ACCESS TO CALIFORNIA COASTAL HISTORICAL AND REAL-TIME DATA VIA THE WORLD WIDE WEB AND ITS APPLICATIONS

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ABSTRACT

In 1991, a study was undertaken by the Center for Coastal Studies (CCS) at Scripps Institution of Oceanography (SIO), funded by the Minerals Management Service (MMS), to determine the characteristic oceanic circulation patterns in the Santa Barbara Channel and Santa Maria Basin, an area of significant Outer Continental Shelf (OCS) oil and gas activity. An array of twelve current meter moorings measure continuous time series of currents, temperatures and salinities of the water column as well as bottom pressure at each mooring location. Data from the current meter at 5 m depth are telemetered daily to CCS via satellite. This is done to secure some of the measurements and to monitor the integrity of the moorings. As a side benefit to this research program, these near real-time data are collected and published on a World Wide Web site to aid MMS and other agencies in their oil spill response efforts in the study region. It is important to these oil spill response efforts that a monitoring program remain in place in the Santa Barbara Channel and Santa Marine Basin. An array of four current meter moorings and four National Data Buoy Center (NDBC) buoys is necessary to make this effort viable.

Keywords: Santa Barbara Channel, Santa Maria Basin, California, circulation study, bottom pressure, Data Zoo, oil spill response, current meters, near real-time data, historical data.

INTRODUCTION

In 1991, the Minerals Management Service (MMS) of the U.S. Department of the Interior entered into a Cooperative Agreement with the State of California, and ultimately with the Center for Coastal Studies (CCS) at Scripps Institution of Oceanography (SIO), University of California San Diego (UCSD), to study the ocean circulation in the Santa Barbara Channel and the Santa Maria Basin. This is the primary area of Outer Continental Shelf (OCS) oil and gas activity in the Pacific OCS region regulated by the MMS. The ongoing Santa Barbara Channel-Santa Maria Basin (SBC-SMB) study has maintained twelve moorings in and around the Santa Barbara Channel since 1991.

From March 1991 until December 1995, ten current meter moorings were located in the Santa Barbara Channel, one mooring was located on the 100 m isobath off of Point Sal and one in the Santa Monica Basin (Figure 1). In January of 1996, nine of these moorings were moved north to the Santa Maria Basin (Figure 2) leaving three moorings in the Santa Barbara Channel, two at the western entrance, SMIN, SMOF and one at the eastern entrance, ANMI.

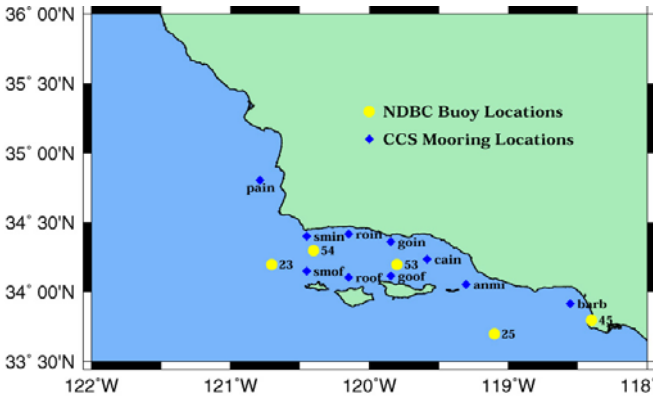

Figure 1. CCS/MMS mooring and NDBC Buoy locations, 1991 - 1995.

The original charter of the SBC-SMB study Data Management task was to archive data from historical physical oceanographic studies of the California coast. Some of these studies include the: Coastal Transition Zone (CTZ), Coastal Ocean Dynamics Experiment (CODE), Super Coastal Ocean Dynamics Experiment (SuperCODE), Observations of Persistent Upwelling Structures (OPUS), Central California Coastal Circulation Study (CCCCS), and the Northern California Coastal Circulation Study (NCCCS). The data from these studies were acquired from

