

**Characterizing the Spatial and Temporal Variation in  
Turbidity and Physical Water Quality Characteristics in San  
Diego Bay:  
A Study to Determine a Cost-Efficient Strategy for Long-  
term Monitoring**

**Quarterly Report**

A Project for:

Environmental Projects to Benefit San Diego Bay  
San Diego Unified Port District  
Environmental Services Department

*Prepared by:*



Tierra Data Inc.  
10110 West Lilac Road  
Escondido, CA 92026  
P (760) 749-2247; F (760) 751-9707



## Table of Contents

1.0	INTRODUCTION .....	1
2.0	METHODS.....	1
3.0	RESULTS.....	4
4.0	DISCUSSION .....	8
5.0	REFERENCES .....	9



## 1.0 Introduction

This project was designed and funded to reestablish a cost effective strategy for characterizing the spatial and temporal variation of turbidity and physical water quality characteristics within San Diego Bay. The most effective and complete approach to understanding the Bay is to combine long-term monitoring with experimental research and development of conceptual models of how the ecosystem works with disturbance. This is the only way to determine the cause and effect of changes in the Bay ecosystem (DON and SDUPD 2000). The collection of baseline information investigating natural spatial and temporal trends independent of those caused by specific projects provides important long-term monitoring data for a diverse array of physical and biological research, now and in the future, within San Diego Bay. This study accomplishes one of the monitoring needs identified in the *San Diego Bay Integrated Natural Resources Management Plan (INRMP) 2000*.

San Diego Bay is a productive, natural, deepwater harbor supporting diverse ecosystems and a host of national defense, commercial, and industrial interests. A high potential for conflict between natural resources and human interests in the Bay establishes a need to separate natural changes from human-induced changes. Separating natural variability from anthropogenic disturbance and understanding ecosystem change over the long term are problems that plague researchers worldwide, because of the relative lack of long term baseline data sets about basic ecological parameters (Landres et al. 1999).

This baseline characterization of basic physical properties of water (turbidity, temperature, dissolved oxygen, etc.) provides vital information on the health of San Diego Bay. Existing, in situ, multi-parameter meters (sondes) supplied by the Port of San Diego (Port) are currently in place at two stations collecting six physical measurements: turbidity, dissolved oxygen, temperature, salinity, pH, and conductivity on a continuous basis (Figure 1). In developing a long-term database, this project integrates previously selected monitoring sites and technology that allows for seamless data integration with data collected since November 2000.

Initial examination of data collected between January and March 2008 at monitoring Station A and Station B has already provided interesting correlations with respect to tidal changes and rainfall events. The installation of a third station within the south bay near National City is planned for March/April 2008, which will provide sampling locations within three distinct regions of the Bay. Consistency and sustainability of data acquisition remains the focus of this monitoring effort.

## 2.0 Methods

YSI data sondes and associated equipment supplied by the Port were obtained by Tierra Data Inc. (TDI) in October 2007 for evaluation and trouble shooting. The previous configuration of the equipment integrated the YSI sondes with Ocean Sensor units, designed to serve as both the power source and data storage location for data obtained from the YSI sondes. The Ocean Sensor units were problematic, and therefore engineered to discontinue their use, streamlining the data collection hardware. Battery storage devices were developed out of four- inch ABS pipe and cost effective, easily replaceable, water proof connections. The YSI sondes were reprogrammed to store collected data internally. Initial field tests were conducted at TDI within a controlled environment.

