Identifying Biological Hot Spots in the Northern California Current

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Background

- Logical starting point
  - Begin by identifying where hot spots occur
- Also need to know:
  - How persistent they are
  - Community characteristics
    - Community composition, dominant species, biodiversity, etc.
  - Driving forces that structure these areas

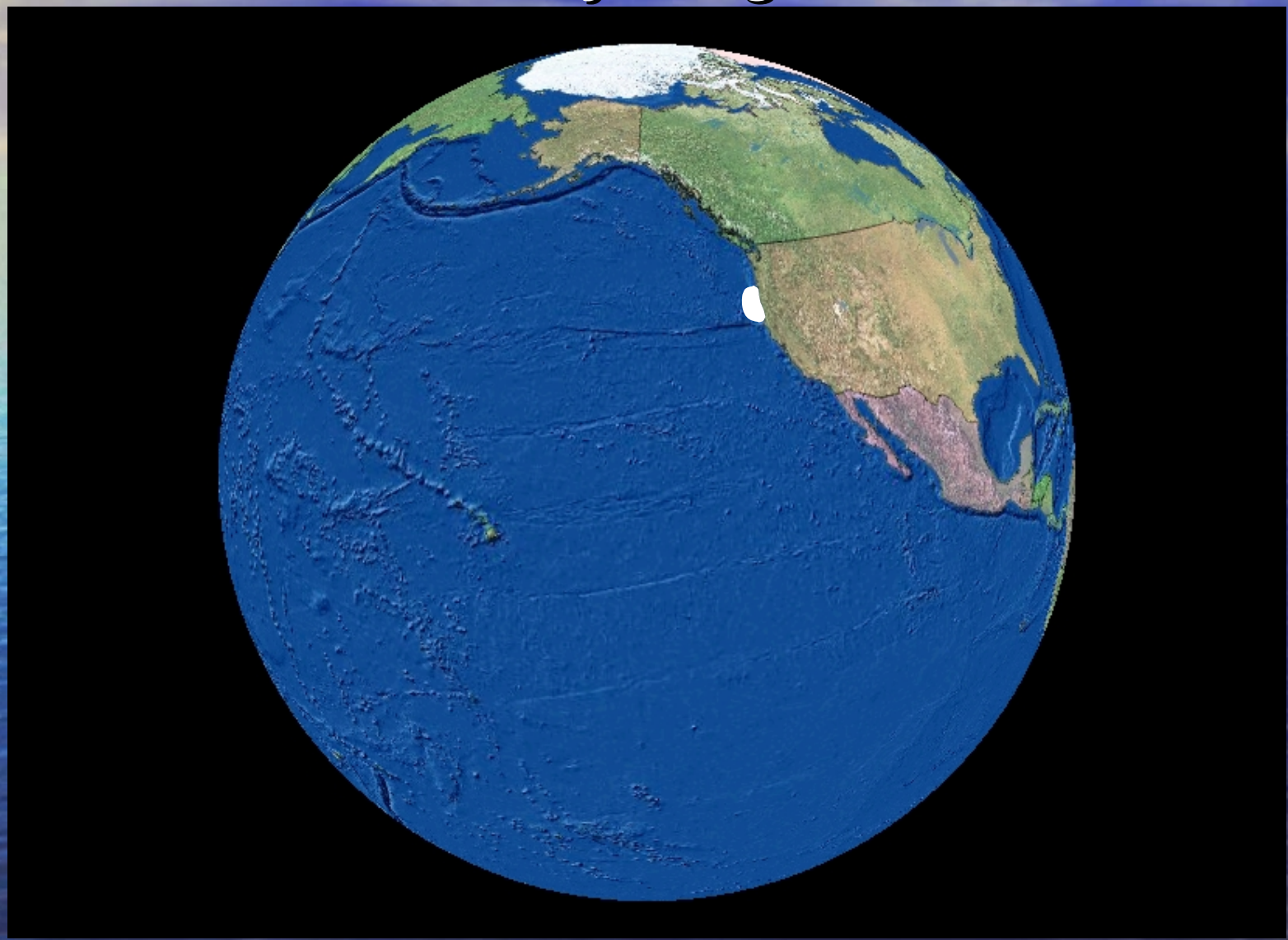
Current understanding

- Species diversity and dominance of surface zooplankton and coastal pelagic nekton have been determined to vary between geographic regions
- Species assemblages have been shown to vary both with distance from shore and latitude
- California Current ecosystem has undergone dramatic shifts in abundance and species composition at both the lower and higher trophic levels

