Hydrodynamic affects on the spatial and temporal bloom of phytoplankton in Lake Washington

By: Kevin Schock

With help from:

Hans Berge

Rob Blomquist

Curtis DeGasperi

Hydrodynamic affects on the spatial and temporal bloom of phytoplankton in Lake Washington

- Motivation
  - Determine the affect hydrodynamics have on the phytoplankton.
    - Local mixing
    - Global advection
  - Quantify turbulent eddy diffusion.

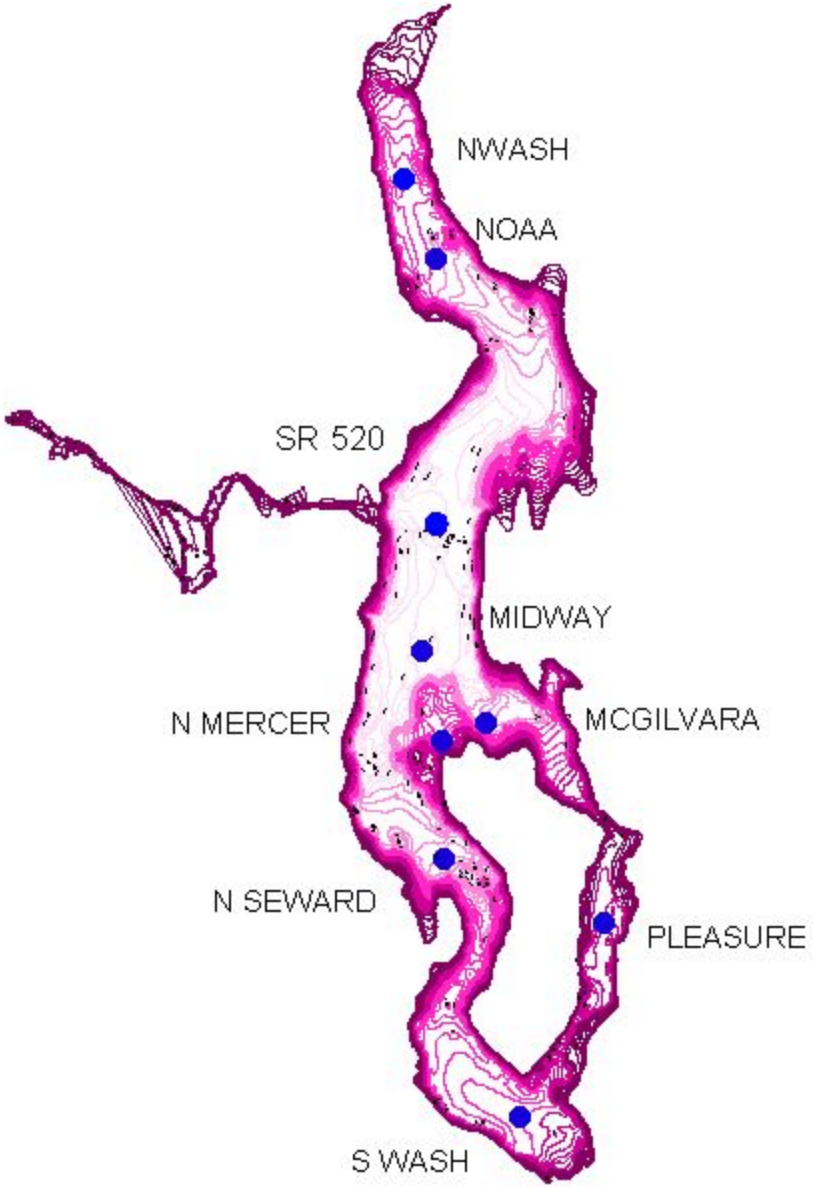
Methods: Instruments

- Turbulent Mixing
  - Self-Contained Automated Microstructure Profiler (SCAMP) samples 100 times per second.
    - Temperature
    - Fluorometer
    - Conductivity
    - Depth
- Particle size and distribution
  - Laser in situ scattering and transmissometry (LISST-100)
    - Particle size distribution (2 - 500 microns)
    - Volume scattering function
- Quantitative Phytoplankton samples
  - Discrete grabs
    - Order and Class identification
    - number and volume
- Vertical Structure
  - Richard Brancker Research, XR-T420 T/24 Thermistor arrays
  - RD Instruments, 300 kHz Acoustic Dopplers
  - Sontek, 1500 kHz Acoustic Dopplers

Methods: Field Monitoring

- Time Series monitoring:
  - Thermistors arrays and Dopplers deployed for periods of 30 days or more. These instruments and deployments help us characterize the internal wave field and large scale water flows.
- Synoptic monitoring:
  - SCAMP, LISST-100, and Quantatative Phyto grabs. These instruments and deployments help us characterize local mixing conditions which can be caused by larger scale events.