## Location Map for Port of San Diego Water Quality Sensors

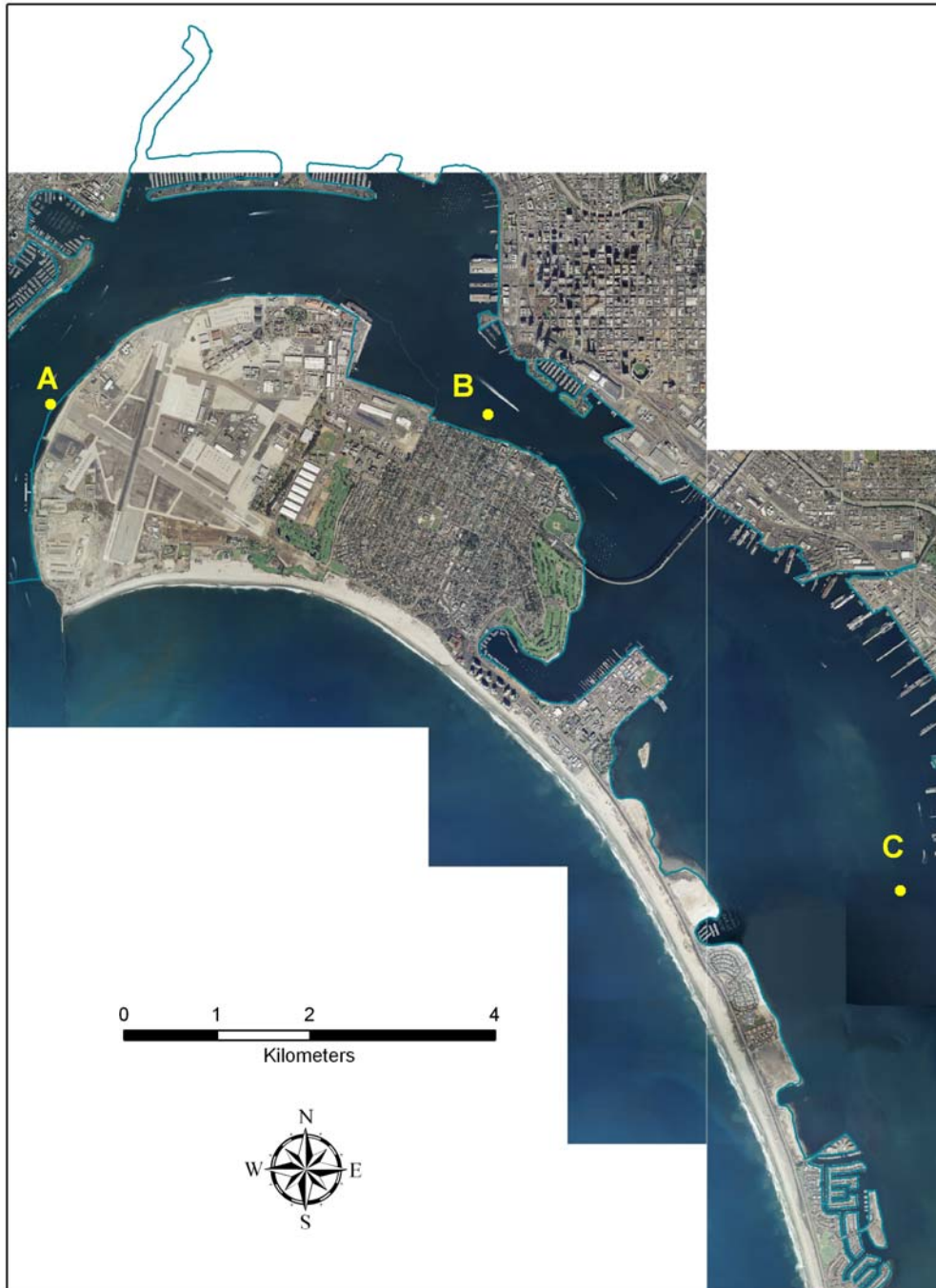


Figure 1. Port of San Diego water quality sensor locations.

Using coordinates supplied by the Port, SCUBA divers located sampling Stations A and B and affixed mooring hardware to permanent pilings or mooring blocks associated with previous establishments on site. Divers used stainless steel cable, shackles, and swivels of easy deployment and removal to affix units to mooring hardware (Photo 1). Test data collection in San Diego Bay began on December 28, 2007 at Station A, near pier Bravo located in the North Bay (off Coronado Island) and continued for a period of 14 days. The initial test period produced acceptable data for all six water quality parameters within expected values. Sampling was expanded to encompass Station A and Station B on January 9<sup>th</sup>, 2008.

Of the four YSI sondes originally obtained from the Port, three units performed adequately; however, one unit failed to calibrate within defined parameters. On February 28, 2008, the non-functioning unit was shipped to YSI for service and calibration, along with an additional YSI sonde, obtained from the Port, that required a new pH probe.