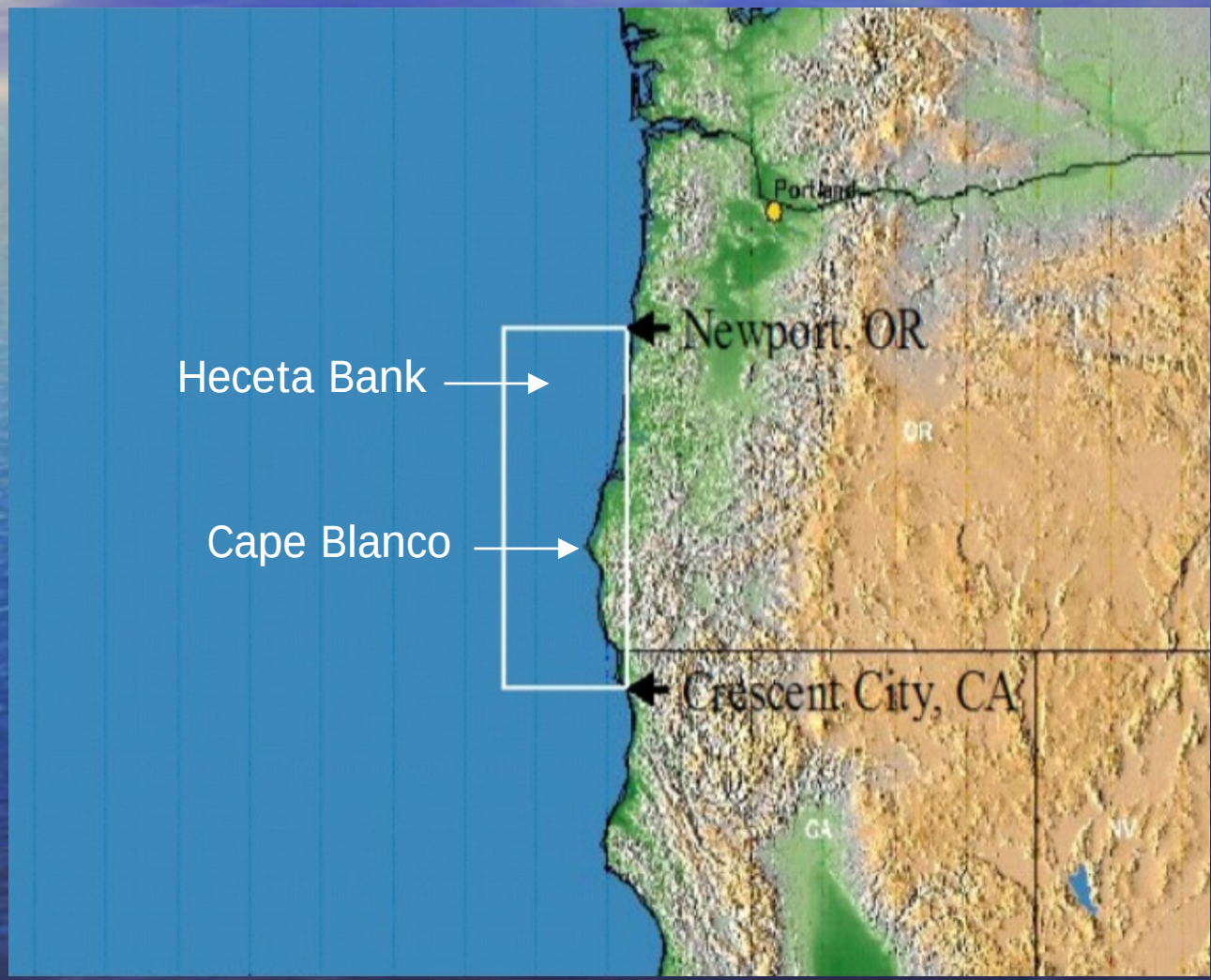
Objectives of the Study

- Identify regions of high levels of phytoplankton and surface zooplankton productivity
- Identify regions of persistent high levels of surface zooplankton and nekton biodiversity
- Identify dominant members and the structure of the nektonic communities within these regions
- Examine the habitat characteristics associated within these areas

Study Region



Study Region



Data Collection

- Sampling was conducted during a 2 week period in June and August of 2000 and 2002 as part of the U.S. GLOBEC mesoscale surveys
- Stations were sampled along both regular transects and also in areas of special biological interest
- At each station a CTD cast, neuston tow and pelagic surface trawl were made and a chlorophyll sample collected

Identifying Biological Activity

- Several biological parameters examined:
  - Chlorophyll concentrations
  - Surface zooplankton biovolume and diversity
  - Nekton abundance
  - Nekton species diversity
  - Nekton biomass
- Hot spot = An area with greater than average biological activity in terms of nekton density, species richness, and/or biomass

Identifying Hot Spots

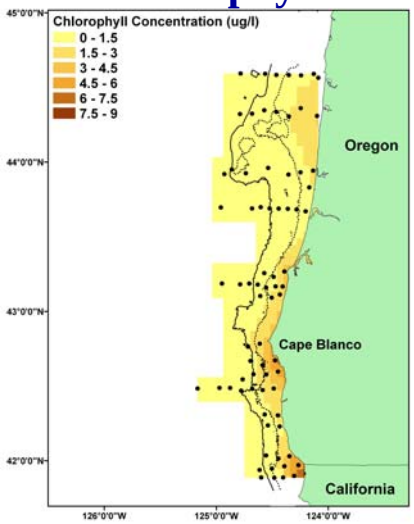
- Geostatistical modeling techniques
  - Designed to model spatially dependent data by incorporating spatial autocorrelation
- Optimally predict values at intermediate sites
- Assess error associated with predictions
- Geostatistics vs. classical methods
  - When accounting for spatial autocorrelation, conclusions about environmental control over distribution and abundance changed dramatically
- Although our data are not synoptic, maps of temperature and chlorophyll closely match with satellite imagery

Statistical Procedures

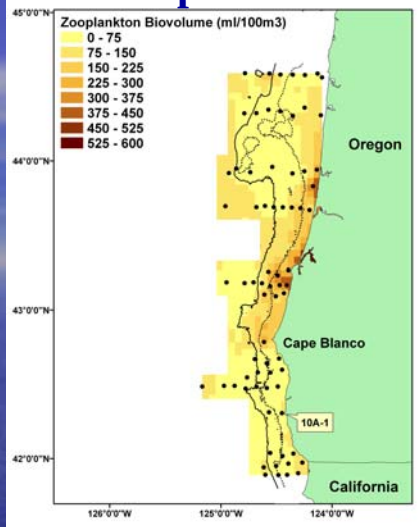
- Group differences in species composition between hot spots and non-hot spots were tested with a multi-response permutation procedure (MRPP)
- Ordination of the sample stations in species space was done using non-metric multidimensional scaling (NMS) using the geographic location of hot spots as a categorical variable
- Correlations of environmental variables with each axis were used to measure the relationships of these variables to species data
- Identification of the primary species for each hot spot was done using indicator species analysis (ISA)

