History of Habitat Mapping and Change Detection in the Elkhorn Slough NERR

Seafloor Mapping Lab – California State University Monterey Bay

The Seafloor Mapping Lab (SFML), within the Division of Science and Environmental Policy at California State University Monterey Bay, specializes in high-resolution acoustic remote sensing for coastal habitats. Combining research and education with state-of-the-art geospatial technology, the SFML offers unique hands-on, field-to-finish experience to students while conducting professional habitat mapping surveys for resource management and basic research along the continental margins. http://seafloor.csumb.edu

Erosion

1980s

Bathymetry by leadline technology, cross-sectional profiles

The first study examining tidal scour in the Elkhorn Slough environment was conducted in 1988 by Oliver et al, data were recorded using calibrated lines laid across the slough. The study determined that extensive erosion had occurred since the opening of Moss Landing Harbor, resulting in a 6 meter increase in depth at the slough mouth, as well as an 8% annual loss of salt marsh habitat due to increasing tidal volume and tidal currents between 1980 and 1988.

1993 Project Goals

- *Provide baseline bathymetric, hydraulic, tidal and erosion data*
- *Determine rates of sediment transport*
- *Determine if rate of erosion by tidal scour continues to increase, or is slough approaching equilibrium*

Between 1982 and 1992, 45 years after the Army Corps of Engineers breached the dunes in front of the Elkhorn Slough mouth to create the present day Moss Landing Harbor entrance, tidal volume, surface area and currents in the slough had all increased by > 40%, and rates of increase in main channel and tidal creek width were as high as 1 m/y in areas near the railroad.


REGISTER-PAJARONIAN

Elkhorn Slough washing out to sea

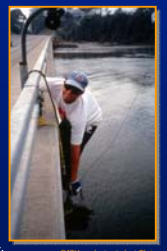
Clinton plan nears passage by Congress

Tidal action scours unique wetland

1993

Bathymetry recorded via acoustic technology- singlebeam sonar

In 1993, Malzone and Kvitek used differential GPS (dGPS) and survey grade single beam sonar to conduct an even more detailed study. The new dGPS provided horizontal accuracy of 2m. Malzone and Kvitek arranged 67 cross sections along the main channel and 6 more across the Parson's Slough mouth (Figure 1). From these data Malzone calculated an erosion rate of 8.0 x 10^4 m3/yr between 1988 and 1993.



SJSU graduate student Chris Malzone installs an S4 current meter off the Hwy 1 bridge at the mouth of the slough

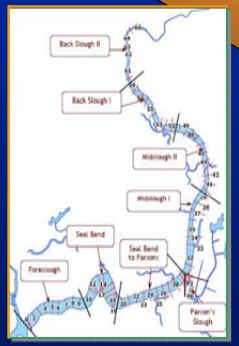


Figure 1. Location of Malzone's bathymetric cross-sections and Dean's erosion-pattern divisions.

CSUMB student Edwin Dean mans the GPS reference station

2001

Bathymetry via multibeam sonar

2001 Project Goals

- *Determine if the rate of erosion in the slough main channel is slowing*

CSUMB student Jere Brantner establishes a GPS base station for reliable differential corrections of acoustic mapping data

In early 2001, Brantner surveyed the main channel from the mouth to Kirby Park. This study gained an unprecedented level of resolution through the use of multibeam sonar and real time kinematic (RTK) GPS, a positional accuracy of 3cm horizontal was achievable. This system allowed a 100% coverage bathymetry model to be created for the surveyed area. To facilitate RTK GPS, a base station was erected at benchmark ELK1 at the overlook near the Elkhorn Slough Visitors center. Brantner calculated that within the surveyed area, there was a rate of loss of 4.66 x 10^6 m3/yr of sediment between 1993 and 2001, an increase of 15% from Malzone's calculation of sediment loss.

Due to the dramatic advancement in hydrographic technology, each successive study has revealed the slough and its erosional patterns at an ever increasing resolution.

