



# Cal Poly Pier Water Quality Monitoring System

## Final Report

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## Introduction

In September of 2002, Tenera Environmental partnered with California Polytechnic University, San Luis Obispo to team with the faculty, staff, and students of the Biological Sciences Department to install a water quality monitoring hydrostation at the end of the Cal Poly Marine Science Research and Education Facility Pier (Cal Poly Pier) in San Luis Obispo Bay. The hydrostation was to consist of an array of instruments deployed from the pier to measure temperature, salinity (conductivity), dissolved oxygen, fluorescence, turbidity, and the presence of hydrocarbons. Continuous monitoring of these variables in San Luis Obispo Bay was intended to provide valuable near-real-time information from which correlations to nearshore pollutants could be made. In addition, this information was to be available for use by the public, local businesses, county officials and educators via the Internet. Funding for the installation was provided by the Avila Beach – Public Recreation and Environmental Restoration Mitigation Project and administered through the Regional Water Quality Control Board – Region 3.

This report presents a description of the subsequent installation and a timeline of the project through the end of 2005, the performance period for this funding support.

## System Design

Tenera Environmental and Cal Poly staff worked with representatives of Aanderaa Instruments on the design and construction of the hydrostation during the winter and spring of 2002-2003. The station was to consist of two parts. An instrument array that would be deployed from the Cal Poly Pier that would monitor temperature, salinity

(conductivity), dissolved oxygen, fluorescence, and turbidity, and a hydrocarbon analyzer that would be separate from the array, but would sample the near-surface water in the same general vicinity. The data acquisition system for the hydrostation was to be housed in the laboratory and office building located at the end of the pier, adjacent to the hydrostation, and would periodically collect and record information from each of the sensors and make it accessible to the public via the Internet.

The hydrostation instrument array, in its current configuration, is shown in **Figure 1**. Located at its uppermost elevation (-1.5m MLLW), is a Wetlabs ECO-FLS Fluorometer. This instrument measures fluorescence as an indicator of phytoplankton density in the upper water column. It is the only fluorometer in the array and was placed where light levels and the density of photosynthetic plankton within the water column were anticipated to consistently be at their highest. The presence of some toxic phytoplankton (i.e., *Pseudo-nitzschia* spp., *Gonyaulax* spp.) have been documented in the San Luis Bay area by local and federal programs (Mussel Watch). However, the frequency and magnitude of toxic blooms in this region is unknown. Recent studies have shown direct correlations between toxic phytoplankton abundance, fish kills and degraded water quality. Because toxic phytoplankton abundance in the water column fluctuates over relatively short time scales (3-4 days) in response to nutrient fluxes from San Luis Creek, randomized shore based sampling techniques are not sufficient for monitoring water quality. Monitoring of water column fluorometry provides a real-time indication of water quality, and contributes to maintaining the safety of the public that utilize San Luis Obispo Bay.

Positioned at five different depths (-2.0m, -3.5m, -5.0m, -7.0m, and -8.0m MLLW) below the fluorometer, are conductivity/temperature (CT) sensors. As indicated by their name, the CT sensors measure conductivity (used to calculate salinity) and temperature at each depth, which provides an indication of the influence of runoff and off cold water oceanic upwelling. The lowest CT sensor was replaced in 2004 with a CTD sensor that also measures depth (pressure). This provides information on both tide and wave height, which can be directly validated by the NOAA tide gauge station.