Data collected by YSI sondes is downloaded monthly onto a laptop computer using ECO Watch software. Data files are saved in both ASCII and Excel file formats for storage, data manipulation, and graphics display. Individual files are integrated by station to form a continuous data record and provided to the Port for web based publishing. Each YSI sonde is cleaned and recalibrated after each data download and battery voltage is checked to ensure adequate power for the next sampling period.



*Photo 1. YSI sonde with stainless rigging (weight is removed once the unit is affixed to the bottom).*

## 3.0 Results

Data collected at each station varied in relation to the others, primarily due to the relative proximity of each to the open ocean and localized tidal influences. Station A and Station B recorded water temperatures, salinity, and pH within expected levels (Appendix A). Dissolved oxygen varied from 7.27 to 11.63 mg/ml; fouling of the sensor probe was apparent from a gradual decrease in readings during two of the sonde deployments.

Turbidity at Station A, varied from 0 to 10 NTUs and tidal fluctuations were observed to have noticeable effect. Peak turbidity measurements occurred during the largest tidal changes associated with spring tides and the lowest measurements occurred during peak flood tide times when clean, clear, ocean water dominated the station's location (Figure 2). Figure 2 illustrates that the peak turbidity is correlated with the steepest slope of the tidal change (Figure 3). Turbidity observed during relatively moderate tidal changes was lower in magnitude over a twenty four hour period than turbidity during the greatest tidal change for the same month (Figure 2 and Figure 3 in comparison to Figure 4 and Figure 5). Tidal influences at Station B were less pronounced than those observed at Station A due to the fact that Station B is further from the open ocean and located at a wider portion of the bay. Fouling of the turbidity sensors was intermittently evident at both Stations A and Station B; large amounts of kelp (*Macrocystis pyrifera*) and eelgrass (*Zostera marina*) were removed from near the sonde at Station A on two occasions.

Daily rainfall amounts from San Diego Lindbergh Field were plotted from National Weather Service (NWS) data for the month of January 2008, to compare salinity and turbidity sonde data from Station A (Figure 6). A correlation between salinity and turbidity with respect to rainfall events was evident at station A, where depressed salinity levels and peak turbidity measurements were observed on the same day or just after significant rain totals (Figure 8 and Figure 9). The greater depth of Station B ( $z=39$  vs.  $z = 26$ ) and problems with fouling at Station B reduced the confidence to establish correlations between rainfall events and sonde measurements for monthly data sets. The sonde at Station B is likely located below the level of significant freshwater mixing to detect salinity changes, though data sets display variable dissolved oxygen (DO) patterns not yet understood by the limited data set. Turbidity data from Station B was plotted against rainfall totals from February 2008 for the same period, and a similar correlation observed at Station A in January 2008 was evident.

