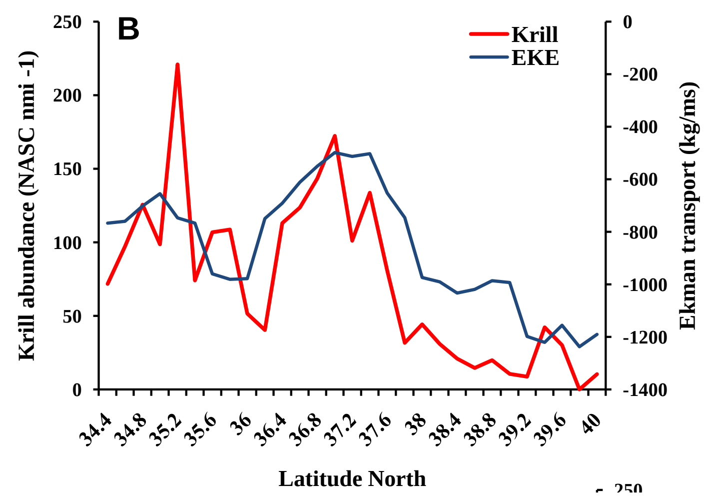


Hotspot Correlation with Alongshore Velocity

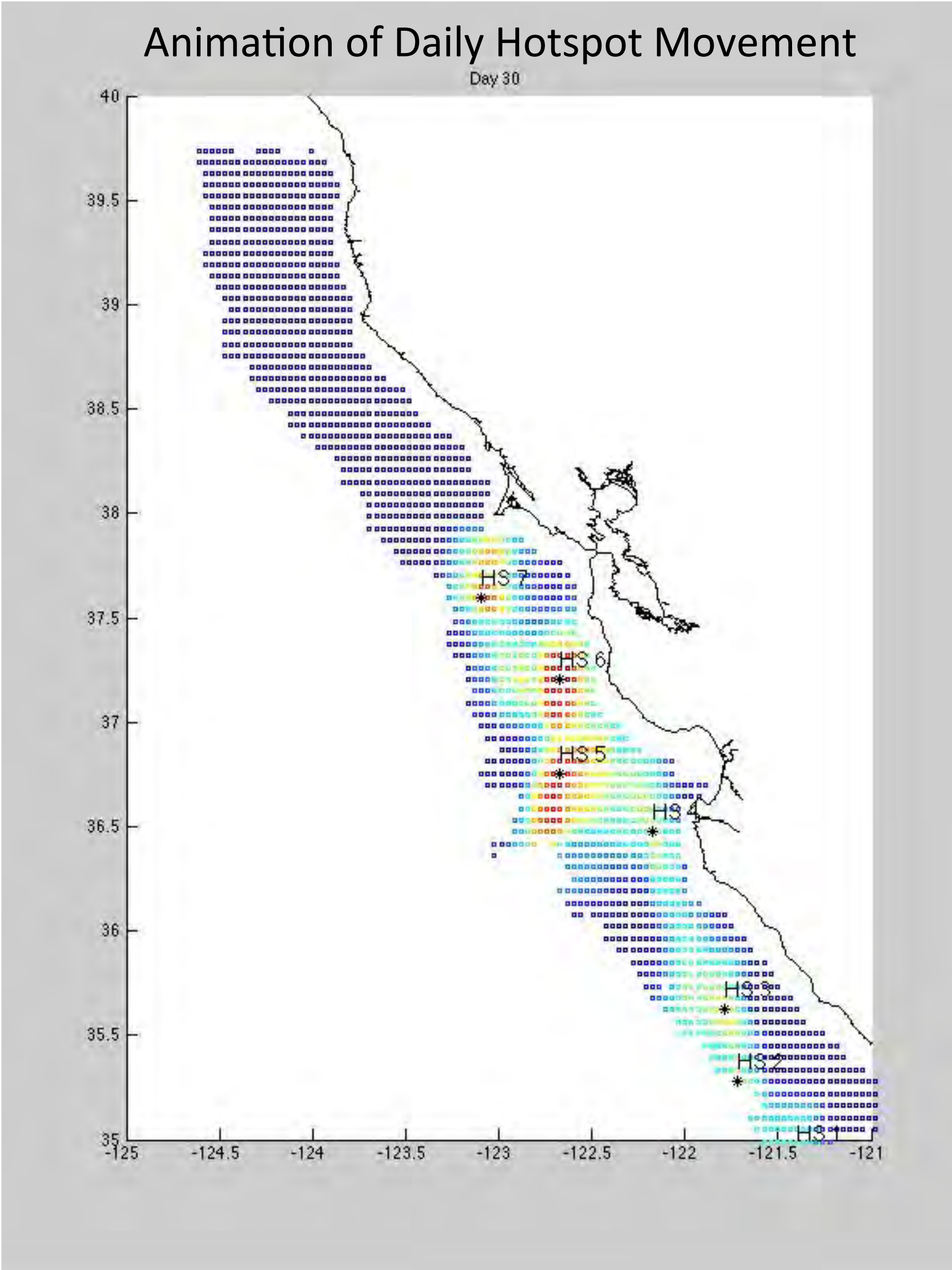


Hotspot Correlation with Ekman Transport





1. Strong equatorward alongshore currents (i.e. Upwelling Events) are more likelyto the North of Pt. Reyes compared with regions to the South.
2. These currents inhibit the formation of hotspots during these periods.