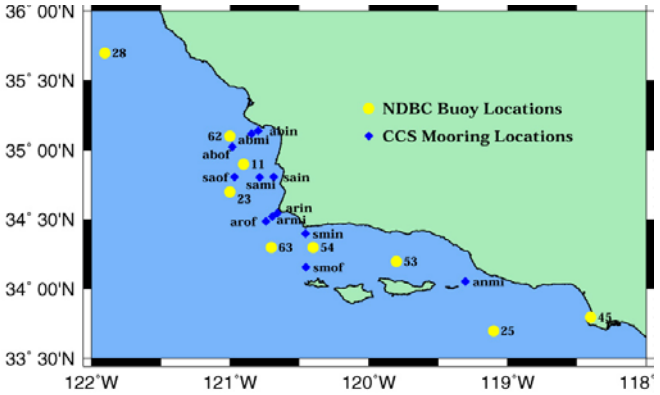

Figure 2. CCS/MMS mooring and NDBC Buoy locations, 1996 - present.

the original investigators, converted to a common ASCII format when possible, and published in an Internet-accessible archive called the Data Zoo. Along with these historical data, data collected from the SBC-SMB moorings are archived in the Data Zoo as well.

The development of the Data Zoo coincided with the development of the World Wide Web (WWW), which gives graphical access to data on the Internet via universally available browsers. With the advent of this new paradigm, the Data Zoo has evolved into not only a static archive of data, but a means of delivering oceanographic and meteorological data in near real-time. MMS currently funds the Data Zoo and its real-time component, the Oil Spill Response Website, to provide access to historical, and study data to the research community, and real-time data to assist oil spill response efforts in the Santa Barbara Channel and the Santa Maria Basin.

MATERIALS AND METHODS

In May 1996, MMS identified a need for near real-time environmental data in the Santa Barbara Channel and Santa Maria Basin to assist MMS, the Marine Spill Response Corporation, U.S. Coast Guard, the National Oceanic and Atmospheric Administration (NOAA) HAZMAT, and the oil industry in their efforts to predict oil spill trajectories and to help direct cleanup efforts during an oil spill event. A website was created to augment the Data Zoo archive which provided the near real-time data collected as part of the SBC-SMB study in an easily accessible format. The URL for the site is: www.ccs.ucsd.edu/oilspill.

The moorings deployed in the SBC-SMB study area (Figure 3) consist of three (or two depending upon the depth of the mooring) current meters at 5 m, 45 m, and 100 m depth, temperature logging thermistors located at various points along the mooring string, and a pressure sensor mounted in the mooring anchor. The current meters measure north and east current vectors, temperature, and conductivity (salinity). The thermistors provide additional temperature observations of the water column and the pressure sensor provides bottom pressure measurements at each

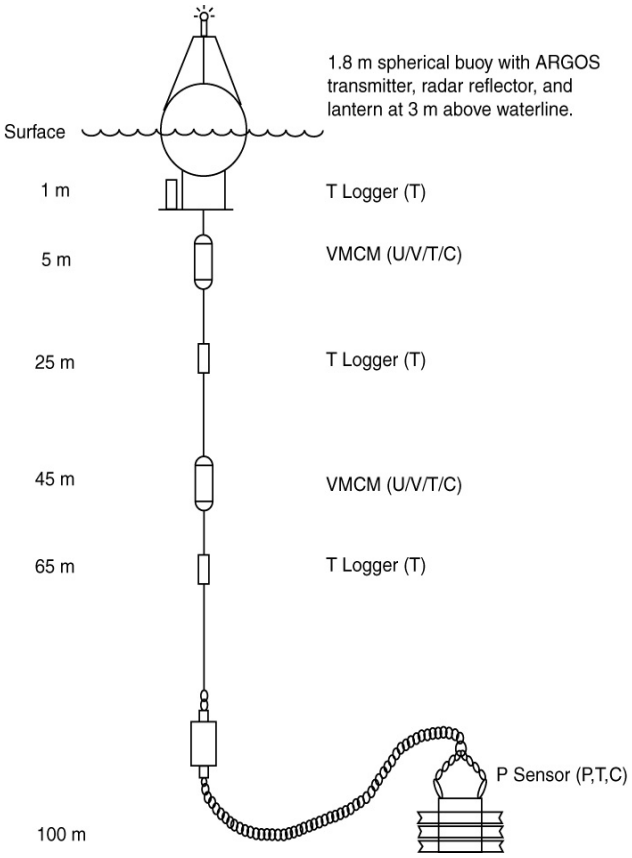

Figure 3. Typical CCS mooring configuration.

