Catalina Conservancy Divers Thermograph Project

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Catalina Island Water Temperatures

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  - El Nino Events
- Short-term Variation Analysis
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- Conclusions

What can we learn from ocean temperatures?

- Takes a long time to heat water

Experiment Background

- The Catalina Conservancy Divers is a membership support group of the Catalina Conservancy, a private, non-profit conservation organization dedicated to the preservation of the natural heritage of Santa Catalina Island.
  - The CCD members are divers and boat owners who volunteer their time and services.

- The CCD want to understand and monitor the health of the Catalina underwater habitat.
  - Collect seawater temperatures.
  - Conduct key species counts.

Thermograph housing side view

Thermograph housing - top view

Experiment Description

- An array of underwater thermographs was deployed and has been maintained around Catalina Island at various depths and sites since 1992.

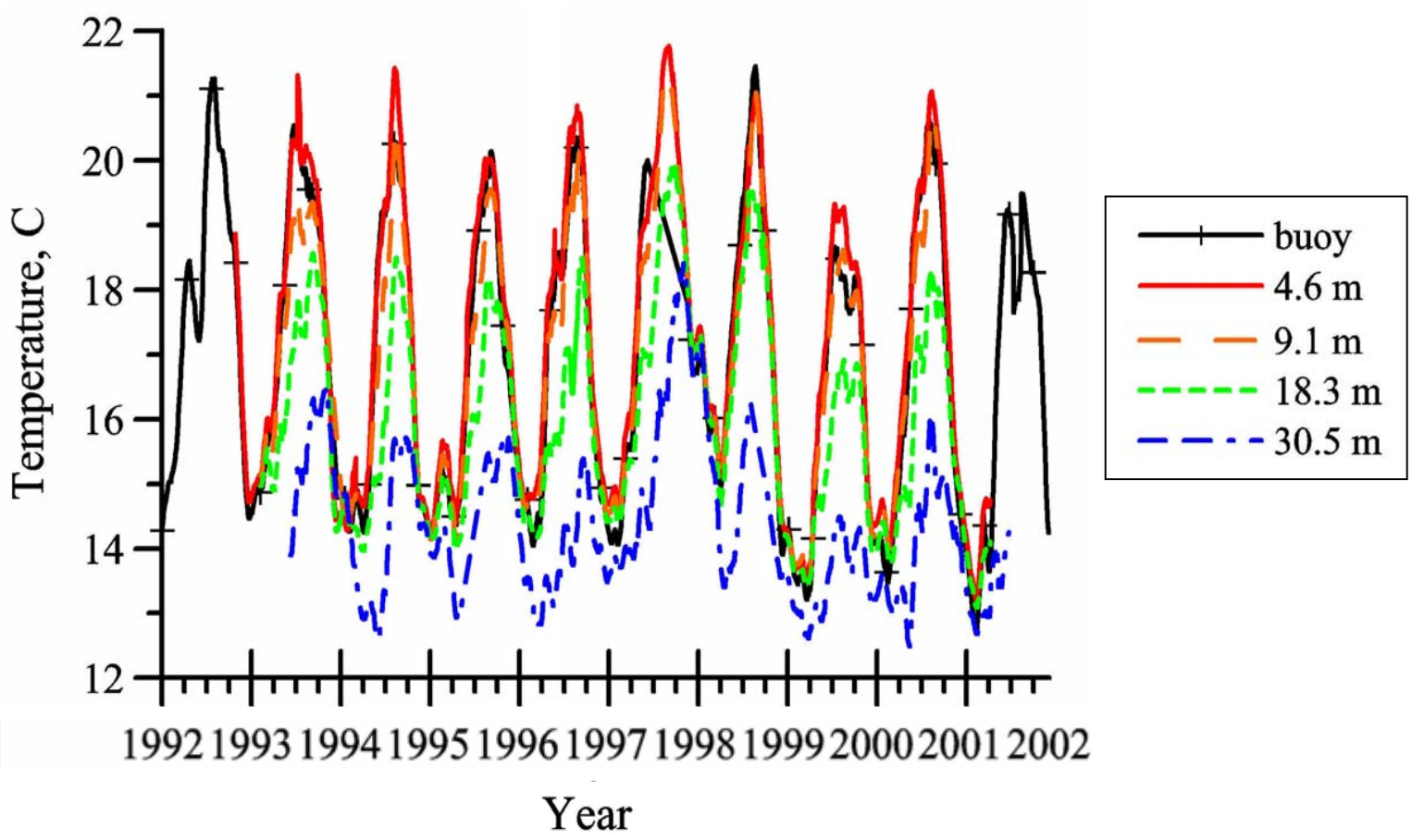
Site	Location	Depths of Instruments (m)
1	WIES	5, 9, 18, 30
2	Pumpernickel	12
3	Italian Gardens	12
4	Casino Point	12
5	East End	5, 9, 18
6	Little Harbor	5, 9, 18
7	Cactus Bay	5, 9, 18