June 2000

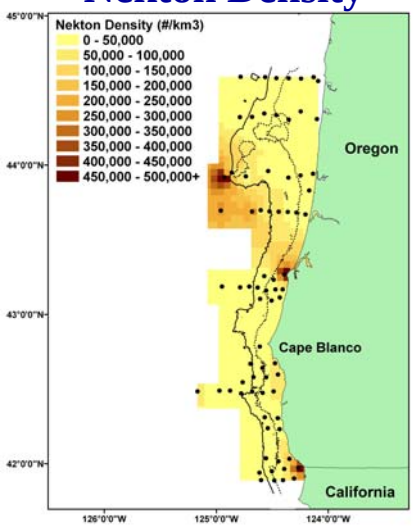
Chlorophyll



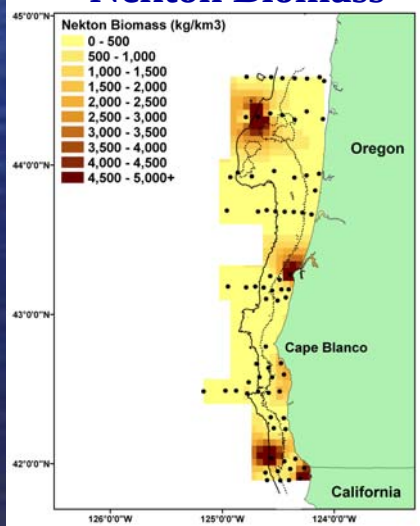
Zooplankton



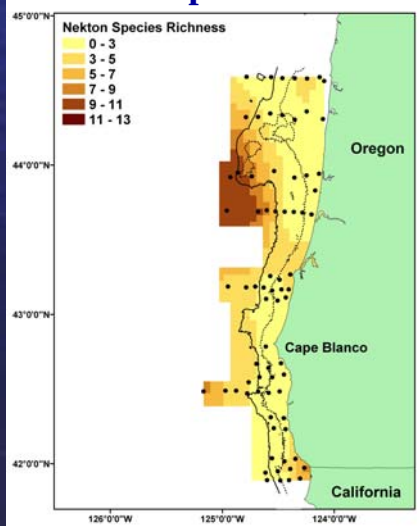
Nekton Density



Nekton Biomass

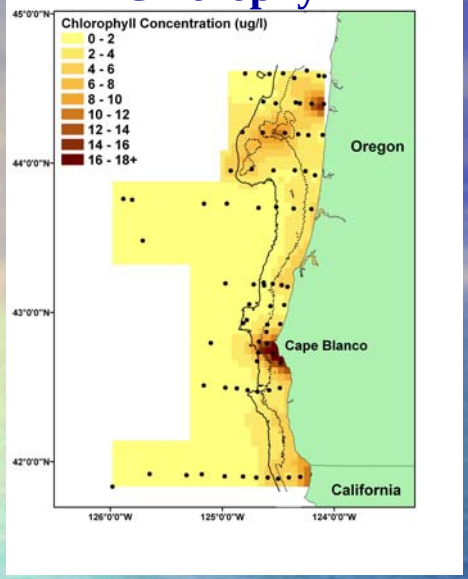


Nekton Species Richness

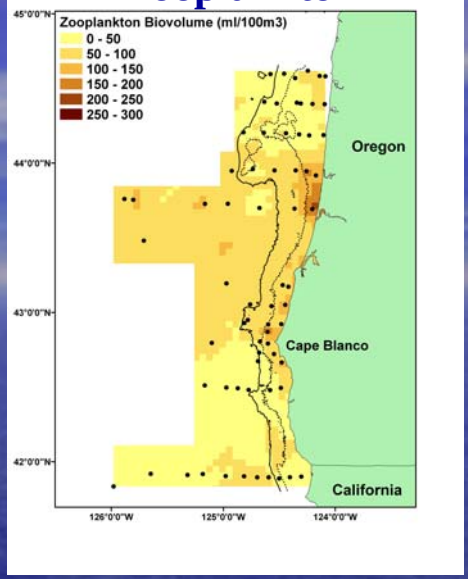


August 2000

Chlorophyll



Zooplankton



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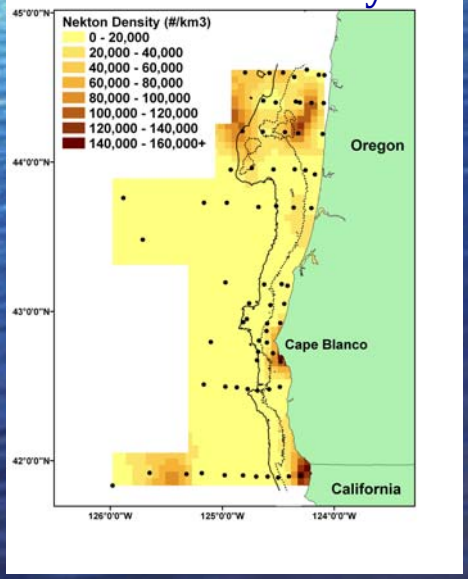

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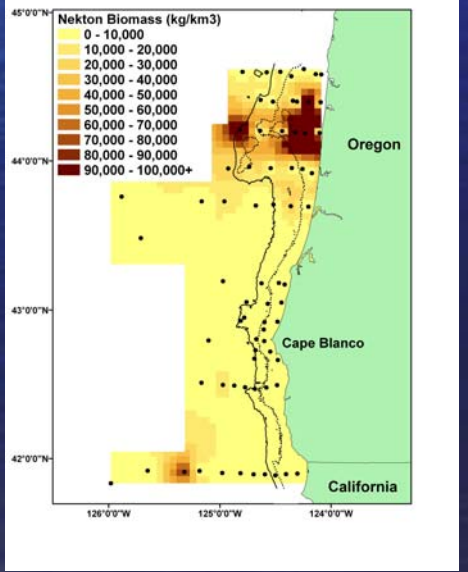
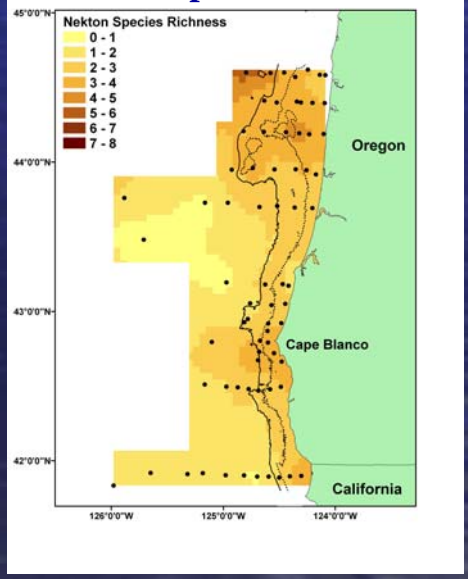
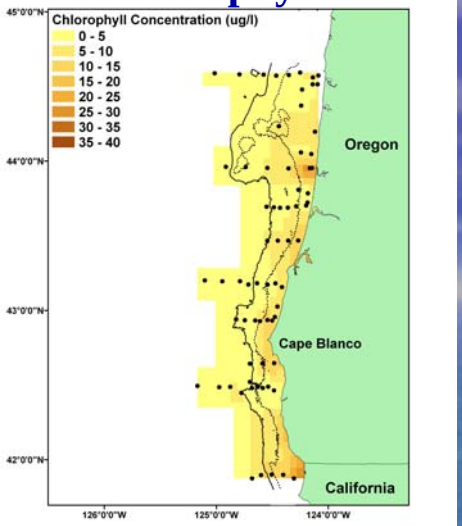