mooring location. The moorings are recovered, instrument data downloaded, and then redeployed every six months. To monitor the integrity of the moorings, and to assure that the mooring maintains position, an ARGOS transmitter placed on the mooring buoy transmits position and in situ data from the 5 m current meter to CCS via ARGOS, a satellite-based location and data transmission service, once or twice each day. The in situ data consists of two-hour averages of north and east ocean current vectors processed onboard each 5 m current meter. The most recent 12 of these data are averaged to give a 24-hour daily average speed and direction vectors for each mooring location.

Along with data from the present array of CCS moorings, meteorological data from the NDBC buoys in the study area are collected as well. Data from buoys 46028, 46062, 46011, 46023, 46063, 46054, 46053 and 46025 (Figure 2) are transmitted to CCS via NOAA/Unidata. Unidata is an organization of over 120 colleges, universities, and other educational institutions funded by the National Science Foundation (NSF) through the University Corporation for Atmospheric Research (UCAR/NCAR) in Boulder, Colorado. SIO is a Unidata member institution and thus has access to the direct National Ocean Data Center (NODC) data feed via the Unidata Internet Data Distribution (IDD) system. These data are hourly averaged and presented in the current/wind vector map on the Oil Spill Website (Figure 4).

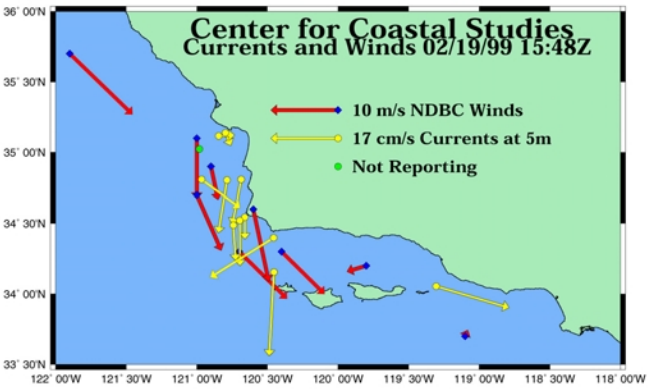

Figure 4. Interactive daily wind and current vector map, Website: www-ccs.ucsd.edu/research/sbcsmb/buoys/immap/.

Advanced Very High Resolution Radiometer (AVHRR) satellite images are downloaded daily from Seaspace Corporation, processed and placed on the Oil Spill Website (Figure 5). These images are subject to occasional cloud cover over the study area which may affect the quality of the images, thus their usefulness in determining flow regimes. The AVHRR web page allows for interactive image manipulation using a menu to select which daily image to view and to adjust the thermal color palate values for that image. This gives the user the ability to enhance different features in the image.

In the event of an oil spill, Lagrangian surface drifter buoys are deployed by CCS within the study area, their positions transmitted via ARGOS to CCS, and posted on the Oil Spill Website (Figure 6). These positions are updated as often as possible, which under normal circumstances, is approximately twice or three times daily, depending upon the transmission quality of the ARGOS satellites.

To enhance the utility of the website, links to other data sources are supplied. One of the more useful links points to the CCS Coastal Data Information Program (CDIP) Website (Figure 7). CDIP is funded by the California Department of Boating and Waterways and the U.S. Army Corps of Engineers. It supplies swell and wave now-casts using swell data measured at the Harvest oil platform off of Point Conception, and forecasts using data obtained from the U.S. Navy Fleet Numerical Meteorology and Oceanography Center in Monterey, California. These data are used as input to a Refraction/Diffraction model which outputs wave direction and energy predictions for the beaches in central and southern California, including the Santa Barbara Channel and Santa Maria Basin (O'Reilly and Guza 1991).

