**SAN LUIS OBISPO SCIENCE AND ECOSYSTEM ALLIANCE**

**WATER QUALITY OBSERVATORY**

**QUALITY ASSURANCE PROJECT PLAN**

WORKING DRAFT

Last Update AUGUST 8, 2010

**Problem Definition/ Background**

Estuaries represent a dynamic interface between freshwater inflows and coastal ocean systems, and they rank among the most productive of marine ecosystems. These environments provide important habitat for a variety of organisms. For example, eelgrass meadows serve as nurseries to many aquatic organisms. Salmonid species depend on estuaries for critical habitat to make physiological transitions between fresh and salt water. Harbor seals and California sea lions frequently use estuaries for feeding (Emmett et al. 2000). Moreover, estuaries buffer storm events and naturally filter out sediments, nutrients, and even some pollutants (Paerl 2004). Additionally, estuaries play vital roles in regional economies by providing shipping, commercial and recreational fishing, recreation, and tourism.

As transitional zones, estuaries are subject to increasing anthropogenic pressures, such as coastal population growth, changing land-use practices, and freshwater nutrient inputs (Lotze et al. 2006). Estuaries receive and process a large portion of land-based nutrients and pollutants entering via surface runoff, atmospheric discharge, and groundwater discharge where much is delivered from urban center and agricultural watersheds (Paerl 2006). Nitrogen, in the form of nitrates, is an essential element controlling estuarine primary productivity (Caffery et al. 2002). Estimates indicate that nitrogen inputs have increased 10-fold in the past century. Current nitrogen loading rates often exceed rates required to sustain desirable primary production. Many estuaries are now facing nitrogen-over-enrichment, or “too much of a good thing” (Paerl 2006). This condition often leads to excessive primary production in the form of algal blooms resulting in eutrophication. Over time eutrophication can lead to chronic oxygen depletion and changes in species composition (Lotze et al. 2006). Persistent nitrogen enrichment is capable of altering ecosystem dynamics, thus reducing an estuary’s economic and intrinsic benefits (Robson et al. 2008).

In response to these perturbations, monitoring efforts have a key role to provide data to managers, charged with the task of ensuring adequate water quality, wildlife habitat, recreational opportunities, and public safety. Most nutrient and water quality monitoring programs are conducted on monthly to weekly intervals. While volunteer monitoring programs may determine the overall seasonal nutrient distribution, they are unable to capture important details of transient events such as diel and tidal cycling, flushing and residence time of water, and episodic weather events and discharges. Capturing these transient events is necessary for accurate assessment of nutrient fluxes, contributing to the majority of annual nutrient budget (Jannasch et al. 2008). Nitrogen concentrations and physical conditions in estuaries should be monitored with a temporal resolution of at least 1 hour to accurately resolve the high frequency and episodic events contribute to environmental variability (Moline 1997, Chapin et al. 2004, Jannasch et al. 2008). Therefore, continuous, environmental sensor networks are important tools to capture critical elements of the hydrologic cycle, nitrogen cycle, and associated ecosystem processes (Jannasch et al. 2008). Sensor networks can provide scientists and managers with the appropriate data sets to accurately identify when and where nutrient loading occurs and lead to the development of management policies.

Morro Bay estuary is a shallow, low freshwater flow estuary located in San Luis Obispo County on the central coast of California (Figure 1). The estuary is recognized by Morro Rock, a State Historical Landmark, dubbed the “Gibraltar of the Pacific”. Morro Bay estuary supports a rich diversity of habitats for numerous plants and animals, including several sensitive and endangered species, such as southern steelhead trout, brown pelican, and southern sea otter. Migratory birds seasonally use habitat as a part of the Pacific Flyway. There is also substantial eelgrass habitat within the estuary serves as a critical nursery for fish communities and an indicator of estuary health (Morro Bay National Estuary Program 2000, Orth et al. 2006).

The Morro Bay estuary watershed covers approximately 48,450 acres, consisting of two main drainage basins through Los Osos and Chorro Creeks, which feed directly into the estuary from San Luis Obispo and neighboring towns. The estuary potentially receives freshwater inputs from groundwater sources and runoff from the coastal towns: City of Morro Bay and Los Osos-Baywood Park (US Army Corps of Engineers Los Angeles District 2003). Morro Bay estuary is approximately four miles long (north-south) and two miles wide (east-west). At high-tide inundation, the bay is approximately 2,300 acres. The bay is open to the ocean at one entrance channel, and a four mile long by one-quarter mile wide barrier-sand dune separates the estuary from the ocean. Morro Bay estuary has mixed semidiurnal tides, and the main transport mechanism for water is tidal exchange (US Army Corps of Engineers Los Angeles District 2003).