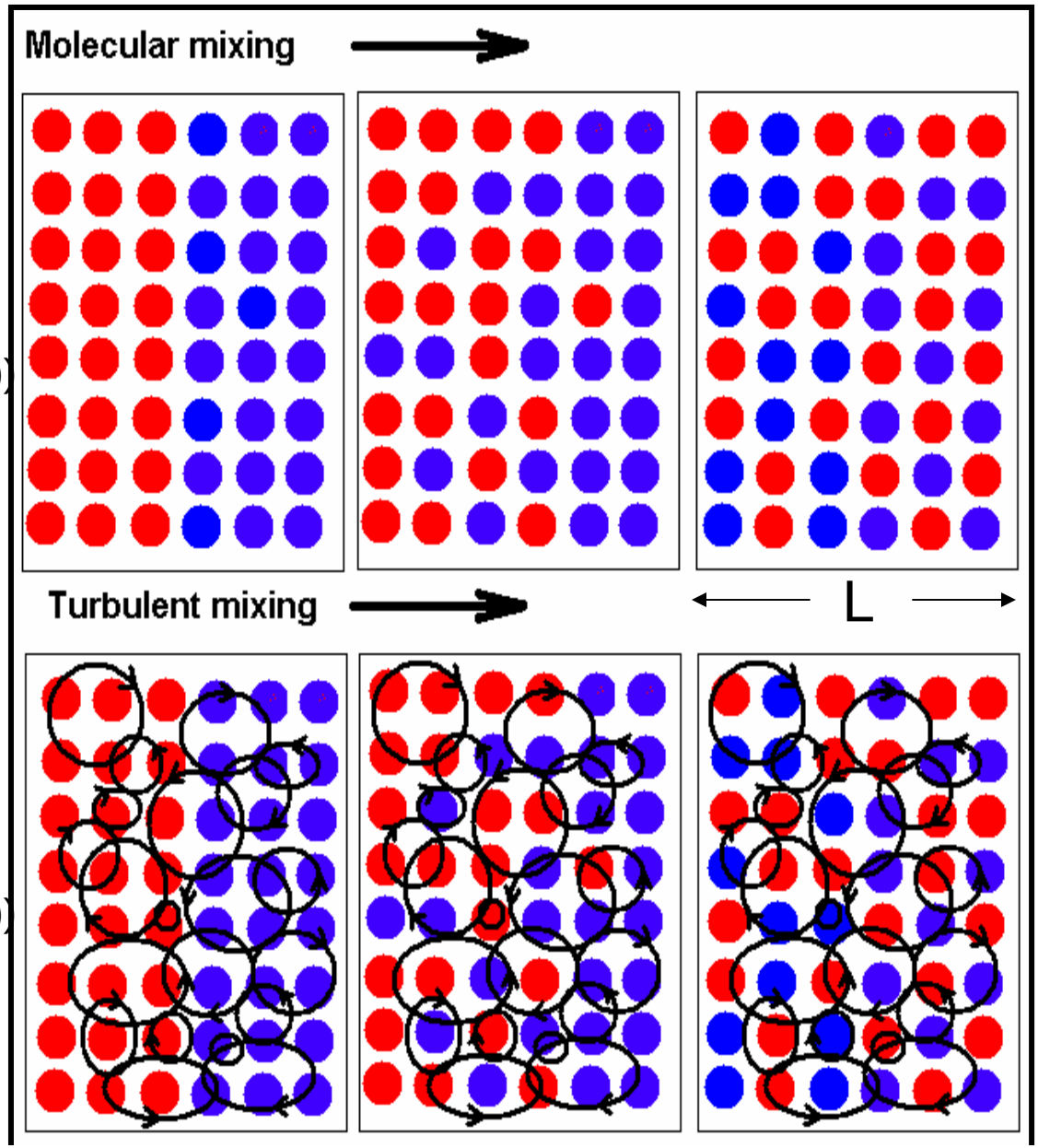
Field Sites


NWASH
NOAA
SR 520
MIDWAY
N MERCER
MCGILVARA
N SEWARD
PLEASURE
S WASH

Local Turbulent Mixing:Continuum

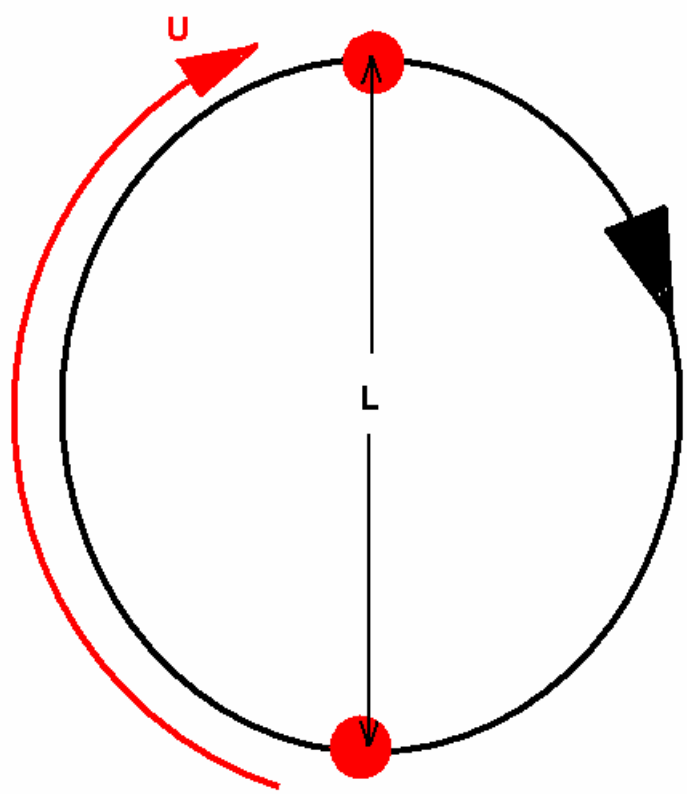
- Molecular Diffusion
- K_m [L^2/T]
  - $1x10^{-6}$ (m^2/sec)
  - Mixing time
  - $T\sim(10(m))^2/(10^{-6}(m^2/s))$
  - T~1,160 days

- Eddy Diffusion
- K_e [L^2/T]
  - $1x10^{-2}$ (m^2/sec)
  - Mixing time
  - $T\sim(10(m))^2/(10^{-2}(m^2/s))$
  - T~0.116 days



Local Turbulent Mixing:Time scales

- **Eddy Turnover**
  - U [L/T]
  - T~L/U
  - Mixing time
  - T~1(m)/(.005(m/sec))
  - T~3.33 (min)