Submarine measurements

Image: Derek Smith

Long-term Variations

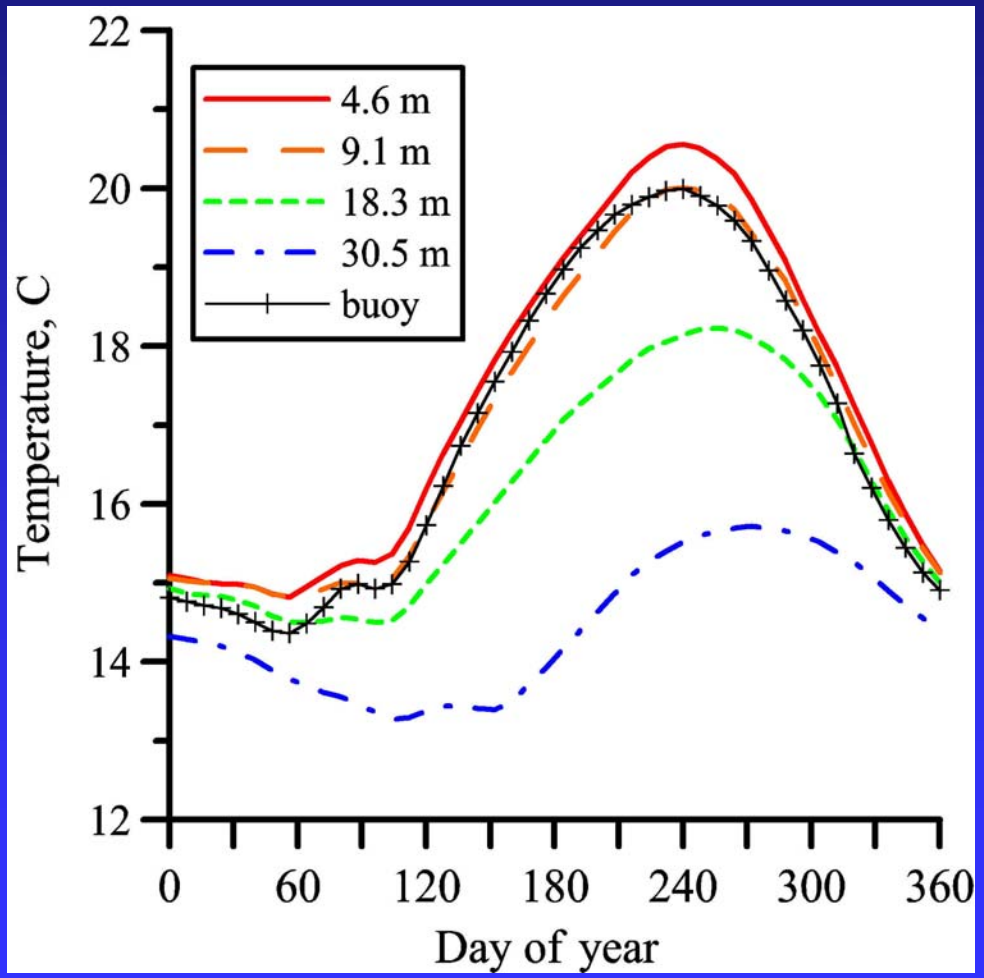
Yearly Variations



Long-term Variations

Yearly Average

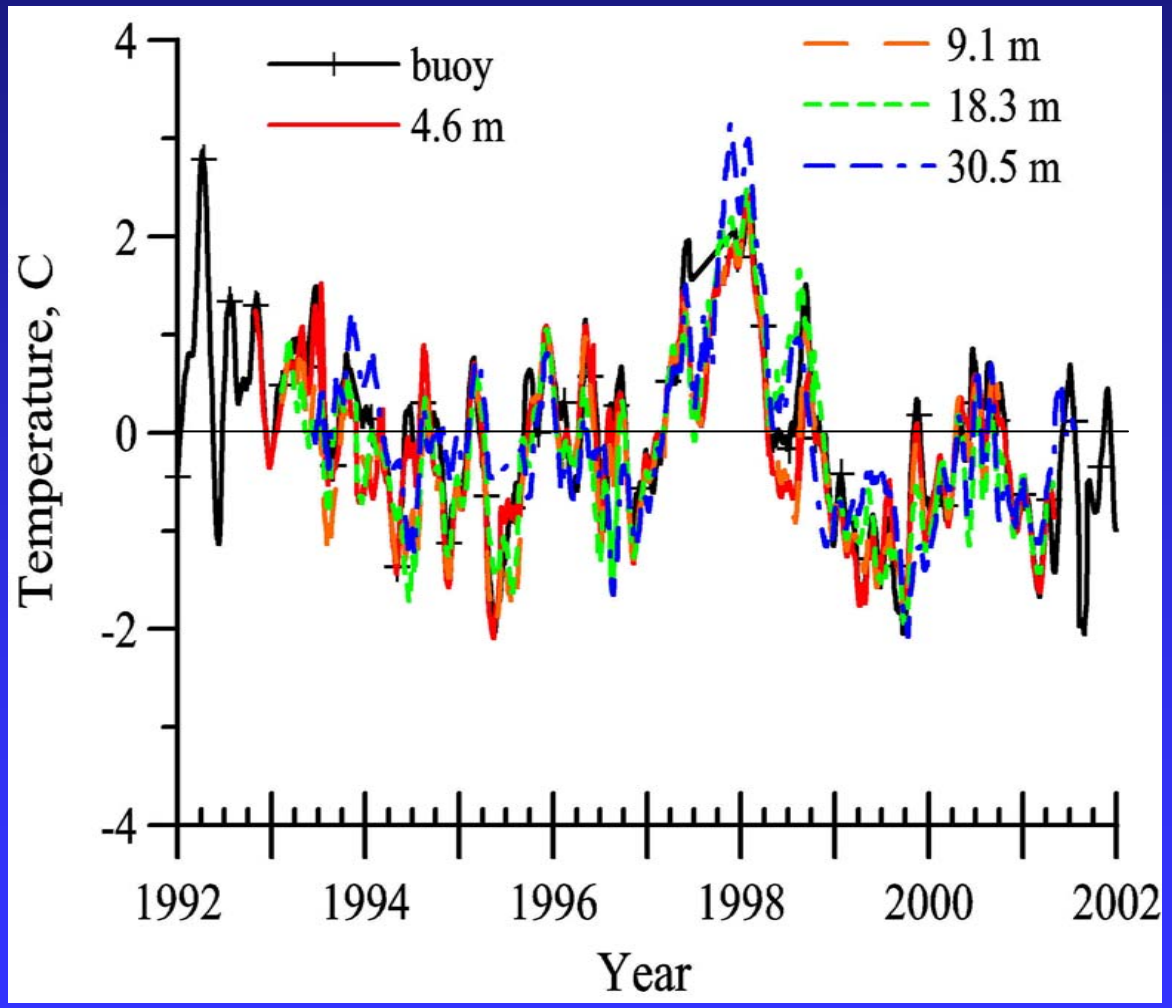
- Daily values averaged over all the years
- Maxima and minima have time lags between the depths.
- Diffusion rates calculated
- Subtle increase in temperature in March at all depths.