Nekton Species Richness

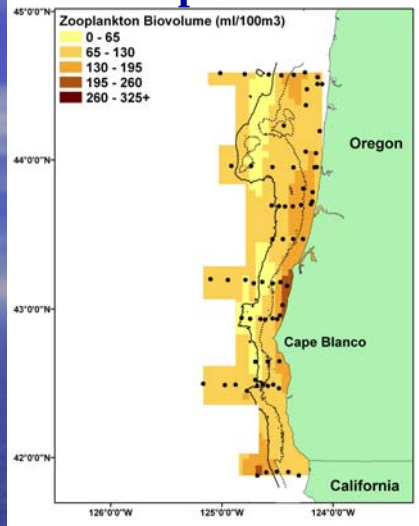


June 2002

Chlorophyll



Zooplankton



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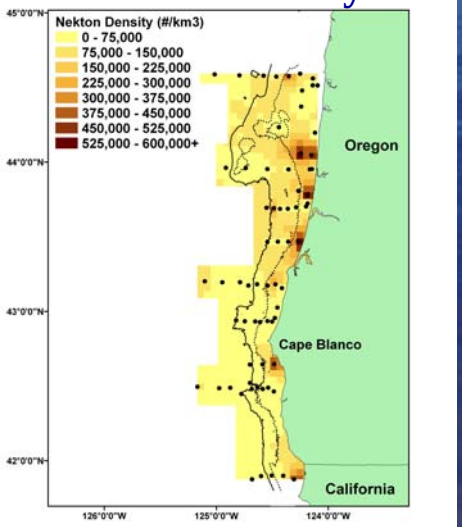

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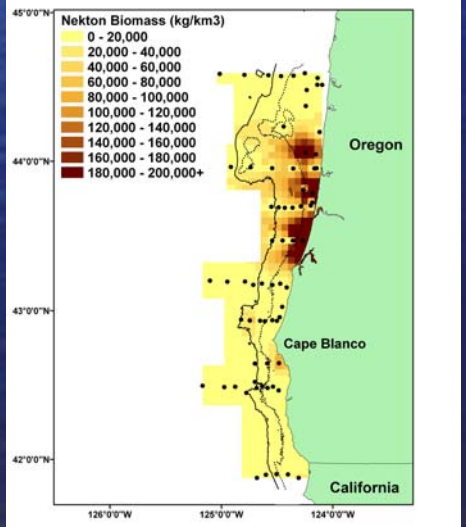

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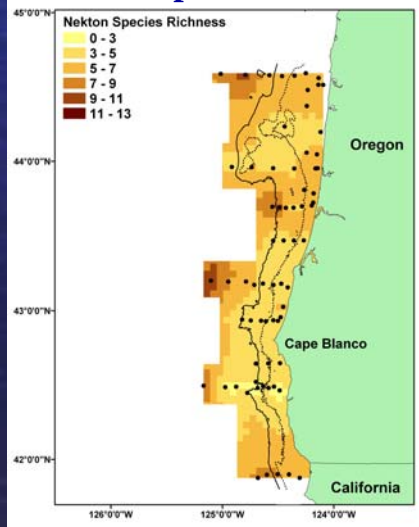
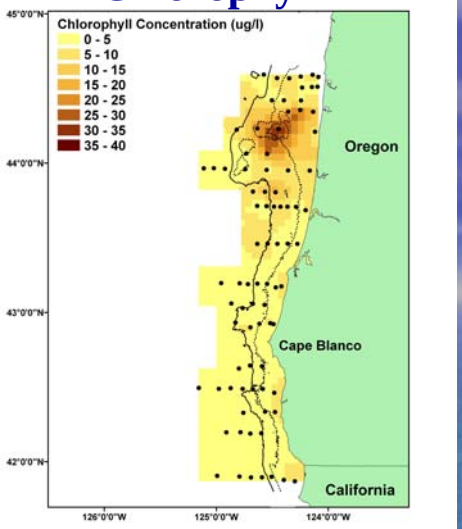
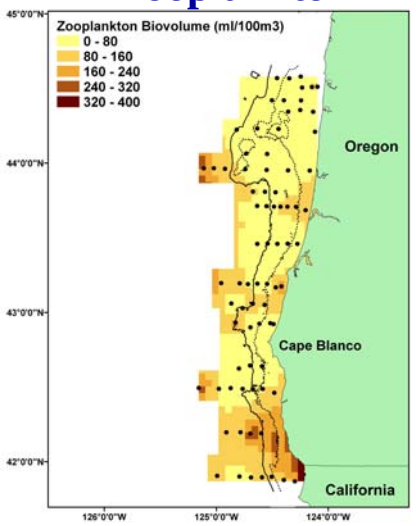


August 2002

Chlorophyll



Zooplankton



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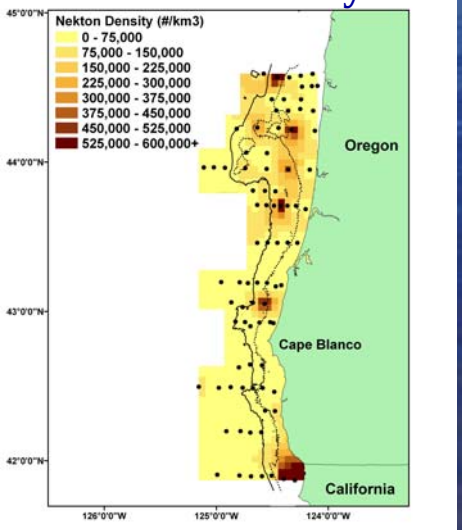

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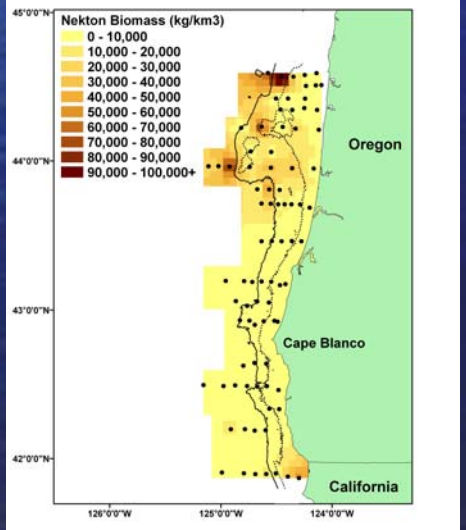