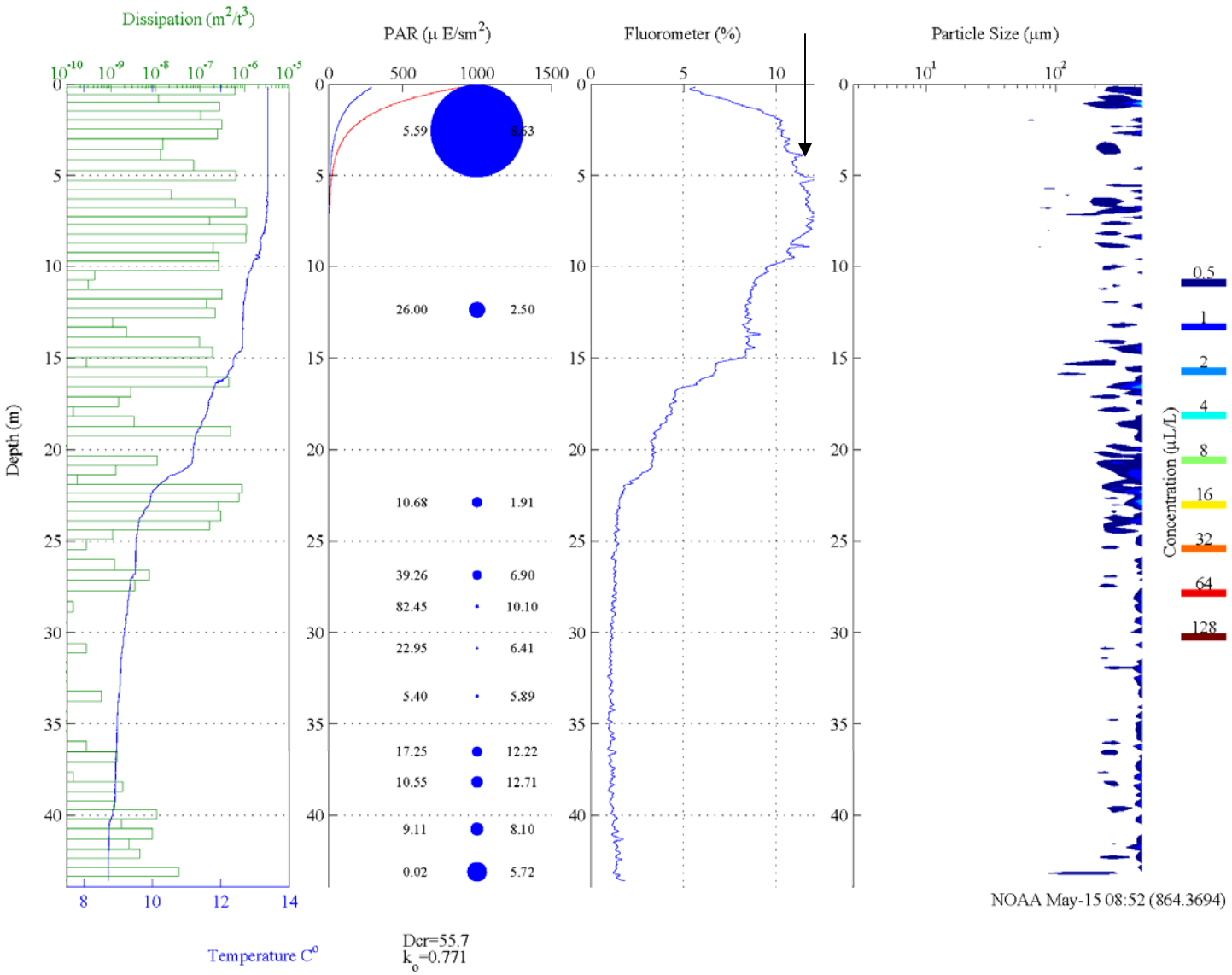
Local Turbulent Mixing: Parameter Estimates

- From the SCAMP temperature profile
  - e=energy dissipation [L^2/T^3]
  - N=buoyancy frequency [$1/T^2$]
- Eddy Turnover
  - $T \sim (L^2/e)^{1/3}$
- Eddy Diffusion
  - $K_e = e/N^2$
  - $T \sim L^2/K_e$