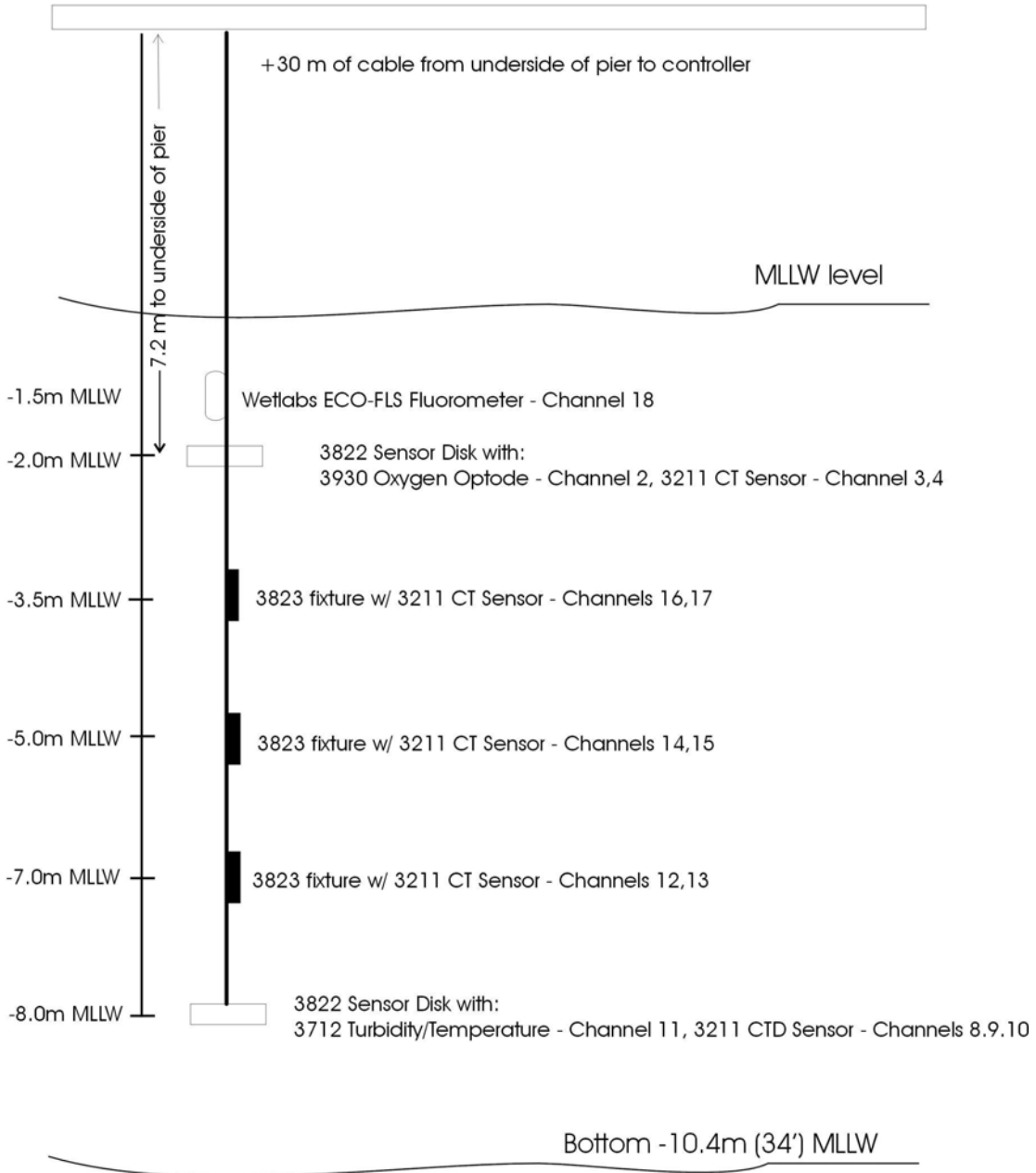
In addition to the CT sensor, an oxygen optode is installed at the -2.0m MLLW level. This sensor measures dissolved oxygen using an optical fluorescence technique. Fluctuations in the concentration of dissolved oxygen can be related to changes in biological oxygen demand (BOD), primary productivity, and the presence of some pollutants.

A turbidity sensor is located at the -8.0m MLLW depth. Turbidity is a measure of the cloudiness of a liquid. Increased turbidity can be due to run off from nearby San Luis Creek, turbulence due to wave action, or blooms of microscopic plants or organisms.

# Instrument diagram with wiring and channel assignments.

There is ~2 m of extra flylead cable if you need to cut the end and resplice new connectors for the controller.

Underside of pier +7.2 m(23.6') MLLW



**Figure 1.** Cal Poly Pier Hydrostation sensor array.

The Turner Designs TD-4100 hydrocarbon monitor (**Figure 2**) is installed separately from the previously described hydrostation sensor array. The monitor is a flow-through device that measures the concentrations of aromatic hydrocarbons (including gasoline, oil, and diesel fuel) in the seawater flowstream optically. The hydrocarbon monitor is located on the deck of Cal Poly Pier near the hydrostation sensor array. Water is drawn into the monitor via a pump located at this same elevation. After passing through the monitor the water is discharged back into the ocean. Since the levels of hydrocarbons are measured optically, no chemical reagents are introduced into the discharge flow.



**Figure 2.** Cal Poly Pier Hydrostation, hydrocarbon monitor.

The data acquisition system for both parts (sensor array and hydrocarbon monitor) of the hydrostation is located in the laboratory/office building at the end of the pier about 50 feet from the array and monitor. The data acquisition system consists of an Aaderaa Instruments data logger and a PC that controls the logger, provides the algorithms for converting raw sensor data to useable units, and provides the interface for directing data to the Internet.

