San Diego Coastal Ocean Observing System

California Clean Beaches Initiative

Final Report
January 2005

to
City of Imperial Beach
Contract # 401-663-605-000

"Funding for this project has been provided in full or in part through a contract with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendations for use."

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I. Introduction

A. Problem Statement

The city of Imperial Beach experiences a significant number of beach closures as a result of high concentrations of indicator bacteria. For example, the beach was closed 39 times in the year 2000, with over half of the closures occurring in dry summer months when beach attendance is at a peak. Not only is the incidence of bacterial contamination and associated beach closures and postings a problem, but time lags between sampling of the coastal water and completion of the analysis likely result in situations when beach waters may be clean when posted, and not clean when not posted.

Possible sources of bacterial contamination responsible for bacterial exceedances include discharge from the South Bay International Water Treatment Plant (SBIWTP) outfall, the Tijuana River outflow, northward flow of contaminated waters from Mexico, local runoff from Imperial Beach, and sewage spills. Implications involving the status of beaches have been differentiated into two classifications: beach closures and beach advisory/posting. The County of San Diego Department of Environmental Health (DEH) will issue an advisory or beach posting if urban runoff or any nonpoint source causes bacterial exceedances. If, however, bacterial exceedances are caused by a reported sewage spill, DEH will post a beach closure. While the source of a beach closure is well known, beach postings can occur throughout the year in both wet and dry weather. A general advisory/posting is issued by the DEH following .2" or more of rainfall as sampling has shown increased bacterial levels due to urban runoff. The DEH will issue dry weather advisory/postings following bacterial level exceedances during routine monitoring. Throughout this report, we examine bacterial levels exceeding current standards and do not differentiate between postings and closures. The focus of this report remains on transport mechanisms from potential source locations and preliminary ocean observing results. The multiplicity of possible sources within close proximity of a few miles radius to the beaches of Imperial Beach has made source identification difficult and has resulted in stalled mitigation and abatement efforts. Under the present level of understanding, it is difficult to assess how these sources contribute to the city's beach contamination problems. While source identification is the first step in any mitigation or abatement program, the statistics of beach warnings suggest that the sources and physical transport processes in this region are complex. Physical properties of the area need to be examined and continuously monitored with sufficient detail within time and space if solutions to beach advisories resulting from non-local pollution are to be developed.

B. Description of the Coastal Monitoring System

Scripps Institution of Oceanography has established the San Diego Coastal Ocean Observing System (SDCOOS) (www.sdcoos.ucsd.edu) under contract to the City of Imperial Beach through funding provided by the California Clean Beach Initiative. The area monitored encompasses a region spanning from Point Loma to the U.S. - Mexico Border and waters offshore to distances of approximately 16nm (30 km). The backbone of the coastal monitoring system is an array of high-resolution radars designed to provide a spatial map of the local ocean surface currents on a real-time basis. The basis for the system is the scattering of radio waves from ocean surface waves over known regions of the ocean. Through appropriate signal processing of the radio waves scattered back to

the radar, currents can be determined at a large number of discrete locations, referred to as range cells, at locations spaced as closely as .16nm (300m) apart. Refer to appendix 2 for technical details covering HF radar operation. The Coastal Ocean Dynamics Radar (CODAR) sites are in operation by a large number of research institutions at sites on both the east and west coasts of the United States. The regional coverage provided by the current array and the direct measurement of the ocean's surface currents allows the tracking of transport routes from various potential pollution sites and will identify which regions of the coastline may be impacted by surface flow from offshore or non-local sites. The immediate application of the current maps has been to provide a framework for interpreting results from water quality testing programs. Much has been learned from investigating time histories of the surface current fields in regions of contamination as time histories allow transport routes to be tracked backwards in time to determine the source origins.

The radar array is composed of three installations located at the following sites: Border Field State Park, Point Loma, and a third site located on the Coronado Islands. The installation on the Coronado Islands was made possible through a collaborative arrangement with Mexican research scientists at Universidad Autonoma de Baja California (UABC) The Center for Scientific Investigation and Higher Education of Ensenada (CICESE), who operate a similar current mapping radar unit south of the border. The placement of the radar at an offshore site is highly favorable since it provides current mapping coverage very close to the shore. The HF radar signal is lost once it propagates over land making near shore measurements difficult. An offshore site is not shadowed by land allowing for improved coverage. An offshore site also improves the geometry for total vector calculation. In more technical terms, a single 25MHz HF radar site measures radial velocity over 19nm (35 km) centered at the antenna (see figure 7). Combined radial data from two systems will produce a surface current direction and magnitude (see figures 8-12). Surface currents cannot be resolved on the direct line (known as the baseline) between radar systems, because equal but opposite radial vectors cancel one another. For this reason a third system offshore whose radial vectors combine along the baseline aids in overall coverage. Further details regarding HF radar principles for measuring surface currents can be found in appendix 2. The real-time surface current maps generated by the radar array are complemented by satellite remote sensing and a number of in-water monitoring systems deployed locally offshore of Imperial Beach. Vertical profiles of currents including those associated with ocean surface waves were continuously measured closely offshore of the City's beaches using an Acoustic Doppler Current Profiler (ADCP) and the density stratification of the water column was continuously measured with a vertical temperature sensor array. The vertical structure of the currents and the density stratification are important parameters to measure since they indicate the potential for sub-surface waters to either penetrate to the surface or be transported cross-shore into the surf zone. In addition, a water quality monitoring system is mounted on the Imperial Beach pier near the center of human contact activities. This system includes the measurement of salinity, temperature, turbidity, and chlorophyll, as well as a current meter to measure the long-shore transport in the surf-zone which is closely tied to the direction of the swell breaking on the beach. The current profile and wave heights and direction are also measured off the end of the pier. The real-time water quality parameters measured at the pier site are used to investigate whether measurable

parameters exist which allow the real-time determination of water origin or provide indication of contamination events. Basic meteorological variables are also measured at the end of the pier and tied into a central data logging and distribution system.

The long-term benefits of the monitoring system result from two modes of use. In the first mode, direct operation of the system provides real-time information regarding the environment, providing an early warning of potential contamination due to onshore flow. First responders for water quality (Department of Environmental Health, Marine Safety Officers, City officials) are the primary users of this information. The second mode of using the information is to generate a large data base describing how this coastal region responds to different environmental forcing such as tides, wind, different swell conditions, and heavy precipitation, and how these forcing events and the different flow configurations associated with them coincide with the occurrence of fecal contamination at the beaches. Through an understanding of the coastal response to these various forcing events, statistical predictors of beach closures can be developed. Local and regional managers can use the information to guide the development of future water quality clean up projects.

II. Work Completed

A. Task Schedule

The City of Imperial Beach was responsible for completing three of the four project tasks, Task 1 – Project Management and Administration, Task 2 – Quality Assurance Project Plan, and Task 4 – Reporting. UCSD – SIO was responsible for the performance of work in Task 3 – Statement of Work that consists of four major tasks as outlined in State Water Resources Control Agreement Number 01-074-550-2 and shown below.

1.0 Project Management and Administration

1.1 Provide all technical an administrative services as needed for contract completion; monitor, supervise and review all work performed; and coordinate budgeting and scheduling to assure that the contract is completed within budget, on schedule, and in accordance with approved procedures, applicable laws, and regulations.

1.2 Ensure that the contract requirements are met through completion of quarterly progress reports and through regular communication with the SWRCB Project Representative. The progress reports shall describe activities undertaken and accomplishments of each task during the quarter, milestones achieved, and any problems encountered in the performance of the work under this contract. The description of activities and accomplishments of each task during the quarter shall be in sufficient detail to provide a basis for payment of invoices and shall be translated into percent of task work completed for the purpose of calculating invoice amounts.

1.3 State Disclosure Requirements – Include the following disclosure statement in any document, written report, or brochure prepared in whole or in part pursuant to this contract:

"Funding for this project has been provided in full or in part through a contract with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do no necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsements or recommendation for use." (Gov. Code 7550, 40 CFR 31.20)

1.4 The Contractor and any of its contractors shall notify the SWRCB Project Representative at least ten working days prior to any public or media event purblicizing the accomplishments and/or results of this contract and provide the opportunity for attendance and participation by SWRCB representatives.

1.5 Complete a one-page contract summary form (form to be provided by the SWRCB within three months of the contract execution

1.6 Award contract(s) to appropriate organizations(s) to perform tasks as outlined in this agreement. Document steps taken in soliciting and awarding the contract and submit them to the SWRCB Project Representative for review. Document all contractor activities in quarterly reports.

1.7 At the completion of this project and prior to final payment, the Project Representative shall fill out and provide a project survey form to the SWRCB Project Representative.

Task Deliverables: 1.2 Quarterly Progress Reports, 1.5 Contract Summary Form, 1.6 Subcontractor Document, 1.7 Project Survey Form

2.0 Quality Assurance Project Plan

2.1 Prepare and maintain a Quality Assurance Project Plan (QAPP). The SWRCB Project Representative prior to the implementation of any sampling or monitoring activities shall approve the QAPP.

Task Deliverables: 2.1 QAPP

3.0 Statement of work

SDCOOS was responsible for the performance of the work as set forth herein below and for the preparation of products and reports as specified in this Exhibit. During the course of the project, SDCOOS staff promptly notified the Contract Manager of events or proposed changes that affected the scope, budget, or schedule of work performed under the agreement.

3.1. Coastal Ocean Dynamics Application Radar (CODAR)

3.1.1 Conduct site planning and assessments for three CODAR potential site locations. Site assessment matrix to include criterion based on geographic orientation and exposure to achieve maximum effectiveness of the instrumentation to achieve the goals laid out in this contract, availability of utilities for support of the remote site CODAR hardware, data telemetry options, and site security. Select appropriate operating RF frequency within operating band of CODAR system and existing band usage.

3.1.2 Obtain necessary permissions or collaborative agreements from the various land managers/owners for the three CODAR site locations.

3.1.3 Issue appropriate subcontracts with vendors for the fabrication of instrumentation.

3.1.4 Physical installation of CODAR instrumentation at three sites. Installation to include appropriate equipment enclosures to protect instrumentation from the environment, routing of appropriate utilities to the instrumentation, securing of CODAR antennas to appropriate existing

structures, and routing of RF antenna cables to the instrumentation enclosure.

3.1.5 Install a Central Site Computer for the merger of CODAR data fields from the three respective remote sites into a map of ocean surface currents for the region.

3.1.6 Establish internet telemetry links between the Central Data Processing Center and the remote CODAR stations using telephone landlines, wireless technology, or other appropriate internet access technology.

3.1.7 Conduct radar antenna pattern measurements over the ocean using a small craft and a portable RF transponder unit. Integrate measured antenna patterns into radar signal processing algorithms. Repeat antenna measurement procedure if antennas are moved over the course of this project.

3.1.8 Optimize operation of CODAR array to provide real-time ocean surface current vector fields. Implement necessary procedures to have system operate on a continuous basis.

3.1.9 Integrate data with other Task efforts listed below.

3.2. Nearshore Currents and Water Type Sampling System

3.2.1 Fabricate a bottom-mounted current profiler system composed of a) an acoustic Doppler current profiler (RDI or similar) b) a conductivity and temperature sensor (Seabird or similar). Both sensors a) and b) of the system to be appropriately integrated to provide data output using a single power and communication cable over distances to at least 750m. System will be mounted to a bottom support and appropriately treated with anti-fouling paint and other protective measures to minimize sensor fouling from biological growth. Bottom support to be designed to minimize effects of scour.

3.2.2 Conduct a site assessment to choose an appropriate deployment site either north or south of the City of Imperial Beach Pier in water depths between 5m – 20m. Site to be selected on criterion for effectively monitoring water transport to beaches of heavy usage.

3.2.3 Deploy both systems at the chosen site using an appropriate work vessel. Install armored data and communication cable between the sampling system and an appropriate piling at the end of the IB Pier. Cable to be secured by piling clamps fabricated by contractor. Route cable on Pier to first floor of IB Pier Lifeguard Tower in consultation with City of IB personnel.

3.2.4 Install system operation and communication computers in the first floor of the IB Pier Lifeguard Tower. Computers to conduct continuous real-time acquisition of data streams from the in-water sensors.

3.2.5 Invert water velocity data from the system to extract surface wave properties (wave height, period, and direction). Data inversion to be conducted on a continuous real-time basis.

3.2.6 Integrate data with other Task efforts listed below.

3.3. Surf-zone Currents and Water Quality Sampling System

3.3.1 Fabricate an environmental sampling system for the measurement of the long-shore currents and water quality parameters. System to be composed of a current meter (Sontek or similar) and seawater sampling intake mounted on a piling on the south side of the IB pier in shore of the Lifeguard Tower. Piling location to be within the surf zone at region influenced by long-shore transport. The current meter and seawater sampling intake to be placed at an appropriate depth to ensure the system is operational over all water level fluctuations due to tides and waves.

3.3.2 Install pumped sampling system to bring water from the seawater intake to a water quality sensor suite (YSI or similar) located on the pier. Water quality parameters to be measured include conductivity, temperature, turbidity, and dissolved oxygen. A flow cell is to be integrated into the seawater sampling system to allow continuous measurement of these parameters and provide the capability for placement of additional sensors within the sampling system. A tap shall also be available to provide for obtaining discrete water samples for conducting culture analysis of bacteria. Pump and sensors to be mounted in an accessible location on the underside of the pier to minimize vandalism. Site placement of pump and sensors to be determined with cooperation of City of IB personnel.

3.3.3 Install data and power cable to operate sampling system from the first floor of the IB Pier Lifeguard tower.

3.3.4 Integrate data with other Task efforts listed below.

3.4. Water Column Stratification Measurement System

3.4.1 Fabricate a buoy and mooring system designed for the measurement of water column temperature structure. Temperature sensors to be spaced vertically at 10ft (3m) increments from the surface to the seafloor. Buoy is to be deployed at an appropriate site offshore Imperial Beach to measure water column stratification over a 99ft (30m) depth in a region near the South Bay Ocean Outfall. Deployment to be conducted with a suitable work vessel as determined by the contractor. Exact mooring location to be reviewed with U.S. Coast Guard.

3.4.2 Fabricate a vertical array of water temperature sensors spaced at 1m depth increments. Vertical array to be mounted to the outermost piling on the IB Pier. Route a power and communication cable to the first floor of the Imperial Beach Lifeguard Tower in consultation with City of Imperial Beach personnel. Data to be logged on real-time basis from a logging station.

3.4.3 Integrate real-time measurements of water column stratification with other Task efforts listed below.

3.5. Central Data Acquisition and Real-Time Data Distribution System

A central data acquisition and real-time data distribution system will be developed to merge measurements conducted under efforts 1.1- 1.4 above into a centralized database. Data will be accessible via an internet accessible, real-time data distribution system.

3.5.1. Merge various data streams from Tasks 1.1- 1.4 into a centralized database on a real-time basis.
3.5.2. Develop web access tools for interfacing data users to centralized database. Generate summaries of real-time data and provide real-time access to these summaries.
3.5.3. Provide maintenance of database and internet based distribution system as needed.

Task Deliverables: 3.1 Installation and operation of Coastal Dynamics Application Radar (CODAR) system, 3.2 Installation and operation of nearshore current profiler/directional wave gauge and salinity/temperature sensor, 3.3 Installation and operation of surf-zone current meter and water quality sensors, 3.4 Installation and operation of water column temperature sensors, 3.5 Development and implementation of a central data acquisition and real-time data distribution system

4. Project Implementation

Data obtained through the course of the two year effort will be interpreted with the joint goals of identifying the transport processes that are relevant to coastal water quality at Imperial Beach and the identification of remote pollution sources which impact Imperial Beach. Our approach to these goals will be a focused analysis effort using both statistical analysis techniques and a hypothesis-based physical transport approach. The two methods have distinction: while a statistical approach may provide a rigorous mathematical basis for the statistics related to beach closures, a parallel analysis of the data guided by the physics of transport mechanisms in the region provide an enhanced understanding of how pollution may be transported. These complementary analysis approaches will be applied to the data directly obtained and funded within this contract as well as the data from the enhanced bacteria monitoring efforts to be conducted by other groups who perform monitoring in this region.

4.1 Reports
Reports will be generated on a quarterly basis and submitted to the office of the Contract Manager. Reports shall include the following items:

4.1.1. Written progress of the project describing activities undertaken, milestones accomplished, problems encountered in the performance of the work under this agreement.
4.1.2. Data summaries of the data aquired under the monitoring efforts.
4.1.3. Summary of preliminary findings from data interpretation efforts.

The task schedule presented below was based upon a nominal start date of July 1st, 2002. Task durations are shown in brackets next to the scheduled completion date based on a July 1st, 2002 start. As a result of the monitoring and research goals of this project, tasks undertaken in the contract were parallel efforts that continued through the specified 2 year period of performance. Hence, tasks were not completed in sequential order through the period of performance.

TASK ITEM	**Schedule completion date based on a July 1, 2002 start**
1.0 Project Management and Administration	
1.1 – 1.2 Quarterly Progress Reports	continuous effort through June 30, 2004 (24 months)
1.3 – 1.4 state disclosure and notification requirements	continuous effort through June 30, 2004 (24 months)
1.5 Contract summary form	December 16, 2002 (6.5 months)
2.0. *Quality Assurance Project Plan*	
2.1 prepare and maintain QAPP	January 2004 (19 months)
3.1. *Coastal Ocean Dynamics Application Radar*	
3.1.1 – 3.1.3 site planning, array design, order system	September 15, 2002 (2.5 months)
3.1.4 – 3.1.6 system installation	January 31, 2003 (7 months)
3.1.5 – 3.1.8 system calibrations and optimization	September 15, 2003 (14.5 months)
3.1.9 data integration	continuous effort through June 30, 2004 (24 months)
3.2. *Nearshore Currents and Water Type Sampling*	
3.2.1 – 3.2.2 system fabrication, site planning	December 15, 2003 (5.5 months)
3.2.3 – 3.2.4 system installation	January 15, 2003 (6.5 months)
3.2.5 – 3.2.6 data integration	continuous effort through June 30, 2004 (24 months)
3.3. *Surf-zone Currents and Water Quality Sampling System*	
3.3.1 fabricate system	December 15, 2002 (5.5 months)
3.3.2 install system	January 15, 2003 (6.5 months)
3.3.3 install data cable / logging computers	January 15, 2003 (6.5 months)
3.3.4 data integration	continuous effort through June 30, 2004 (24 months)

3.4. *Water Column Stratification Measurement System*	
3.4.1 – 1.4.2 system fabrication and installation	January 1, 2003 (6 months)
3.4.3 data integration	continuous effort through June 30, 2004 (24 months)
3.5. *Central Data Acquisition and Real-Time Data Distribution System*	
3.5.1 – 3.5.3 database development, data merger, online access tool development	continuous effort through June 30, 2004 (24 months)
4.0. *Reporting*	
4.1.1-4.1.3 progress reports of activities, milestones, data summaries, and interpretation efforts	continuous effort through June 30, 2004 (24 months)

B. Project Management and Administration

The City of Imperial Beach conducted all technical and administrative oversight of the project to ensure that the described tasks were completed in accordance with the State's grant agreement and met the project's goals.

The City of Imperial Beach prepared and administered the subcontractor, the University of California, San Diego for the completion of Task 3 – Statement of Work through an agreement for professional services issued on July 1, 2002 with a termination date of June 30, 2004. On September 15, 2004 an amendment was issued to extend the contract rhrough November 30, 2004. The City also secured the collaboration of the County of San Diego Department of Environmental Health for support with beach water quality data sharing and other information related to routine coastal monitoring activities conducted as part of AB411.

As noted in the grant agreement, the City is required to include the State Disclosure Statement on all documents, reports or brochures associated with the project. The City took appropriate steps to include the statement. The disclosure is included on the cover of this report

Notification was issued to whe SWRCB Project Representative of any an all public media events publicizing the accomplishments and/or results of this project with at least ten (10) days notice.

The City completed the one-page contract summary form and provided it to the SWRCB on December 16th, 2002.