There are several potential pathways for nitrate inflows within Morro Bay estuary: surface runoff, creek inflows, groundwater inputs, and ocean inputs. Winter rain events lead to significant surface water inputs through land runoff and elevated creek flows. Surface water inputs flush nitrates and other chemicals into the estuary. The California Men’s Colony water treatment facility is located next to Chorro Creek and has had several accidental overflow of nitrate rich wastewater into Chorro Creek each year. Another mechanism for nutrient input into the estuary is submarine groundwater discharge during the neap tides of the tidal cycle. A recent study provides evidence that neap tides enhance nutrient-rich groundwater pulses (de Sieyes et al. 2008). Homes in Los Osos/Baywood Park are presently using septic systems, which have the potential to increase groundwater nitrate input into the estuary. Along with freshwater inputs, the ocean also supplies nitrates during upwelling events and off-shore current events (Emmett et al. 2000).

In response to these chronic issues, a group of scientists, resource managers, and stakeholders formed the San Luis Obispo Science and Ecosystem Alliance (SLOSEA) in 2006. The vision for SLOSEA is to provide data for improved understanding of the Morro Bay ecosystem, form the framework for cohesive ecosystem-based management of the region, and provide a forum for discussion between scientists, local policy makers, and resource managers. This framework has six linked initiatives: Water Quality, Sustainable Fisheries, Invasive Species, Fragile Habitats, Climate Change, and Marine Economy.

The Water Quality initiative’s purpose is to map and interpret the spatial and temporal changes in the physical and chemical characteristics of water quality in the Morro Bay ecosystem. To accomplish this objective, the Water Quality initiative funding has provided a water quality observatory of three fixed and one roving water quality monitoring stations within Morro Bay estuary.

**Project/ Task Description and Schedule**

To accomplish SLOSEA’s Water Quality initiative, 4 fixed water quality stations have been deployed since 2006 in strategic locations in the Morro Bay estuary (see Station Map) Back Bay, BS1, was the first station installed on December 21, 2006. BS1 is located at the back of the estuary to provide data in a lower tidal-flushed region (35°20. 029' N, 120°50. 835' W). BS1 is the only station without a current profiler. Bay Mouth, BM1, was installed on April 4, 2007, and is located near the mouth of the estuary and mounted to a Coast Guard T-Pier (35°22. 251' N, 120°51. 535' W). BM1 provides a critical location, since large volumes of water flow in front of the stations four times a day. CM1 is located at the confluence of Chorro and Los Osos Creeks, and it was installed on November 26, 2007 (35°20. 284' N, 120°49. 950' W). This location captures combined signals from both creeks. CM2 was installed on November 20, 2007 in Chorro Creek (35°20. 535' N, 120°49. 691' W). CM2 was retired on March 23, 2009. Since the retirement of CM2, the sensors have been redeployed as a roving survey unit, RV1. RV1 deployed during slack tide survey missions to sample the surface water characteristics and the spatial patterns between the fixed stations in the estuary.

Each water quality station was designed in collaboration with Satlantic, Inc and modeled after the Land/Ocean Biogeochemical Observatory (LOBO) mooring system developed by Monterey Bay Aquarium Research Institute (MBARI). Each fixed water quality station is composed of a solar powered battery, antenna, GSM Cellular Modem, Satlantic STOR-X data logger, Sea-Bird CTD sensor, Satlantic ISUS-X nitrate sensor, WET Labs Turbidity and Fluorometer, Aanderaa Oxygen Optode, and Nortek Current Profiler (Morro Bay Monitoring Station Diagram.pdf). As of October 6, 2009, BS1 holds a Novalynx meteorological station. Each station turns on every 15 minutes, collect data for 2 minutes, and send raw data to a Cal Poly Server for processing. Processed data is uploaded on the SLOSEA website for general public access ([www.slosea.org](http://www.slosea.org)).