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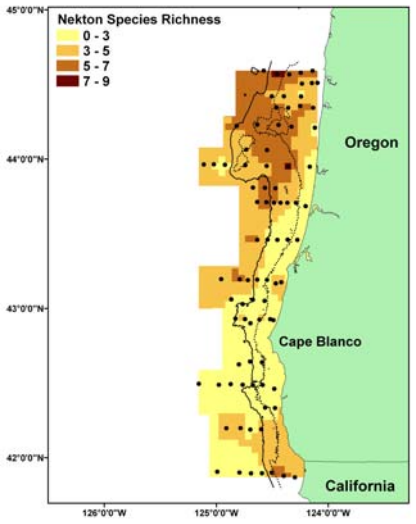
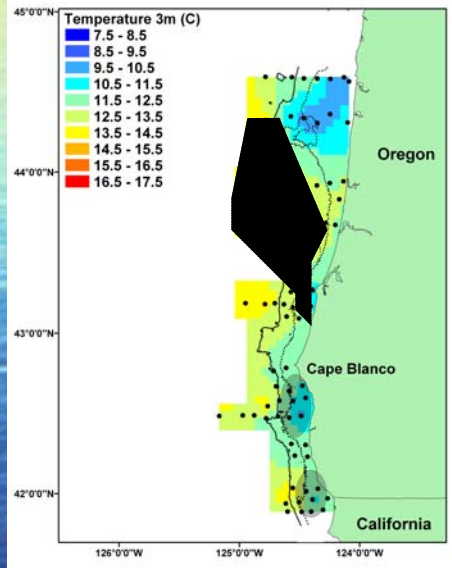
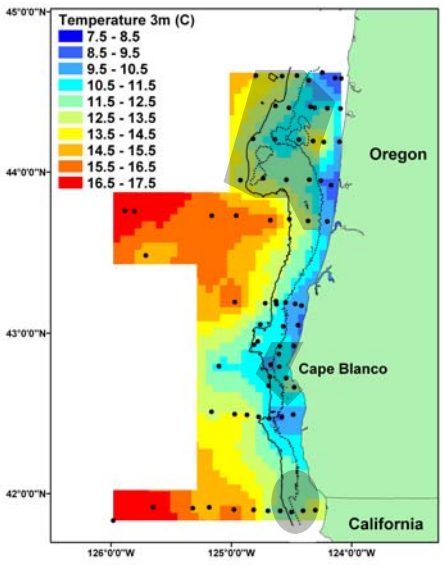


Hot Spots

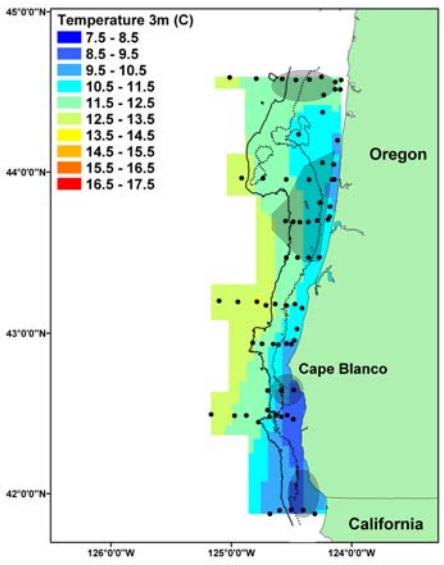
June 2000 Hotspots



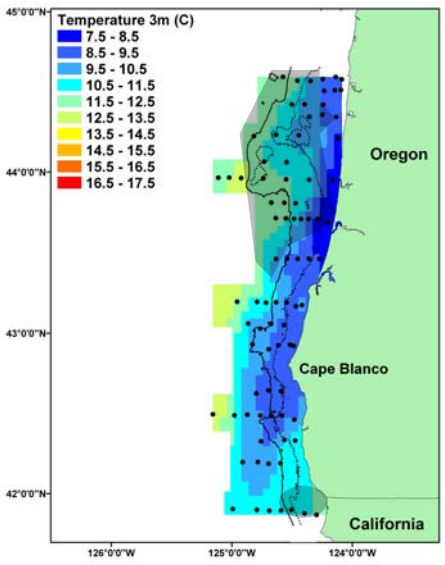
August 2000 Hotspots



June 2002 Hotspots



August 2002 Hotspots



MRPP Results

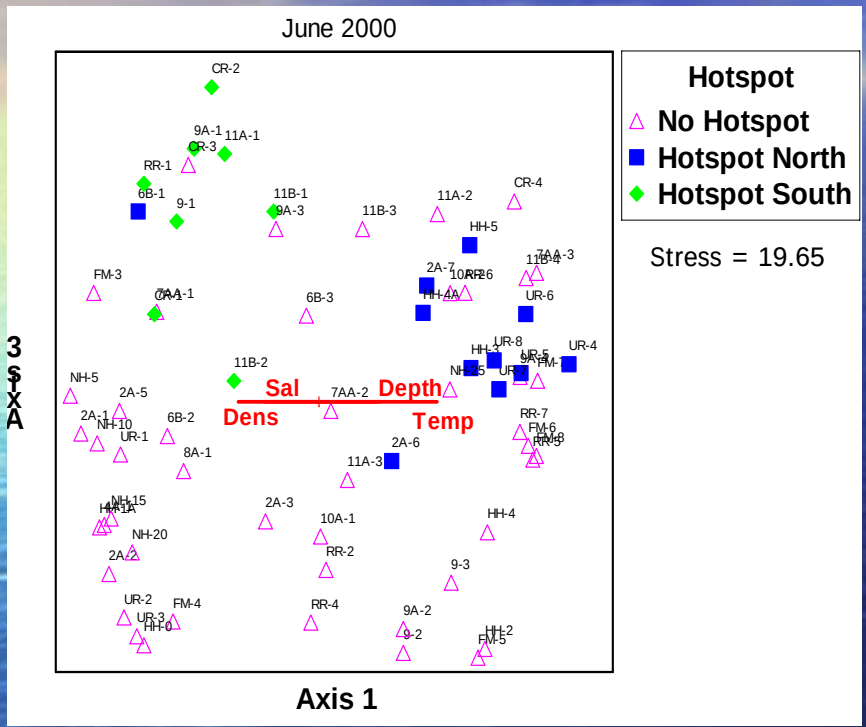
Cruise	Chance-corrected within-group agreement, *A*	*p*-value
June 2000	0.1480	<0.0001
August 2000	0.1748	<0.0001
June 2002	0.0789	0.0001
August 2002	0.0947	<0.0001