The City entered into contract with the Regents of the University of California to secure the technical expertise of the University of California, San Diego; Scripps Institution of Oceanography (SIO) in order to implement the technical components of the project described in Task 3. SIO was responsible for the Imperial Beach (IB) Pier design and installation of the Coastal Ocean Dynamics Application Radar (CODAR), the Nearshore Currents and Water Type Sampling System, the Surf-zone Currents and Water Sampling System, the Central Data Acquisition and Real-Time Data Distribution System, and corresponding Reporting. Details of the work performed in each of these tasks are found in Sections II.D – II.I

C. Quality Assurance Project Plan

The City coordinated and finalized the QAPP for the project with assistance from the County of San Diego's Department of Environmental Health and SIO. The QAPP was prepared in accordance with the SWRCB outline and requirements in place at the time and completed in January 2004.

D. Coastal Ocean Dynamics Application Radar (CODAR)

i. Site Installations & Networking

By October 2002, three months after the project start date, all three CODAR sites were identified and two systems were installed. The first system was installed at Point Loma (site name SDPL) on August 30th, 2002 and the second at Border Field State Park (site name SDBP) on September 7th, 2002. Permission for these installations was obtained from California State Parks, local and national Navy Public Works Offices, and Space and Naval Warefare Systems Center (SPAWAR) system center in Charleston,

North Carolina. System optimization had also begun by making antenna pattern measurements (transponder runs) from a small vessel for both SDPL & SDBP.

Through the remainder of 2002, the focus of efforts with CODAR systems was on establishing reliable communication lines from Scripps to Border Field State Park and Point Loma for system maintenance and real-time data transfer. The networking infrastructure at the Border Field State Park site consists of a wireless link. An antenna is installed on a light post at the park that directs a signal to the Marine Safety Center located at the foot of the Imperial Beach Pier. Upon receiving the signal at the IB Pier, the network is connected to a high-speed cable modem installed by COX Cable Company.

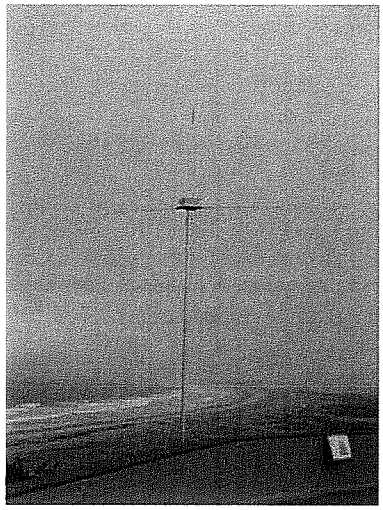


Figure 1. CODAR antenna at Border Field State Park.

High-speed internet access to the Point Loma CODAR site was initially provided by SPAWAR Naval Systems Center. However, we experienced difficulties in maintaining stable communications to this site, possibly due to firewalls on SPAWAR's network. We researched an alternative networking topology based on an existing wireless backbone installed on Mount Woodson which provided access to the University of California, San Diego (UCSD) network. The Mount Woodson site was installed by a networking research consortium funded by the National Science Foundation (HPWREN & ROADNet). We were able to take advantage of the Mount Woodson local access point to continue a network connection out to Point Loma. The wireless system was operational by February 2003 and proved to be a stable communication link. Collaborative efforts with HPWREN and ROADNet continued for the development of telemetry links to the third site on South Coronado Island. Essentially, we were able to extend the wireless link from Mount Woodson to Point Loma, to South Coronado Island and finally extend further to Mexico on connectivity through the Mount Woodson link.

Figure 2. CODAR and wireless equipment at Point Loma installation. Directional antennas pointed toward Scripps and South Coronado Island are shown.

The third CODAR installation on South Coronado

Figure 3. Helicopter drop at South Coronado Island.

Island of the Mexican owned Coronado Islands began with paperwork that had been submitted by October 2002. Permission for the installation was granted from the Mexican Department of State by the end of the year and system design was underway. Due to the remote location of this site, a solar panel system needed to be designed and installed for power. Access to the island is also limited and system installation required helicopter transport of heavy equipment. Permits for the helicopter lift of equipment from Border Field State Park to South Coronado Island included (a) clearances from Tijuana air traffic control for a U.S. owned helicopter to enter Mexican airspace (b) permission from the Mexican Navy to land a helicopter on South Coronado Island (c) permission from the U.S. Border Patrol to stage a helicopter lift operation from Border Field State Park and (d) submittal of U.S. Customs paperwork for the transport of scientific instrumentation outside the U.S. By mid-February, 2003, the final CODAR installation on South Coronado Island and the associated support infrastructure including a solar power system, wind generator, and a wireless telemetry system was complete. Antenna pattern measurements were also made for this site's optimization.

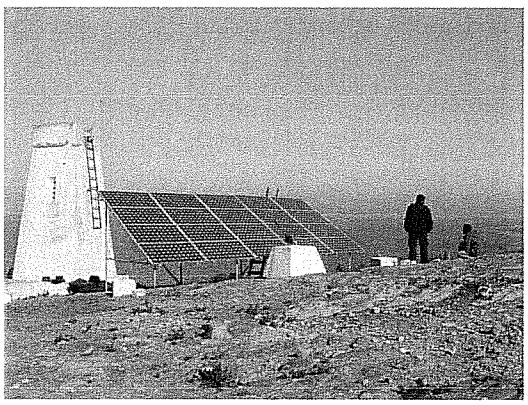


Figure 4. Solar panel array at South Coronado Island.

Since February 2003, CODAR data from a system operated by colleagues at CICESE/UABC located near Rosarito Beach, MX has been integrated with data from sites at Border Field State Park, Point Loma and South Coronado Island. Costs for integrating the Rosarito Beach system and wireless data telemetry were provided by funds received from the National Science Foundation. The integration of this fourth site enables mapping of surface currents further south into Mexico. Wireless equipment at Rosarito beach and the previously mentioned existing backbone link to UCSD enabling access to Point Loma, Coronado Island, and Rosarito are efforts funded by another source.

Surface current maps produced from the CODAR systems have been processed and posted to the web in near real-time at http://www.sdcoos.ucsd.edu/ since the start of the program. Various products from the CODAR data have since been (and continue to be) developed, including a 24 hour average which indicated the long term circulation for the region and estimated alongshore flow off of the Tijuana River mouth for indicating where a potentially polluted river plume may advect.

Following the installation and networking of all CODAR sites, radar installations entered a maintenance and upgrade phase, which involved system software upgrades, data archiving, and daily upkeep of equipment and the network. Improvements

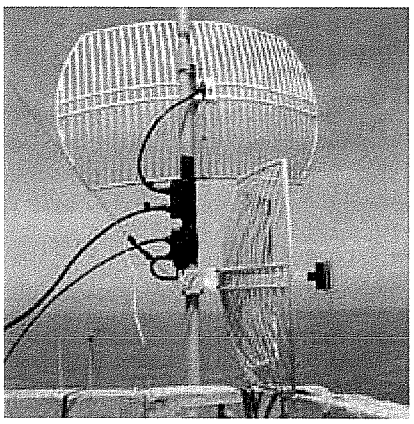


Figure 5. Directional antennas for wireless communications at South Coronado Island.

on this system continue today. Recently, we have been focusing efforts on developing an improved data transfer and archiving method for coastal radar data. Data transfer involves an Object Ring Buffer which reliably transfers data from remote sites to a computer network at the San Diego Supercomputer Center. The computer network then hosts a central database and repository for coastal radar data that can be accessed via the internet.

ii. Surface Current Synopsis

The CODAR system has been running for over two years. A summary of the operational periods for each site is presented in Figure 6 below:

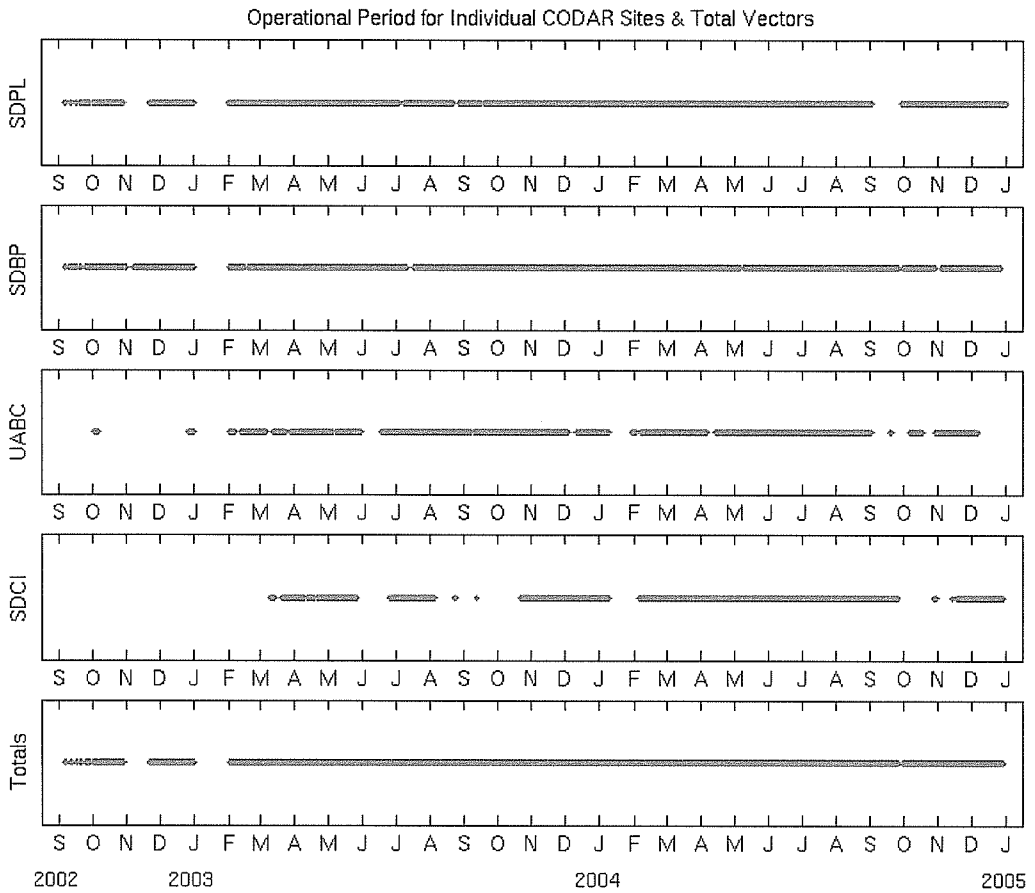


Figure 6. Operational periods for each CODAR site as well as total vectors resulting from the combination of data from two or more sites. The four-letter designation on the vertical axis of graph refers to short hand CODAR site names. SDPL: San Diego Point Loma; SDBP: San Diego Border Park, UABC: Universidad Autonoma de Baja California, SDCI: San Diego San Clemente Island

Gaps in the data are due to software bugs or hardware failures that required either additional development activities or the deployment of staff to the remote sites for hardware repair. Gaps tend to be larger for more remote sites where access is limited to

favorable weather conditions. An example of data gathered by each site is shown in Figure 7 below:

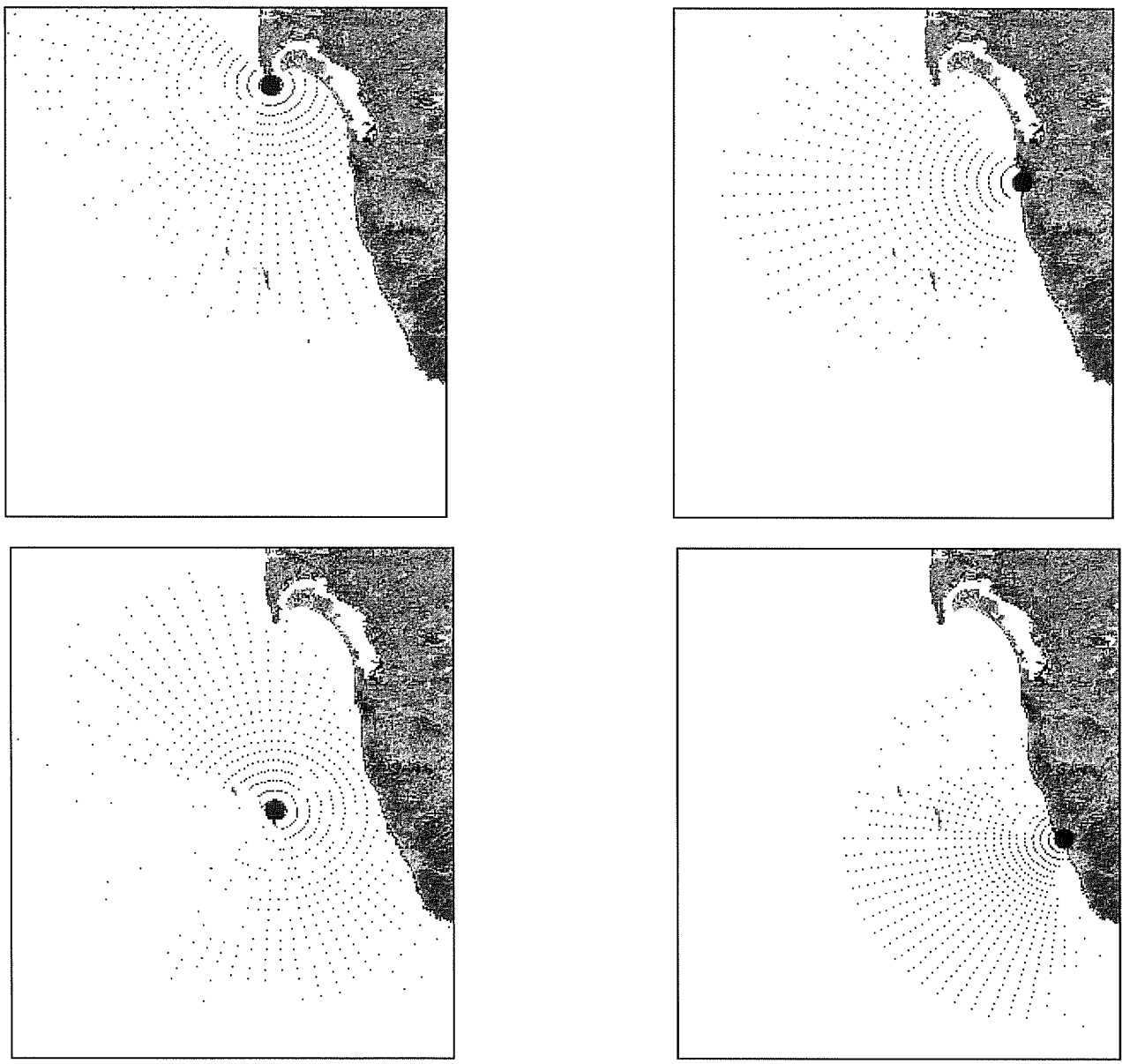


Figure 7. Example CODAR radial data from each site; Point Loma (upper left), Border Field State Park (upper right), South Coronado Island (lower left), and UABC (lower right).

Radial data from each site (shown above) is combined on an hourly basis to give a total surface current map each hour. The volume of data collected by the system is beginning to lend itself to a variety of statistical analyses. Some elementary analyses and observations are summarized next.

Statistical analyses often begin with determining the mean state of a dataset before delving into mechanisms that give rise to variability about the mean. The mean flow of surface currents off of the San Diego coastline is a predominant southward flow (Figure 8).

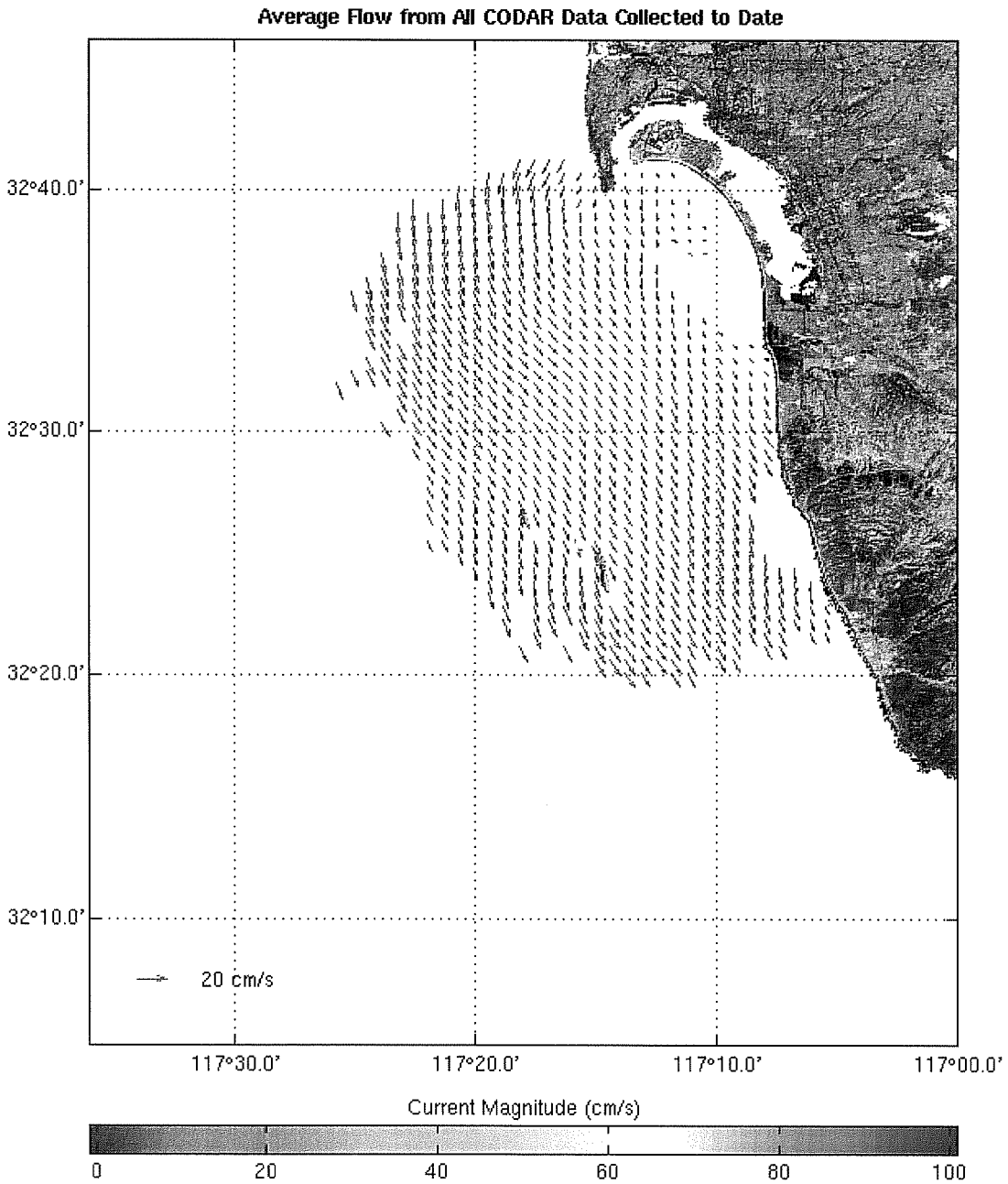


Figure 8. The mean surface current flow for all CODAR data collected to date (Sept 2002 through Dec 2004).

Although a simple uniform southward flow is observed in mean state of surface currents, there is large variation about this mean state in the form of flow reversals over the span of one day and eddies that last anywhere from hours to days. Examples of some variations about the mean state are shown in the following figures.