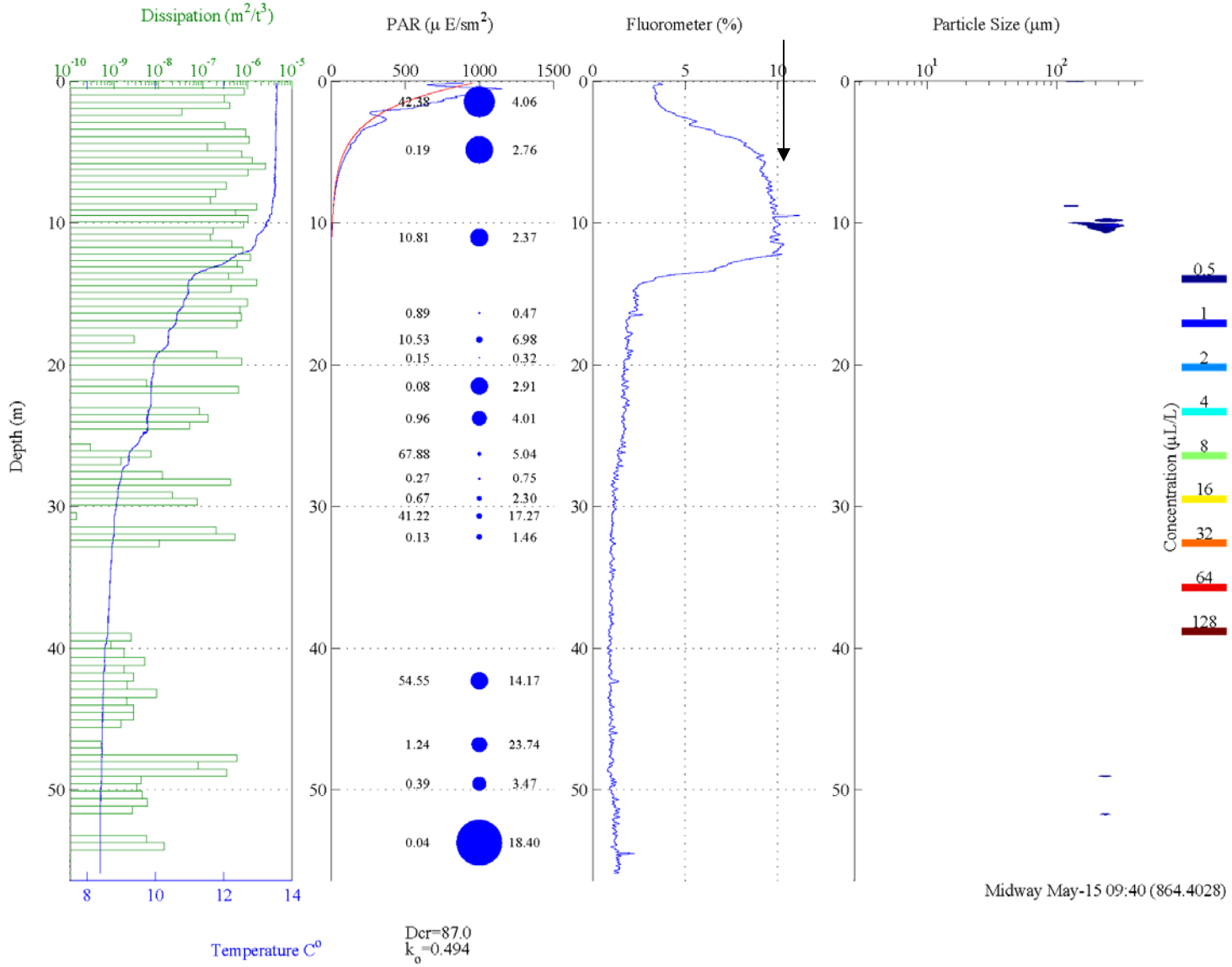
Local Turbulent Mixing: Time Scales

- Turbulent Mixing time scales (T_e)
  - 10's of hours to seconds
- Biological time scales (T_b)
  - days to minutes
- If $T_e > T_b$ then biological processes occur faster than physical.
- $T_e > T_b$ implies that an isothermal profile does not mean uniform biological profile.

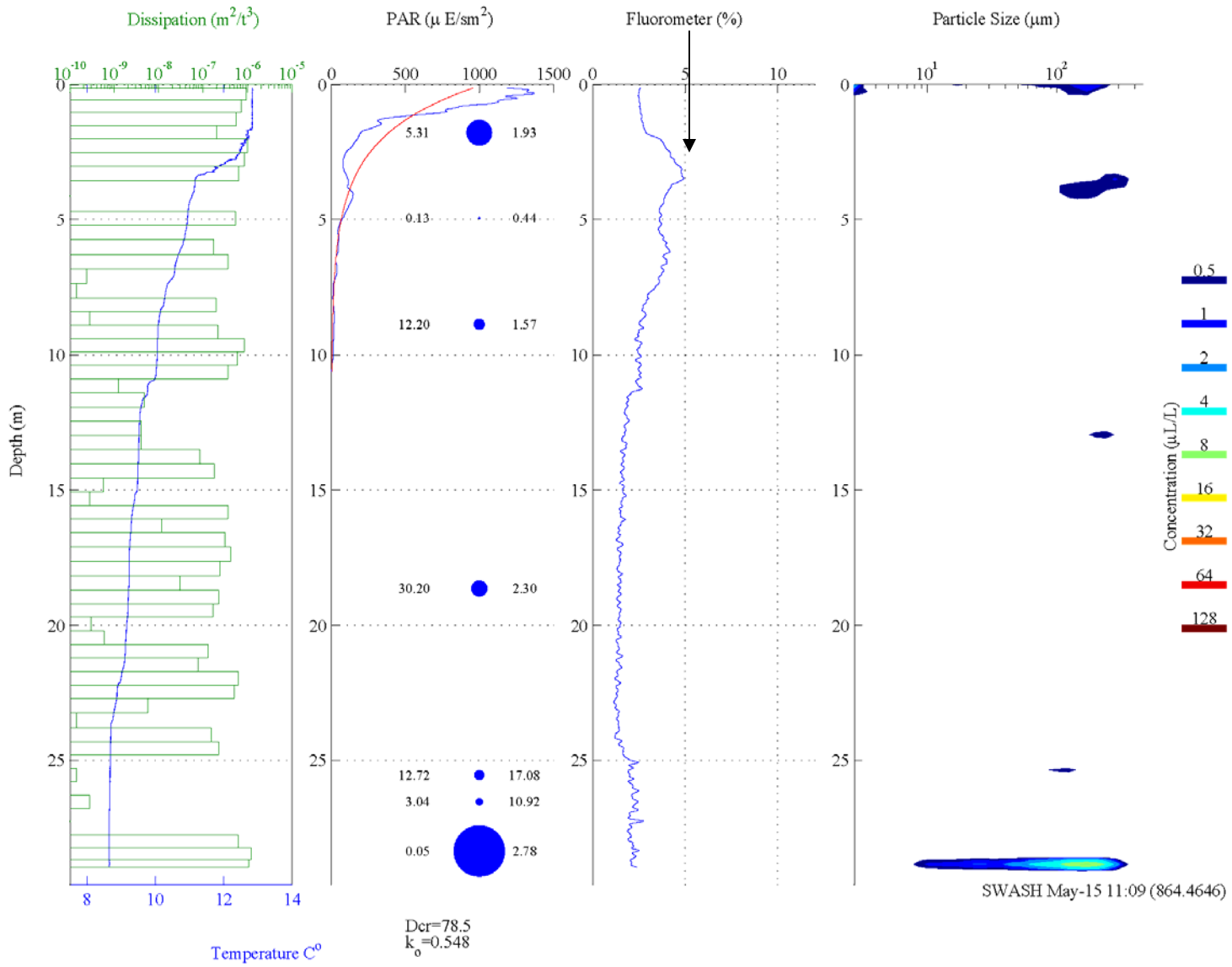
Local Turbulent Mixing: Field Observations



