Texas Automated Buoy System Provides Situational Awareness of Winds and Currents on the Coast of Texas.

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Abstract

Texas has established an operational system that provides observations of wind and currents to the State On-Scene Coordinator. The Texas Automated Buoy System (TABS) began in 1994 with five current meter buoys. Buoys measure current velocity 2m below the surface and transmit data on a regular schedule via satellite communications. Most buoys measure winds using acoustic wind sensors and some buoys are configured with profiling current meters. Larger buoys use solid-state accelerometers to measure waves. Buoys use solar panels to charge lead-acid batteries and can operate unattended for periods up to a year with the limitation being summertime biological fouling.

TABS makes use of six different types of buoys with each filling its own particular niche to support trajectory modeling. These include TABS I, II, 2.25m and 3m buoys. A new coastal monitoring buoy (CMB) is a 1.4m solar charged buoy designed for extended operation in shallow water to measure current profiles, waves and MET data. The TABS Responder is a small, lightweight, rechargeable buoy designed for short deployments from any vessel of opportunity at the site of an oil spill. Designed for shallow water (<40m), the buoy measures waves, current profiles and meteorological data. GERG has a fleet of four Responder buoys that will be capable of deployment with short notice in the event of an emergency.

Data from the buoys are transmitted to computers at College station TX where they undergo automated quality control before posting on a dedicated web page. Data are disseminated via the internet to the state and federal governments.

Public presentation of the data takes place in three different time frames. Data are available in near real time on a web page that displays data for the past four days. A Real Time Analysis program process the data every 24 hours and presents a series of data products including stick plots, current and wind roses, and distribution tables.

A monthly Hindcast Analysis looks at the previous month's data, performs additional quality control, and prepares final plots. Finally a monthly Climatology program produces climatological summaries of the all data by month and year.

1. Introduction

When an offshore spill occurs, the Texas General Land Office (GLO) requires immediate information about current velocity to quickly evaluate the trajectory and potential impact of spilled material. Aided by such data, the spill-response management team can make critical decisions about operations and logistics. In fiscal year 1994, the GLO contracted with the Geochemical and Environmental Research Group (GERG) at Texas A&M University (Bender et. al, 2007) to design and build six Texas Automated Buoy Systems (TABS). In subsequent years, the GLO funded GERG to build and test additional buoys, including spares, and to deploy them at the locations shown in Figure 1 (See Table 1 for coordinates).

The TABS buoys measure current velocity and water temperature six feet below the ocean surface and transmit the data to shore via satellite data modem for use in spill response operations. The map and table of locations are comprehensive. They give all locations occupied by TABS buoys since the inception of the project. When a TABS buoy is moved to a new location it is given a new designator letter. Thus, the data set associated with a letter is from a single location. This protocol facilitates use of the archive database and simplifies changes to the U. S. Coast Guard Aids to Navigation database. Presently there are nine active buoy locations: B, D, F, J, K, N, R, W and V. Buoy locations A, C, E, G and S have been discontinued, however site H which had been discontinued was re-occupied during the summer of 2005.

TABS has proved its worth during real spills and realistic drills. In its first ten years of operation there were 20 major spills in which NOAA personnel worked with the GLO and consulted TABS data (Martin et al., 2005). During the Buffalo Marine Barge 292 oil spill, for example, the National Oceanic and Atmospheric Administration HAZMAT modeling team and the GLO's trajectory modeling team used TABS data and computer simulations to forecast the movement of the oil to an unprecedented level of accuracy (Martin et al., 1997). The trajectory modelers did not have to begin their work with only educated guesses about the offshore currents. The currents were known within minutes of the spill and were continuously tracked for the next 24 days. Midway through the spill TABS data showed the direction of the coastal current switching from up-coast to down-coast. The benefit to cleanup and protection operations was that the Incident Command could make the decision to stand-down an alert to the Sabine Pass area and refocus efforts down-coast a full day earlier than would have been possible prior to TABS.

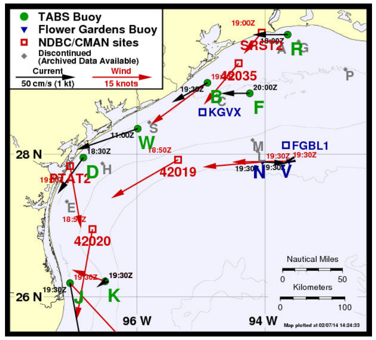


Figure 1. TABS Buoy Map as shown on TABS web page. Green filled circles and blue triangles are operational TABS buoys. Red open squares are NOAA buoys or CMAN stations. Red arrows represent wind vectors and black arrows represent current vectors. Grey circles represent discontinued sites.