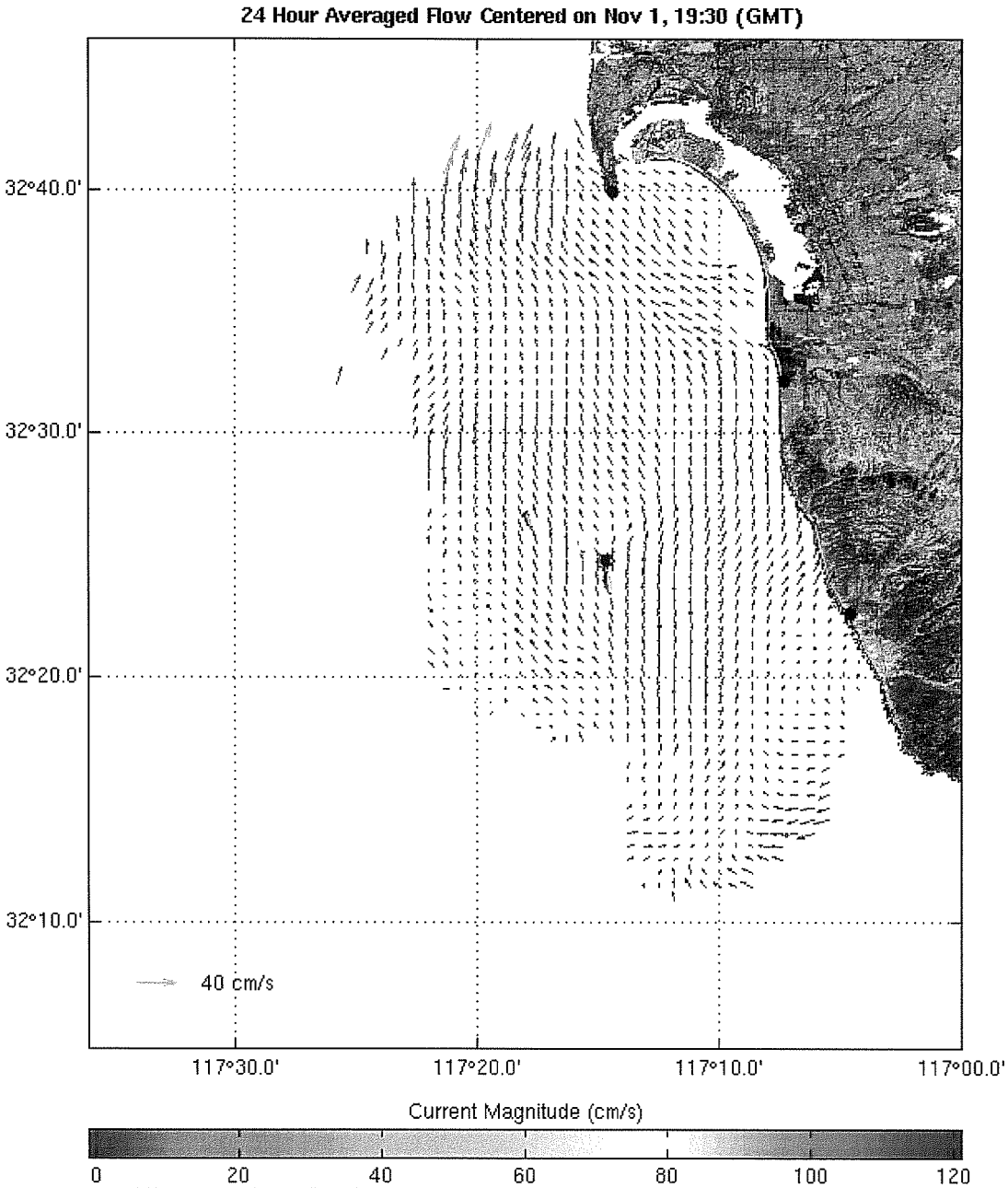


Figure 9. While the dominant flow is southward for the region, northward flow is commonly observed as shown here on November 1st, 2003. Initial observations suggest this occurs most often in winter with the arrival of storms. Northward flow has obvious consequences relating to the transport of potentially polluted waters from the Tijuana Estuary to South Bay beaches.

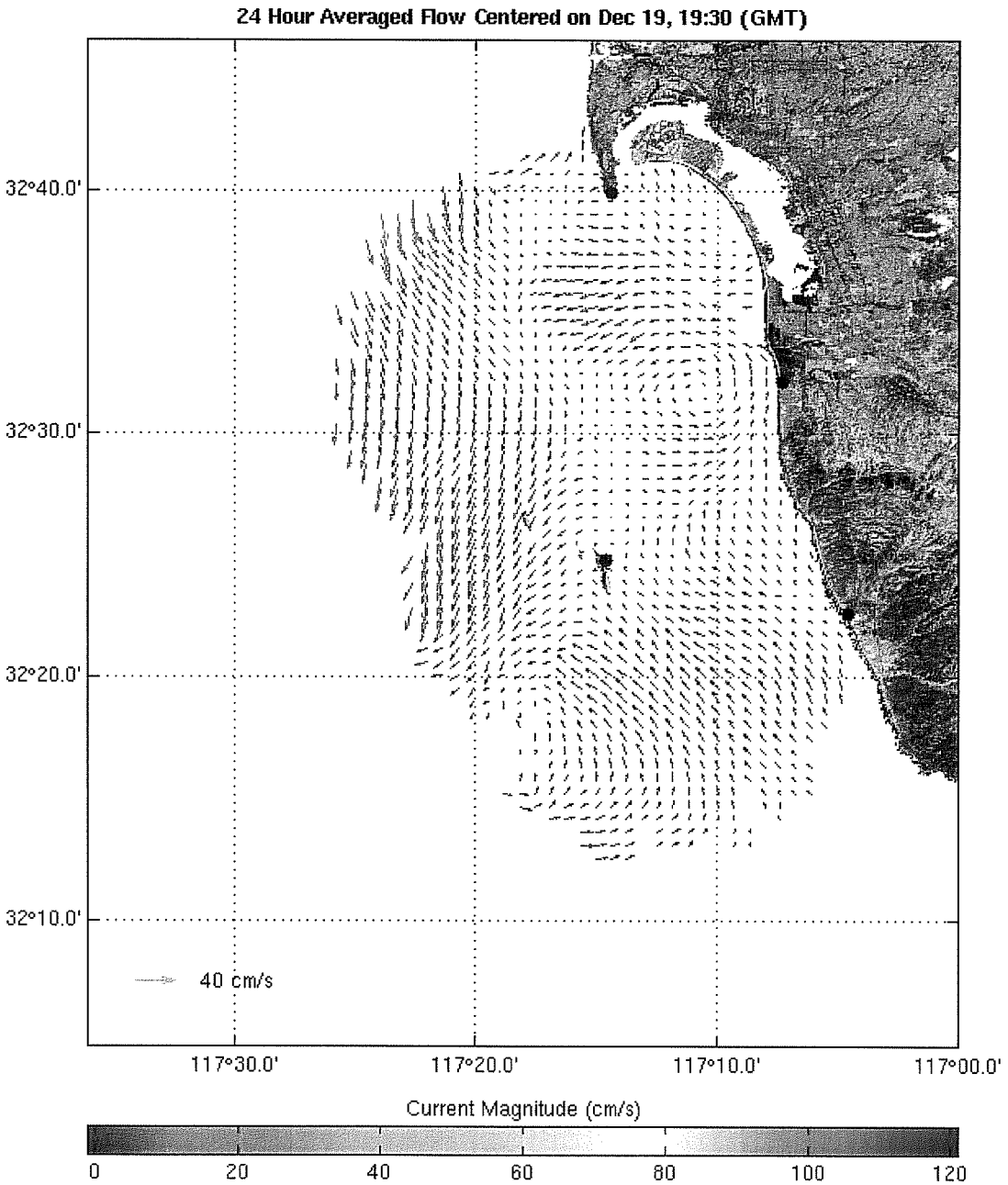


Figure 10. This counter-clockwise eddy was observed on several occasions and can persist for anywhere between one and five days. One important feature of this eddy is the localized northward flow that brings water from the Tijuana Estuary to South Bay beaches. Ongoing studies will help determine the mechanisms that give rise to this eddy formation and provide a predictive capability to the region.

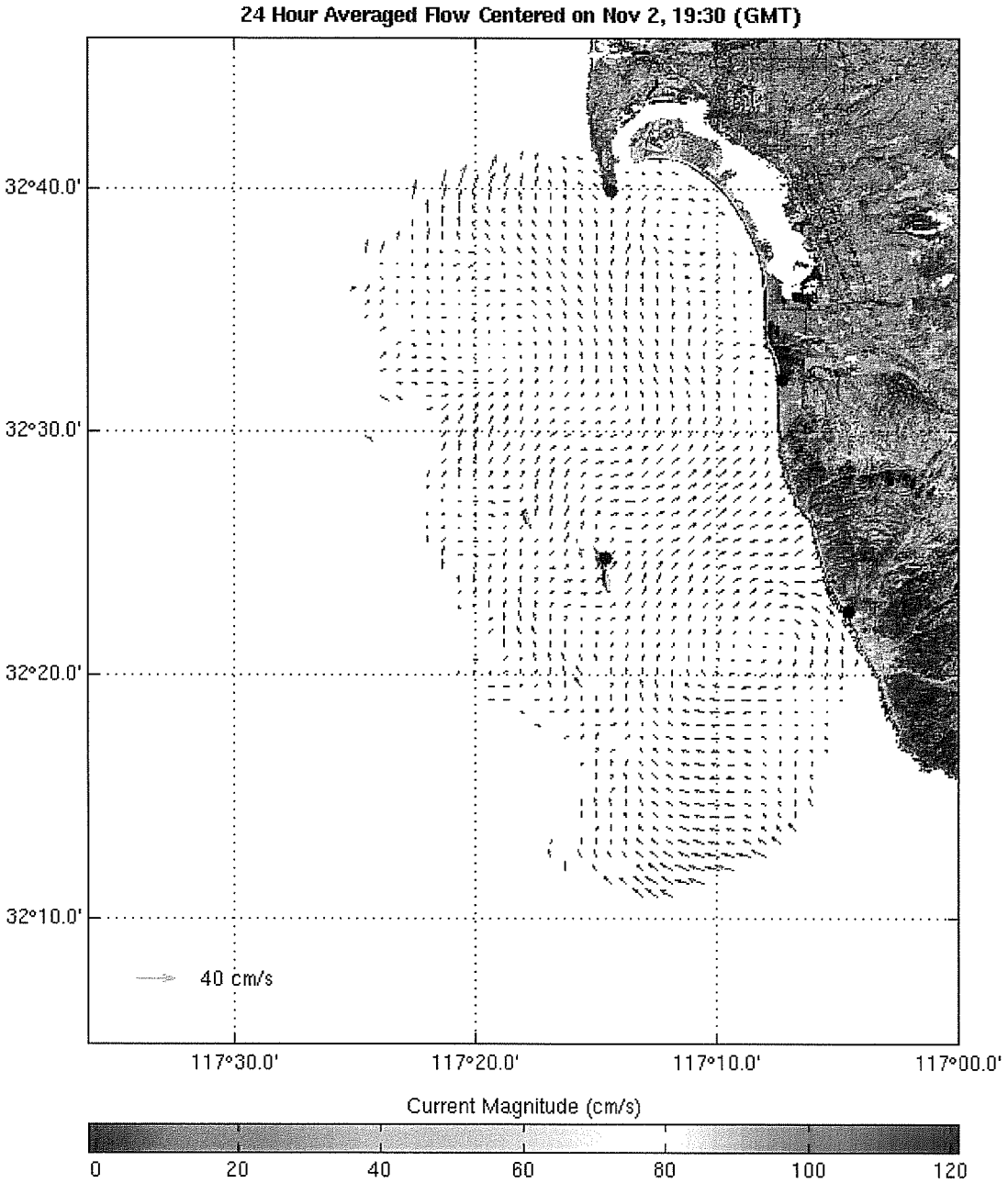


Figure 11. Clockwise eddies are also observed in the data as shown here on November 2nd, 2003. This eddy was observed offshore of the southernmost UABC site in a predominantly northward flow pattern.

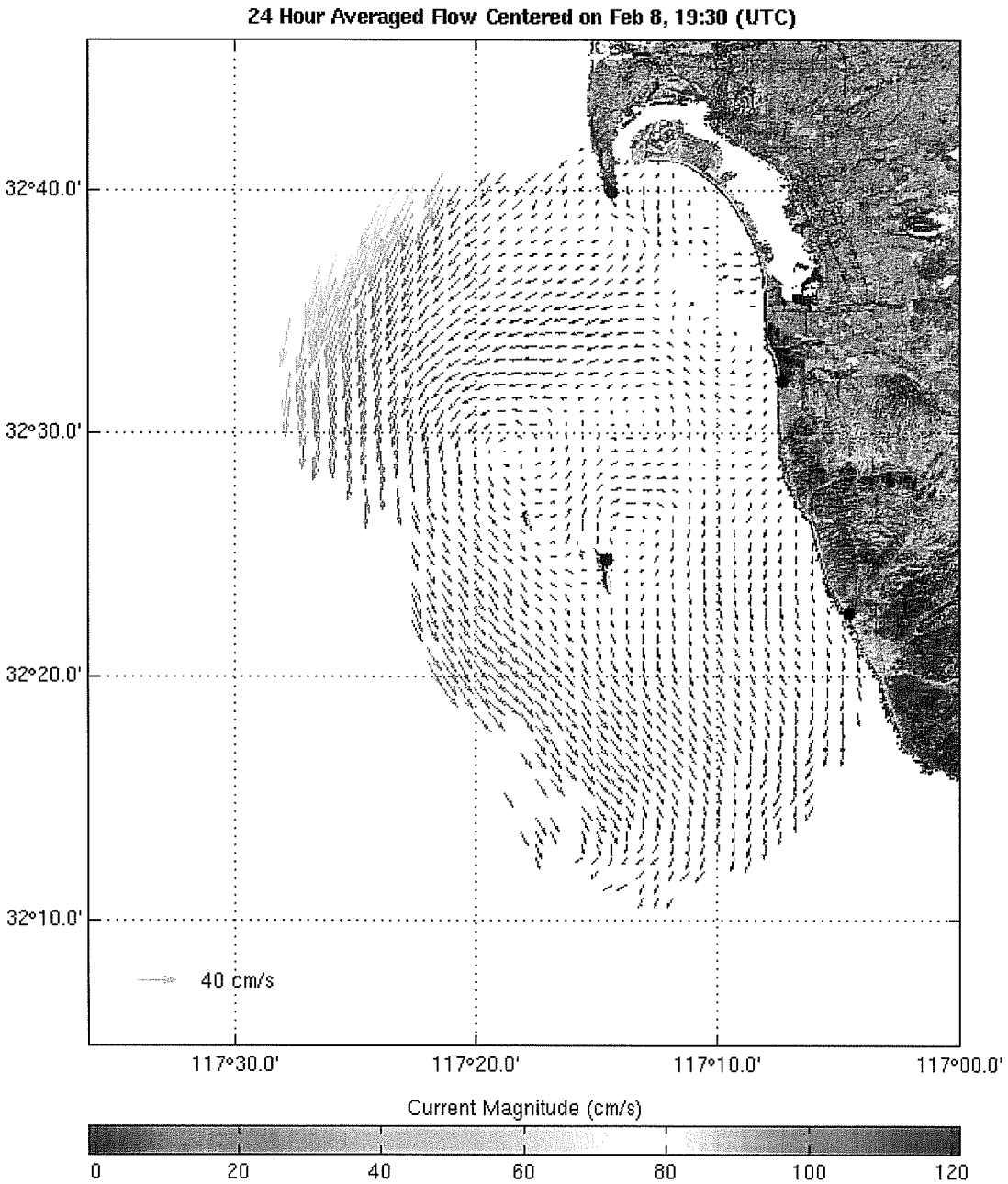


Figure 12. This flow pattern from February 8th, 2004 demonstrates the variation is space and orientation that eddies have in the region. Three eddies are observed in this region just north of the Coronado Islands. Two counter-clockwise eddies are situated to the north of a clockwise eddy and the three eddies seem to be interacting as flows converge in the center.

E. Nearshore Currents & Water Type Sampling

i. Site Preparation & Hardware Installation

By October 2002, the system design for a bottom-mounted Acoustic Doppler Current Profiler (ADCP) off of the end of the IB pier had been completed and fabrication was underway. An offshore piling required cleaning for installation of cable conduit from the pier to the instruments. Further development on the system was delayed until favorable conditions permitted the piling to be cleaned. In the meantime, the remaining supporting infrastructure on IB pier was developed along with tasks associated with the surf-zone current measurements (see section 2.4). By July 2003, the ADCP was deployed on a tripod (Figure 13) approximately 200 ft (61m) from the end of the IB pier. Data is then transmitted in real-time through cabling to the IB pier tower, wirelessly to the shore tower, then through a high speed cable modem back to Scripps. We began displaying real-time current profiles and wave data from the ADCP on the SDCOOS site on October 7th, 2003 following quality assurance.

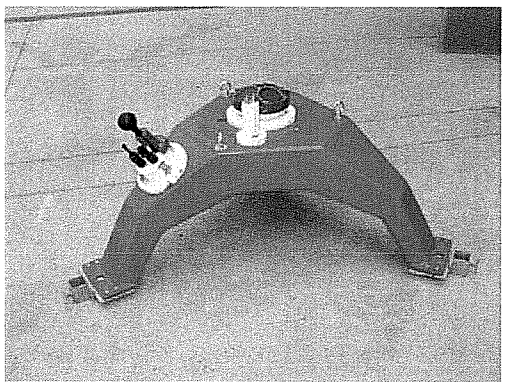


Figure 13. Underwater tripod with an acoustic doppler current profiler (ADCP) mounted in the center. The white pressure case on the side of the tripod is for connecting the ADCP to an underwater cable.

The data inventory for the waves ADCP shows a few large gaps spanning several weeks after the initial deployment in July 2003 followed by a relatively stable period from mid-October 2003 through the end of February 2004 (Figure 15). These large initial data gaps resulted from a number of power outages on IB pier. Many of these outages were not reported to SDCOOS staff which delayed troubleshooting and restarting the system. Several steps were taken to make the system more stable including the deployment of an uninterruptible power supply (UPS) for computers and software improvements enabling recovery from unplanned shutdowns. In addition, staff from the Imperial Beach Safety Center were asked to communicate power outages to SDCOOS staff so that the system can be restarted.

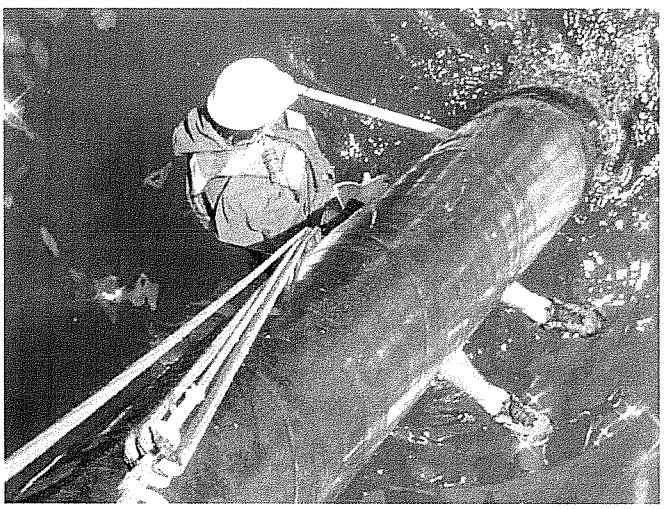


Figure 14. A bosun's chair was used to lower personnel to the waterline at low tide to clean growth off an offshore piling. A conduit for the underwater cable was attached to the clean piling using stainless steel clamps.