Local Turbulent Mixing: Field Observations

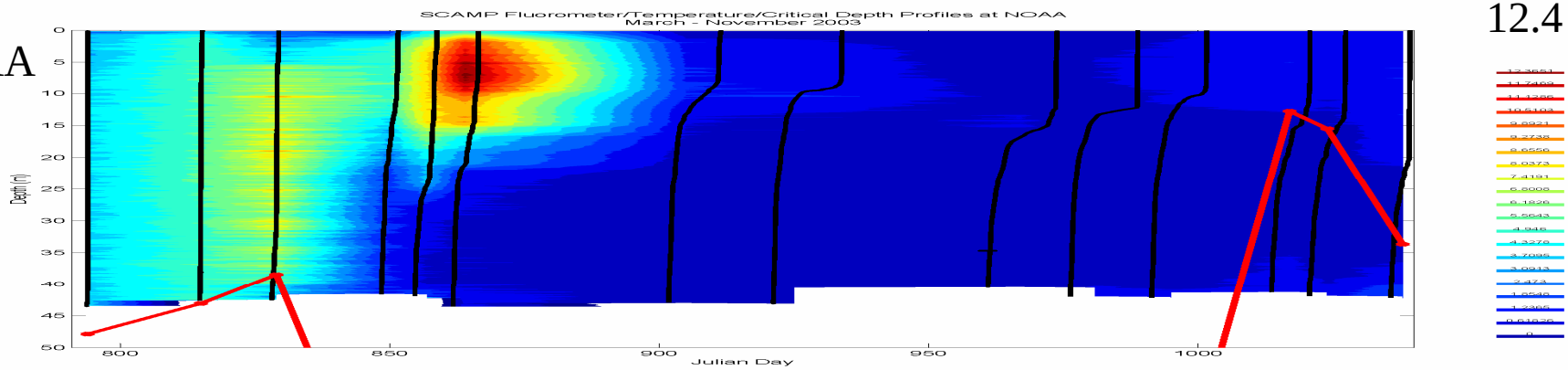


Local Turbulent Mixing: Field Observations

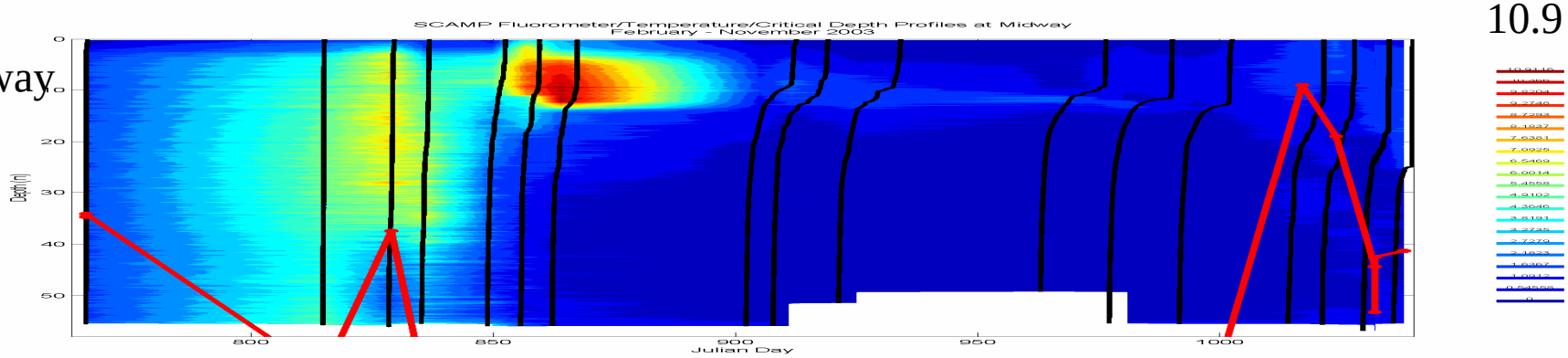


Global Processes: SCAMP Fluor/Temp Field Observations