Long-term Variations

Yearly Anomalies

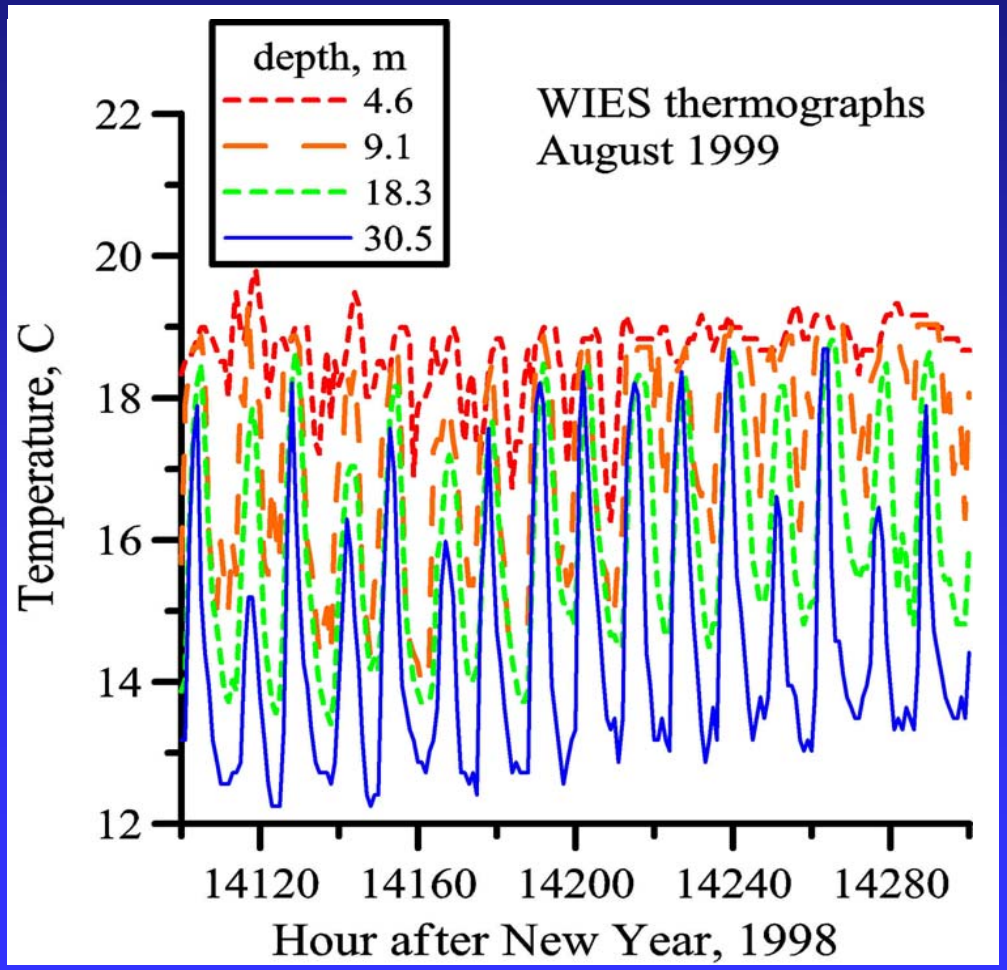
- Yearly Average subtracted from daily temperatures
- 1997-98 El Nino is evident
  - 3^{o} C deviation