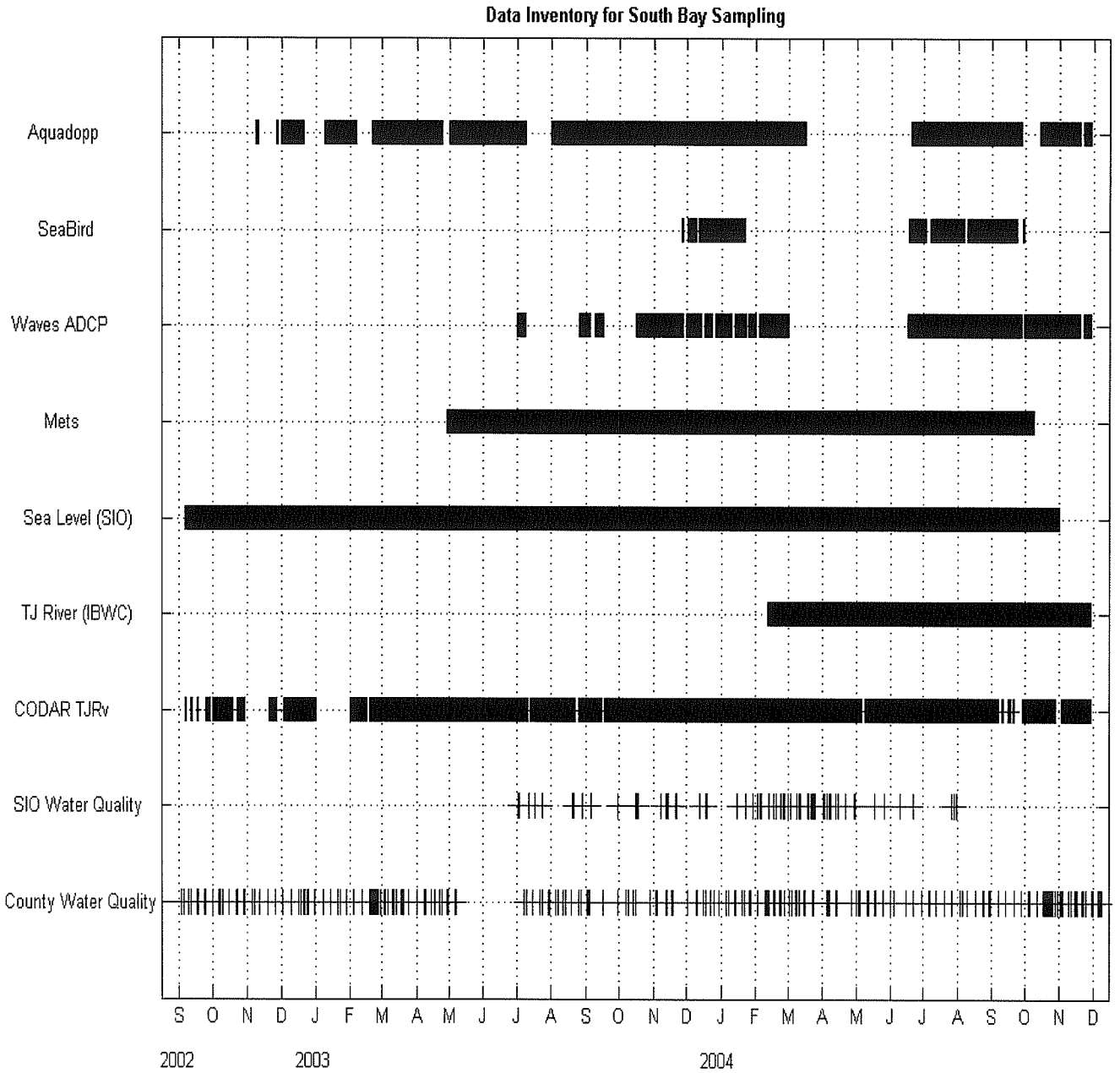


Figure 15. Data inventory for several SDCOOS instruments as of roughly October 2004. Deployment, recovery and gaps in the data record are discussed throughout the text for the SeaBird, waves ADCP and mets (meteorological instruments). CODAR TJ River is the alongshore water velocity extracted from CODAR data near the Tijuana River for determining where potentially polluted waters may advect. Sea Level data obtained from SIO and flow data for the Tijuana River collected by the IBWC have been added to data displayed on the SDCOOS web site to enable more comprehensive real-time analysis. Water quality samples collected by the county as well the enhanced bacterial monitoring program are shown to indicate where data overlap occurs.

The ADCP had to be recovered in early March 2004 when local teens caught their fishing lines on cables, tested their strength and ultimately caused irreparable damage to instrumentation. A major overhaul of the system was required due to this act of vandalism. The system was redeployed on June 16th, 2004 with the addition of a SeaBird instrument (see section 2.4 for its initial deployment) which measures temperature, conductivity (salinity) and density and a WetLabs FLNTUS optical sensor for measuring water turbidity and plant biomass (chlorophyll). The SeaBird began having communication problems in late September 2004 and was repaired. The ADCP continues in normal operation today.

ii. Examples of Data

The following plots are examples of data obtained from the ADCP, SeaBird & WebLabs optical instrument. Real-time versions of these plots are also available on the SDCOOS web site.

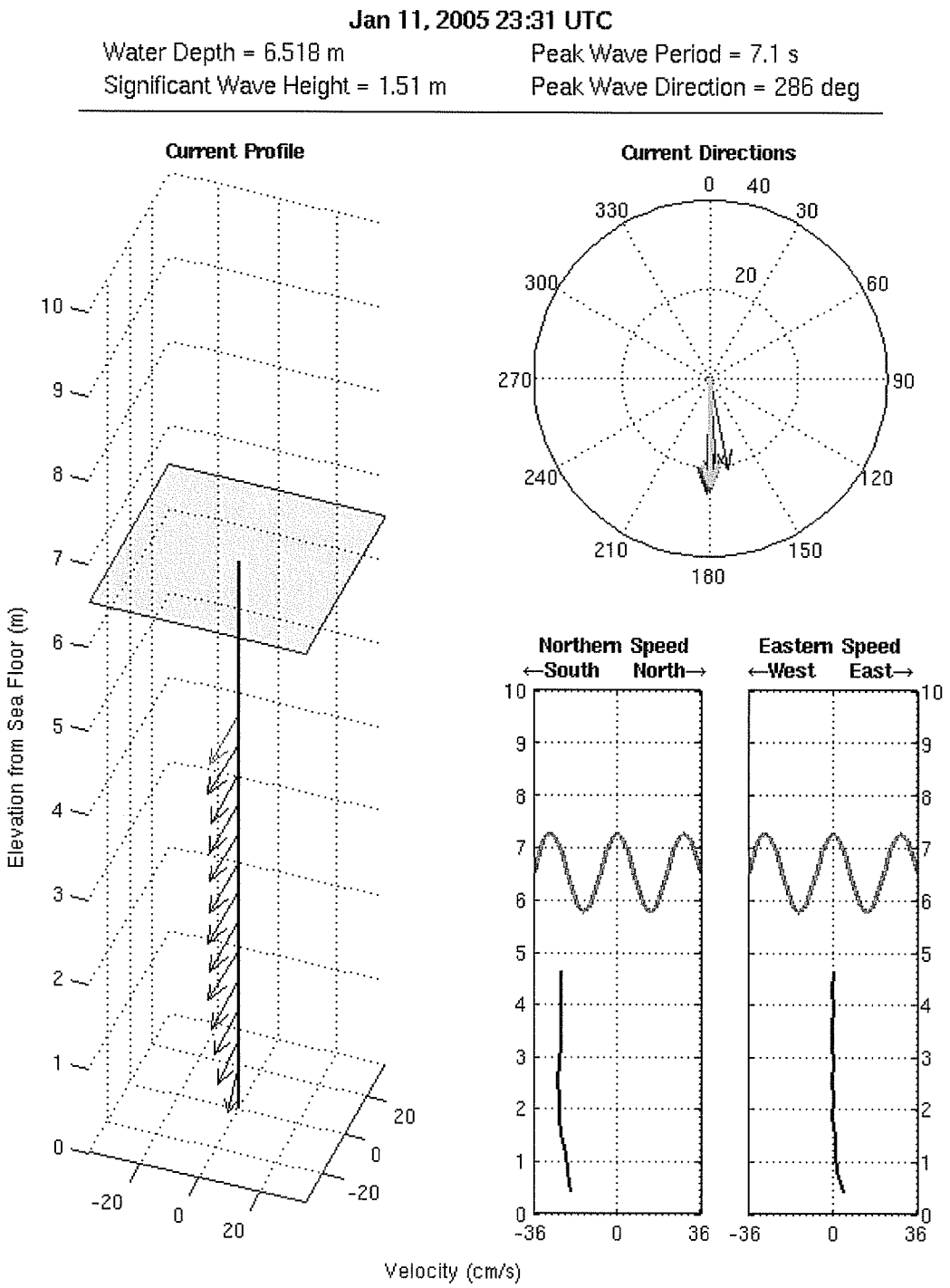


Figure 16. Current profile information obtained from the ADCP. The left panel shows a three-dimensional view of the water level and current direction and magnitude. The upper right panel shows the current direction and magnitude as viewed directly overhead while the lower right panel shows the water level, wave height and current magnitude in the cardinal directions.

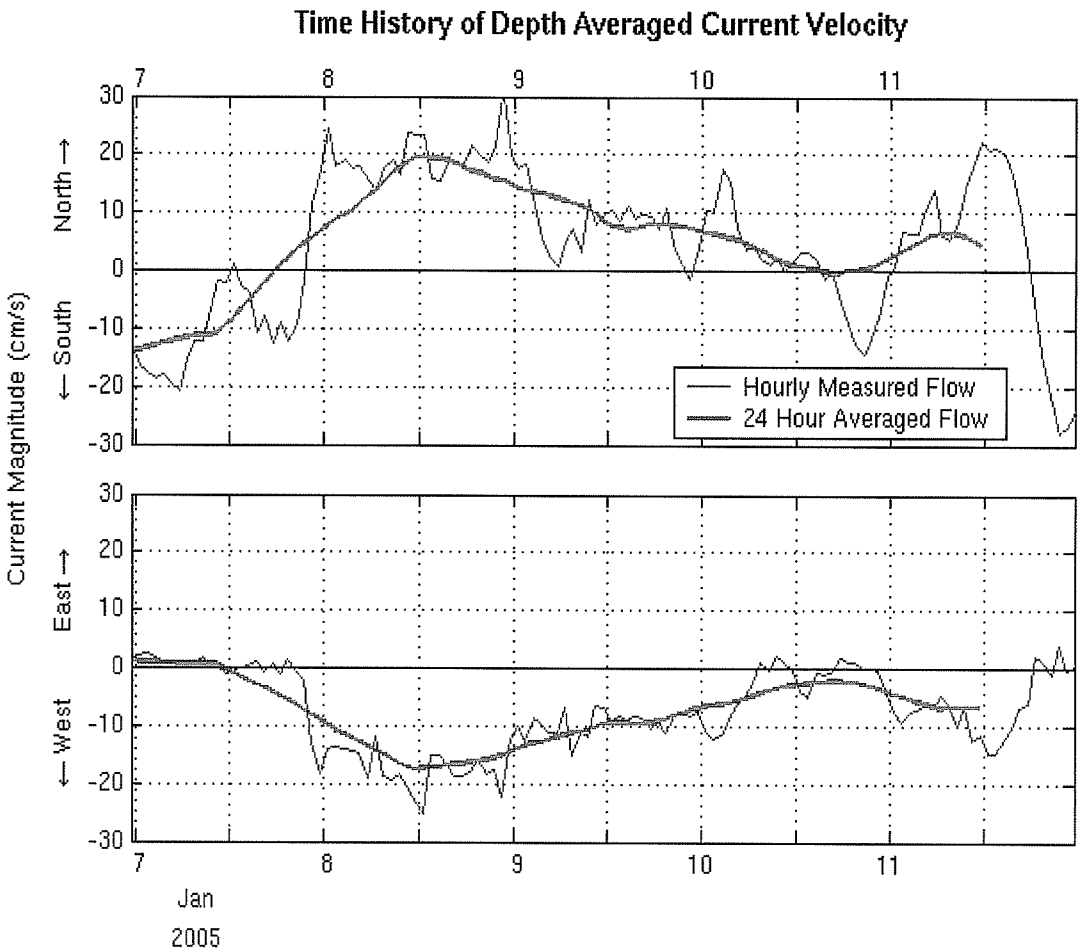


Figure 17. Time history of alongshore (north/south) and cross-shore (east/west) current magnitude as measured by the ADCP.

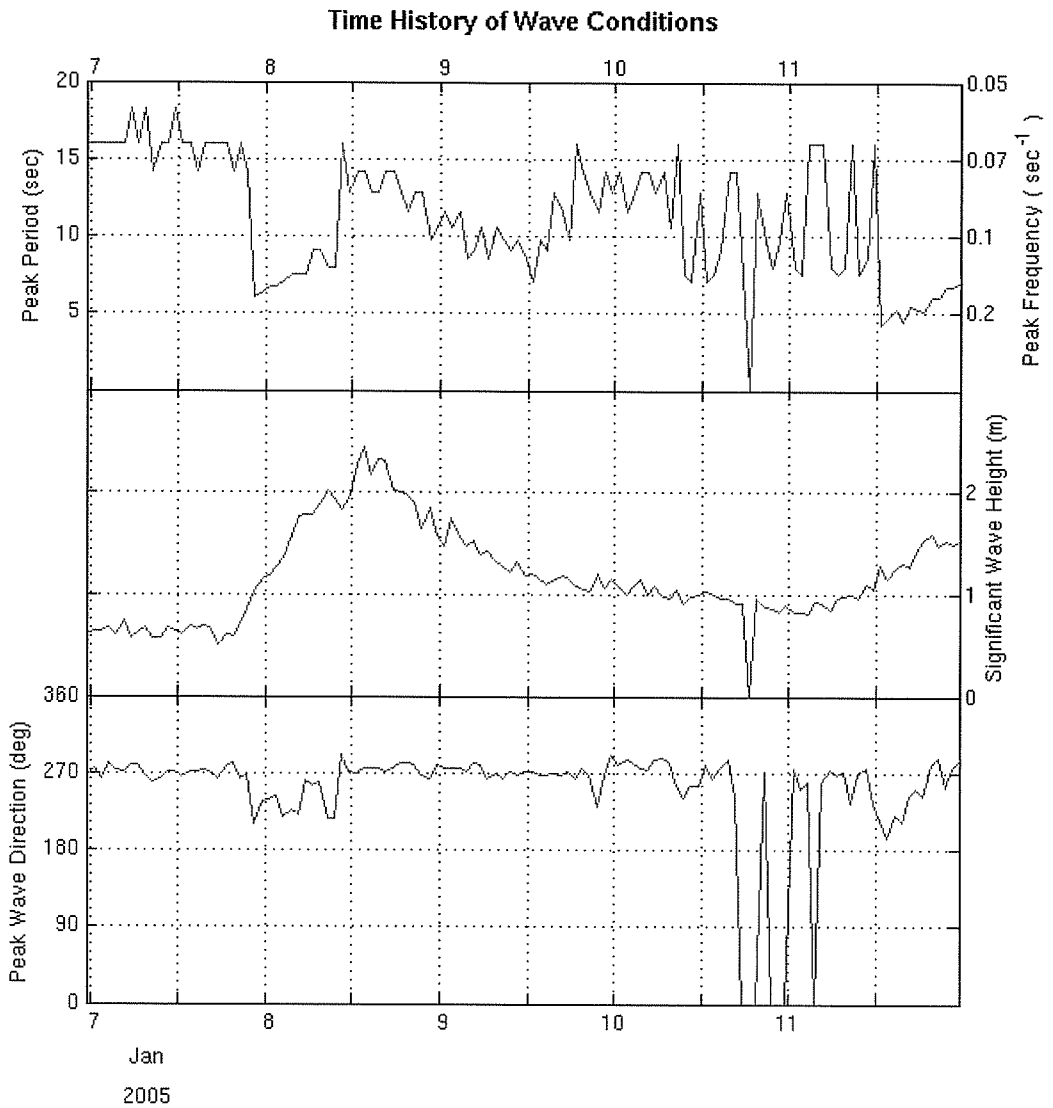


Figure 18. Time history of wave conditions at IB Pier as measured by the ADCP.

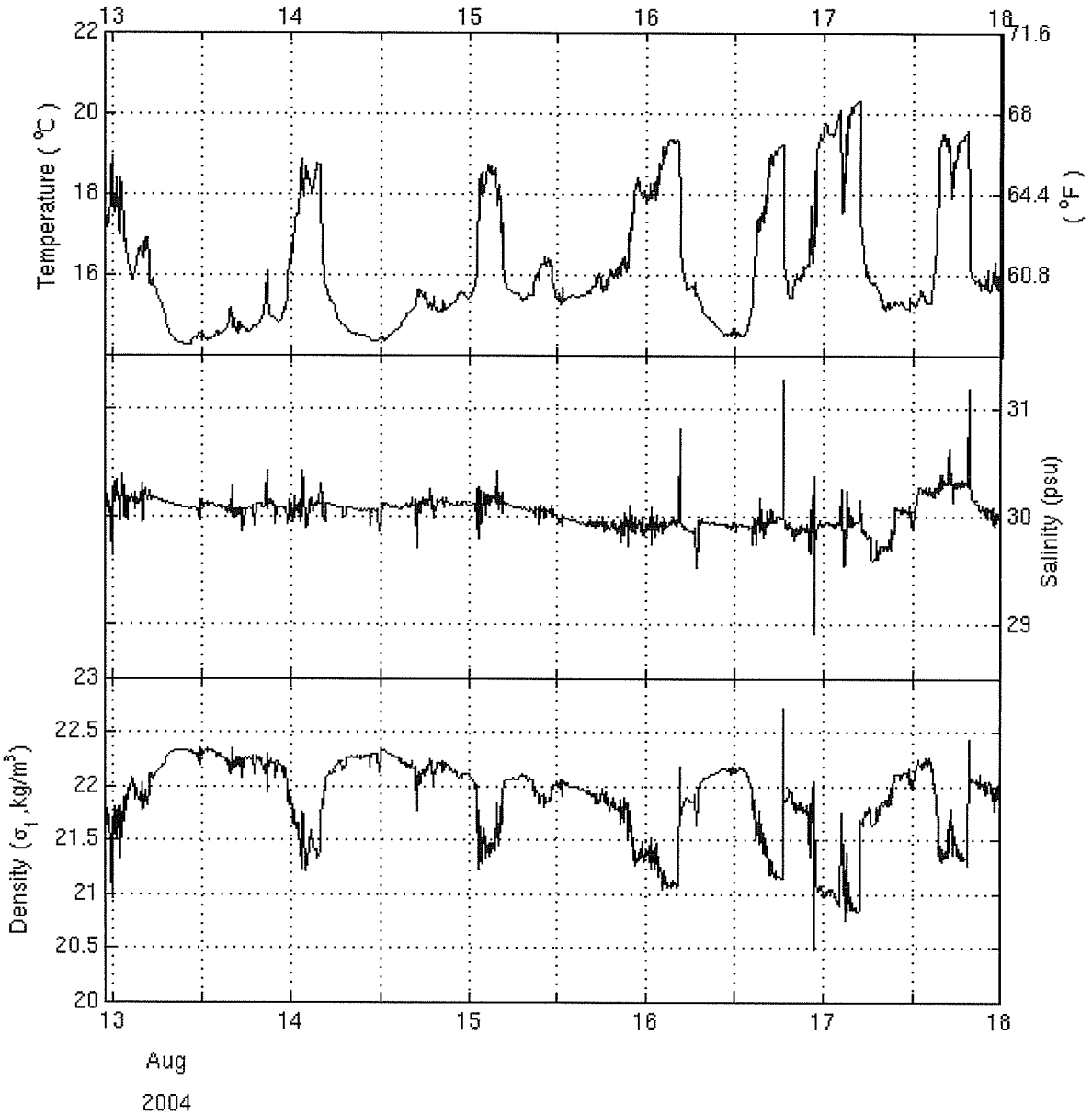
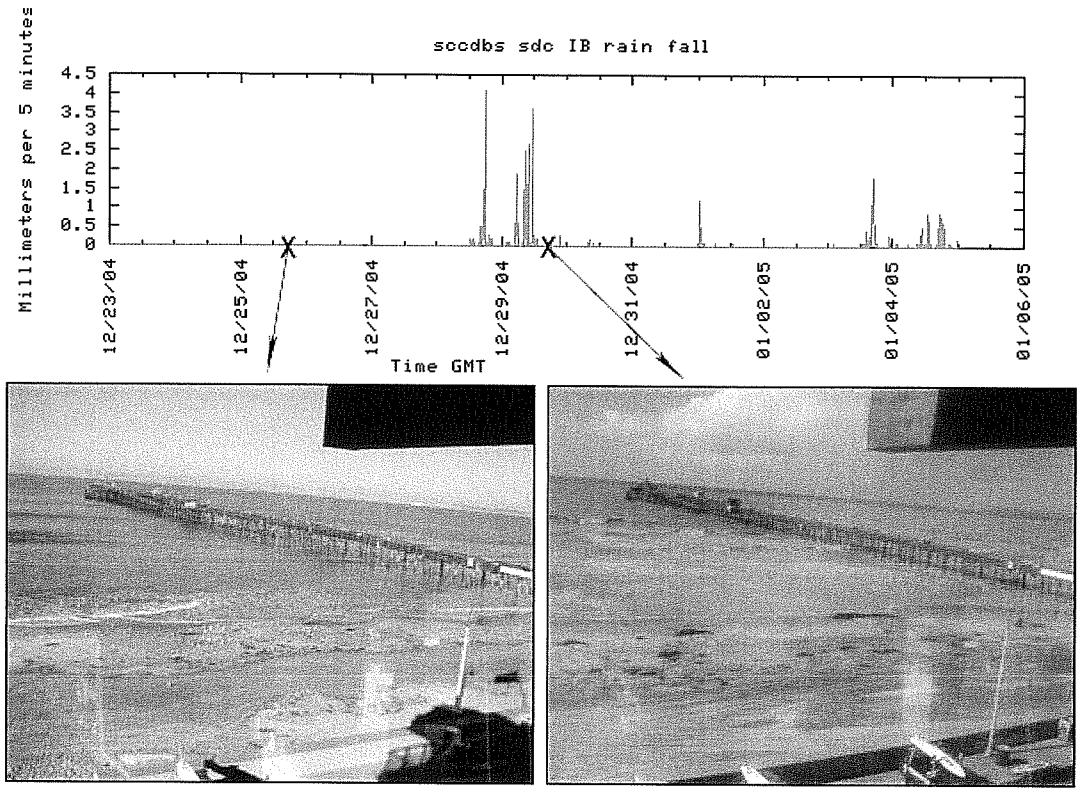


Figure 19. Time history of Temperature, salinity & density at the end of the IB pier as measured by the SeaBird.



