

SMS 491/ EDW 472
Spring 2008

Nitrate dynamics in an estuary
Case study: Elkhorn slough

(This activity is modified after: *Adams L. G. and G. I. Matsumoto. 2007. Investigating coastal processes and nitrate level in the Elkhorn slough using real-time data. Oceanography 20:200-2004*)

Tidal wetlands are dynamic ecosystems of high biological productivity that provide essential habitats for fish, birds, amphibians and many species of invertebrates. They are also among some of the ecosystems most affected by human activities. Hydrologic manipulations such as diking, ditching, dredging and filling for commercial, residential and agricultural developments, along with global anthropogenic effects (e.g., global climate change) have resulted in a significant alteration and loss of these habitats. In addition, high nutrient loads that result from agricultural practices, industrial wastes, and sewage and storm water input affect the overall health of these fragile ecosystems.

Elkhorn Slough, a tidal wetland system in central California, is one such example (Van Dyke and Wasson 2005). The opening of an artificial mouth to Monterey Bay in 1947 resulted in significant tidal scouring, erosion and loss of habitat. In addition, nitrogen concentrations in the slough appear to have increased significantly since the 1970's (Caffrey et al. 1997).

In recent decades, restoration and preservation of fragile estuarine ecosystems became a major concern and the majority of the wetlands of Elkhorn Slough are now managed for conservation purposes. It is paradoxical, however, that restoration and conservation efforts require further hydrologic modifications. Successful restoration and preservation efforts therefore require a careful evaluation of historic patterns of change along with continuous, long-term monitoring programs. Salt water intrusion and elevated nitrate concentrations in groundwater and surface water of the slough are two major subjects of concern.

You were hired by the Elkhorn Slough Foundation to evaluate nitrate concentrations and identify sources, pathways, and processes that are likely to affect nitrogen concentrations in the estuary. Your report will help the Elkhorn Slough Foundation develop a management program to address nitrogen sources of pollution, predict how hydrological modifications for restoration efforts would affect nitrogen sources and pathways within the estuary, and help determine the allocation of funds for the maintenance (and possible expansion) of current real time monitoring system.

Pre-class preparation:

Prior to next class (April, 1) you are asked to:

1. Read the article assigned to you and write a short summary of the key points presented in the article (including a description of the methods)- see list of references below
2. Make yourself familiar with the area by visiting:
<http://www.nerrs.noaa.gov/ElkhornSlough/welcome.html>
(Please read the introduction and the cultural history page)
3. Make yourself familiar with the map of the area and the location of moorings (two maps): <http://www.mbari.org/lobo/network.htm>

In preparation for your investigation, use the reading material and your general knowledge in Oceanography to address the followings:

- Define a problem to be investigated
- Describe the study area
- Hypothesis what processes may affect nitrate concentrations and transport in the estuary

References:

1. Caffrey J. , S. Shaw, M. Silberstein, A. De Vogelaere, and M White (1997). Water Quality Monitoring in Elkhorn Slough: a summary of results 1988-1996. ELKHORN SLOUGH TECHNICAL REPORT SERIES 1997:
(<http://www.elkhornslough.org/research/PDF/1997volsummary.pdf>)
2. Chapin T.P. , J. M. Caffrey, H. W. Jannasch, L. J. Coletti, J. C. Haskins and K.S. Johnson (2004). Nitrate Sources and Sinks in Elkhorn Slough, California: Results from Long-term Continuous in situ Nitrate Analyzers. *Estuaries* Vol. 27, No. 5, p. 882–894.
3. Van Dyke E. and K. Wasson (2005). Historical Ecology of a Central California Estuary: 150 Years of Habitat Change. *Estuaries* Vol. 28, No. 2, p. 173–189.
4. William W. Broenkow and Laurence C. Breaker, "A 30-Year History of Tide and Current Measurements in Elkhorn Slough, California" (November 18, 2005). *Scripps Institution of Oceanography Library*. Paper 8.
(<http://repositories.cdlib.org/sio/lib/8>)

Class activity:

Goals: evaluate sources, variability, and pathways of nitrogen in the Elkhorn Slough.

- 1) Each member of the team will provide a brief summary, describing the issues related to her/his area of expertise (learned from the assigned literature). Allow approx. 5 minutes per team member.
- 2) Use the map of the area (see <http://www.mbari.org/lobo/network.htm>) to highlight what you predict are the origins and pathways of nitrate in the slough. Use different color pencils to represent the natural sources and the anthropogenic sources.
- 3) Locate the monitoring buoys on the map:
All the buoys are located in areas that are heavily farmed> However, buoys L01, L02, L04 and L05 are located within the boundaries of the Natural Estuarine Research Reserve system, which is tightly regulated. Buoy L03 is located in the Old Salinas river, a heavily farmed area that is not as regulated.
Buoy LML is located in Moss Landing Harbor and buoy M1 and M2 are located off shore from the estuary, in Monterey Bay.
- 4) Get familiar with the data. Go to <http://www.mbari.org/lobo/loboviz.htm> where you can find real time data from the different buoys. You will be using these data to evaluate sources and pathways of nitrate in the Elkhorn slough.

You can use any approach you want for your investigation but below are some pointers to help you start the thinking process. (Instructions on how to use the program are given in class):

- Compare the ranges of nitrate concentrations measured by the different buoys (using all data available). Where and when do you find elevated concentration of nitrate?
- Is there a relationship between precipitation, salinity and nitrate levels?
- Is there a long-term trend of increased/decreased nitrate concentrations in the Main Channel?
- Examine daily and seasonal fluctuations of nitrate in this ecosystem and the processes that may affect these fluctuations.

For example: plot nitrate, water depth (what information does it provide you?), salinity and temperature measured at buoys L01, L02 and L03 during 2006 for the following dates: January 9-14, March 9-14, June 9-14 and September 9-14.

1. Do you see any rhythmic or consistent pattern in your graphs?
If yes, how would you explain this pattern?
 2. Are there differences in the trends observed between the different months?
Which month in your data set varies most?
- How do nitrate concentrations vary with time? Prepare a list of different time scales of variability in nitrate concentrations (e.g., daily, monthly, seasonally, annually etc), and suggest what could be some of the processes contributing to the variability in each case.

Homework: Based on your findings, redraw your map of how nitrate enters and circulates through the slough and write a brief report (5 pages max) to the Elkhorn Slough Foundation. The report should describe the area of study, define the problem of investigation, summarize your key findings, point out problems and limitations of the available data, and lastly include recommendations for future monitoring efforts.