Hotspot Analysis

<u>Through Time</u>

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

Size of Hotspots - 2000-2008
20m Upper Limit of DVM

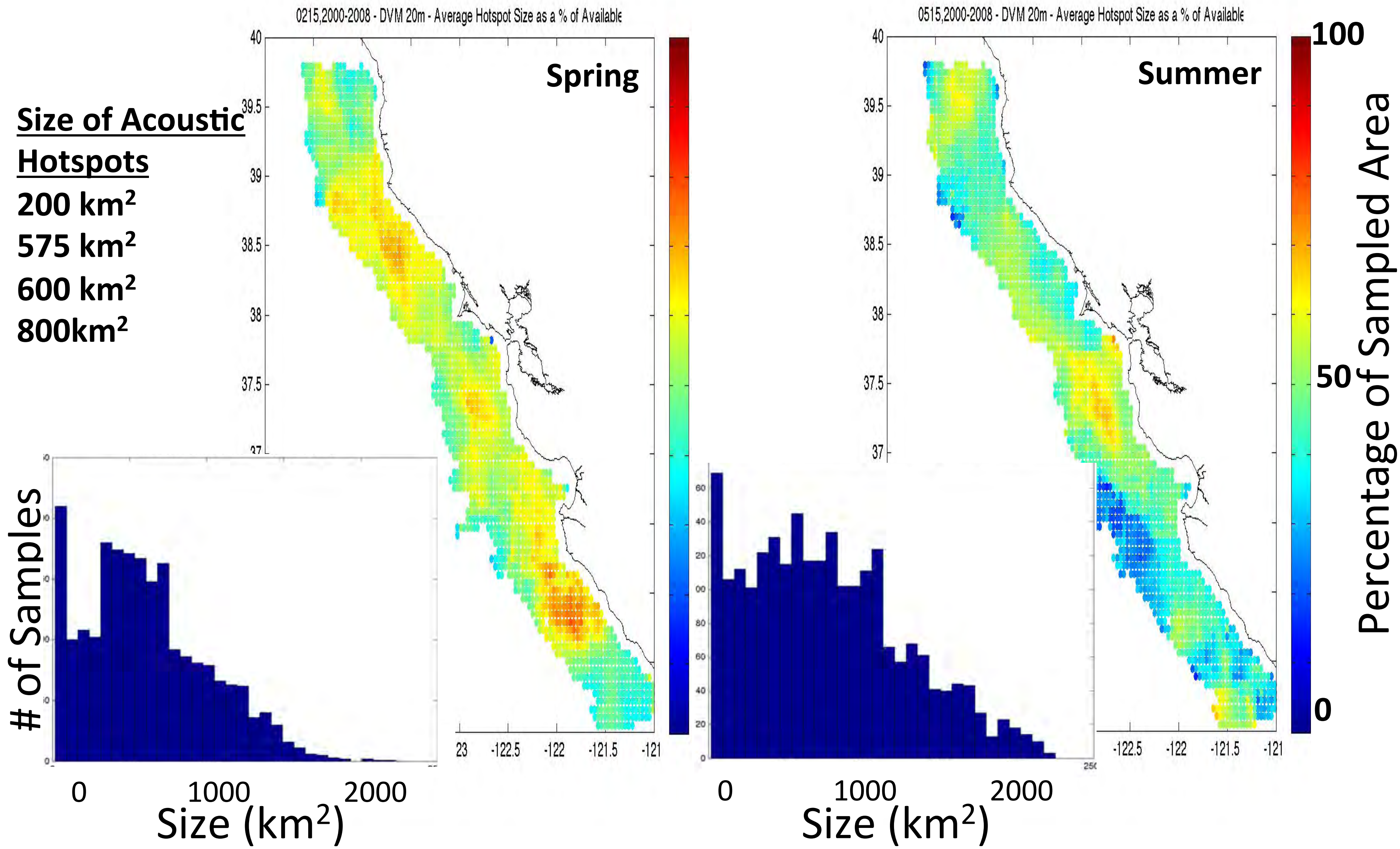
<u>Size of Acoustic Hotspots</u>

200 km^2

575 km^2

600 km^2

800km^2



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
California SeaGrant (Project No. ENV-022)

-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
```