Above: Ocean water *before* storms (Dec 25, 2004).

Above: Ocean water *during* storms (Dec 29, 2004).

F.

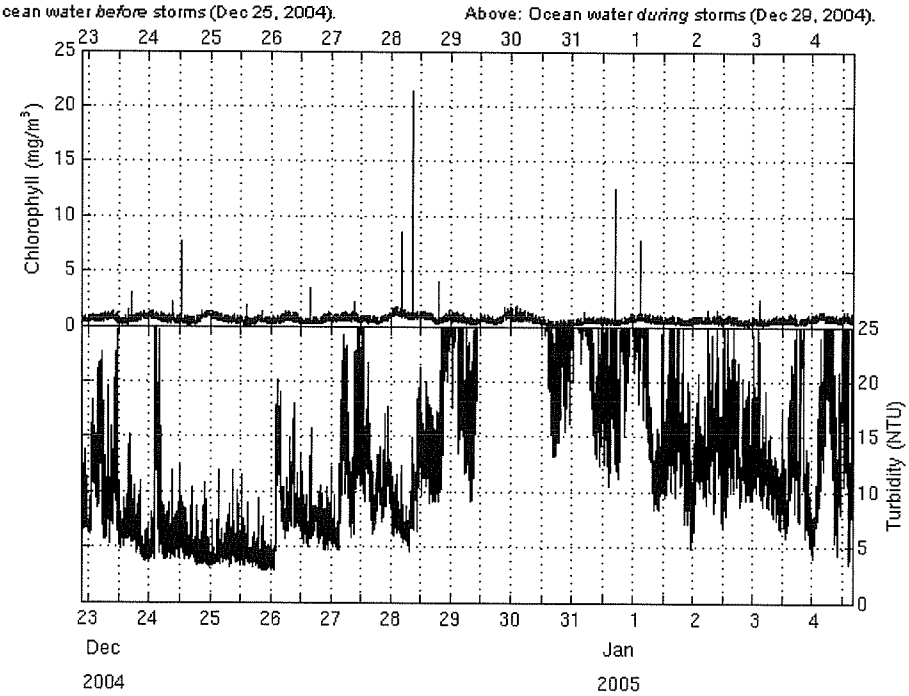


Figure 19. Chlorophyll (plant biomass indicator) and water turbidity measured by the WetLabs optical instrument off the end of IB pier (bottom panels) has shown good correspondence with rainfall measured at IB pier (top panel) and images obtained from the IB web-cam (center). The web-cam image acquired on December 25th, before the storm, shows clear blue water while turbidity measurements are low. Immediately following the storm, on December 29th, web-cam images show waters have changed from clear blue to murky brown, which is reflected in high turbidity measurements, as the Tijuana River plume was advected northward into Imperial Beach. This is one example of how turbidity measurements may be used by city staff to assess water visibility and the potential presence of Tijuana River plume water.

F. Surfzone Currents & Water Quality Sampling System

i. Site Preparation & Hardware Installation

Prior to installing instruments on the IB pier, computers and supporting infrastructure were installed on both the pier and shore lifeguard towers. A computer network was established on shore at the at the safety center with a 2-way directional wireless antenna to send and receive data from the pier tower. On the pier tower, cabling was routed down to instruments on the pier pilings from a computer cage inside the tower. Finally another 2-way directional antenna was mounted on the pier tower to enable data communication back to Scripps as well as remote management of the instruments on the pier.

The current meter portion of the surfzone system had been designed, purchased, and installed on the south side of IB pier's piling 28 by October 2002. The pier piling was cleaned by Scripps divers prior to installing the instrument (aquadopp) inside a copper nickel tube to protect it from the elements and biofouling. The mounting system had survived several storms. However, quality assurance on the data indicated that the current meter had been rotated by large waves during winter storms. Despite several attempts to rotate the instrument, the current meter was not rotated until August 3rd, 2004 when conditions were favorable and personnel were available. Ever since the instrument was rotated into its proper orientation, it has been producing reliable data that agrees with measurements from CODAR and ADCP data as well as qualitative observations made by IB lifeguards.

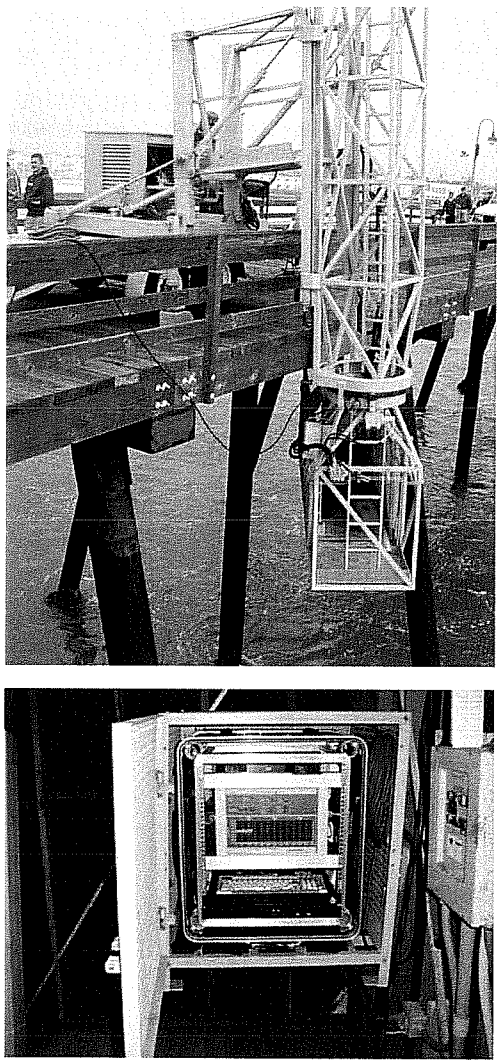


Figure 20. Scripps staff from the Marine Physical Laboratory installing a signal cable on the underside of the Imperial Beach Pier (top). This cable connects the current meter to the lifeguard tower allowing real-time access to the data. Also shown is the computer system that was installed in the lower floor of the lifeguard tower (bottom). This system forms the hub for the environmental sensors that are located on the pier.

The water quality system consists of a WebLabs FLNTUS optical instrument for measuring water turbidity and chlorophyll and a SeaBird for measuring ocean temperature and salinity. The system was deployed November 24th, 2003 on a pier piling directly beneath the lifeguard tower. Prior to deployment, the piling was cleaned of barnacles and the FLNTUS was deployed by a team of both divers and top side personnel. Cabling from the instrumentation to

the logging

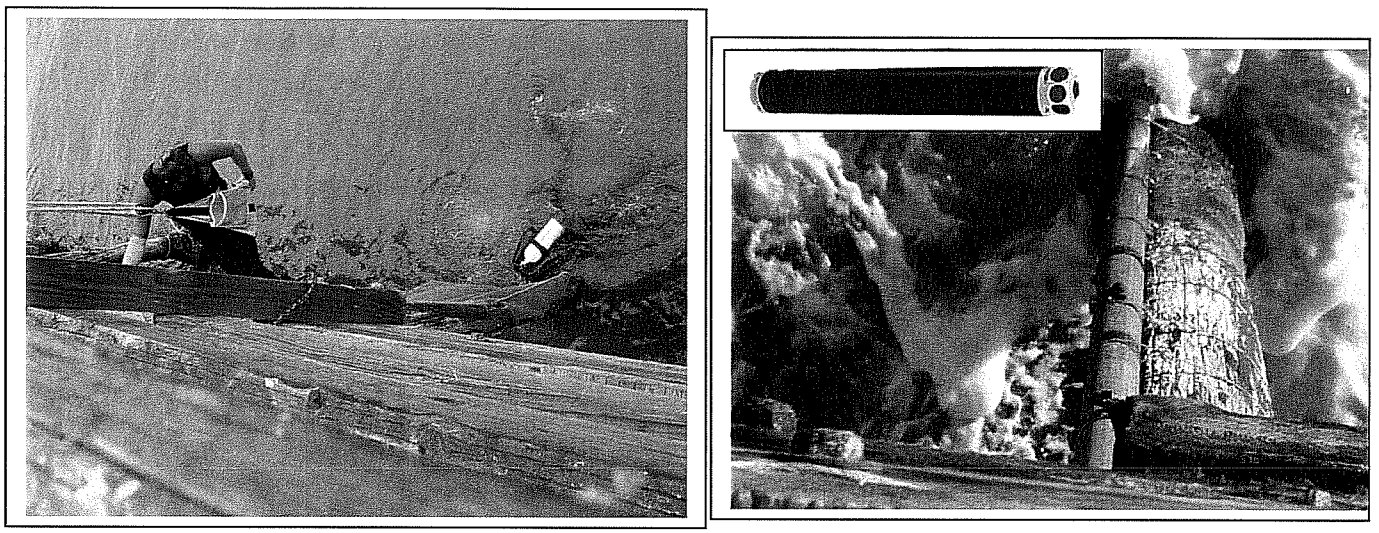


Figure 21. Photograph of divers installing the equipment onto a piling on the south side of the Imperial Beach Pier (left). Axel Pierson is suspended from a bosun's chair guiding the hardware into place. The current meter mounted to the pier piling (right). The current meter (see inset) fits into the end of a copper/nickel pipe with the sensing head sticking 2" out of the end. This pipe is banded to the wood piling by stainless steel bands. The instrument is protected from the elements and biofouling inside the pipe.

system inside the pier tower was completed on December 2nd, 2003 enabling real-time transmission back to Scripps. The surf zone proved to be too harsh of an environment for these relatively sensitive instruments. By late January 2004, we had to recover our water quality system due to storm damage. The instruments were securely mounted to the pier piling but the communications cables were damaged and began transmitting bad data. The instruments were sent back to the factory for repair and recalibration while a new deployment scheme was devised. With recovery of the bottom-mounted waves system in early March 2004, we decided to engineer an integrated system with both the water quality sensors and the waves ADCP mounted on the tripod (see section 2.3). This provided a much more stable environment for the water quality instruments although we encountered problems with fishing line getting wrapped around the optical instrument. After another recovery and redeployment in December 2004, the optical instruments are now working reliably and have shown responses in water turbidity following several large

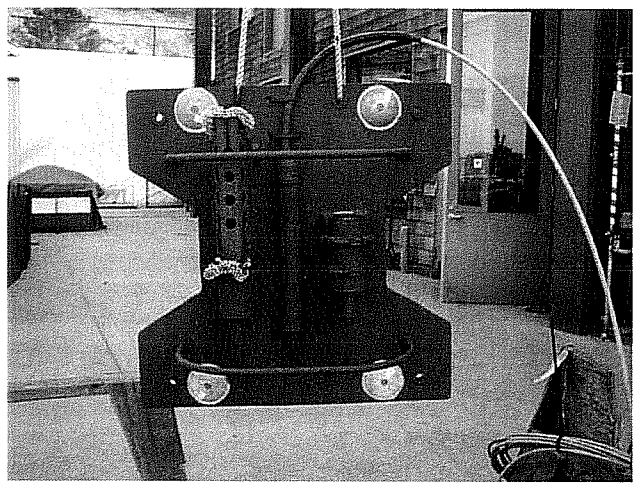


Figure 22. The water quality system ready to be deployed. The system is coated with anti-fouling paint. The copper 'brillo' pads are fixed to either end of the conductivity and temperature probe to provide additional anti-fouling protection. The armored cable provides power and communication to the system.

storms.

ii. Examples of Data

Figure 23 is an example of data obtained from the aquadopp current meter in the surf zone. Similar example plots for the water quality sensors (SeaBird & WebLabs optical instrument) can be seen in section 2.3.2. Real-time versions of all plots are available on the SDCOOS web site.

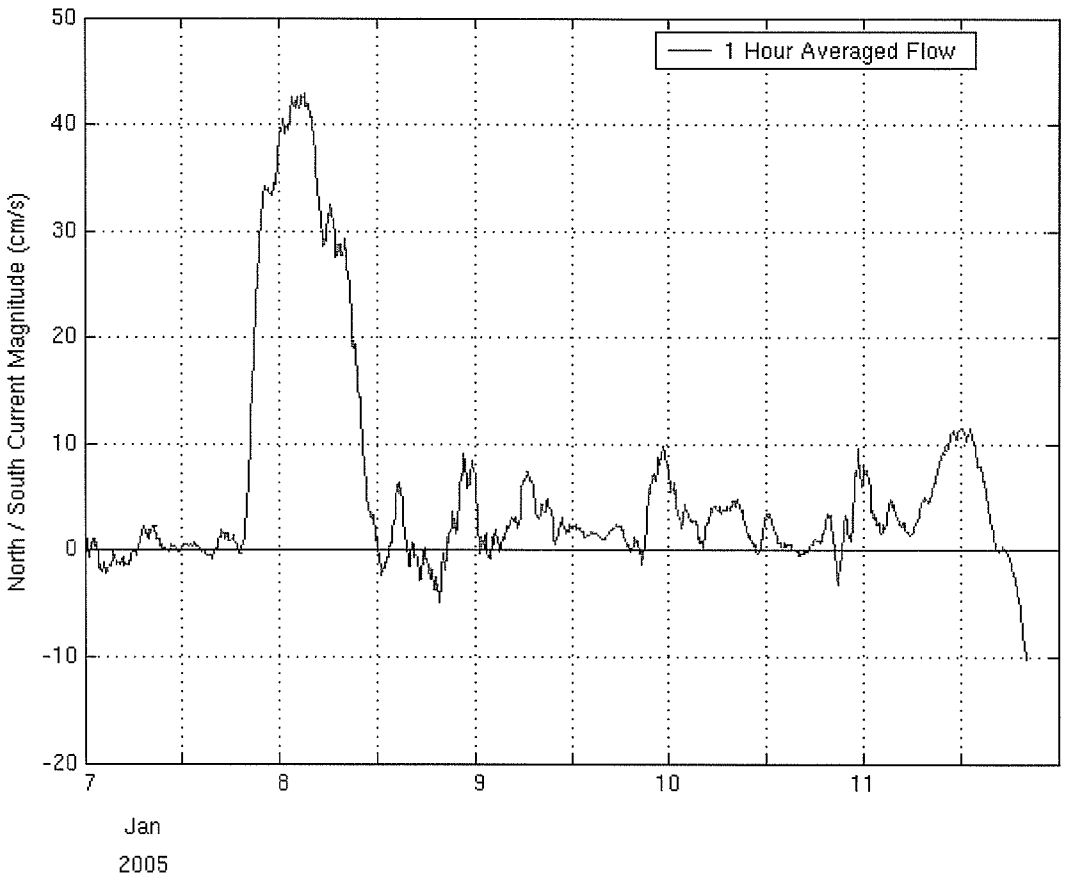


Figure 23. Hourly averaged alongshore flow in the surfzone at IB pier. Positive values are northward flow while negative values are southward flow. The large northward event on January 8th coincides with large amounts of rainfall resulting in high turbidity and continued beach closures.

G. Imperial Beach Pier Meteorological Station

By leveraging funds from other federal programs, we were able to install a meteorological station on the roof of the IB pier tower. The station provides atmospheric pressure, humidity, rainfall rate, air temperature, solar radiation wind speed and wind direction in real-time through existing infrastructure installed for other IB pier sensors. The station was installed in April 2003 and had has provided reliable data ever since. The wind and rain data are of

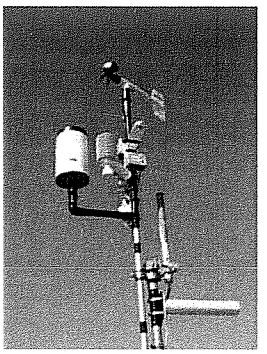


Figure 24. Meteorological station installed at IB pier.

particular interest since winds play an integral role in driving coastal flow and local rainfall data are critical to understanding the influence of local runoff on beach water quality. Plots of all data are available in real-time at the SDCOOS web site. An example of the rainfall rate plot is shown in Figure 24.

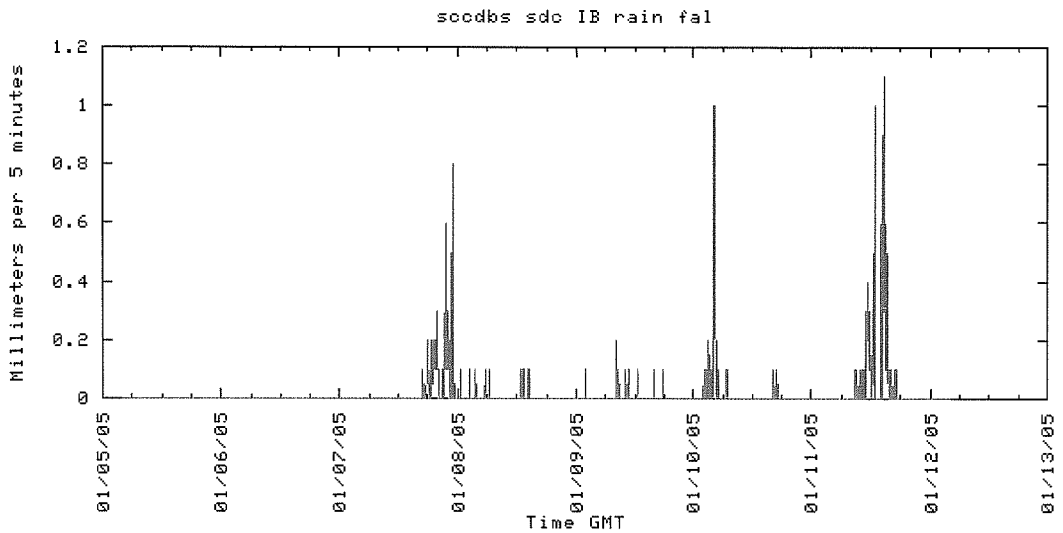


Figure 25. Rainfall rate data as presented on-line at the SDCOOS web site in real-time. Several rain events occurred during early January 2005. Note the rain event on the 8th and corresponding northward flow observed by both the aquadopp in the surf zone (Figure 23) and the ADCP further offshore (Figure 17).

H. Water Column Stratification Measurement System

i. Buoy Construction & Deployment

The water column stratification measurement system was designed and built by April 2003. The system consisted of a temperature string for measuring water temperature at 4m increments from the surface to the sea floor, an ADCP (provided through separate funds) for measuring currents through the water column and a GPS for tracking the buoy. An interim system consisting of another temperature string with 16.4ft (5m) resolution through the water column was deployed at the wye of the IBWC South Bay Ocean Outfall, near the planned deployment site for the buoy. Although this was intended as an interim system, it continues to be serviced today. The interim system is not real-time but, once data is recovered, it is processed and posted to the SDCOOS web site. The buoy system was deployed on September 5th, 2003 in 92ft (28m) water depth near the center of the wye diffuser of the South Bay Ocean Outfall.