RESULTS

Through numerous oil spills and oil spill drills, the Oil Spill Website has proven a valuable asset in predicting oil spill trajectories. Scientists are studying the driving mechanisms of the circulation in the SBC-SMB study area by analyzing the seven-year time series collected for the

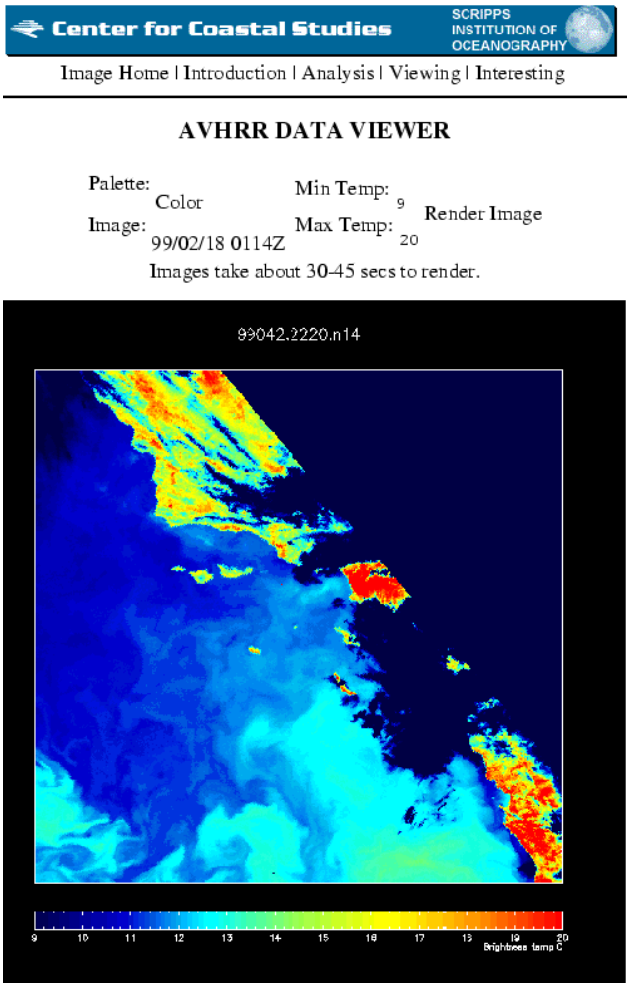

Figure 5. Interactive AVHRR satellite image viewer, Website: /www-ccs.ucsd.edu/research/sbcsmb/sat_images/dataviewer.cgi.

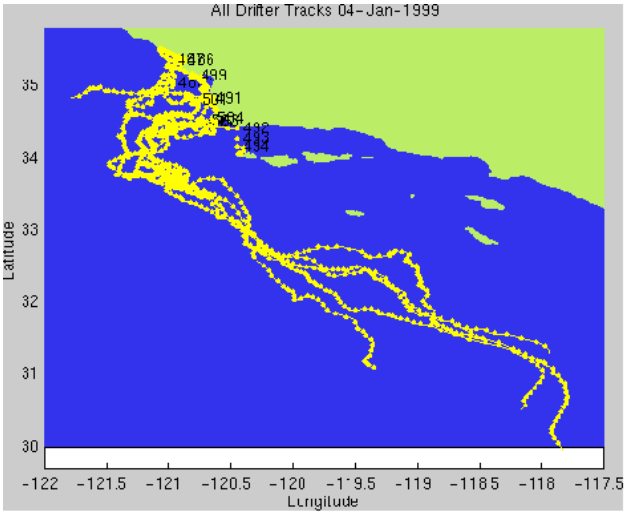

Figure 6. Lagrangian surface drifter buoy tracks, Website: www-ccs.ucsd.edu/research/sbcsmb/ drifters/realtime/d5latest.gif.