Short-term Variations

Sample 100-Hour Time Series

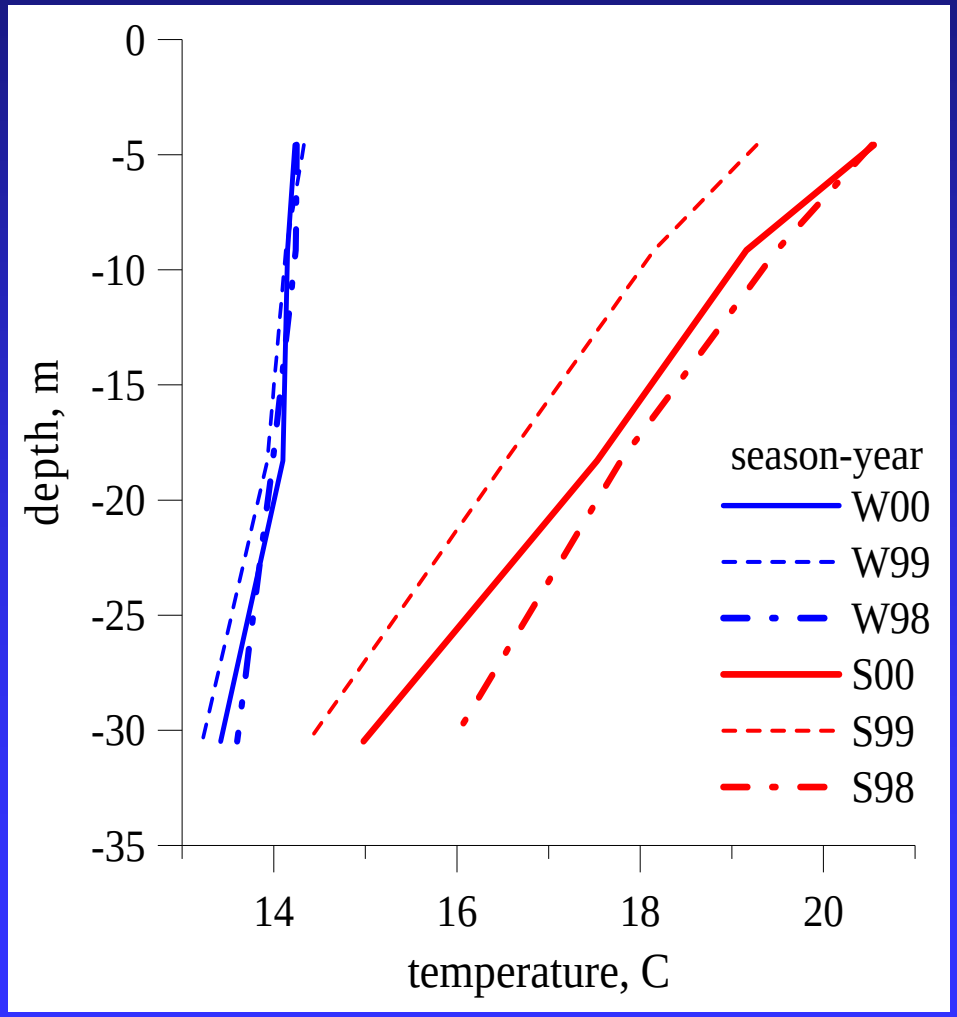
- A trend of decreasing temperature with depth.
- Cyclic fluctuations that increase in amplitude with depth.
  - 6 C at 30.5 m
  - smaller modulations at 4.6 m
- Major fluctuations have a period of about 12 hours.



Short-term Variations

Stratification

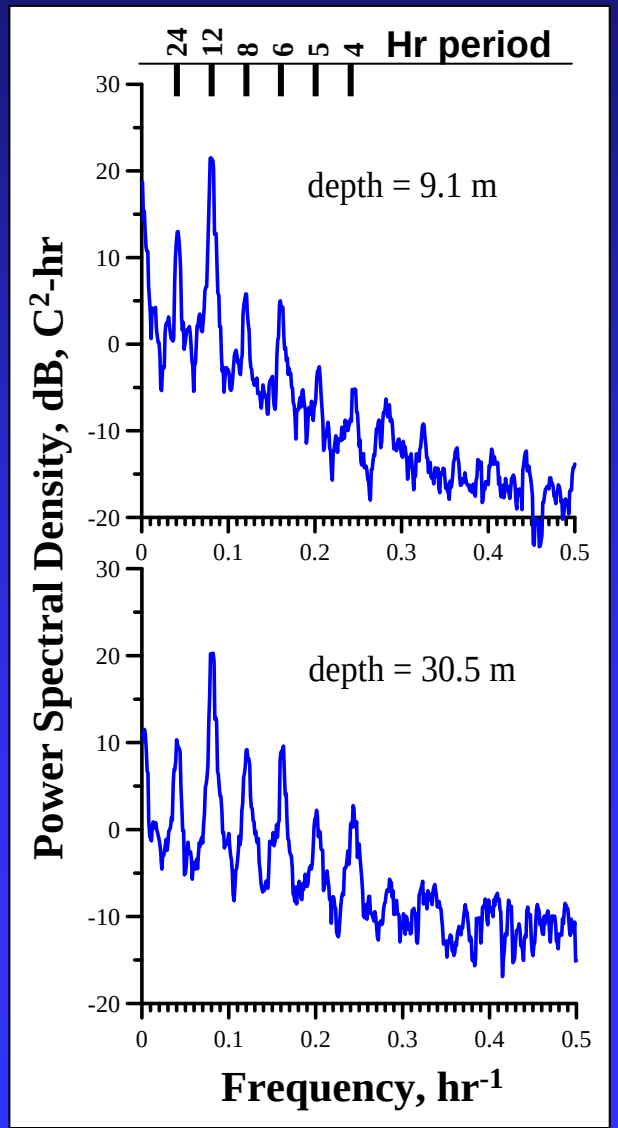
- Summer:
  - Stratified structure.
  - Temperature gradient of 0.2 C/m.
- Winter:
  - Stratified below 20m.
  - Temperature gradient of 0.05 C/m.
- A 2 m amplitude tidal cycle in the summer should result in an increase of 0.4 C. Yet we see up to 6 C at 30 m depth.