**Project Management**

Morro Bay Water Quality Monitoring Stations is part of the SLOSEA’s Strategic Plan. Funding is provided through the David and Lucile Packard Foundation and the Coastal Conservancy. Project objectives are in collaboration with the Morro Bay National Estuary Program, California State Parks, and the Central Coast Regional Water Quality Control Board. The initial design and installation included personnel and resources from Satlantic, Inc., Tenera Environmental, and Penscil, Inc.

The Principle Scientist of the Water Quality Monitoring Stations is Mark Moline, PhD., the Director of the Center for Coastal Marine Sciences at California Polytechnic State University. This project also supports two Senior Research Scientists, two SLOSEA Graduate Fellows, and multiple Cal Poly undergraduate students.

**Special Training/ Certification**

Transportation to Sensors:BS1 and CM1 are the two stations that are only accessible by boat or kayak. As this is a project through Cal Poly, only Cal Poly persons can be certified to operator Cal Poly boating vehicles. For kayak operation, one must successfully pass Kayak Certification through a designated 3rd party. For motor boat operation, one must receive a California State Boating Certificate and pass boating checkout with Cal Poly Pier Facilities Manager.

Field Work: For field work, each person involved need to be trained with proper cleaning protocols of the sensors.

Data Management: For interactions with the instruments, via computer, the person needs to be trained on instrument communication through HyperTerminal or other computer sensor interface programs. For interactions with instruments by opening them up, the person need to have a background and training in electronics.

Education: All research participants are specialists in their given areas including oceanography and marine engineering. Information on researchers can be found at Cal Poly’s Center for Coastal Marine Science (CCMS) website at <http://www.marine.calpoly.edu/community/>. Specifically see:

1. Dr. Mark Moline – Director of CCMS, Professor of Biology at Cal Poly & Principle Scientist

* + Ph.D, UC Santa Barbara, Biology
  + B.A., St. Olaf College, Biology
  + Research Areas: Biological Oceanography, Phytoplankton Ecology, Phytoplankton Physiology, Polar Marine Ecosystems, Climate Change, Phytobiology, Bio-optics, Remote Sensing, and Biogeochemistry including:
    - Autonomous Underwater Vehicles (AUVs)
    - High Frequency Radar (HFR) Surface Current Mapping
    - Profiler-based Studies of Phytoplankton Bioluminescence
    - Hyperspectral Remote Sensing

2. Ian Robbins – Senior Research Scientist

* M.S., California Polytechnic State University, San Luis Obispo , California (2006), Major in Biological Sciences
* B.A., University of Hawaii, Hilo, Hawaii (2000), Major in Marine Science

3. Brian Zelenke – Senior Research Scientist

* M.S., College of Oceanic & Atmospheric Sciences, Oregon State University, Corvallis, Oregon (2005), Major in Oceanography with a concentration in Physical Oceanography
* B.S., Cum Laude, Humboldt State University, Arcata, California (2002), Major in Oceanography with minors in Applied Mathematics and Physical Science

4. Johanna Weston – Graduate Student in Marin Biology

* M.S., California Polytechnic State University,San Luis Obispo, California(in progress), Major in Marine Biology.
* B.S., University of Dallas, Irving, Texas (2008), Major in Biology with a minor in Environmental Science.

**Documents & Records**

For detailed procedures of the water quality stations, Satlantic, Inc provides a Morro Bay Monitoring System Operation Manual. This document is referenced during all field excursions and lab operations.

Each field excursion can be documented in several ways depending on the nature of each field activity. First, each boating trip is documented by a Boating Float Plan through the Cal Poly CCMS Pier Facilities, where the trip location, purpose, and timing are described (SLOSEA\_Example\_100630\_Float\_Plan\_MB.pdf). Second, each field activity is documented in both a “SLOSEA WQ” Google Calendar and in a continuously updated “SLOSEA\_WQ\_Station\_FieldWork\_Timeline.pdf”. The personnel involved, weather conditions, tide conditions, purpose, and accomplishments are described in the Google Calendar and the spreadsheet. The Google Calendar is viewable by SLOEA WQ personnel, and each updated spreadsheet is distributed to SLOSEA WQ personnel via email. Third, when instruments are either removed or redeployed on a different station, the change is added to a continuously updated “SLOSEA\_WQ\_Sensor\_Location\_Timeline.pdf” spreadsheet. This document is also emailed to SLOSEA WQ personnel. Since processing data and public viewing on the website is dependent on the instrument serial numbers, when an instrument serial number changes the script for processing data must be changed by the SLOSEA WQ Information Technology and Network Support person. Each script modification is note documented in the script. Fourth, each field activity is documented in the researcher’s field lab notebooks

Each time an instrument is communicated with directly via computer a capture text is collected. Each capture text is named with the date, primary instrument serial number, and location (station name or lab) (SAMPLE\_100503\_STORX22\_BS1\_CaptureText.TXT). Information that is collected within the capture text can vary between instrument types. For the STORX and the ISUS, the time, date, and voltage supply are always collected. Additional information collected can range from port configurations, deployment configurations, modem configuration, and files present on the flash drive.