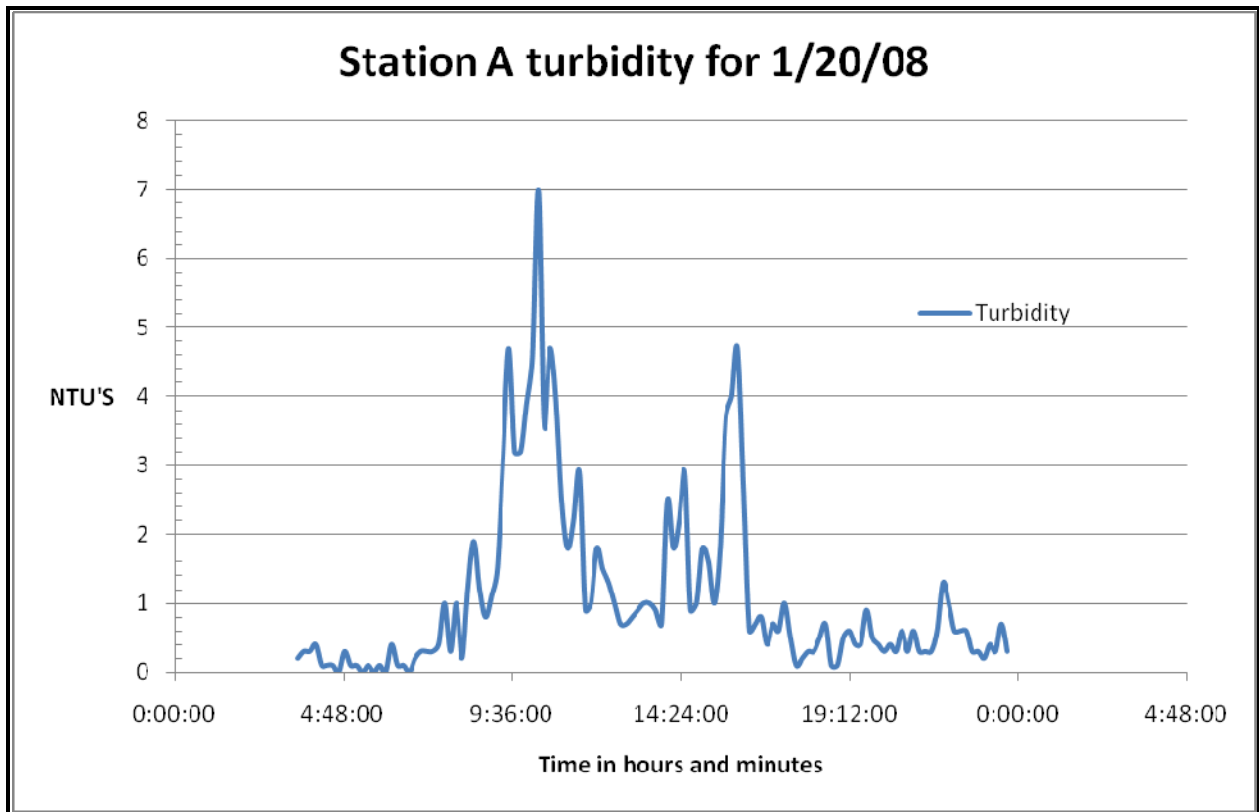


Figure 2. Station A turbidity for a 24 hour period during the maximum tidal change in January