H_0: No difference in community composition between hot spots and no hot spots

Results indicate significant differences for each cruise

NMS Ordinations

June 2000



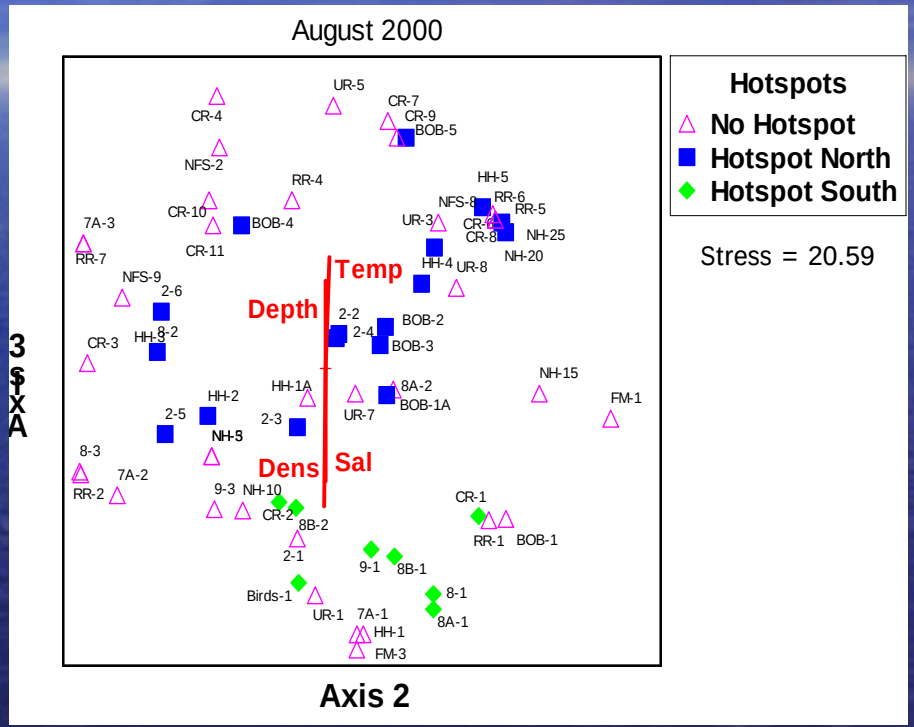
R^2 = 0.653 for 3-D ordination

Axis 1: R^2 = 0.254

Axis 3: R^2 = 0.230

Temp r = 0.752

August 2000



R^2 = 0.621 for 3-D ordination

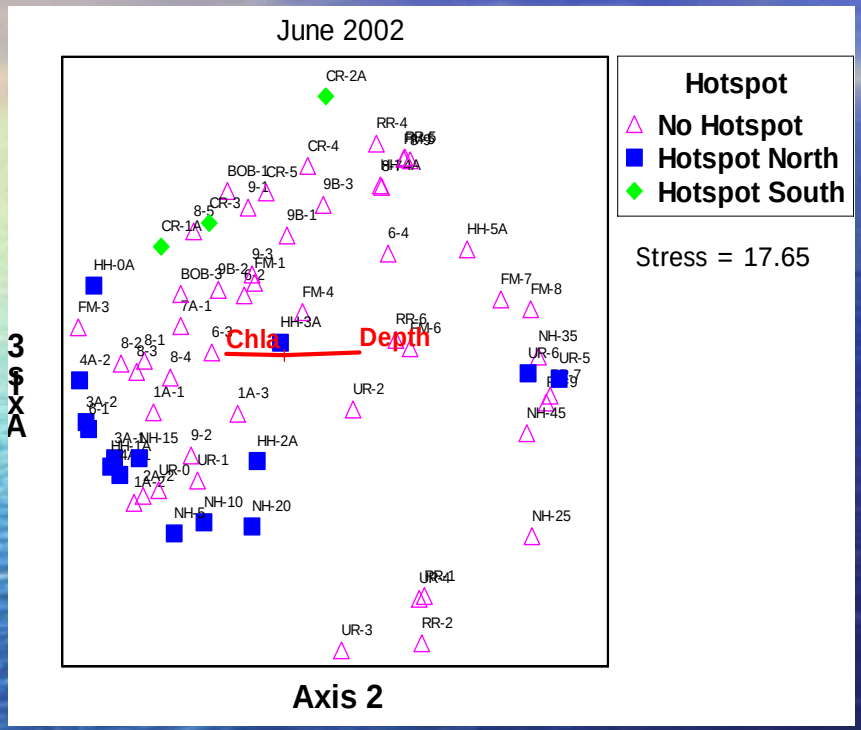
Axis 2: R^2 = 0.197

Axis 3: R^2 = 0.257

Temp r = 0.625

NMS Ordinations

June 2002



R^2 = 0.757 for 3-D ordination

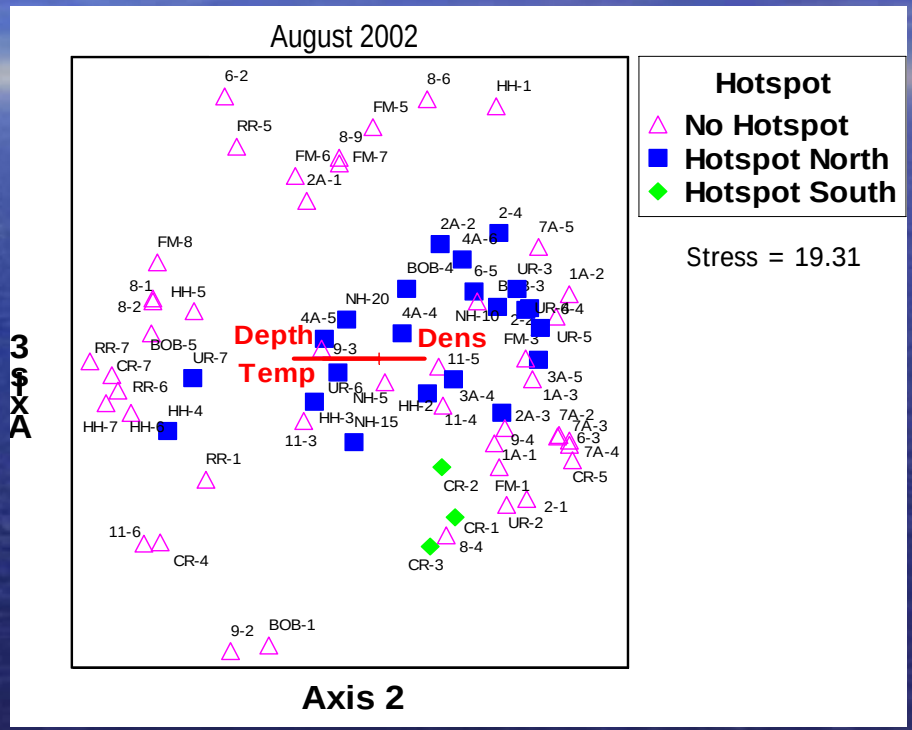
Axis 2: R^2 = 0.424

Axis 3: R^2 = 0.225

Chl r = -0.475

Temp r = 0.385

August 2002



R^2 = 0.707 for 3-D ordination

Axis 2: R^2 = 0.327

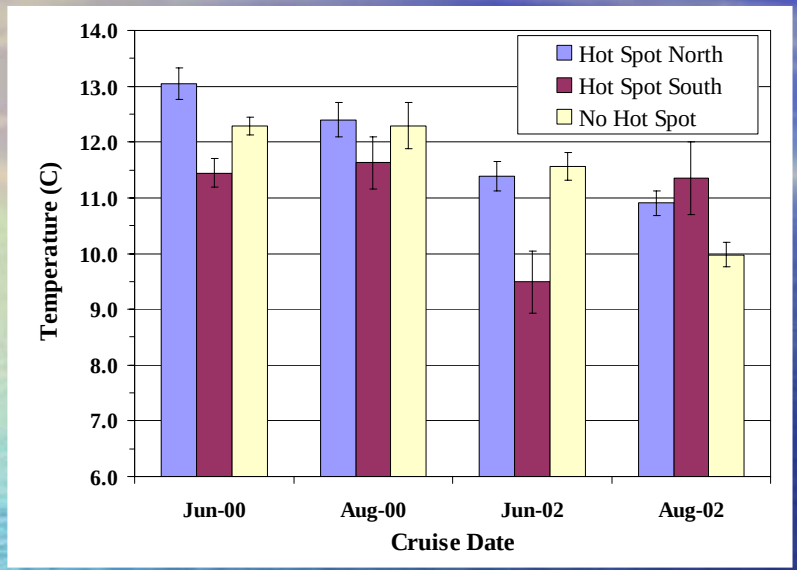
Axis 3: R^2 = 0.209

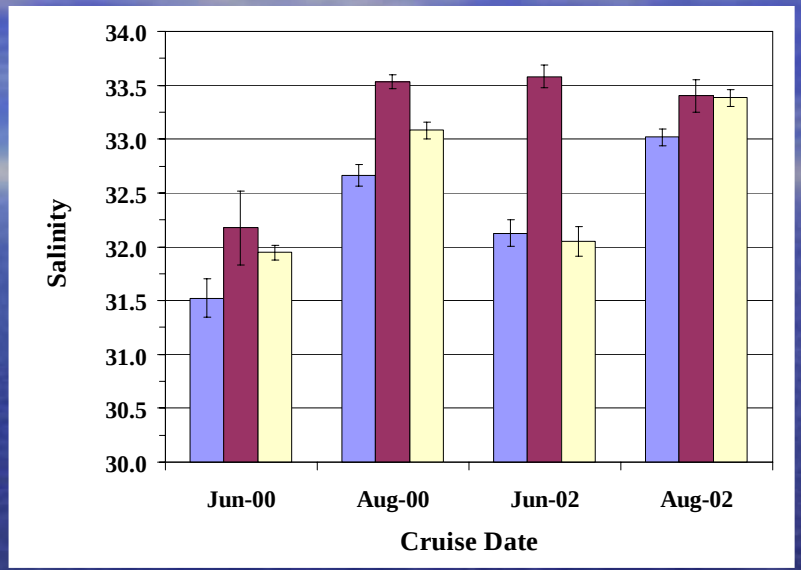
Temp r = -0.438

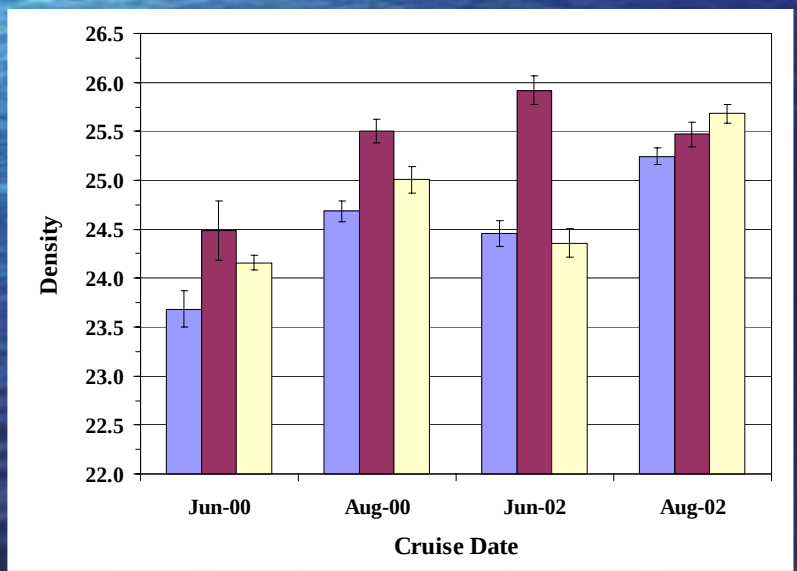
Indicator Species Analysis

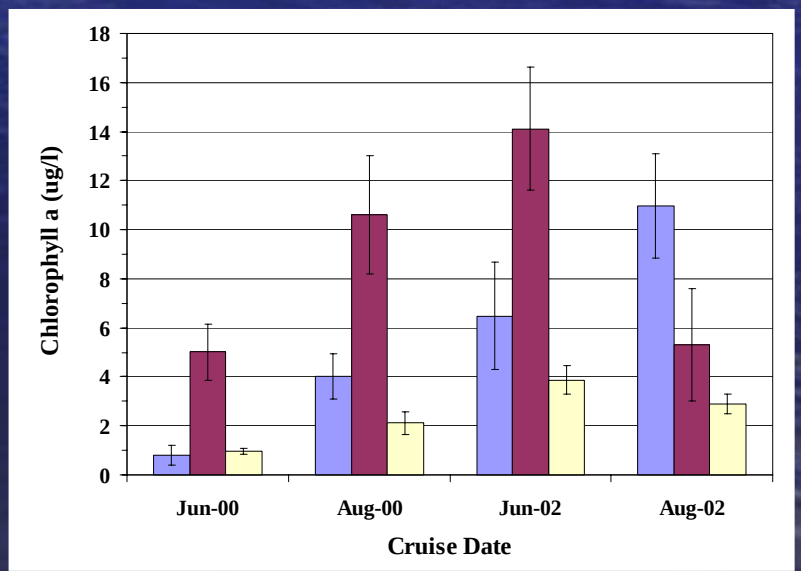
	Hot Spot North	*Hot Spot South*	*No Hot Spot*