**Data Generation & Acquisition**

This section describes how each of the water quality stations work, how each sensor samples the water column, and how the systems transmits the raw data.

*Sampling Design (Experimental Design)*

*Water Quality Observatory*

The stations were designed to support physical, chemical, and biological sensors. The sensors were chosen for their ability to withstand environmental forces over a one year period within an estuary and be accessible by small boat. BM1 and BS1 water quality sensors are located at fixed depth, and CM1 water quality array floats at the water surface. Each station is composed of a solar powered battery, telemetry, Satlantic STOR-X data logger, Satlantic ISUS-X nitrate sensor, Sea-Bird CTD (SIP-37) sensor, WET Labs Fluorometer and Turbidity (FLNTUS), Aanderaa Oxygen Optode 3835, and Nortek Current Profilers (Continental Profiler and Aquadopp Profiler).

The Satlantic STOR-X Datalogger/Controller is a compact, low power data logger that provides scheduled data acquisition in remote field applications. It acquires and logs data from up to five instruments according to a user specified sampling schedule, entering a low power deep-sleep mode between events to conserve power to allow deployments for extended periods. All recorded data is date and time stamped from the STOR-X’s precision onboard real-time clock (RTC) to allow post-processing software to correlate all attached sensor data in time, as well as correlation between each monitoring site. A dedicated serial port on the STOR-X interfaces to an external GSM modem. The GSM modem is used to email recorded data and an activity record to the server computer. In addition the STOR-X uses the GSM modem to download new schedule files from the server computer (Satlantic\_STOR-X-manual-revD3.pdf).

The Continental Profiler is a sensor manufactured by Nortek AS, used for water current profiling. The Continental uses the Doppler Effect to measure water current velocity by transmitting short pulses of sound, listening to their echo and measuring the change in frequency of the echo. Although available in several configurations, the Continental used in the Morro Bay Monitoring System is a 2-D model intended for profiling along a horizontal segment.

The Aquadopp Profiler is a sensor manufactured by Nortek AS, used for water current profiling. As with the Continental profiler, the Aquadopp uses the Doppler Effect to measure water current velocity by transmitting short pulses of sound, listening to their echo and measuring the change in frequency of the echo. Available in several configurations, the Aquadopp used in the Morro Bay Monitoring System is a 2 MHz right-angle model intended for shallow water applications.

The MBARI In Situ Ultraviolet Spectrophotometer (MBARI-ISUS-X v. 2, commonly referred to as the ISUS-X) uses ultraviolet absorption spectroscopy to measure in situ dissolved nitrate (µMol/l) (Satlantic\_Operation Manual for the ISUSX.pdf). This sensor is a chemical-free, solid-state instrument that offers easy, accurate, real-time, and continuous nitrate concentration measurements. The ISUS-X uses a copper bio-fouling guard to reduce fouling on the sample probe. The ISUS-X Sensors are used to collect data from WET Labs ECO\_FLNTUS, Sea-Bird SBE-37SIP, and Aanderaa Oxygen Optode.

The SBE 37-SIP MicroCAT is a sensor manufactured by Sea-Bird Electronics used to measure temperature (ºC), pressure (db), and conductivity (S/m) in water (Seabird\_CTD\_37SIP\_UserManual.pdf). The SBE 37-SIP has an integral pump to flush the conductivity cell prior to measurement. The sensor contains an anti-fouling device to extend deployment time. The model used in Morro Bay has a 20 m pressure sensor. Density (1000 kg/(m^3)) and salinity (‰) are derived from the temperature, pressure, and conductivity measurements. After contracting with Twin Cities Surveying, Inc. in November 2009, the CTD pressure sensors at BM1 and BS1 are geographically referenced for mean low low water, and the pressure measurements are converted to tide (m) measurements.