Short-term Variations

Frequency Analysis: WIES Summer 1999

- 1000 hours
- Well-defined peaks in the WIES data are also found in the water height records of Los Angeles Harbor.
  - M_2 semi-diurnal tide
  - Diurnal tide
- Peaks at 4 other frequencies not seen in the LA Harbor data.
  - The power values are greatest at the deepest depth.



Short-term Variations

Frequency Analysis: WIES

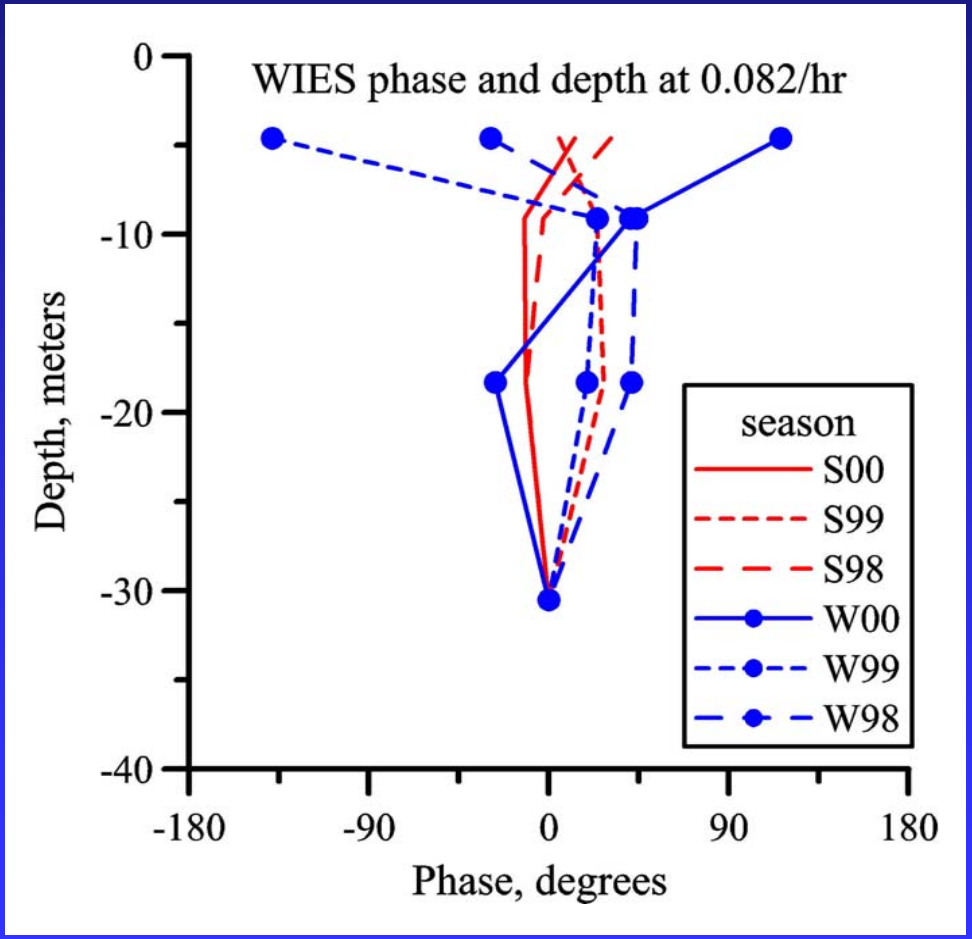
- Coherences between the depths are high, averaging 0.9 at the semidiurnal frequency and 0.4 at the ultrasemi-diurnal frequencies. The coherence was computed such that random noise would have an average coherence of 0.1.

- There are systematic differences between the winter and summer seasons.
  - Summer fluctuations are more energetic than the winter ones by approximately 10 dB.
  - The ultrasemi-diurnal peaks are much weaker or even nonexistent during the winter.