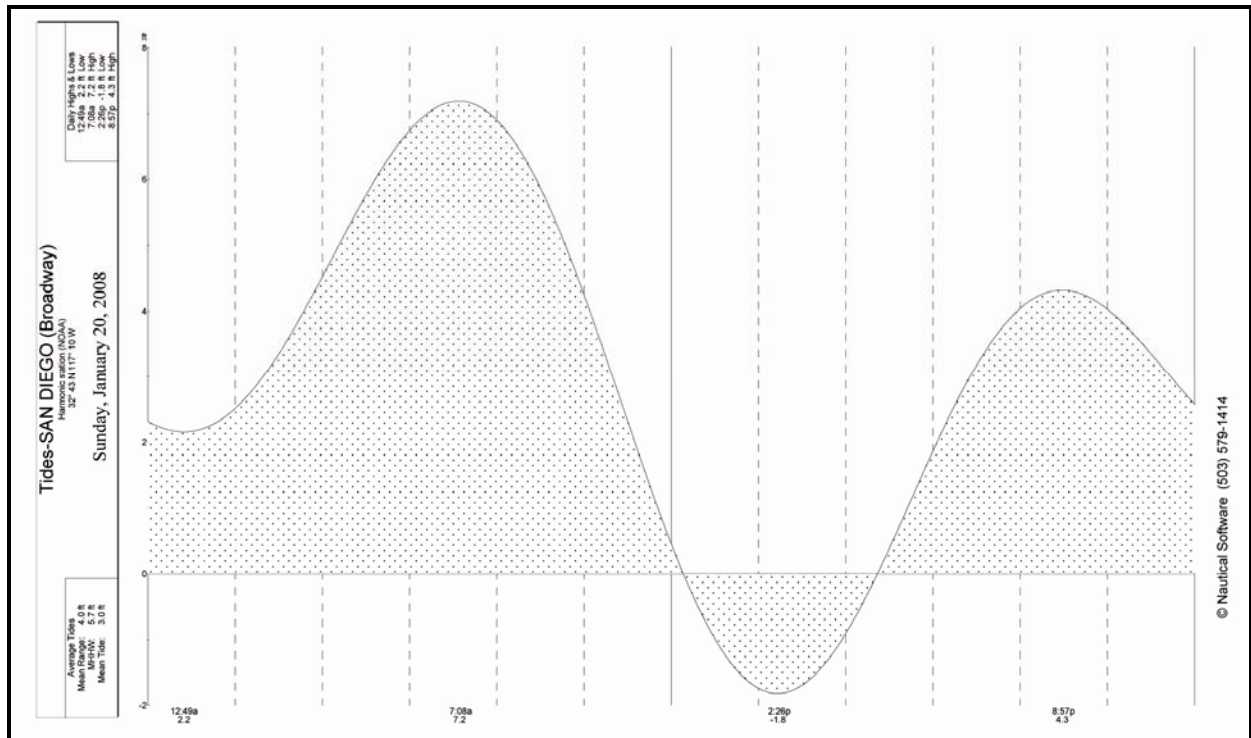


Figure 3. Tide graph for 1/20/08 showing areas of greatest change in tidal height.

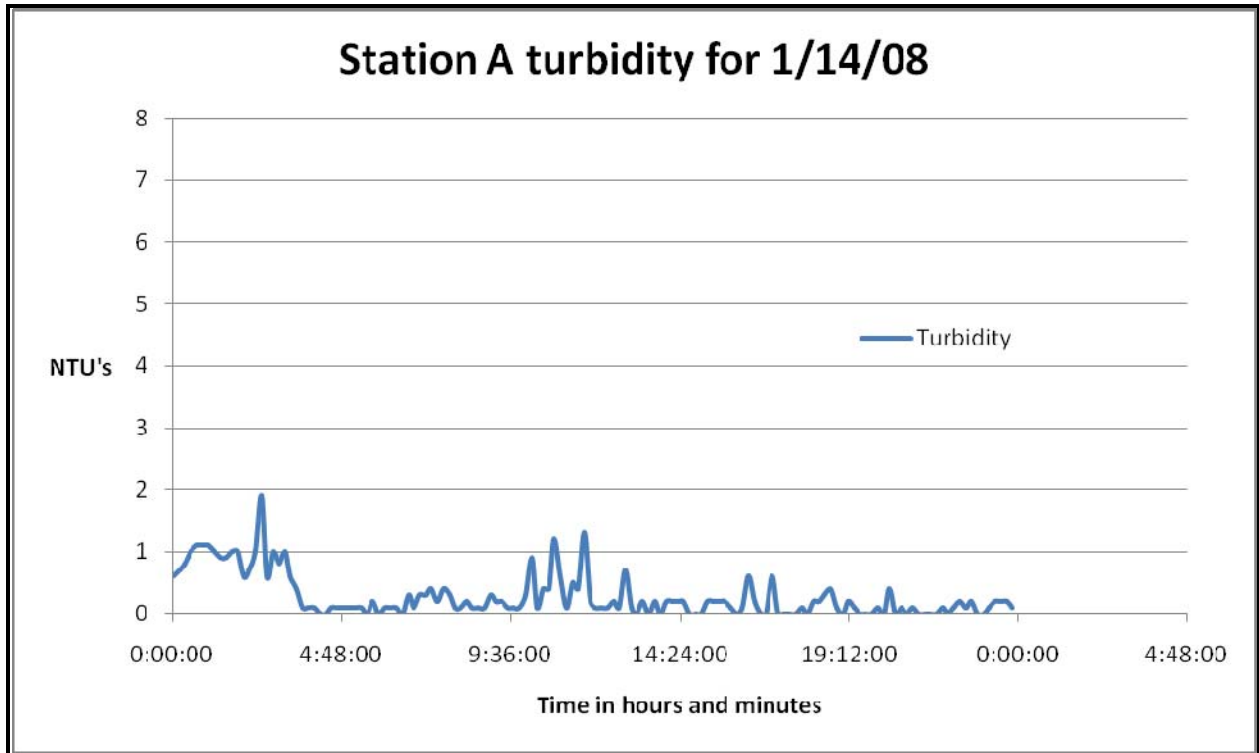


Figure 4. Station A turbidity for a 24 hour period during the lowest tidal change in January.