# Hydrostation Installation Chronology

## Sensor Array

The hydrostation sensor array was deployed on September 22, 2003. The array is situated beneath the pier, just inboard of one of the pilings. This location shields the array from potential encounters with boats or debris that could damage the sensors or data cable. The array is anchored using an 815-pound railroad wheel (**Figure 3**).



**Figure 3.** Railroad wheel used to anchor the sensor array.

slackening the cable, the array can be lifted onto the pier deck for cleaning, maintenance, or repairs. When the cable is tightened using the winch, the array is secured in its appropriate position by the weight of the wheel.

After the deployment of the instrument array (**Figure 5**) in September, there was a storm event during the first winter. It was discovered that the movement of sand beneath the pier was sufficient to leave the railroad wheel suspended from the array above the bottom. To avoid a repeat of this situation, the winch is periodically backed-off and then retensioned to assure that the wheel remains in contact with the bottom.

On January 30, 2004 Tenera Environmental inspected and cleaned the sensor array. The array

The upper end of the array is secured to a horizontal I-beam that supports the upper deck of the pier. The lower end of the array is attached to a cable that is fed through the cross bars welded to the wheel and secured to a winch affixed to the steel railing that encloses the pier deck (**Figure 4**).

In this fashion, the railroad wheel acts as a pulley at the end of a clothesline. If the winch is backed-off,



**Figure 4.** Sensor array tensioning winch.

was first inspected by a pair of Tenera's divers, who assessed the condition of the cable, sensors, and railroad wheel anchor. The entire array was found to be fouled with a layer of hydroids and bryozoans that, at times, reached a thickness of about four inches.

Beneath this layer, much of the cable surface and the bodies of the individual sensors were encrusted with barnacles and tubeworms. The instrument cable showed no evidence of abrasion or other damage.

The railroad wheel was stable on the bottom, in its proper position, and in excellent condition. The chafing gear (3 inch ID reinforced PVC hose) that protects the tensioning cable from abrasion by the wheel was in good shape. The plastic coating on the tensioning cable showed some wear near the top deck of the pier, but the cable itself was undamaged. Following this inspection, the divers videotaped the entire submerged portion of the array. The divers then used 3M scrub pads and plastic brushes to perform a cursory cleaning of the cable and the sensor housings and mounts. All of the sensing surfaces were avoided during this portion of the cleaning operation. The array was then switched off at the scanner box in preparation for removal from the water.



**Figure 5.** Instrument array suspended above water off the pier showing locations of sensors at five depths.

When tension on the cable was removed, the array moved easily through the chafing gear on the railroad wheel. As the winch was backed-off, the array was lifted from the water and laid on the deck of the pier. All of the cable and sensor surfaces were thoroughly cleaned. The sensing surfaces were only touched with cotton swabs, wooden utensils or other soft instruments. While the hydroids and bryozoans were easily removed, removing the hard-shelled encrusting organisms from the sensing surfaces was a time consuming and delicate job. The fluorometer was the most severely fouled sensor on the array. The entire downward facing surface (which includes the sensing windows) was encrusted with acorn barnacles (*Megabalanus californicus*) up to about 3/8 inch in diameter. The copper wiper, which is supposed to cover the fluorometer sensing windows and keep them from fouling between readings, was clean, but was not positioned over the window and appeared as though it never had been. The instrument was carefully cleaned without using metal tools or abrasives (fingers, cotton swabs and wooden tools). After cleaning, the wiper was left in a position that did not obscure the windows. Electrical power was

not returned to the array until it was placed back in the water, so it is uncertain if the wiper was functional. After cleaning had been completed, the number two CT sensor (the level just below the upper sensor disk) was removed from the array so the integrity of its connectors could be checked. This sensor had been giving erroneous readings. The electrical connections were tight and dry. All metal surfaces were shiny with no evidence of corrosion. The connection was cleaned, as a precaution, and reassembled.

All of the array hardware was checked for wear and corrosion. Bolts, shackles, electrical connections, and fasteners were checked to assure that they were tightly secured. The array was then returned to the water and the winch used to take up the slack in the tensioning cable. Based on the observations made during the cleaning, Tenera recommended that the array be lifted to the pier deck, cleaned and inspected on a monthly basis.

Monthly cleaning has followed this initial assessment, with responsibilities transitioning to Cal Poly, who will see the long term maintenance of the array. During the spring of 2004 the malfunctioning CT sensor was replaced with a new unit, and the fluorometer was returned to its manufacturer for repair. During the summer of 2004 the array was removed and returned to Aanderaa for the modifications necessary to allow the bottom CT sensor to be replaced with the previously mentioned CTD sensor.