The Oxygen Optode 3835 is a sensor manufactured by Aanderaa used to measure absolute oxygen concentrations in water using optical methods (Aanderaa\_Oxygen\_Optode\_3835\_UserManual.pdf). The operation of the Optode is based on the luminescence quenching principle, with a fluorescent indicator embedded in a gas permeable foil. A black optical isolation coating protects the foil. The Oxygen Optode measures dissolved oxygen concentration (μMol/l) and dissolved oxygen saturation (%).

The ECO-FLNTUS is a sensor manufactured by WET Labs to measure chlorophyll A fluorescence and turbidity (WETLabs\_Eco\_FLNTUS\_UserManual.pdf). The ECO- FLNTUS is a dual-wavelength, single-angle sensor for simultaneously determining both chlorophyll fluorescence (μg/l) and turbidity (NTU). The turbidity measurements are sampled with 700 nm wavelength, and the fluorescence measurements are sampled at 470/695 nm.

Along with water quality instrumentation, BS1 has a Novalynx 110-WS*-*16 Modular Weather Station, which measures wind speed (m/s), wind direction (ºTrue), solar radiation (W/(m^2)), rainfall (mm), air temperature (ºC), dew point (ºC), wind chill (ºC), and barometric pressure (hPa) (Novalynx\_MetStation\_110-ws-16\_UserManual.pdf). The meteorological station was deployed on October 6, 2009, and it has a data logger. The meteorological station sensors sample every 5-seconds. The 5-second data is stored in the meteorological station data logger and is manually downloaded off the data logger every 30-40 days. The meteorological station is also connected and configured with the STOR-X, and the meteorological data is also collected during the STOR-X’s 2-minute sampling period every 15 minutes.

At each fixed station, the STOR-X controls the sampling and data transmission. One of the three operation modes for the STOR-X is called the Schedule Operation. A Schedule.TXT files controls timing of applying and removing power, acquiring data from sensors, and connecting with the modem to transmit packaged RAW data to a Cal Poly Server. STOR-X schedule files are generated by Satlantic Schedule File Generator. Each STOR-X serial number has a unique Schedule. TXT file. Updates to the schedule file are noted in the heading of each Schedule. TXT file. The Schedule.TXT files repeat the following pattern each 15 minutes:

00:15:00 POWER +V +1 +2

00:15:11 ACQUIRE 120 1 2 3

00:17:14 POWER -1 -2 -V

00:20:00 GSMSEND 1

At each STOR-X, port 1 is configured for an ADCP, port 2 is configured for the ISUS-X, which is configured for the CTD, ECO FLNTUS, and Oxygen Optode, and port 3 is configured for the Novalynx Weather Station. During the POWER period, power is applied to the designated ports and the connected instruments receive power. The 11-second delay between POWER and AQUIRE allows instruments to complete initial start-up procedures before sampling begins.

During the ACQUIRE period, the STOR-X collects raw data from the configured ports and applies a STOR-X timestamp to the beginning of each line of data. This ensures a uniform time stamps across all sensors regardless of the individual sensor time stamp. The STOR-X clock is configured to Coordinated Universal Time (UTC) for standardization across STOR-X locations and time of year. Each day, the STOR-X creates two data files. The first data file is YYYYDDD. raw, where YYYY is the 4-digit year and DDD is the day of the year, Julian date. This data file contains all data collected up to a successful send email call in a given day. After a successful send email call, the STOR-X copies this data to an YYYDDDF.raw file. At midnight of each day the STOR-X copies the entire contents of the YYYYDDD.raw file to the YYYYDDDF.raw file. The YYYYDDD.raw file is then deleted. The STOR-X uses its own local precision real time clock to generate file names.

During the GSMSEND period, the STOR-X connects with a GSM Cellular Modem. Each modem contains a unique SIM card. The modem follows a specific sequence to check signal quality, connect to Cingular, create an email, package the email with the YYDDD.raw file, connect with the Cal Poly Server, and transfers the email to the server. After a successful modem connection and file transfer, the STOR-X checks the schedule file folder on the server for a new schedule file and retrieves the schedule file if it is available. If the file is not present, the STOR-X simply continues to use its existing schedule. The STOR-X will continue to download the schedule file each time it checks, even if it has not changed. After checking and possibly retrieving a new schedule file, the STOR-X continues to the next step in the schedule file.