June 2000	Bocaccio juv Cabezon juv Dover sole larvae Pacific clubhook squid Several rockfish spp juv	Chinook subad & adult Steelhead juv Market squid Pacific herring adult Surf smelt adult Whitebait smelt juv	No significant Indicator Species
August 2000	Coho subad & adult Coho yearling Jack mackerel adult Pacific mackerel adult Pacific sardine adult	Chinook subad & adult Chinook subyearling Chinook yearling Steelhead juv Medusafish adult Surf smelt adult Wolf eel juv	No significant Indicator Species
June 2002	Chinook yearling Coho yearling Pacific sanddab adult	Rex sole larvae Rockfish juv Wolf eel juv	No significant Indicator Species
August 2002	Northern Anchovy adult	King-of-the-Salmon juv Pacific herring adult Ragfish juv Surf smelt adult	No significant Indicator Species

Habitat Comparisons Between Hot Spot Regions



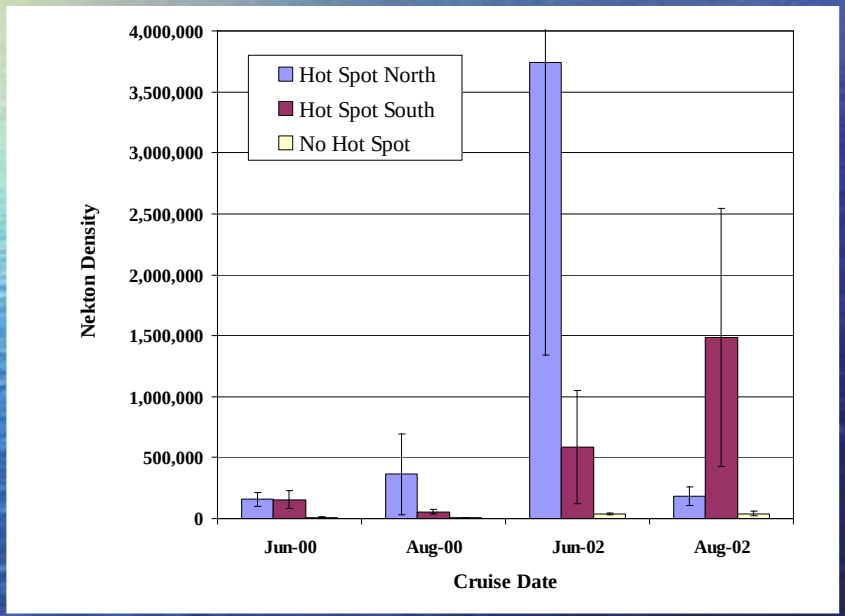




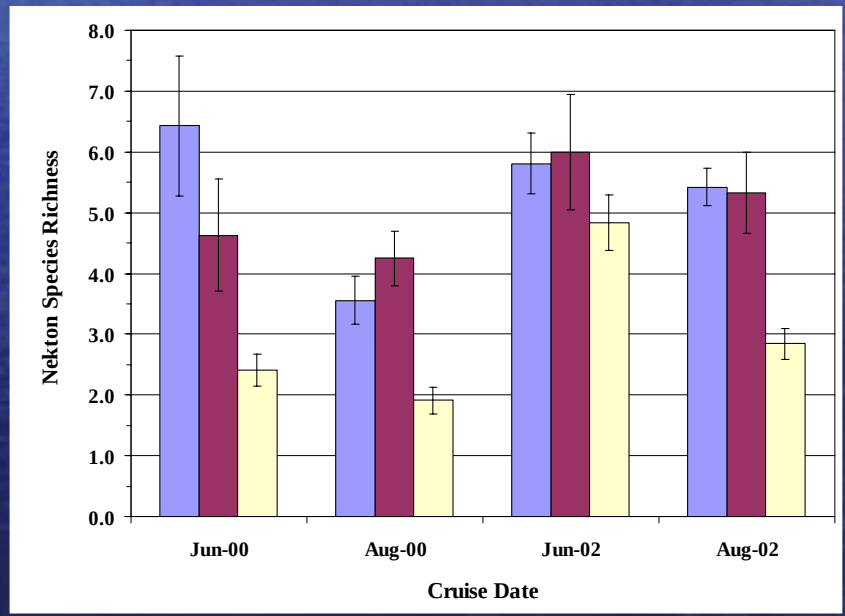


Nekton Comparisons Between Hot Spot Regions

Nekton Density (#/km^3)



Nekton Species Richness



Results – Dominant Members of Hot Spots

- Indicator Species Analysis
  - Most common member of northern hot spot
    - Coho yearlings
  - Most common members of southern hot spot
    - Chinook subadults and adults
    - Surf smelt adults
    - Pacific herring adults
- Northern hot spot more important to young nekton
- Southern hot spot species tended to be adults

Conclusions

- General locations of hot spots in north and south were persistent across seasons and years
- Size of hot spots varied seasonally and annually
- Communities within hot spots varied seasonally and annually
- Temp, salinity, density, and depth were significant parameters explaining different communities in north and south hot spots especially in 2000, but was not as clear in 2002
- None of the environmental variables examined seemed to reliably indicate the presence or lack of a hot spot

Acknowledgements

- For field work and technical assistance
  - Bob Emmett
  - Todd Miller
  - Suzan Pool
  - Paul Bentley
  - Joe Fisher
  - Bruce McCune
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  - NMFS, Northwest Fisheries Science Center