Short-term Variations

Semi-diurnal Frequency Phase Differences

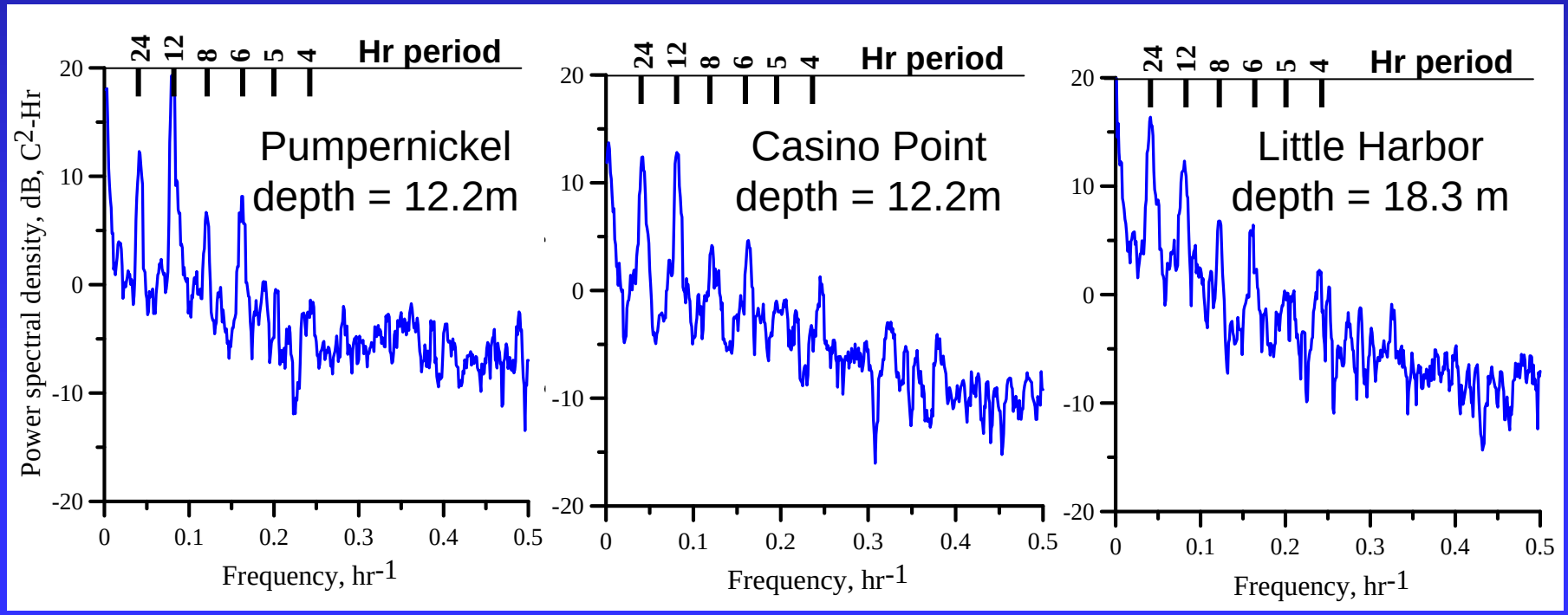
- Phases relative to the variations at 30.5 m
- There is a seasonal difference in the phases.
  - Summer: variations at all depths are in phase.
  - Winter: the 4.6 m data are opposite in phase from the deeper depths.
- A similar relationship exists for the diurnal peaks, too.