In the event the STOR-X is unable to connect to the modem or the modem is unable to connect to the server, the raw day file is stored within the STOR-X flash drive for up to 30 days before automatic deletion. The non-transmitted, internally stored data is manually downloaded back in the lab, and manually added to the server.

*Survey Station*

The three fixed monitoring stations provide a three-year data set for strategic locations in Morro Bay. To enhance the understanding of the spatial dynamics and connectivity between the stations, a roving station was deployed on survey missions throughout Morro Bay. The roving station is composed of two arrays of instrumentation: water quality and bathymetry. The water quality array is composed of a Satlantic STOR-X data logger, Satlantic ISUS-X nitrate sensor, Sea-Bird CTD (SIP-37), WET Labs Fluorometer (FLNTUS), and Aanderaa Oxygen Optode 3835 installed on a cage. The STOR-X is configured to QUICKLOG sampling mode, where power is continually applied to the sensors. Similar to the Schedule sampling procedure, the STOR-X timestamp is applied to the beginning of each line of data and the data is stored as an YYYYDDD.raw file within the flash disk. The bathymetry array is composed of a CEEDUCER PRO dual channel echo sounder (200/30 KHz) and differential GPS (CEEDATA Manual V 2.1.2.pdf). The two arrays are deployed from the sides of a 13’ Boston Whaler. The water quality cage is hung at a fixed depth of 0.2 meters below the surface. All survey missions occur during slack tide to minimize the influence of tide and during low wind conditions to reduce the effect of waves. The boat is driven at 1.5 knots to minimize the production of bubbles and mixing of the water. The water quality and bathymetry sensors operate independently with the continuous sampling frequencies by the internal clocks in each system’s datalogger. At the beginning of each survey missions, the internal clocks of the two systems are synchronized. The bathymetry dataset is corrected for tide and heave utilizing the hydrographic surveying package HYPACK and the tide data from BM1. The water quality and bathymetry datasets are merged together to produce on combined dataset.

**Quality Control Requirements**

This section describes the quality control requirements for the processing of the raw data from the fixed water quality monitoring stations.

*Processing Water Quality Data*

The raw data from the fixed stations is first stored on a server. The overall processing of the raw is completed by the SLOSEA WQ Information Technology and Network Support person with a semi-automated procedure. The raw data is downloaded from the server, which contains day files with 2-minute periods of data separated at least 15-minutes apart with specific instrument serial numbers. The raw data then is sorted periods of time with identical instrument serial numbers. Each folder with identical instrument serial number is preprocessed using the instrument calibration files with a program developed by Satlantic, SatCon (Satlantic\_SatCon\_Manual.pdf). SatCon extracts the data from each instrument in a raw file and creates a txt format file for each instrument. The instrument txt files are manually separated into month specific folders. The first processing step utilizes a MATLAB script developed by Cal Poly and heavily relying on the uniform STOR-X timestamp. For each 15-minute period, theoretically each instrument samples for 2-minutes. Each parameter is averaged over the 2-minute period and then assigned a timestamp to the nearest 15-minute period. If there is no value for a 15-minute period, then that parameter is assigned as Not a Number, NaN. This is critical to maintaining a uniform time series. Each value is subjected to a threshold processing to ensure QA/QC. For each station a minimum and maximum value for each parameter has been assigned after consideration of sensor ratings and physical limits. The parameter range thresholds are summarized in “SLOSEA\_WQ\_QA-QC\_Parameter\_Range\_Thresholds.pdf”. Parameter values that fall below or exceed pre-determined thresholds are assigned as a NaN, thus maintaining a uniform time series. The QA/QC threshold data are visually inspected to ensure logical and responsible data. Each parameter is assigned a unique vector names (SLOSEA\_Modeling\_Read\_Me\_v4.1.pdf). The processed data is complied into two different formats: a MATLAB format file and a CSV format monthly files. The CSV files can be selected and downloaded for public use from the SLOSEA website.

**Instrument/ Equipment Testing, Inspection, Maintenance**

This section describes the instrument and equipment cleaning, maintenance, and testing.