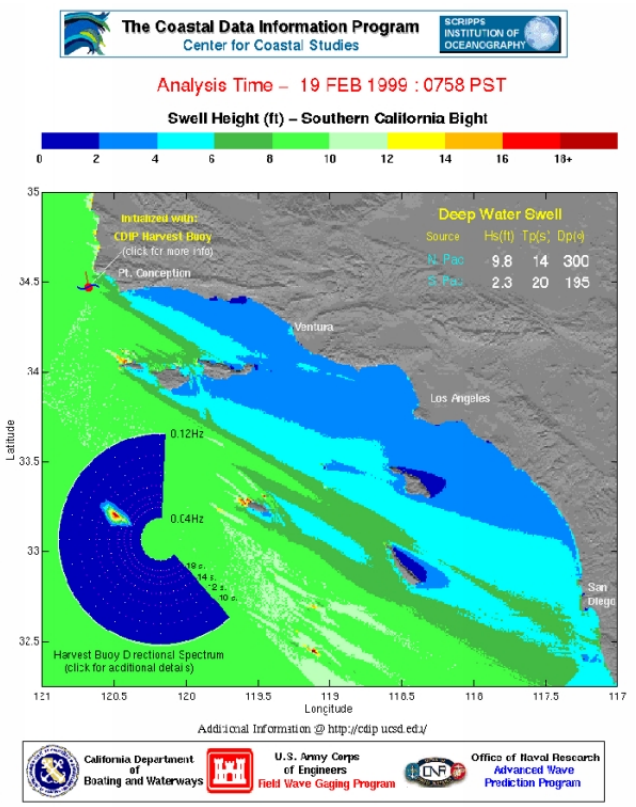

Figure 7. Coastal Data Information Program (CDIP) Southern California Bight Swell Model, Website: cdip.ucsd.edu/ models/ socal_now.shtml.

study. From these data, an understanding of the characteristic flow regimes in the region is evolving. The interaction of the California Current and the seasonal winds around Point Conception play a significant role in the forcing of these different flow regimes.

The Internet has proven an excellent means of delivering near real-time data, given its ability to make available graphical as well as textual and tabular data, in a platform independent and intuitive way. The Oil Spill Website allows users to view daily average wind and current data, as well as to view the time series and tabular data used to make these averages. This facility enables users to view trends in these data and to better forecast conditions in the study area.

As this site evolves, more functionality will be added to enhance its usefulness and reliability. Feedback from users, such as the MMS and NOAA HAZMAT, has helped CCS tailor this product to better suit the requirements of the community.

DISCUSSION

Oceanic surface currents move spilled oil over the ocean's surface. Wind has its effect on spilled oil movement indirectly by the ocean currents it forces. To accurately predict oil spill movement, we must have an understanding of the characteristic flow regimes and their causal forcing in the Santa Barbara Channel. SBC-SMB Circulation Study results indicate that near surface circulation in the Santa Barbara Channel area is primarily driven by the wind stress and pressure gradient through the channel area. The wind stress along south central California coast is generally equatorward (upwelling favorable) and the along-channel pressure gradient is directed poleward most of the year. The time series measurements of the wind stress and the alongshore pressure gradient are significantly anticorrelated, and their relative strengths determine the particular surface flow regime in the channel area. Figure 8 (Harms and Winant 1998) exhibits the effect on the surface circulation in the Santa Barbara Channel by varying the relative strengths of the wind stress and the alongshore pressure gradient. This information is a valuable tool to the oil spill trajectory forecaster.

Figure 9 (Harms and Winant 1998) visually describes the six characteristic flow regimes of the Santa Barbara Channel area. They are the Upwelling, Relaxation, Cyclonic, Propagating Cyclones, Flood East, and Flood West flow regimes. When the wind stress is significantly larger than the alongshore pressure gradient, the Upwelling flow regime exists. When the pressure gradient dominates significantly over the wind stress, the Relaxation flow regime is formed. When the opposing wind stress and along-shore pressure gradient both become strong, the flow transitions to the Cyclonic flow regime. When the wind field is unidirectional over the entire channel area (typically during winter storm conditions), and the along-shore pressure gradient is weak or in the same direction as the wind stress, the Flow East and Flow West conditions occur. The Propagating Cyclone regime may dominate the channel flow during a transition to another flow regime, or may be superimposed on one of the other flow regimes just described.

The oil spill trajectory forecaster who understands the flow dynamics summarized above, can make a reasonable estimate of the existing flow regime in the channel area, and its relative intensity, by studying real-time data from the field array described in Figure 2. From this, intelligent estimates of a simulated flow field can be made. This capability is essential in forecasting oil spill trajectories successfully during an oil spill crisis in the Santa Barbara Channel area, with or without an oil spill trajectory model. If the forecaster has a trajectory model, the accuracy of his modeled trajectories is greatly improved by this information.