Table 1. Locations of TABS Buoys

Buoy	Depth	Latitude (N)	Longitude (W)	Date First Deployed
A*	40 ft.	29° 31.950'	93° 48.733'	06/21/95
B*	63 ft.	28° 58.1850'	94° 54.966'	04/02/95
C*	72 ft.	28° 48.549'	94° 45.126'	04/02/95
D	60 ft.	27° 55.93	96° 48.460'	05/31/95
E*	126 ft.	27° 20.298'	97° 06.000'	05/31/95
F	79 ft.	28° 50.153'	94° 14.131'	02/22/96
G*	41 ft.	29° 33.985'	93° 28.096'	03/11/97
H*	110 ft.	27° 52.406'	96° 33.367'	06/04/97
J	68 ft.	26° 11.300'	97° 03.040'	5/13/98
K	204 ft.	26° 13.010'	96° 29.930'	5/13/98
L**	270 ft.	28° 02.500'	94° 07.000'	4/20/98
M**	186 ft.	28° 11.500'	94° 11.500'	4/20/98
N****	345 ft.	27° 53.382'	94° 02.222'	4/20/98
P***	66 ft.	29° 10.000'	92° 44.250'	8/15/99
R	32 ft.	29° 38.643'	93° 38.386'	7/27/98
S*	72 ft.	28° 26.206'	95° 48.674'	2/19/99
W	73 ft	28° 20.086'	96° 01.328'	11/28/01
V****	90 ft	27° 54.018'	93° 37.260'	01/23/02
X	967 ft	27° 03.9622'	96° 20.2960	Not yet Deployed

* These buoy locations have been discontinued. Data are available in the Website archive.

** These buoys were operated by a project funded by the NOPP, Office of Naval Research through Dynalysis of Princeton. Funding ended in CY1999 and operations ceased. N was resurrected as part of the FGBJIP in 2002.

*** This buoy was operated by a project funded by the Minerals Management Service through Louisiana State University. Funding ended in CY 1999 and operation has ceased.

**** Buoys N and V are operated on behalf of a consortium of oil companies operating in the vicinity of the Flower Garden Banks National Marine Sanctuary

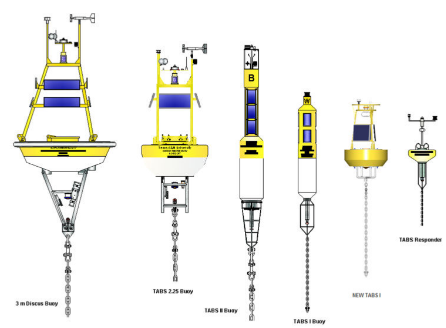


Figure 2. TABS fleet. We currently have deployed one 3m Discus Buoy, three 2.25m buoys, two TABS II buoys, and four TABS I buoys. The new TABS 1 Buoy or Coastal Monitoring Buoy (CMP) will replace the TABS I Buoy. The TABS Responder is a intended for short deployments during an oil spill or other event.

TABS Hardware

TABS buoys have four principal subsystems: the current meter; the satellite communications link; a solar-powered electrical system and the buoy flotation structure (Chaplin and Kelly 1995). The principal current sensor is manufactured by Aanderaa Instruments Ltd. of Norway. Urethane Technologies, Inc. (UTI) provides foam floatation for the aluminum buoy hulls fabricated by GERG. The assembly wiring, system upgrades, maintenance and development of the system, including computer fabrication, electrical system and solar panels, is done by GERG.

The program started with 3 TABS I buoys (Figure 1). Three years later we developed the TABS II buoy for use in deeper water. TABS II buoys can accommodate an Acoustic Doppler Current Profiler (ADCP) as well as other ancillary sensors. We have purchased one 3m discus hull. We have built several 2.25m discus buoys of our own design for a variety of projects, and deployed one at TABS Site K in October 2008. These buoys can also accommodate ADCP's as well as Inertial Measurement Units for measuring directional wave information. An additional TABS 2.25m buoy was built in FY 2013 for future deployment at site X. One 1.4m CMB (coastal monitoring buoy) was also fabricated in 2013 and will be deployed in place of a TABS I buoy.

All TABS buoys currently utilize either the Qualcomm GSP-1620 Packet Data Modem or the GSP 1720 packet data modem which operate through the Globalstar satellite network. The power requirements (5 watts while transmitting) of this modem can be met by all the TABS buoys. Globalstar Corporation provides the satellite data-link service, utilizing a constellation of 48 low earth orbit satellites at a data rate of 9600 bps. Over the past two years this system has gradually been replaced by a newer second generation of satellites following the degeneration of the 1st generation satellites.