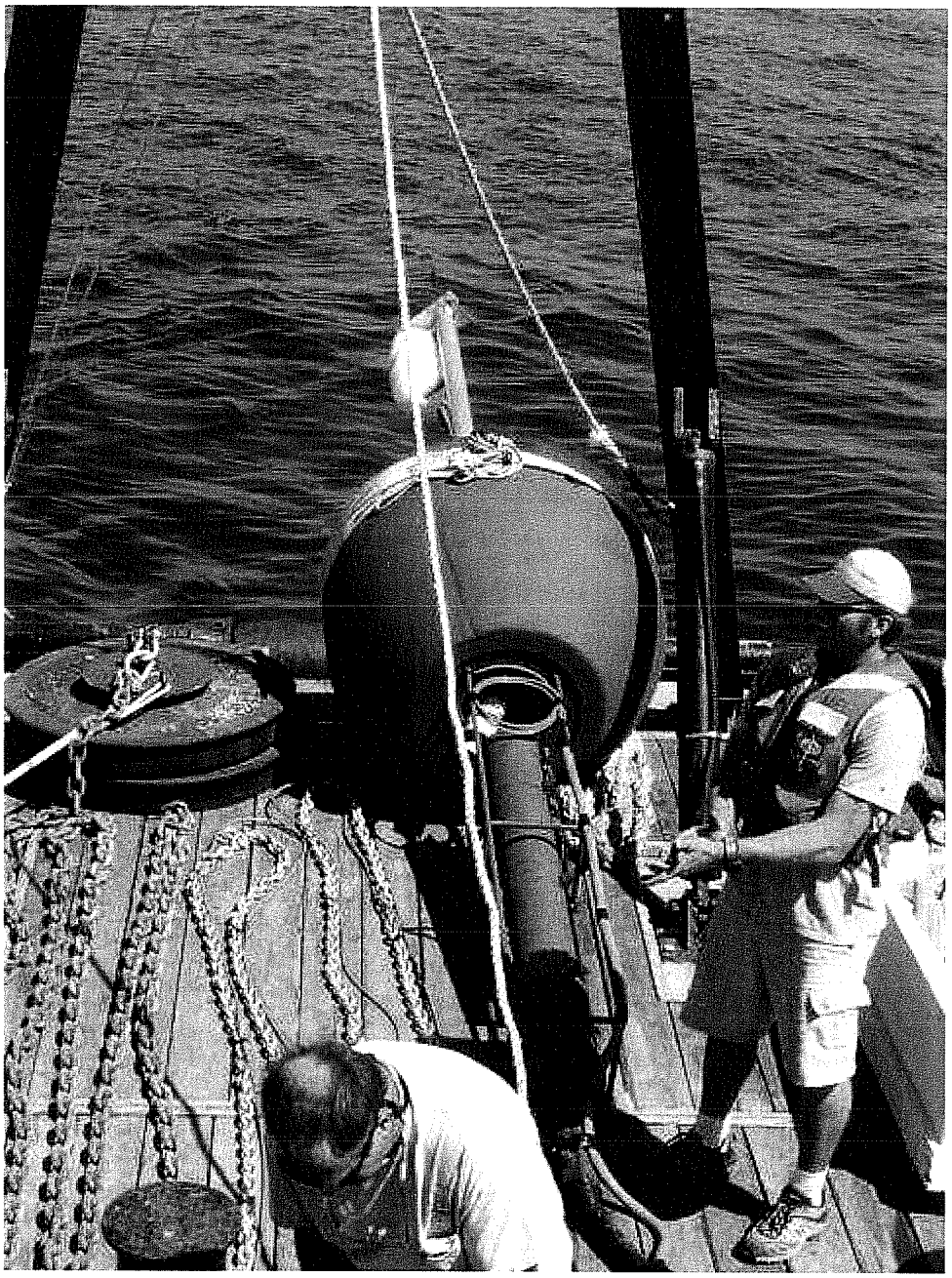


Figure 26. The SDCOOS buoy and mooring prior to deployment near the South Bay outfall. The workboat Sammy G was used for deployment of the mooring and its 2000 pound anchor.

Real-time telemetry of data back to Scripps was established through a wireless link to the IB pier tower, allowing access to real-time water column stratification at the IBWC outfall location. ADCP data was also transferred, but not processed and posted in realtime. In February 2004 there was an apparent theft of the hardware and all data communication with the buoy was lost. Fortunately, IB lifeguards spotted the buoy on September 29th, 2004 close to Mexican waters and SDCOOS personnel were able to recover the hardware. An autonomously recording temperature string has also been in place and providing us continuous observations of stratification at the site. This back up measurement platform allowed us to continue the time series for the duration of the project. Support for additional moorings would be a logical expansion to SDCOOS.

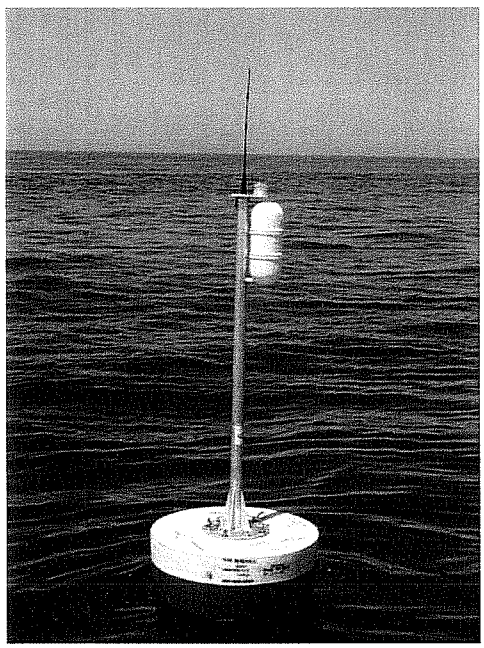


Figure 27. The SDCOOS buoy deployed at its mooring location. The buoy was designed with minimal structural components to prevent vessels from tying off to the buoy and to protect instruments from vandalism. A radar reflector (the wide plastic object) and a solar powered flashing light notifies vessels of its presence in the water. In addition, a Notice to Mariners was filed with the U.S. Coast Guard to identify the SDCOOS buoy in nautical charts of the region. The black antenna at the top of the buoy allows data to be telemetered to shore.

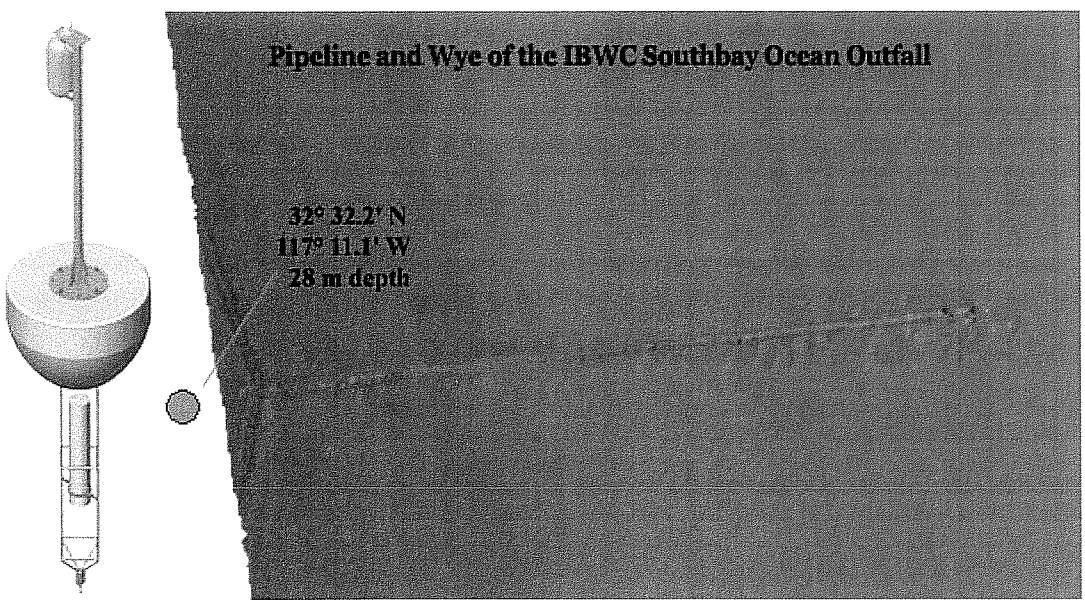


Figure 28. Multibeam bathymetry map showing the IBWC pipeline and diffuser wye and the relative buoy location.

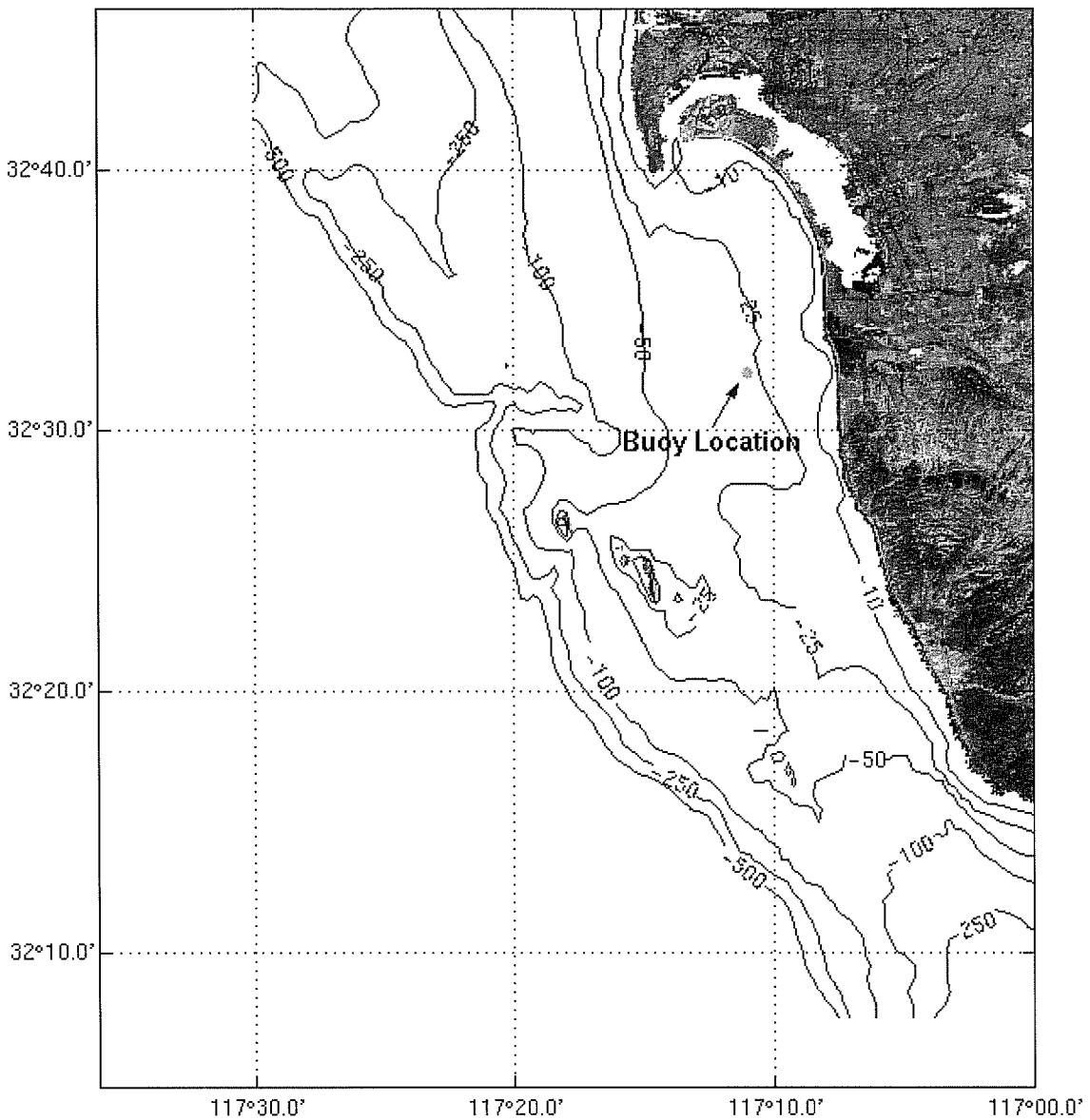


Figure 29. A map of the San Diego South Bay region showing bathymetry contours and the location of the SDCOOS buoy at the South Bay outfall.

ii. Examples of Data

The following figures provide data examples of the information provided by the ocean buoy via the SDCOOS web site.

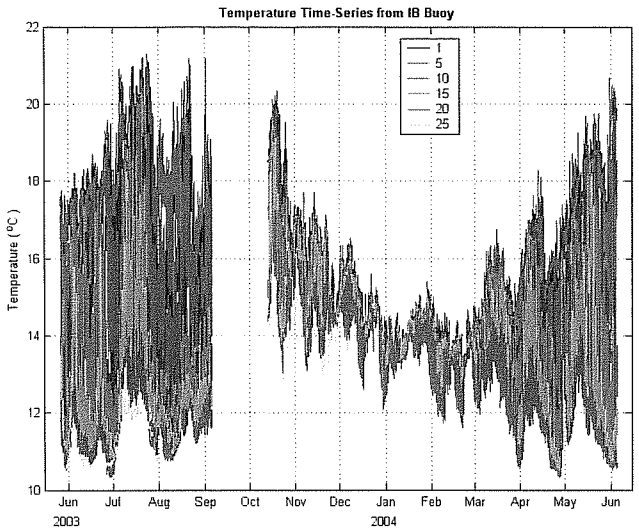


Figure 30. Temperature data collected over one year from the temperature string, which is maintained at the IBWC outfall location. Different colored lines indicate water temperature from different depths (in meters). Temperatures spread over a wide range related to with depth occur when the water column is stratified, reducing exchange of deep water with surface waters. When temperatures from several depths converge, as seen in winter months, then the water column is well mixed and deep water exchange with surface waters is facilitated. During times of weak stratification, outcropping of the outfall plume is possible.

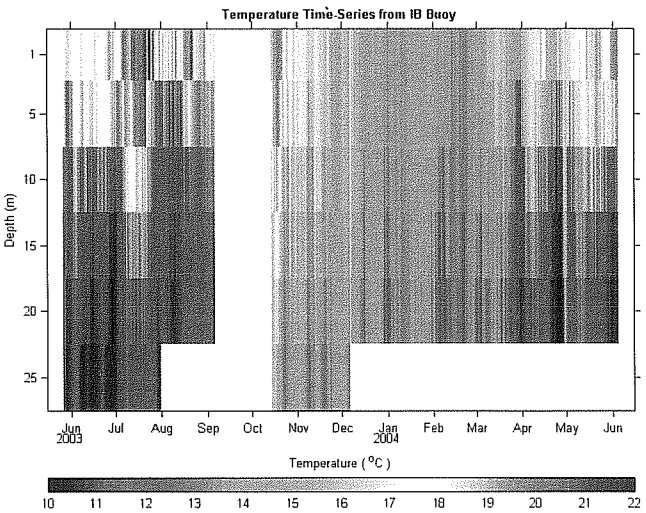


Figure 31. This time-series data is the same as that shown in Figure 29 except that ocean temperatures are mapped as colors here with the depth spread out in the y-axis. Weak stratification in winter months is also apparent in this plot as the entire water column cools to approximately 59°F (15 °C). Note that periods of weak stratification also occur throughout the remainder of the year.

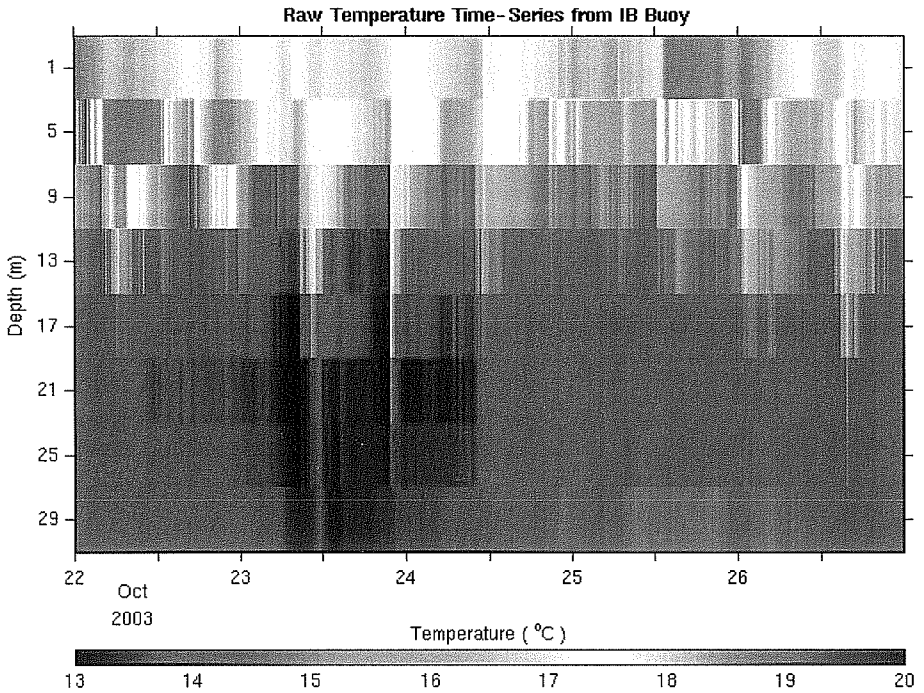


Figure 32. Ocean temperature data from the real-time buoy system is shown above. These same plots were posted to the SDCOOS web site in real-time when the buoy was active enabling periods of weak stratification to be detected and monitored.

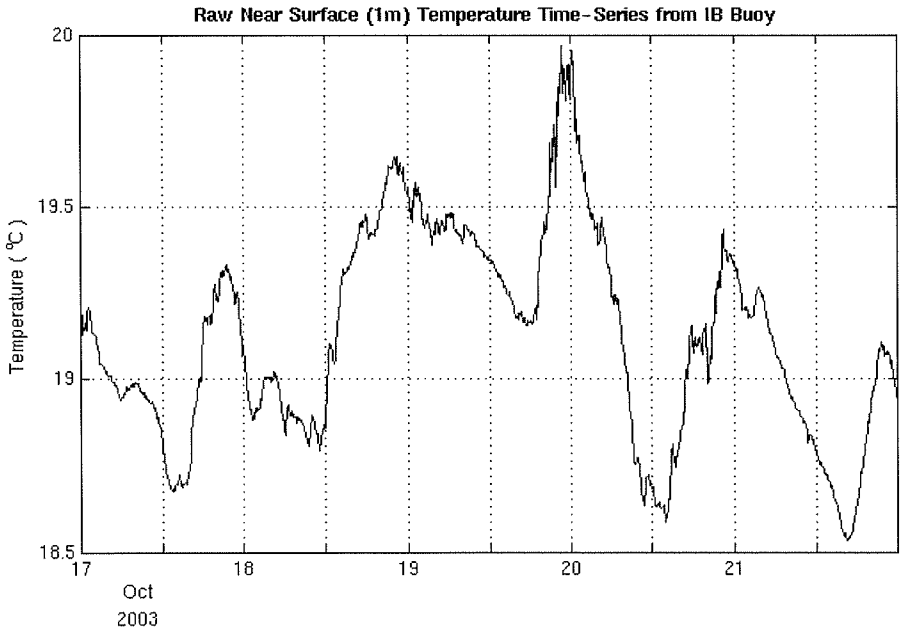


Figure 33. Surface temperature was extracted from the real-time buoy data and plotted as shown above on the SDCOOS web site.

I. Central Data Acquisition & Real-time Data Distribution System

The SDCOOS web page (http://www.sdcoos.ucsd.edu/) established at the beginning of the program has grown dramatically and continues at present. Instead of providing a detailed timeline of the additions and changes to the web site it will suffice to say that as instruments were deployed in the field there were parallel efforts at Scripps to bring the data on-line in real-time after initial quality assurance and control. The following is a summary of the various data products that are (or were at one time) available on the web site as well as some of its roles in facilitating data aggregation, distribution and interpretation.

Figure 34. SDCOOS home page, www.sdcoos.ucsd.edu.