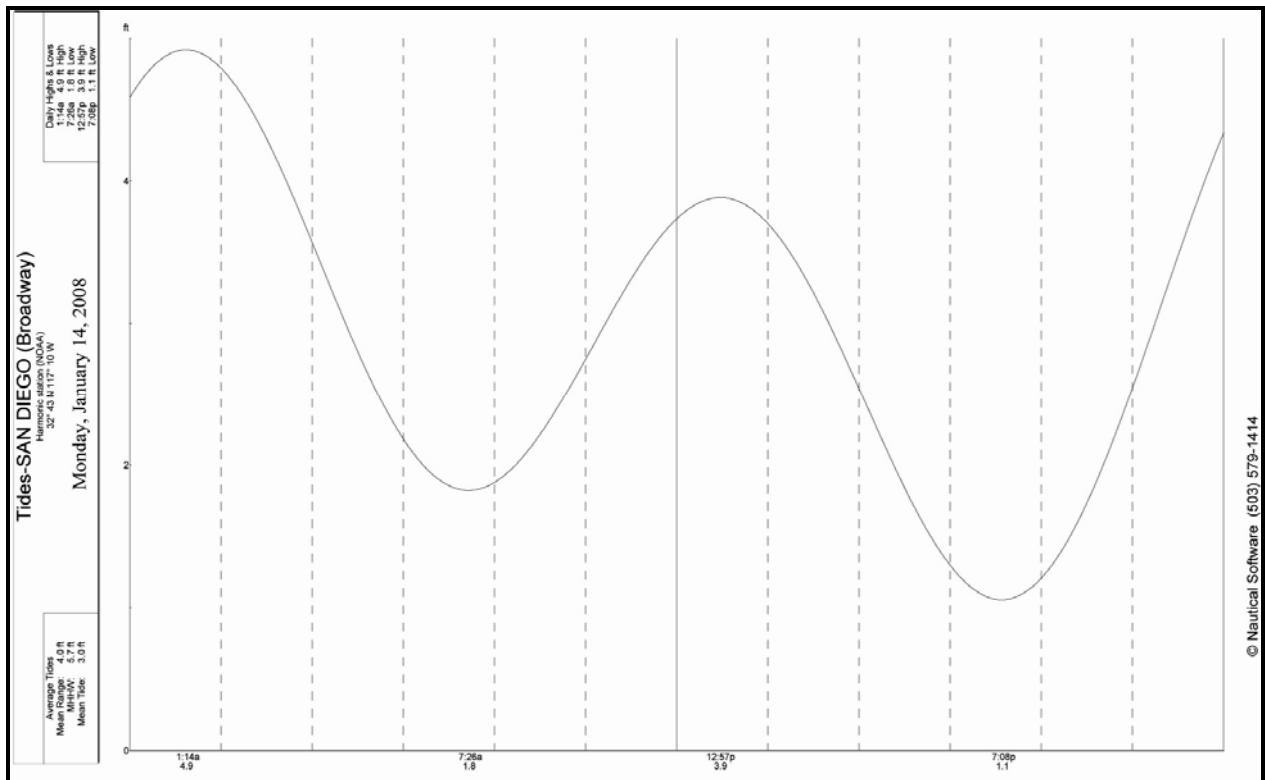


Figure 5. Tide graph for 1/14/08 showing minimal change in tidal height over 24 hour period.