Short-term Variations

Frequency Analysis: All Sites

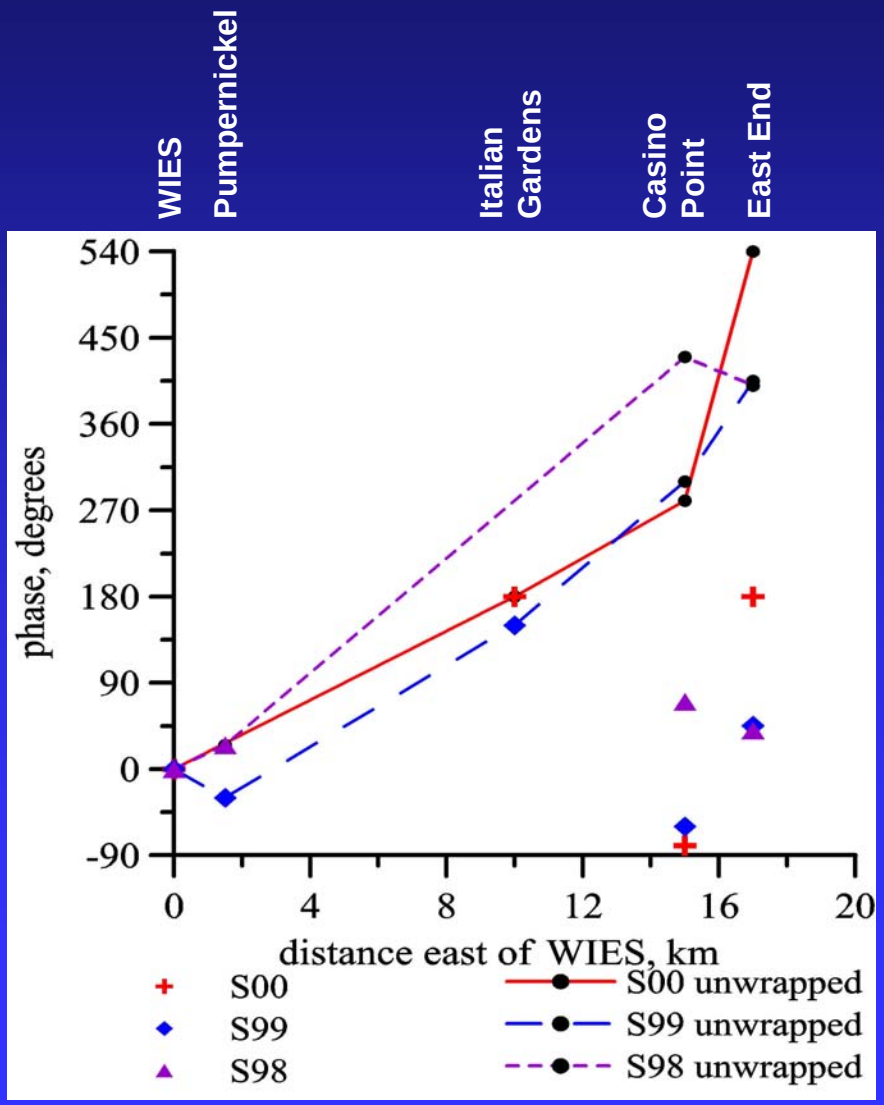
- PSDs for all 7 sites using winter and summer intervals from 3 years
- Large semi-diurnal variations at all sites
- Multiple, ultrasemi-diurnal peaks
  - Except at East End



Short-term Variations

Semi-diurnal Phase Differences between Sites

- Measured the phase difference between the sites, relative to the 18m WIES instrument.
  - 3 Summer intervals
  - Leeward-side sites
- Phase values may be aliased between Italian Gardens and the two easternmost sites.
- Positive progression in phase between the sites indicate a phase velocity from east to west.



Conclusions

Long-term Variations

- Average yearly temperature variation is 6 C at 5 m and only 2.5 C at 30 m.
- Temperature changes at depth lag one month behind those near the surface.
- A small increase in temperature is seen at all depths nearly every March.
- The 1997/98 El Nino resulted in a 3 C increase in temperature.

Conclusions

Short-term Variations

- Significant variations in temperature occur at all study depths and locations about Catalina Island at diurnal and semi-diurnal frequencies.
  - The amplitude of the variations increases with depth.
  - The variations are greater in the summer than in the winter.
  - At shallow depths the variations are in-phase with changes at deeper depths in the summer, but out-of-phase in the winter.
  - The changes in temperature are larger than expected from tidal shifting of the thermocline.
- Variations in temperature also occur at frequencies that are combinations of the tidal frequencies.
- The alongshore scale length of the modulations is tens of kilometers.

Implications

- Surface water is being transported to depth.
  - A summer temperature gradient of 0.2 C/m and a temperature variation of 6 C at 30 m depth is equivalent to a vertical displacement of 30 m.
- Water at a deep depth experiences a daily range in temperature equal to its yearly variation.
  - More nutrients may be available than an analysis of yearly variation would suggest.
  - Temperature sensitive species may move with the change in temperature. Fish counts may not be representative of the actual fish population.
- Nonlinear internal waves are important in larval transport and therefore may be significant to the distribution and dispersal of benthic organisms about the island.