The SDCOOS Home Page has quick links to IB weather information and ocean surface current maps. Links to pages highlighting environmental events are also placed here when they occur. For example, web pages were made during the November fires in 2003, the Bight 03 regional monitoring program, and the US Coast Guards Spill of

National Significance training exercise. A web page of data and imagery from recent storms is currently posted. The home page menu also provides links information about the program, background on the Clean Beaches Initiative Projects, partnership information, and related documents including the quarterly reports.

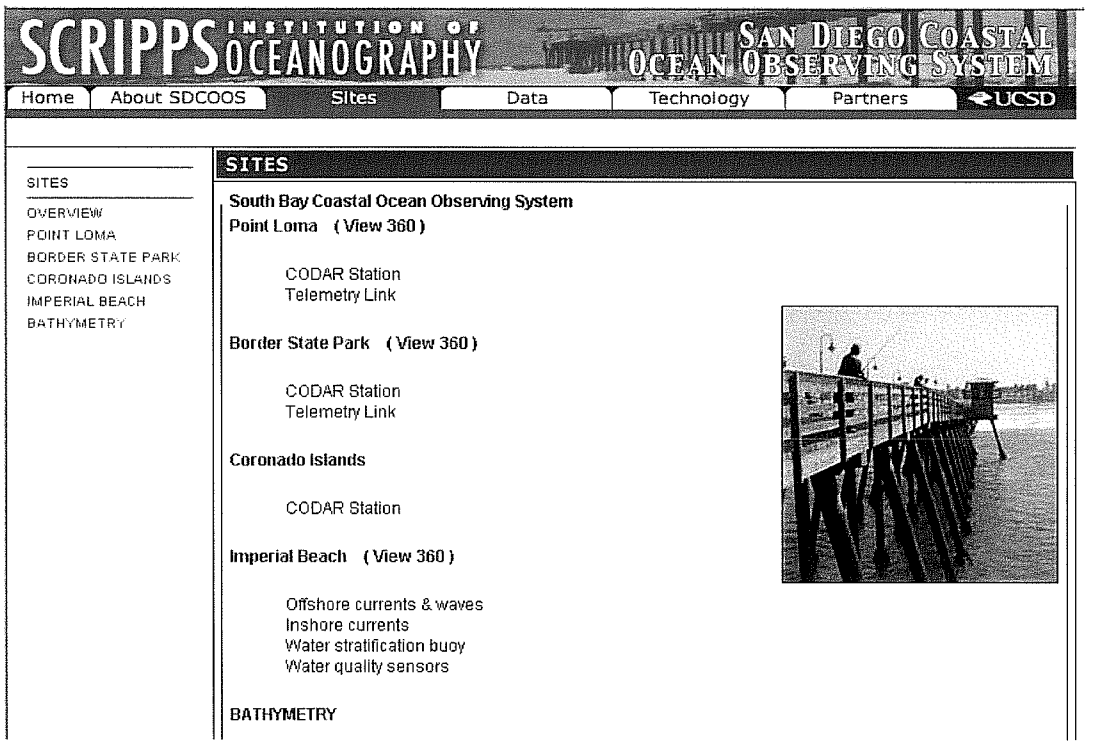


Figure 35. SDCOOS Sites page containing information about equipment deployed at each location.

The 'Sites' page outlines where equipment is deployed, some information about its configuration and pictures of the location. Interactive 360° views are also available for each site.

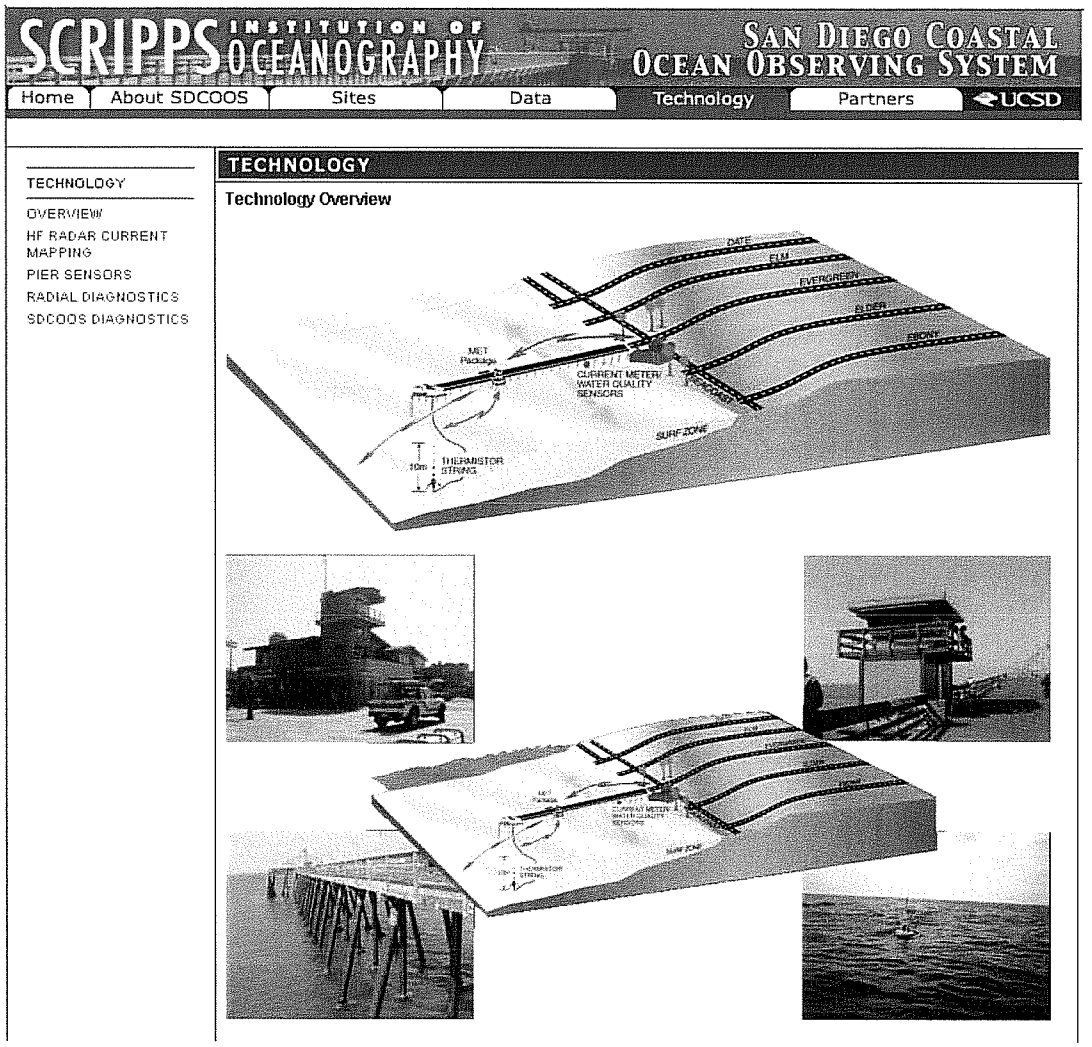


Figure 36. SDCOOS technology overview of equipment and wireless communication at IB pier.

The 'Technology' page provides background of the principles behind CODAR operation and an overview of some instruments and wireless technology used at IB pier to gather and relay data (shown above). Two other diagnostic pages are currently available; (1) Radial Diagnostics and (2) SDCOOS Diagnostics. The Radial Diagnostics page is used by operators to monitor the health of CODAR instruments at each site by cross comparison. The SDCOOS Diagnostics page is used by SDCOOS staff to monitor data flow to the web.

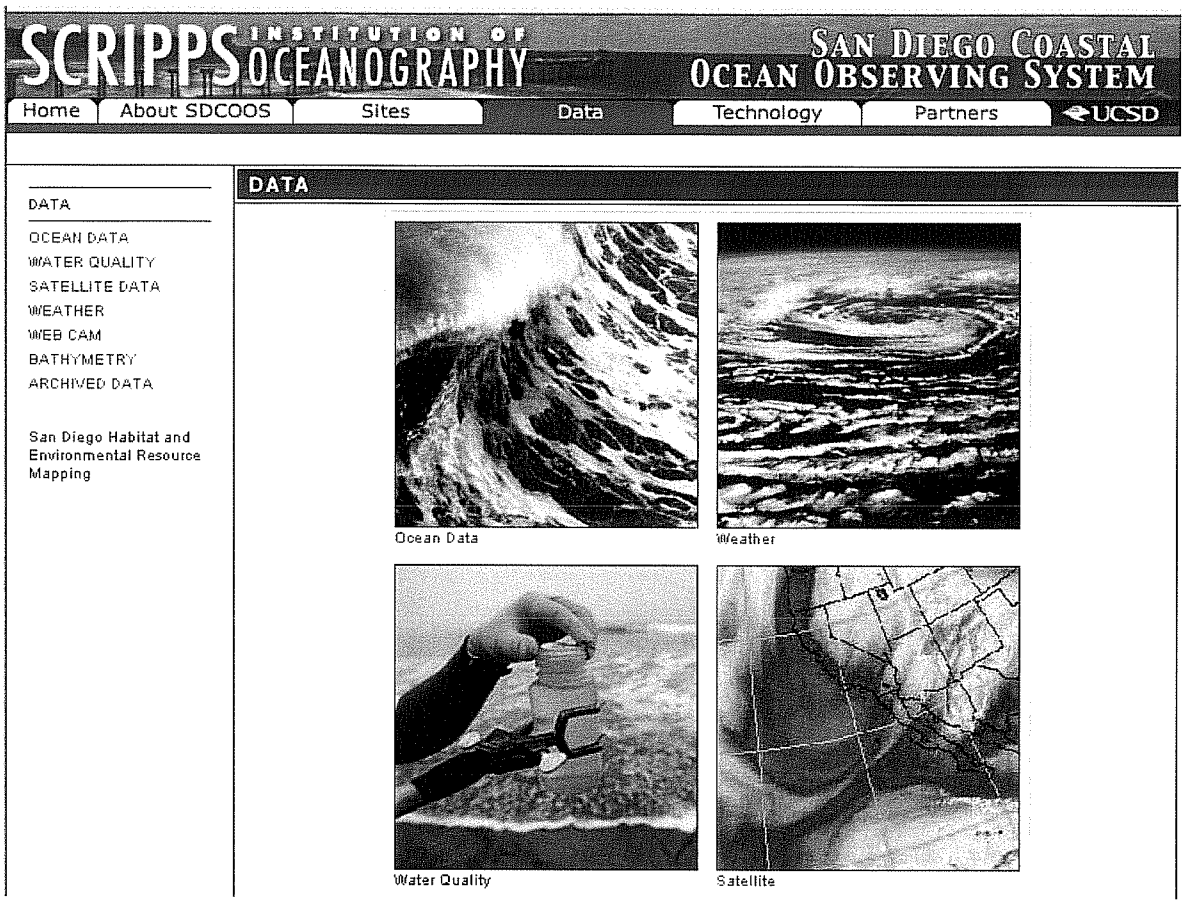


Figure 37. SDCOOS data gateway.

The 'Data' page hosts the crux of the SDCOOS site. It is the most dynamic part of the site as data is continually updated. The Data page is broken into four sub-sections; (1) Ocean Data, (2) Weather, (3) Water Quality and (4) Satellite Data. The Ocean Data page hosts all data from instrumentation funded by this project as well as additional data obtained from other agencies or through other funding sources. The 'surface currents' section contains imagery for the last two days of hourly CODAR data. The most recent 24hr average is also shown because it indicates what the long term flow is without the reciprocative flow of the tides. A vorticity map of the 24hr average data indicates where the flow is turning and helps indicate where eddies may be present.

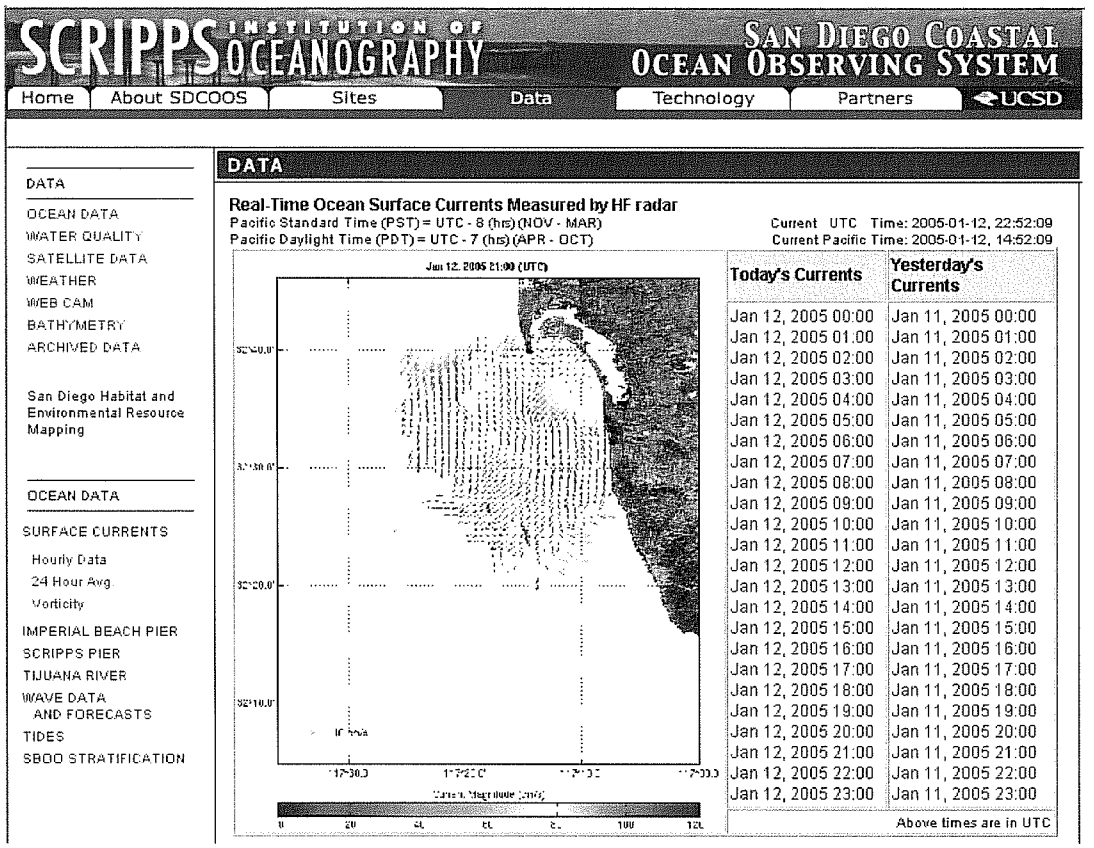
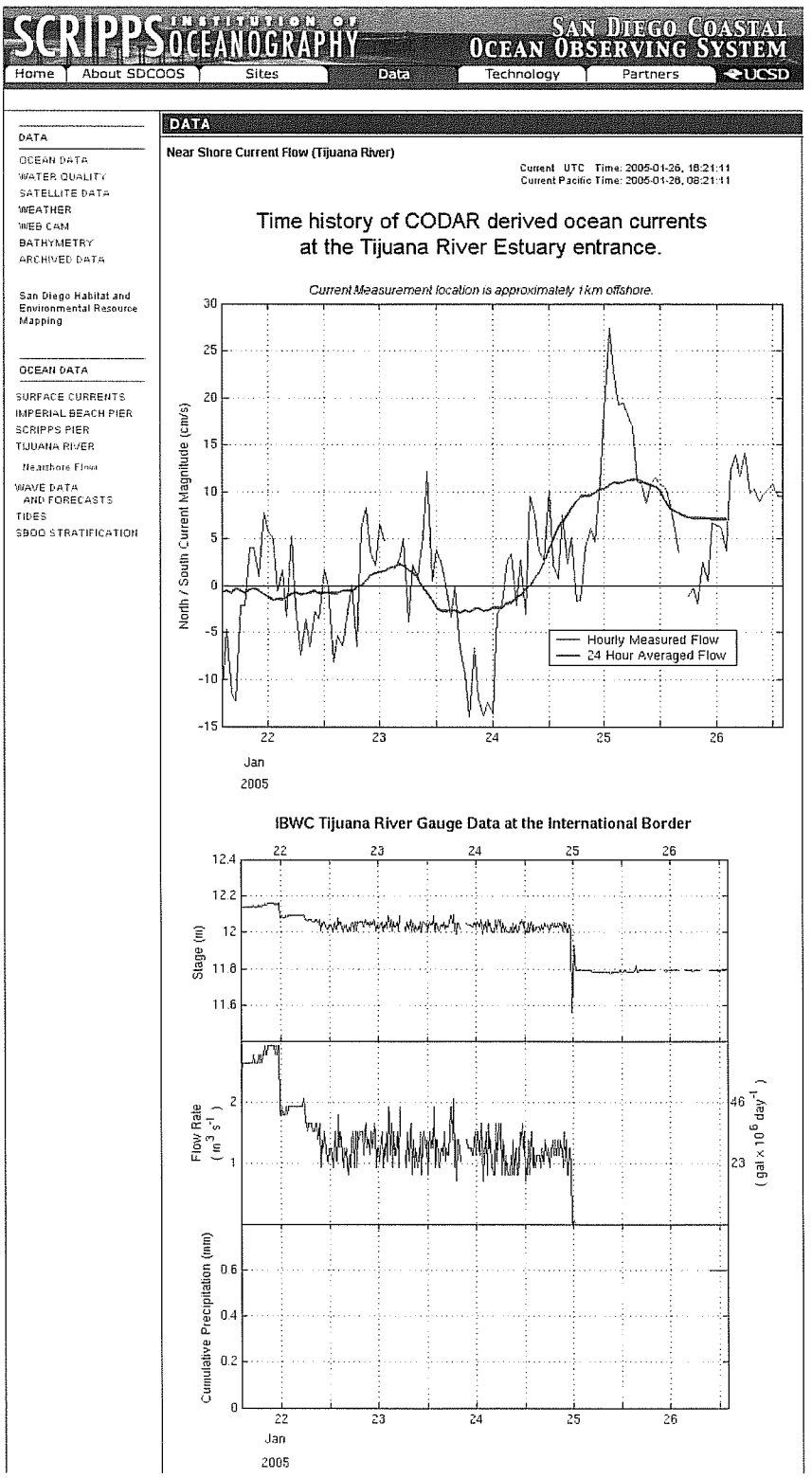


Figure 38. SDCOOS ocean data page. Hourly surface current maps for the past two days are shown.

All the ocean data from sensors mounted on the IB pier are presented on the 'Imperial Beach Pier' section of the Ocean Data page. These include the current meter in the surf zone, the current meter/wave sensor (ADCP), temperature, salinity sensor (SeaBird), and optical turbidity and chlorophyll (WetLabs) instruments off the end of the pier, the meteorological station on the pier tower and the web-cam mounted at the Safety Center. Data from the water column stratification measurement system is hosted under the 'SBOO Stratification' section. During the buoy's operation, several pages were active for displaying temperature data. Since the buoy's recovery, only the summary page is maintained which updates with data from the 'interim' buoy described in section 2.6 above.

Data collected by the International Boundary Water Commission (IBWC) on the stage and flow from the Tijuana River as well as rainfall are gathered from outside agencies and integrated into the 'Tijuana River' section of Ocean Data. Along-shore current velocity extracted from CODAR data is also plotted on this page. This provides a quick assessment of where potentially polluted waters may advect given the river's flow conditions. Managers from the Department of Environmental Health often use this page in conjunction with data from current meters deployed at the IB pier to help assess water quality conditions at South Bay beaches and guide sampling on days that were not scheduled.

The 'Wave Data and Forecasts' and 'Tides' sections under Ocean Data are made up of data obtained from other organizations including the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS) and the Coastal Data Information Program (CDIP). The 'Wave Data and Forecasts' section displays swell predictions at IB pier which are provided by CDIP. Swell maps for Southern California as well as marine forecasts are also displayed. Water level and tide predictions from NOAA/NOS/CO-OPS are displayed under the 'Tides' section.