Through their research and collaboration, CCS, MMS, and industry scientists have developed this forecasting expertise. Their oil spill trajectory predictions were accurate with, and without, the use of oil spill trajectory models during the Heritage platform oil spill that occurred in May of 1995. Oil spill trajectory was accurately predicted during the September 1997 Irene platform oil spill without the use of an oil spill trajectory model.

The data used for oil spill response primarily comes from four current meter moorings and four NDBC meteorological buoys strategically located in the SBC-SMB study area, satellite imagery (two images per day during good weather), and Lagrangian surface drifter buoy tracks from buoys launched at the onset of oil spill response activities.

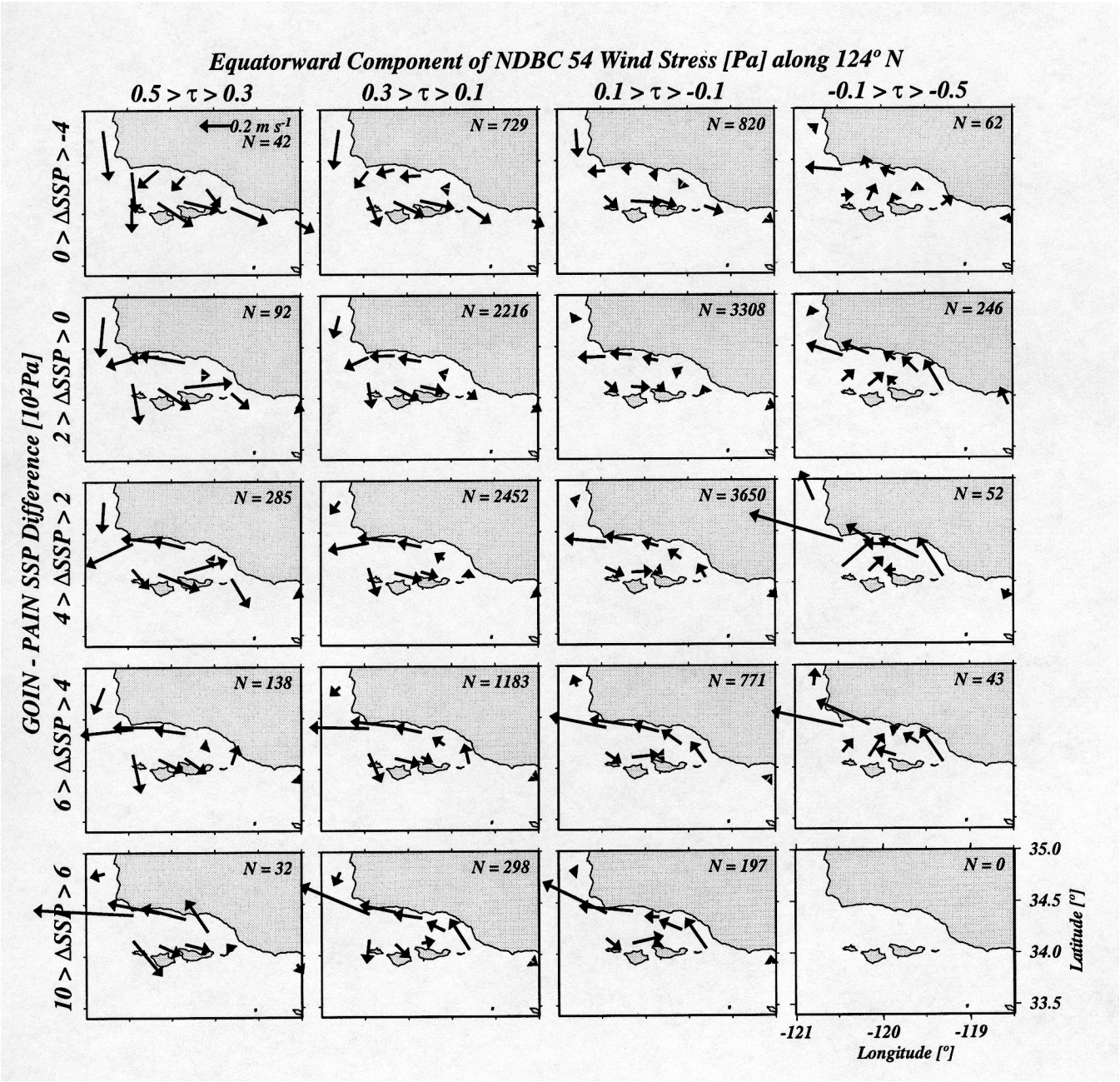

Figure 8. Varying wind stress and alongshore pressure gradient (Harms and Winant 1998).