CSUMB professor Dr. Rikk Kvitek collects high precision GPS data to measure pre & post 1989 Loma Prieta earthquake elevations

Figure 2. Aerial extent of Elkhorn Slough tidal prism showing MLLW (dark blue) and MHHW (light blue) levels as calculated from merged DEM

2003

LIDAR & multibeam bathymetry

A study by Dean increased the survey area to include the shallows of the main channel, the mouth of Parson's Slough, and the area extending upslough from Kirby Park to Hudson's Landing—the same area covered in 1993 by Malzone. The study used previously collected SFML data, additional multibeam sonar bathymetry, and LIDAR (**L**ight **D**etection **A**nd **R**anging) data collected by the NASA Airborne Topographic Mapper (ATM) in 1998. Dean found that the erosion rate remained within an order of magnitude to the previous studies. Approximately 0.45 x 10^6 m3 of material eroded from the survey area, an average erosion rate of 3% of the slough's volume per annum. However, the patterns of erosion had shifted, with some area becoming deposition dominant and vice versa. These results lead Dean to qualitatively divide the slough into seven sections: The Mouth, Seal Bend, Seal Bend to Parson's, Parson's mouth, Midslough 1, Midslough 2, Backslough 1, Backslough 2/Hudsons Landing (Figure 1). The study revealed that most of the erosion occurred downstream of the mouth of Parson's Slough and interpreted this change as an indication that the increasing tidal prism of Parson's Slough had become a dominant influence on tidal scour downstream. Moderate erosion occurred in the middle slough. Only the head of the slough, near Hudson's Landing, showed significant deposition.

2003 Project Goals

- *Assess spatial patterns of erosion and deposition within the main channel and adjacent tidal flats*

GPS terrain mapping lead by CSUMB student Stacy Miller

High precision bathymetric & terrestrial modeling

The 2005 study focused its approach on the creation and analysis of a time-series of high resolution digital elevation models (DEM) of the Elkhorn Slough and its surrounding watershed (Figure 2). Two consecutive DEMs were produced using data from the previous 2001 & 2003 bathymetry surveys, comparing them to determine both the magnitude and the rate of erosion (Figures 3 & 4). A 2003 terrestrial LIDAR data set (NOAA & MBNMS) was also obtained and merged with a bathymetry data set to calculate the tidal prism. The results of both calculations were then compared to previous studies to determine if and where the rate of tidal scour was increasing or decreasing in the slough. Between 2001 and 2003, the net sediment volume change was 0.47%. However, with the removal of Parson's slough mouth from the analysis, that value changes to -1.23%. Between 2001 and 2003, 2.4 x 10^5 m3 of sediment was lost, approximately 1.2 x 10^5 m3/yr, 1.5 times the annual rate calculated by Malzone (1999).

2005

2005 Project Goals

- *Create a bathymetric model of the slough environment, using multibeam sonar, singlebeam sonar and terrestrial LIDAR*
- *Quantify rates and spatial distribution of erosion and deposition*
- *Calculate the tidal prism of the slough for comparison to previous estimates*

The *R/V Mini-me* equipped with a singlebeam sonar system is piloted into shallow tidal creeks by CSUMB student Josh Sampey

Figure 3. Changes in the thalweg depth of the Elkhorn Slough from 1993 to 2005 showing a continuous pattern of downward cutting erosion seaward of Kirby Park.

Figure 4. Change detection 2001 - 2003: sediment erosion and deposition (near the slough mouth) calculated by subtracting 2001 from 2003 multibeam data sets to show vertical change

EQUILIBRIUM ?

CONCLUSION

These progressively more advanced survey technologies revealed accelerating erosion rather than an approach to equilibrium throughout most of the Elkhorn Slough system. The confirmation of unabated and rapidly advancing tidal scour is prompting the ESNERR management staff to consider more drastic and costly solutions to this significant threat to the slough's fragile environment.

OVERVIEW

Habitat change and loss due to anthropogenic and natural factors is the major environmental problem facing many coastal and estuarine resource management agencies. The primary goal and challenge of most coastal environmental change detection programs however, is the ability to detect trends early enough to take appropriate management action before too much "loss" has occurred. Harbor creation at the mouth of the Elkhorn Slough has led to increased tidal scour that is rapidly eroding the banks, salt marsh and main channel estuarine habitat, destroying freshwater wetlands, and inundating an active railroad line. Multibeam and singlebeam sonar surveys of the Elkhorn Slough, combined with high accuracy GPS terrestrial surveys, were used to quantify variation in the rates of habitat change compared to previous baseline data from the1990's and 1980's. The results from the bathymetric time series provide clear evidence for continued high and accelerating rates of erosion and habitat loss since 1993

Reference sources. CICEET Report: *Development of an integrated data acquisition and coastal marine GIS analysis system for habitat mapping and change detection in the Elkhorn Slough NERR*, Kvitek et al (2006). SJSU MS Thesis: Malzone (1999). CSUMB Capstone: Brantner (2001), Dean (2003), Miller (2004), Sampey (2006).