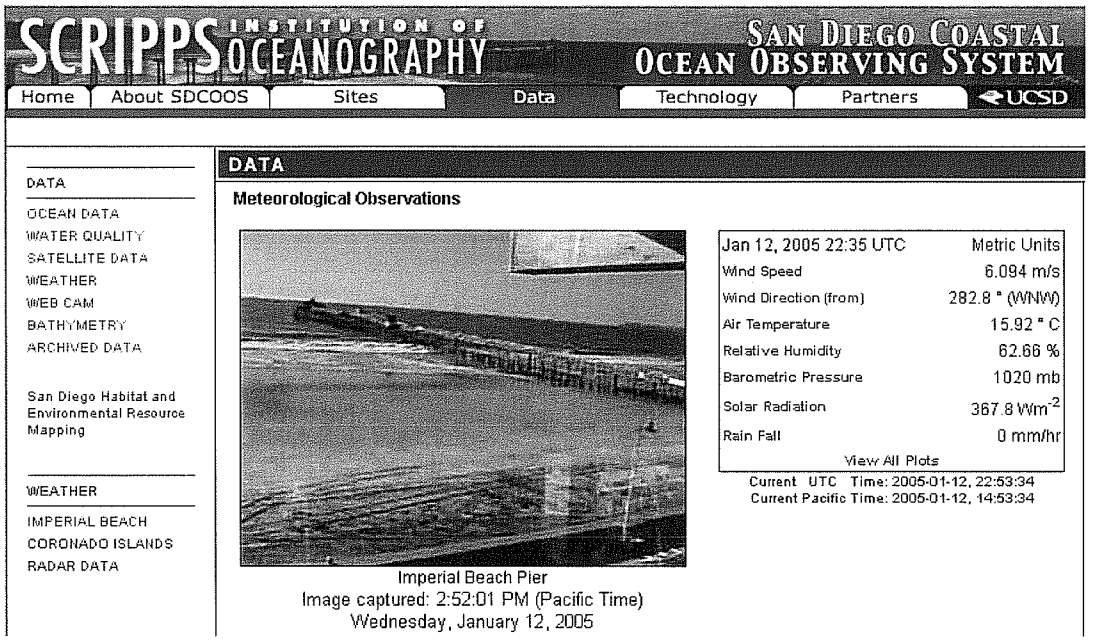


Figure 39. IB pier meteorological data page displays the most recent web-cam image and current atmospheric conditions.

Real-time meteorological data from both South Coronado Island and IB pier are hosted at the 'Weather' sub-section on the Data page. Surface wind data obtained from the Geophysics Branch at the Naval Air Warfare Center Weapons Division is displayed along with precipitation, radar reflectivity, and cloud cover obtained from the NWS.

SCRIPPS INSTITUTION OF OCEANOGRAPHY — SAN DIEGO COASTAL OCEAN OBSERVING SYSTEM

Home | About SDCOOS | Sites | Data | Technology | Partners | UCSD

DATA

DATA
OCEAN DATA
WATER QUALITY
SATELLITE DATA
WEATHER
WEB CAM
BATHYMETRY
ARCHIVED DATA

San Diego Habitat and Environmental Resource Mapping

OCEAN DATA
SURFACE CURRENTS
Hourly Data
24 Hour Avg.
Vorticity
IMPERIAL BEACH PIER
SCRIPPS PIER
TIJUANA RIVER
WAVE DATA AND FORECASTS
TIDES
SBOO STRATIFICATION

Water Quality

	Site Location	Date	Total Coli	Fecal Coli	Enterococci
1	Palm Ave	01-01-2005	= 3000 MPN/100mL	= 800 MPN/100mL	= 324 MPN/100mL
2	Avd. del Sol	01-01-2005	= 1700 MPN/100mL	= 800 MPN/100mL	= 531 MPN/100mL
3	Carnation Ave.	12-29-2004	> 16000 CFU/100mL	> 12000 CFU/100mL	> 12000 CFU/100mL
4	End of Seacoast Dr	12-29-2004	> 16000 CFU/100mL	> 12000 CFU/100mL	> 12000 CFU/100mL
5	3/4 mi. N of TJ River	12-28-2004	NS -99 CFU/100mL	NS -99 CFU/100mL	NS -99 CFU/100mL
6	Tijuana Rivermouth	12-28-2004	NS -99 CFU/100mL	NS -99 CFU/100mL	NS -99 CFU/100mL
7	Monument Rd.	12-28-2004	= 8200 CFU/100mL	= 380 CFU/100mL	= 220 CFU/100mL
8	Border Fence N side	12-28-2004	= 9000 CFU/100mL	= 520 CFU/100mL	= 600 CFU/100mL

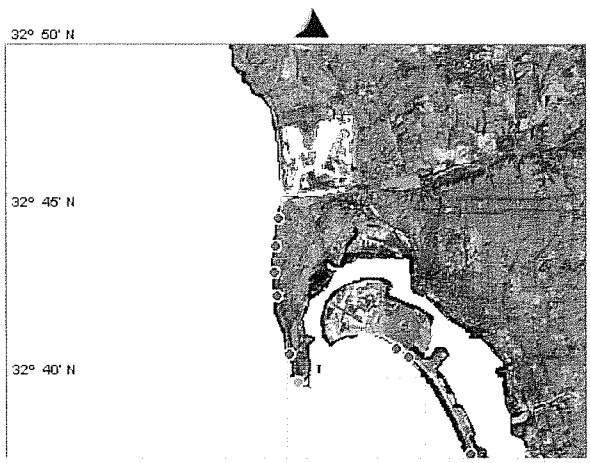
Single Sample standards

Total Coliforms - 10,000 organisms per 100 ml. sample
Fecal Coliforms - 400 organisms per 100 ml. sample
Enterococci - 104 organisms per 100 ml. sample
Fecal:Total ratio -if total coliforms >1,000 & ratio > 0.1

Legend	
◆	No Data Present
◆	At Least One Standard Exceeded
	Approaching Standard limits
◆	Low Bacterial Counts

For more information, please visit
http://www.sdcounty.ca.gov/deh/.
Select "*Beach and Bay Report*" from their 'Key Issues' menu.

Water Quality Testing Stations for the San Diego Region



Click on a dot to view water quality details for that location.

Figure 40. The water quality data is updated by the San Diego County Department of Environmental Health though web-based data entry. The most recent results are posted to this page, as shown above, in both tabular and graphical form. Historical data for all sites can be accessed interactively.

The most recent water quality measurements and AB411 exceedances are displayed in tabular and graphical form on the 'Water Quality' section of the Data page. In addition, historical data for any sampling location can be accessed interactively. Another page, used by County of San Diego Department of Environmental Health officials, allows web-based data entry for updating information on this page.

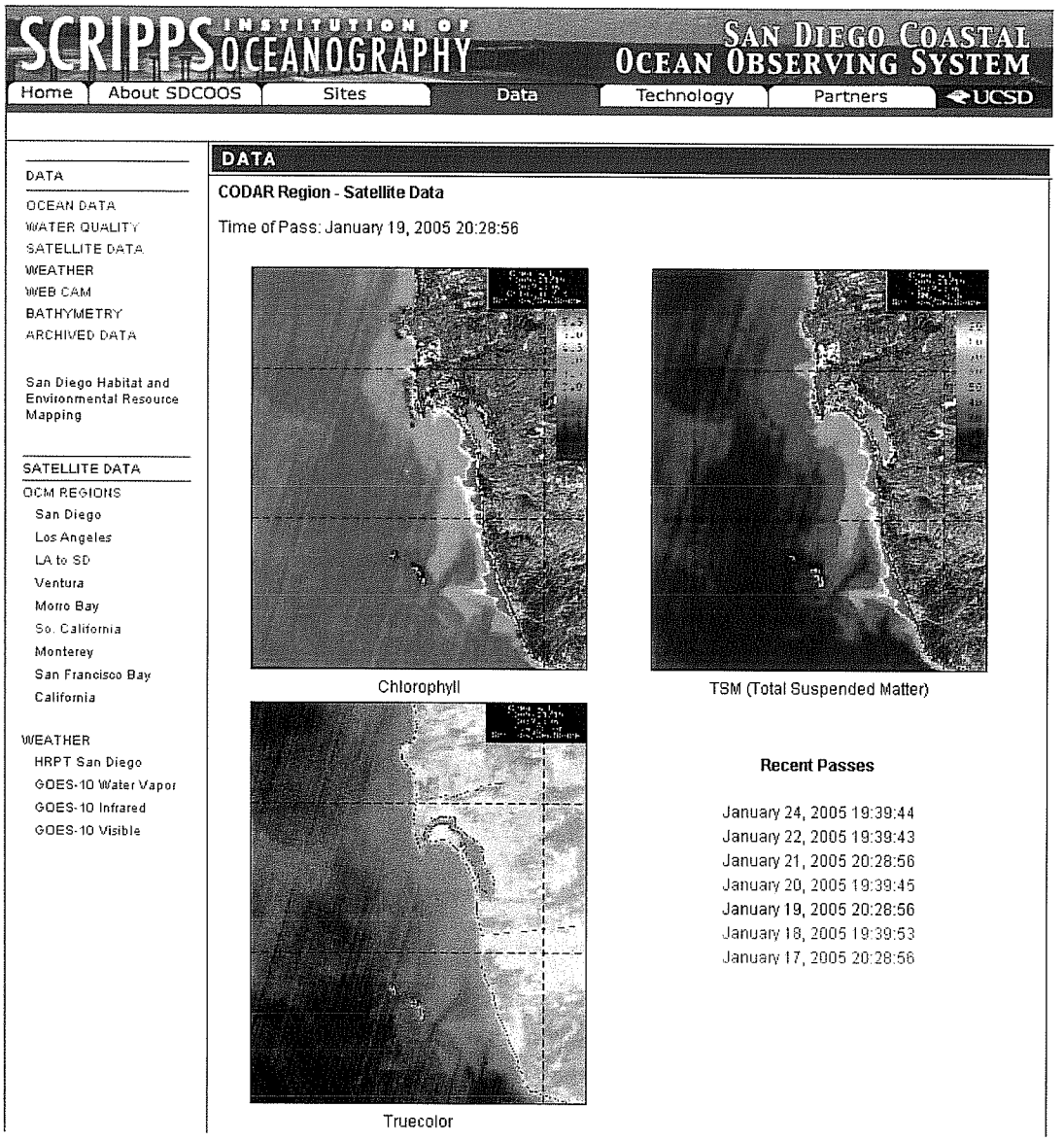


Figure 41. Oceansat-1 data for the San Diego region on January 11, 2005 showing high water turbidity following several storms. Imagery from previous days can also be viewed. Older imagery can be accessed through the archive page.

Through partnership with SeaSpace Corporation and outside sources of funding, we have been obtaining 984ft (300m) resolution ocean color data from Oceansat-1, an Indian satellite, for the state of California. This high-resolution ocean color data shows fine detail in nearshore features such as river plumes that provides accurate measurements of plume locations as well as the detail necessary to understand ocean dynamics driving the plumes. Daily ocean color images from Oceansat-1 are available at the 'Satellite' sub-section of the Data page for several sub-regions throughout the state. Recent weather satellite images obtained from SeaSpace and NWS are also available on this page.

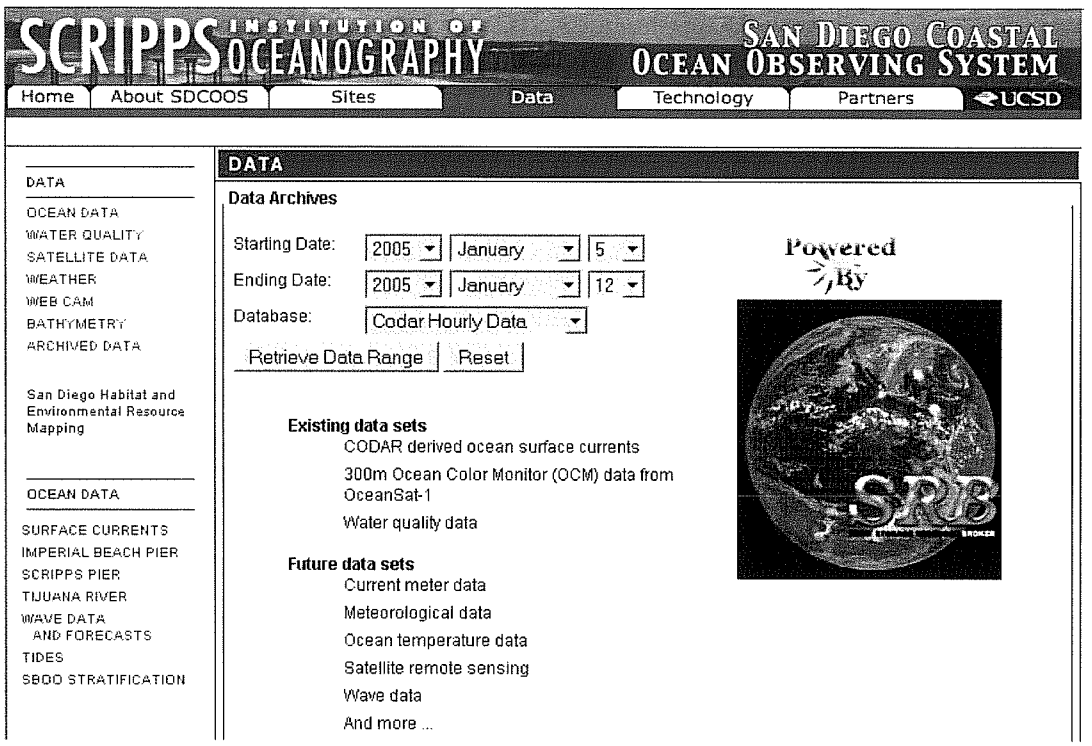


Figure 42. Archived images for CODAR, OCM and water quality can be accessed by searching the archives.

In addition to the four sub-sections mentioned above, there are supplementary pages under the data page for a web-cam at Imperial Beach, an interactive bathymetry site, and an interactive image archive site. Images for hourly and 24hr averaged surface current maps, all OCM regional maps, and interactive water quality maps can all be obtained through a search tool. The archive capabilities were made possible through partnership with personnel at the San Diego Supercomputer Center.

Data support has been provided through the SDCOOS page to programs interested in sampling specific events or features in San Diego waters. A web page was made for the Bight '03 Southern California Regional Marine Monitoring program. The page contained all the relevant plots updating in real-time on a single page for a quick reference to ocean conditions. Plots for specific events were also captured and saved for future reference. This sort of support was especially important to the Bight'03 program because of their interest in sampling specific features (i.e. river plumes). Satellite data from the SDCOOS page enabled 'plume tracking' so that the proper locations could be sampled. A similar page was made for the Coast Guard's Spill of National Significance (SONS '04) exercise program.

The SDCOOS site has been monitored since February 2003 so that web statistics could be compiled. There have been nearly 3,000,000 hits to date with an average of 55 visits per day. The site receives the most visits during weekdays and between 10:00 and 11:00am (Figure 43). Both new and repeat visitors have been growing steadily since the site was launched with an average of 19 new visitors per day. The increasing trend of repeat visitors implies a growing community of users accessing data presented on the SDCOOS site. While the majority of domains are unresolved (possibly consisting of a mixture from all groups), there is roughly equal distribution of use between educational

and commercial domains (Figure 44). Military use is limited but expected to increase as products of interest to the U.S. Coast Guard and Navy are developed. Phone communication with Navy medical and dive officers indicate they do use the data to guide diving operations in the South Bay region.

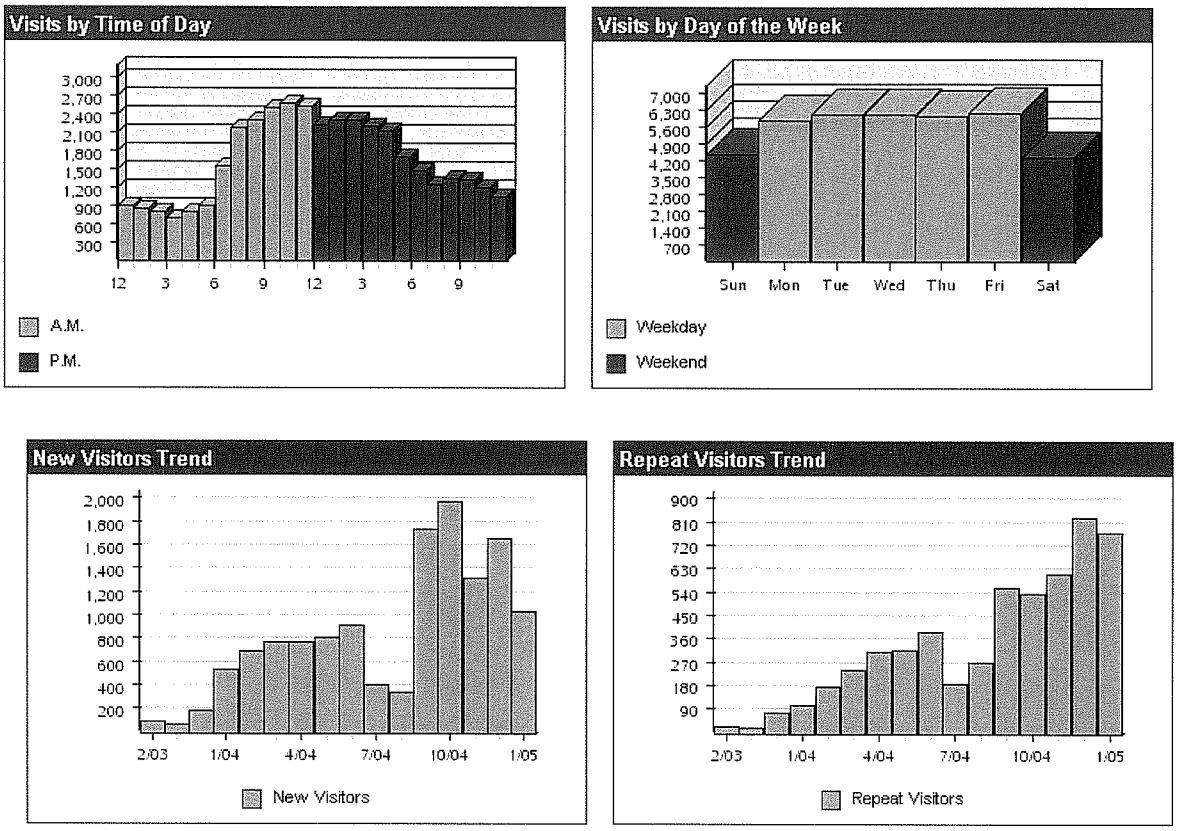


Figure 43. Web statistics for the SDCOOS site since February 2003. The site is most frequently visited on weekdays and between 10:00 and 11:00am. Both new and repeat visitor trends have been steadily increasing since the site was launched.

J. Data Interpretation

Interpretation of various data has been provided in quarterly reports (see appendix 5 quarterly reports 1-7). Further analysis is provided in section 3.0 of this report.

K. Reporting

Quarterly reports were prepared by the project team and submitted to the SWRCB as noted in the agreement. The quarterly reports consisted of project activity summary, milestones achieved, problems encountered, system performance, and data interpretation efforts. The final report was written primarily by SIO staff at UCSD with collaboration from City of Imperial Beach staff and contractors. This final report includes the project's data analysis summary and conclusion in Section III.

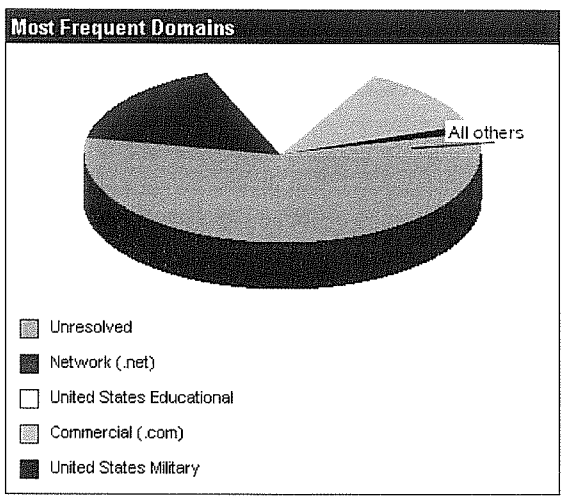


Figure 44. Distribution of domains visiting the SDCOOS site.

Remaining contents of Final Report are in Master File for reference.