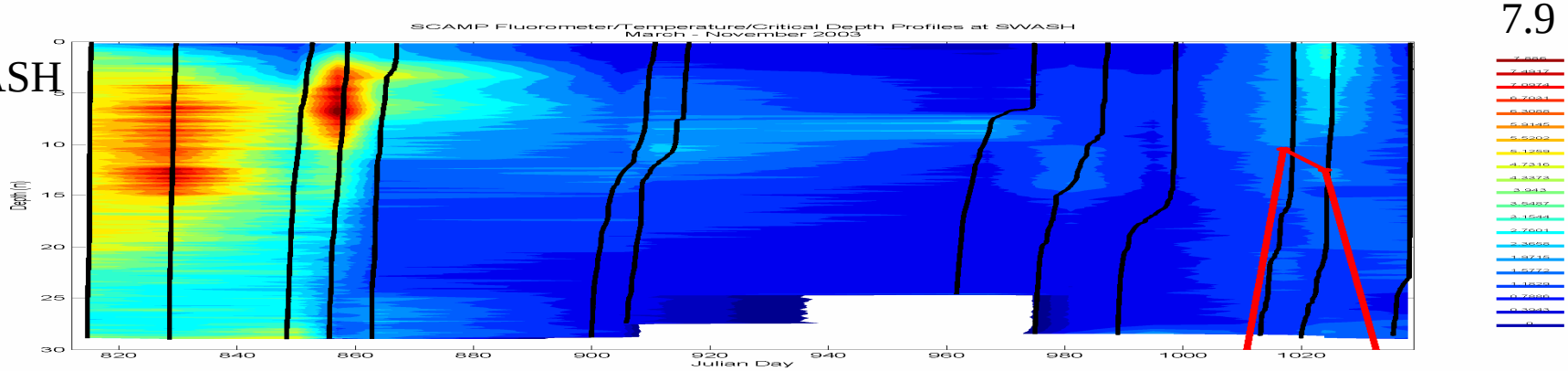
NOAA



Midway



SWASH



Global Processes: Quantitative Phyto Field Observations

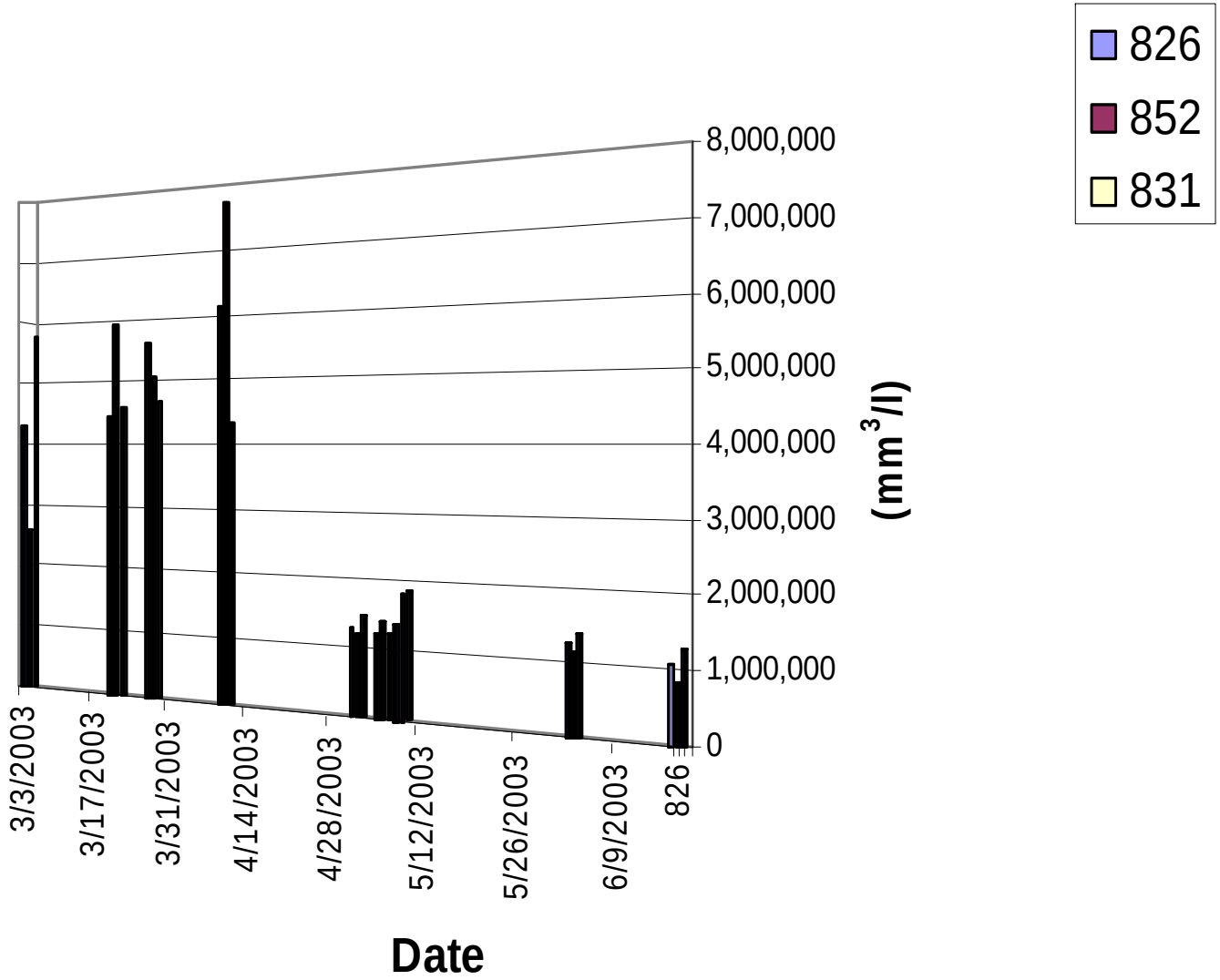
All Phyta

Mean Growth Rate:

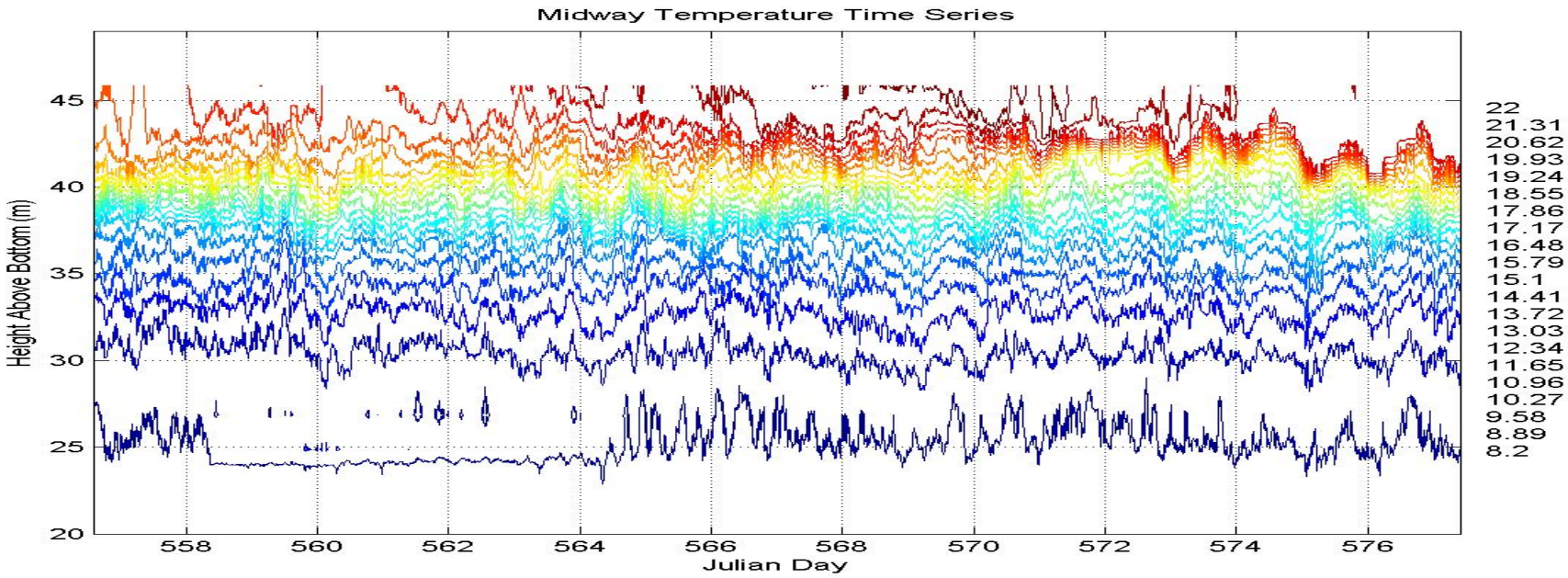
826 = 0.008/d

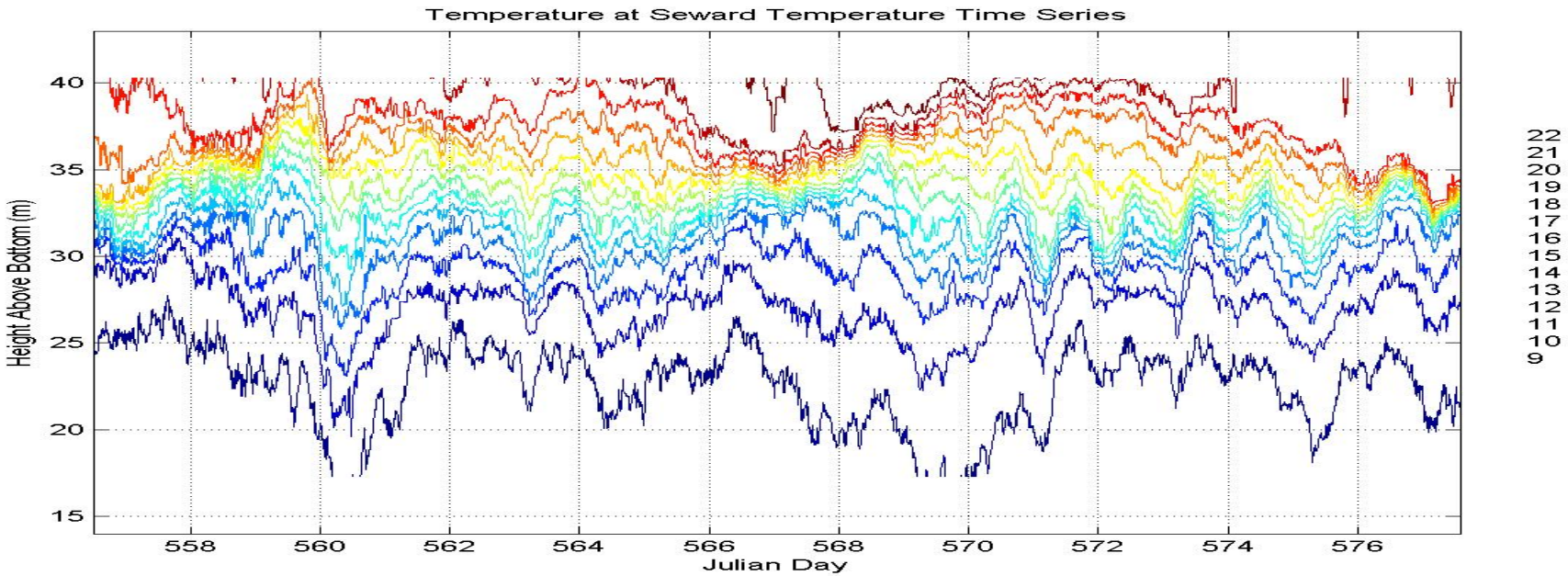
852 = 0.035/d

831 = -0.010/d

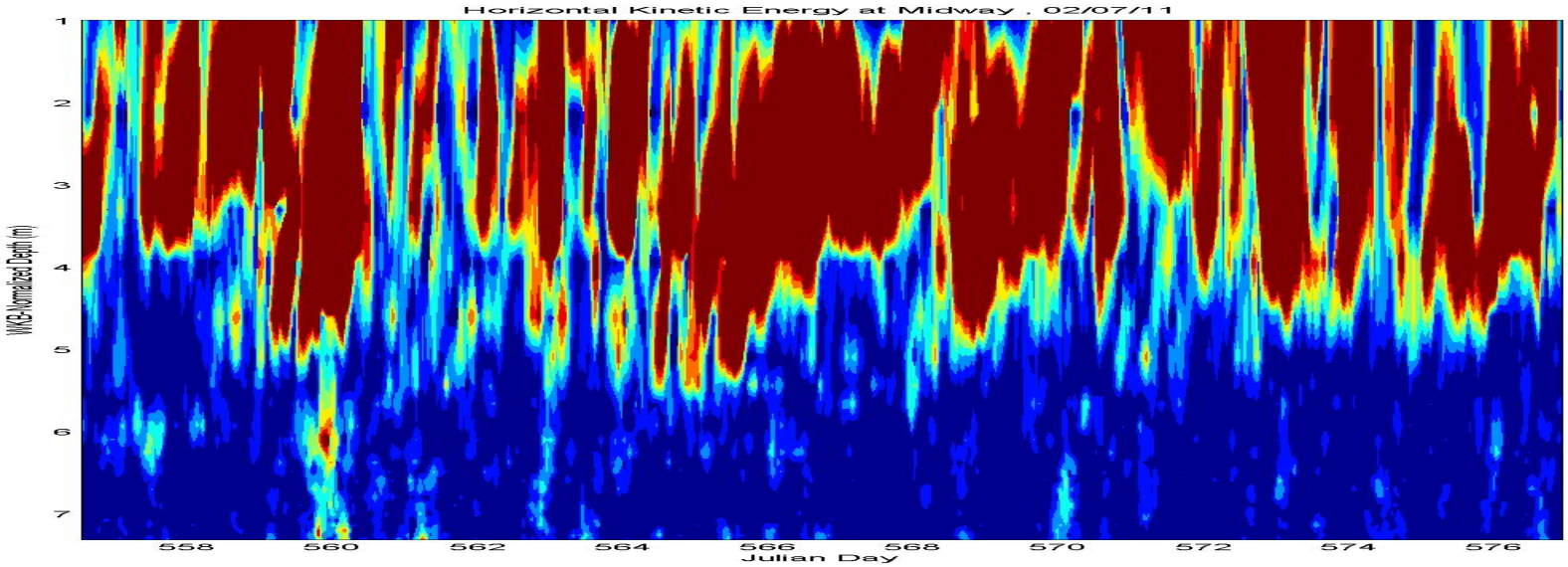


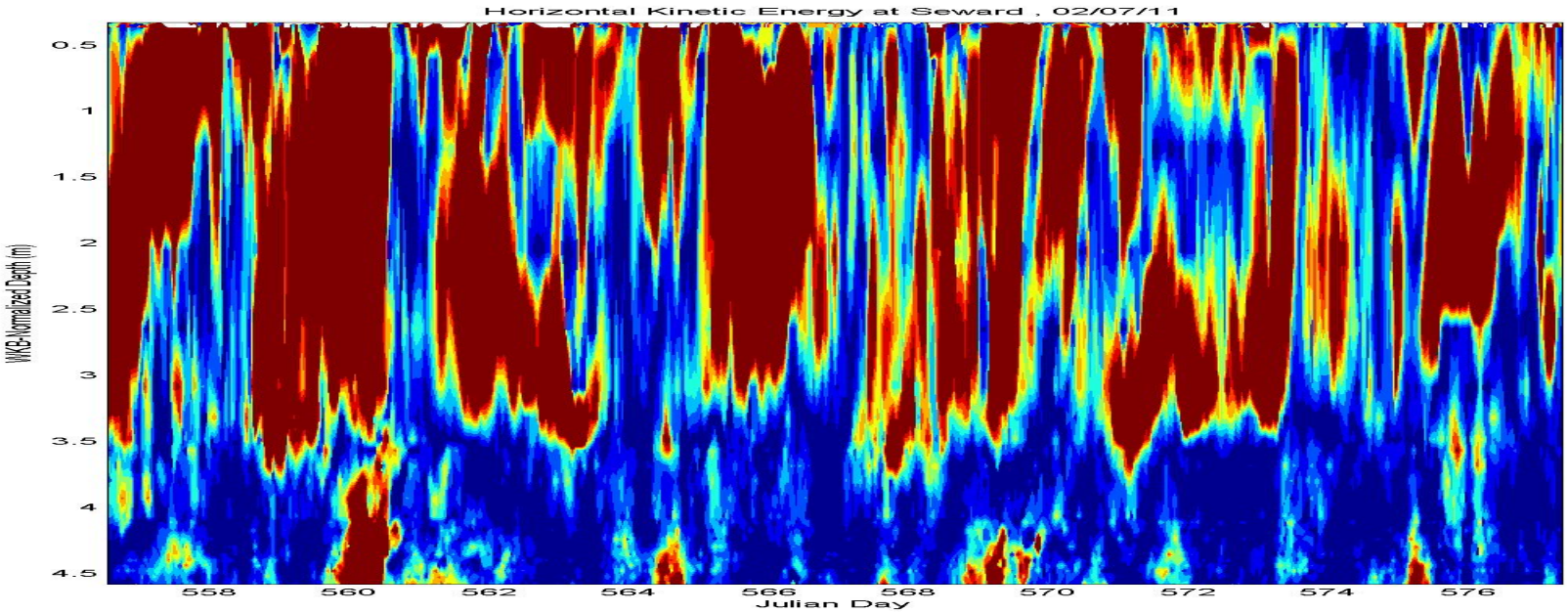
Global Processes: Temp Array Field Observations





Global Processes: RDI Velocity Field Observations





Hydrodynamic affects on the spatial and temporal bloom of phytoplankton in Lake Washington: Summary

- Biological time scales are less than physical mixing scales. How important is photoinhibition?
- Bloom intensity different from North to South. How important is this to juvenile salmon?
- Lake Washington has three distinct layers. How does this affect vertical mixing?