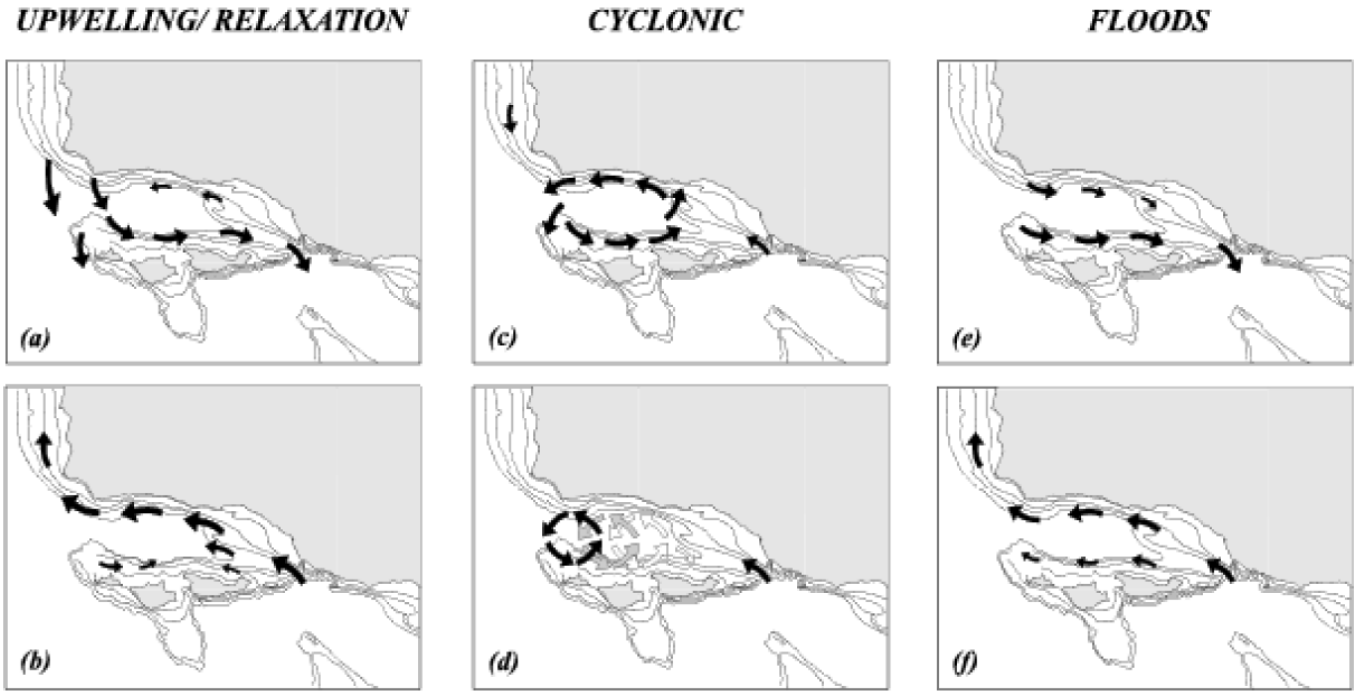

Figure 9. Characteristic flow regimes in the Santa Barbara Channel area (Harms and Winant 1998).

This suite of observations would comprise a long term monitoring program that would remain after the larger field array is finally recovered. The four current meter moorings and four NDBC meteorological buoys are indicated in Figure 2 and designated: ANMI, SMIN, SMOF, SAMI, 23, 54, 53, and 25, respectively.

The mooring array depicted in Figure 2 will be recovered from the field in November 1999. Without the valuable real-time data that these moorings provide, accurate predictions of oil spill movements that do much to protect valuable environmental and socio-economic resources in the Santa Barbara Channel, will no longer be possible. The hope is that state agencies and industry can combine resources to ensure the continuation of this valuable oil spill response resource.

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