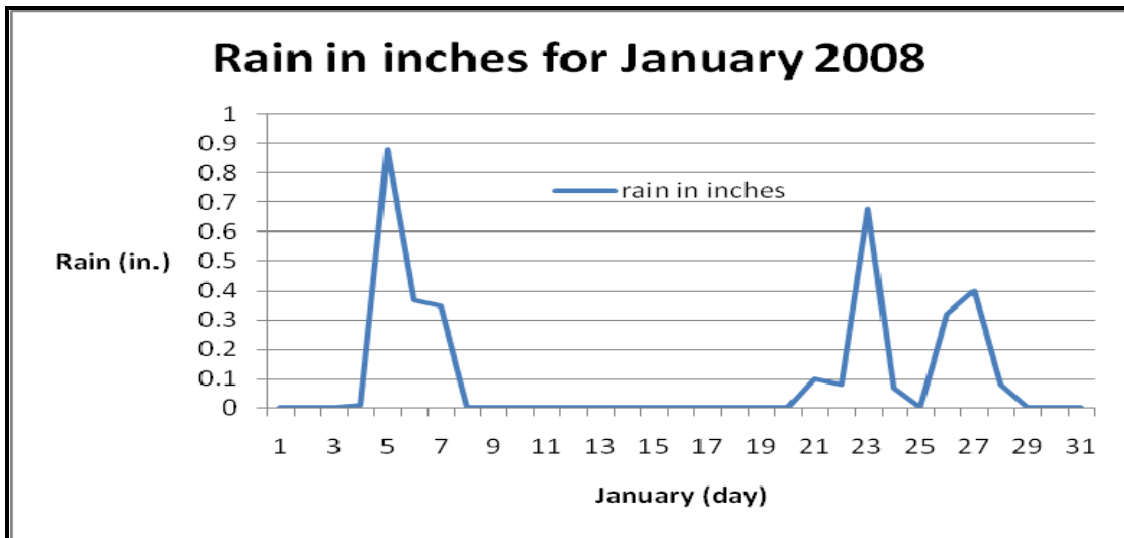


Figure 6. Rain in inches at San Diego Lindberg field for January 2008 from the NWS.

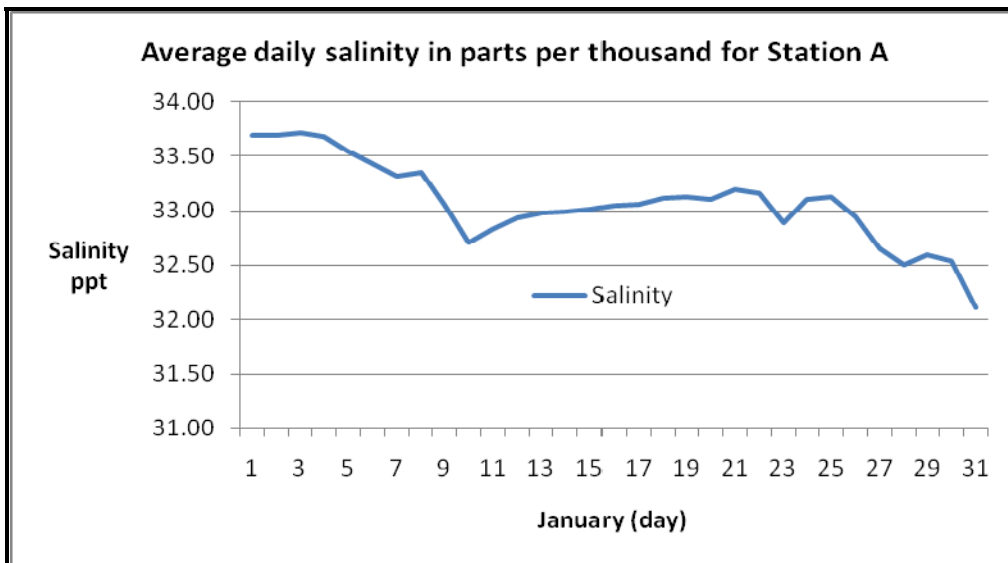


Figure 7. Average daily salinity (ppt) for station A during January 2008.