A break in the internal wiring of the array's data cable necessitated the removal of the array and its return to Aanderaa in the fall of 2005. The system will be redeployed upon its repair and return. Based on the previous dataset from the five depths, it has been determined that the variability in the water column necessitates only monitoring two depths, surface and approximately 7m. The cable has been redesigned for these two depths with the additional sensors used as spares for continuous and uninterrupted data collection.

## **Hydrocarbon Monitor**

The Turner Designs TD-4100 hydrocarbon monitor (**Figure 2**) installation was completed during the summer of 2005 and went into operation on August 24, 2005. Turner Designs sent a representative to the site to train Tenera and Cal Poly staff on operation and calibration. After three months of operation, the seawater intake piping was severely damaged during the storms of December 2005. The system is currently being repaired and redesigned by Tenera and Cal Poly (beyond the performance period of this grant) and is anticipated to be back in operation in February or March of 2006.

## **Ongoing Maintenance**

While the two systems are generally robust, the initial deployments indicate that these systems will require funding to maintain the integrity of the array cable, the sensors, the

sensor calibrations, the hydrocarbon intake piping and the in-water deployment system for the array. *Cal Poly will continue to look for funding beyond the support given in this grant to maintain the system and provide quality data.*

## Data

The data interface for the water quality monitoring system was completed in winter 2004. The instrument array is directly connected to the pier's server, which is mirrored on a second server on Cal Poly's campus to prevent data loss. This mirrored server is coupled with a web server, where the data is made available with open access ([www.marine.calpoly.edu/getwet/](http://www.marine.calpoly.edu/getwet/)) to researchers and the general public. The website displays near real-time data from the instrument array and also can be used to plot and download the archived data over selected time periods and resolutions. The final data and web interface for the hydrocarbon sensor is going through another development phase incorporating the hydrocarbon data and data from a newly installed meteorological station (see below). It is anticipated that the new system will be available for data distribution in February 2005.

## Nexus with Additional Projects

Funding of this project through the Avila Beach – Public Recreation and Environmental Restoration Mitigation Project and administered through the Regional Water Quality Control Board – Region 3 has leveraged a significant number of additional projects and corresponding support to Cal Poly. On the federal level, the real-time monitoring concept started in this project has attracted support from the Office of Naval Research for the real-time IT infrastructure, with their interest in remote observation and operations. Additionally, the National Oceanic and Atmospheric Administration and continued funding for support of real-time monitoring of the parameters highlighted above as part of a nation wide network. This support has supported the computing and technical support. The National Science Foundation has also supported a grant on ocean observing cyber infrastructure that has provided and augmented the technical support for this project.

From the State of California and the private sector, Cal Poly has just been funded by the Packard Foundation, California Coastal Conservancy and the California Ocean Protection Council to establish the ***Morro Bay Ecosystem Based Management Program***. The program applies an integrated approach to the vitally important scientific, resource management, and stakeholder interests related to the health of California's Morro Bay and associated coastal regions. As part of this program, Cal Poly will be establishing water quality monitoring stations throughout Morro Bay. The real-time equipment arrays placed in the watershed creek mouths (2), bay/estuary (2), open coast (1) (Figure 5). Each

station will consist of a seabird 911 CTD, an oxygen sensor, a Satlantic nitrate sensor, and a combination scattering/chl fluorometer. The CTD will allow us to interpret whether the source of sediment and nutrients are terrestrial or oceanic in origin. The CTD will also allow for interpretation of residence times of water masses relative to tides to indicate environmental conditions for low DO events in the bay. The nitrate sensor will track the sources and fates of nitrate in the bay and the fluorometer will be able to delineate phytoplankton communities (Harmful Algal Blooms included) and also use backscatter as a proxy for sedimentation. These are all processes that impact the watershed and have been identified as significant and needs by the Regional Water Quality Control Board. *Data from Morro Bay program will flow into an archive system that has been developed under the water quality monitoring program in San Luis Bay supported by this grant. The cyber infrastructure and associated web interface supporting the instrument array and the hydrocarbon sensor enabled the monitoring program proposal in Morro Bay, CA, and was one of the reasons it was supported.*

*In total, this project has been highlighted in and significantly influenced the funding of 4 projects (above) totaling \$3.85 million. The project was also one of the first sources of funds directly impacting the development of the pier facility into the current Center for Marine and Coastal Sciences. Since then we have also completed or undertaken projects totaling \$1.9 million in pier maintenance and improvements.*