*Cleaning*

The continual collection of long-term data sets requires each station to be fully functional, properly cleaned, and accurately calibrated. All of the instruments deployed are developed to be deployed in marine and estuarine environments and withstand harsh environments for a long period of time without recalibration. Within Morro Bay, the fixed stations are highly susceptible to bio-fouling, geo-fouling, corrosion, extreme weather conditions, and other unforeseen obstacles. To minimize the effect of bio-fouling and geo-fouling, each station is cleaned once a month. Each station is scraped free of organisms, heavy sediment is removed, and trapped debris is removed. The protocols follow are all stations is summarized in ‘SLOSEA\_T-pier maintenance 070820.pdf”. All of sensors are given extreme care during cleaning. During each cleaning, the copper guard on the ISUS-X is replaced and the probe is cleaned (SLOSEA\_Copper Shield Cleaning 070821.pdf, Satlantic ISUS-X V2 Biofouling Guard Maintenance.pdf). To minimize the damage of bio-fouling of the sensors, the outside of the sensors are wrapped in VWR polyethylene construction tape. The solar panel is cleaned of bird dropping using a log scrubber. Since the weather station sensors are not exposed to long periods of salt water, they are cleaned once every 3 months. To minimize corrosion, each station has a mounted zinc anode. In addition, all of the metal pieces deployed (screws, hose clamps, plate) are stainless steel. To protect against weather condition, all of the sensor are secured to the plate and to the fittings. All excess cabling is secured close to the system using zip ties. At CM1 and CM2, solar panel, battery, and modem are separated for the water quality sensors. The connecting power and modem cables are buried into the mud to protect them from the variability in the water column. All of the connectors are molded neoprene with gold pated contacts. All of the cables are neoprene with delrin locking sleeves. All cables and connectors are inspected each cleaning to ensure they are intact and monitor effects of connector corrosion. Unexpected obstacles are difficult to minimize against. An extra set of each supply is maintained in stock at Cal Poly to quickly repair unforeseen repairs.

**Instrument/ Equipment Calibration and Frequency**

This section describes instrument calibration.

*Calibration*

The while the sensors deployed at the water quality stations are extremely hardy, they are not indestructible. Each year, during the dry summer months, the stations are completely overhauled about once a year; the sensors are sent back to their respective companies for operational checks and calibrations. The STOR-X does not undergo calibrations, but it does have firmware upgrades. Unless there is electrical problem with the STOR-X, firmware upgrades and internal battery changes are conducted at Cal Poly. The ISUS-X is also recalibrated at Cal Poly following the protocols in “SLOSEA\_Notes\_on\_ISUS\_Calibration.pdf”. ISUS calibration typically occurs once a year, but if the nitrate values have an unrealistic increase or decrease in values the instrument will be recalibrated. The Oxygen Optode, Eco-FLNTUS, Seabird CTD, and Nortek AD/CP are returned to respective companies for calibration services. All repairs for these sensors are also conducted at their respective companies. If a sensor breaks during the year outside of the annual overhaul, the sensor is quickly shipped back to the company.

**Works Cited**

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**Attached Documents**

Documentation

* SLOSEA\_WQ\_Station\_FieldWork\_Timeline.pdf
* SLOSEA\_WQ\_Sensor\_Location\_Timeline.pdf
* SLOSEA\_Example\_100630\_Float\_Plan\_MB.pdf
* SAMPLE\_100503\_STORX22\_BS1\_CaptureText.TXT
* SLOSEA\_METSTATION\_Protocol for Adding Sensors.pdf

Manuals

* Morro Bay Monitoring Station Diagram.pdf
* Morro Bay System Operation Manual SAT-DN-00392 rev A.pdf
* Satlantic\_STOR-X-manual-revD3.pdf
* Satlantic\_Operation Manual for the ISUSX.pdf
* Aanderaa\_Oxygen\_Optode\_3835\_UserManual.pdf
* Seabird\_CTD\_37SIP\_UserManual.pdf
* WETLabs\_Eco\_FLNTUS\_UserManual.pdf
* Novalynx\_MetStation\_110-ws-16\_UserManual.pdf
* CEEDATA Manual V 2.1.2.pdf

Processing

* Satlantic\_SatCon\_Manual.pdf
* SLOSEA\_Modeling\_Read\_Me\_v4.1.pdf
* SLOSEA\_WQ\_QA-QC\_Parameter\_Range\_Thresholds.pdf

Cleaning

* SLOSEA\_T-pier maintenance 070820.pdf
* Satlantic ISUS-X V2 Biofouling Guard Maintenance.pdf
* SLOSEA\_Copper Shield Cleaning 070821.pdf

ISUS-X Calibration

* Satlantic\_SatView-Manual.pdf
* SLOSEA\_Notes\_on\_ISUS\_Calibration.pdf