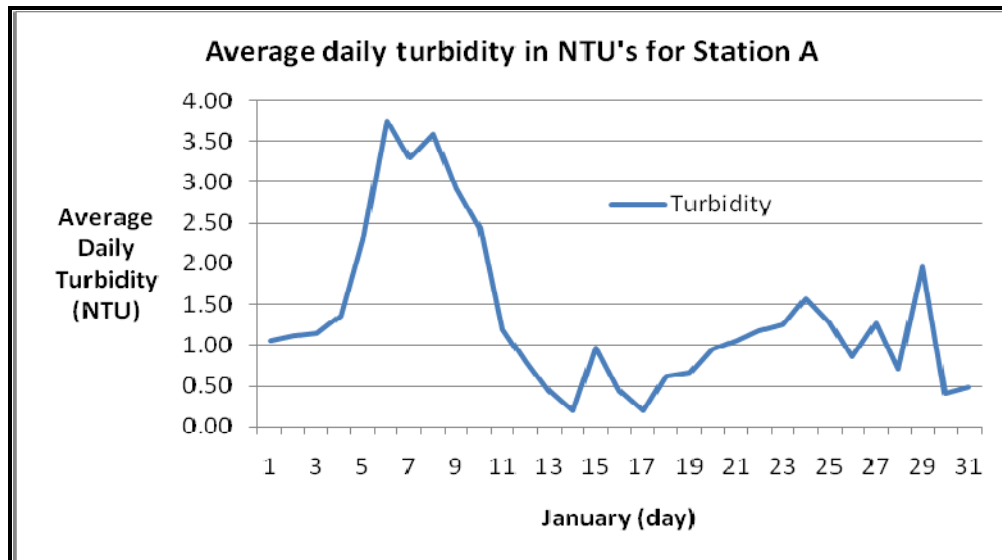


Figure 8. Average daily turbidity (NTU) for station A during January 2008.

## 4.0 Discussion

Results from the monitoring sites gathering water quality data varied in quality and consistency with only Station A producing a comprehensive data set. Problems associated with fouling and calibrations were identified and future data sets should become more reliable. The initial phase of this project was to examine the current equipment and methods previously utilized during the 2001 pilot study, and determine whether these could be amended to obtain the intended water quality measurements. The sondes currently in use, YSI 6820s, are older models configured with only one optical port fitted with a turbidity probe. Dissolved oxygen probes currently in use are membrane models that are easily fouled and require frequent calibration. Upgrading existing YSI equipment would be cost effective by reducing the workload, and providing long term consistency.

An expanded data set will provide the ability to examine patterns and relationships significantly. The addition of chlorophyll *a* probes or redundant sondes would allow for examination of the relationship between chlorophyll *a* and turbidity. Dr Ken Richter, Space and Naval Warfare Systems Command (SPAWAR), is collecting water samples to measure chlorophyll *a* at each of the three stations. Future quarterly reports will include findings. The in situ chlorophyll *a* measurements will provide a preliminary baseline for near surface chlorophyll *a* that can be referenced if long term monitoring eventually integrates additional probes or sondes.

The variability of dissolved oxygen measurements is a concern, and measurements appear to decrease gradually with increased deployment time. Consultations with YSI technical staff in reference to dissolved oxygen inconsistencies centered on the fact that the current DO probe is a membrane type versus the new, recommended, optical probes. Turbidity data from Station A intermittently contained readings out of range, due to fouling, and was smoothed for graphing purposes. Erroneous data points were highlighted in red for archival data sets while analysis was performed on corrected data sets where some measurements were up to two or three orders of magnitude higher. The two additional sonde units are being returned from servicing and will strengthen data consistency and acquisition; sondes can be brought back to the lab for cleaning and calibration rather than serviced in the field.

## 5.0 References

Australian and New Zealand Environment Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ ARMCANZ). 2000. Australian Guidelines for Water Quality Monitoring and Reporting, ANZECC/ARMCANZ, Canberra.

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the Use of Natural Variability Concepts in Managing Ecological Systems. *Ecological Applications*, 9 (4): 1179-1188.

San Diego Bay Advisory Committee for Ecological Assessment (SDBAC). 2005. Senate Bill 68 Report, December 2005. Natural Resources prepared by Elizabeth M. Kellogg, Tierra Data Inc., Escondido, CA.

San Diego Unified Port District (SDUPD). 2000. Bay-Wide Water Quality Monitoring Program, Field Sampling and Data Management Plan, December 2000. San Diego, CA.

U.S. Department of the Navy Southwest Division (USDON SWDIV) and San Diego Unified Port District (SDUPD). 2000. San Diego Bay Integrated Natural Resources Management Plan, September 2000. San Diego, CA. Prepared by Tierra Data Inc., Escondido, CA.

PHOTO FOR WEBSITE INTEGRATION:



Photo 2. Diver prepares to install YSI sonde at Station A.