All TABS buoys have a redundant, independent, communications link based on the Service Argos satellite system that provides both location information and data-collection service worldwide. The current link is only one-way, and data can be sent by the buoy only while a satellite is passing overhead generally about 12 times per day when the system is turned on. Although limited, this system is reliable, consumes very little power, and requires a very short antenna. It is an ideal backup communications system. TABS buoys recognizes when the primary communications system is not functioning and automatically switches to the Argos mode. Operation of the backup system is checked automatically every ten days.

Field Operations

Deployment of the TABS buoys began April 2, 1995, at Sites B and C (Figure 1), followed by deployments at Sites D and E on May 31, and Site A on June 21. Since then, some sites have been relocated, based on experience.

The solid circles in Figure 1 show the present buoy locations, as well as the discontinued (archived) sites. One should keep in mind that the TABS buoys are intended for an oceanographic research mission of long duration. Thus, the TABS buoys must be rugged and have a well-understood mean time between failure (MTBF) which may be different for different seasons of the year. Ideally, buoys will be serviced before the estimated time of failure occurs, in order to minimize maintenance problems. Some specific areas that will be targeted this fiscal year for study and improvement include corrosion control, bio-fouling, durability of solar panels, mooring wear, sensor reliability, power consumption, and computer hardware.

As the reliability of the TABS system has increased over the years, the quantity of service trips has been able to decrease. Increased awareness of the fishing industry and charter fishing industry in the TABS buoy system has resulted in a dramatic decrease in damage to the buoys. This has resulted in fewer unplanned service cruises and greater reliability of the system. Although instances of vandalism or negligence will continue, there has been a noticeable reduction in recent years. Charter sport fishing fleets in south Texas waters keep an eye on the TABS buoys and have called GERG on occasion when they have noticed damage or buoys off location. These fleets use the TABS data daily to organize their fishing trips and they have told GERG that they appreciate the purpose of the program and the availability of the data. GERG has also received calls from charter captains along the Matagorda coast when they have noticed a buoy off location or if the data is not available to them. The increased awareness of the professional fleets has helped reduce the number of service cruises required as well as the amount of maintenance and repairs required on the buoys.

For fiscal years 2014 - 2015, GERG is planning on a service cycle of about 6 months per buoy for traditional spar type buoys, i.e., each buoy will be replaced with a freshly serviced one about every 6 months. Experience with longer deployments showed that bio-fouling becomes a problem after six months at inshore sites. The recovered buoys will be returned to GERG for examination, service and repair. The reliability goal is a MTBF greater than six months, which would provide nearly continuous operation for all seven buoys, given a 6-month service cycle. The driving force for longer service cycles is the reduction of ship time, a significant expense. The exception to this service interval is the TABS 2.25 buoy and the 1.4m Coastal Monitoring Buoy (CMB) which will be serviced annually unless earlier service is required due to collision, damage or component failure.

The quickest way to service a TABS buoy at sea is simply to replace it with a newly serviced one and bring the recovered one back to GERG for maintenance. Disassembling a TABS buoy to replace system components requires several hours, and can become very difficult in rough seas. The GLO has provided funding to maintain several spare TABS I buoys and TABS II buoys, which will permit GERG to accomplish most service visits by the "swap" method. In addition, returning buoys to GERG for maintenance will permit a more detailed inspection that could not be done under a time constraint. A detailed inspection is important for detecting developing problems.

Other factors that significantly affect operational efficiency and cost are a ship's size, speed, lifting capability, and daily rate structure. Over the past few years, both University of Texas and Texas A&M University have stopped operating research vessels in the Gulf of Mexico. We are entirely dependent on commercial vessels which has significantly increased our costs.

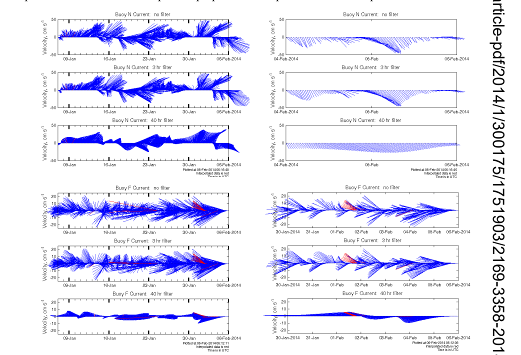
Data Dissemination

After this preliminary processing, the data are then inserted into a database, which facilitates extracting user specified subsets. The GLO has access to this database via FTP over the Internet. The public interface is through the World Wide Web (WWW). Using their browser, the user is able to view either the latest data, or access the database and view archived data. The user can also download the data for later use (Lee et al. 1996). The archived data has proved useful for model initialization, model skill assessment, for operational planning purposes and for research.

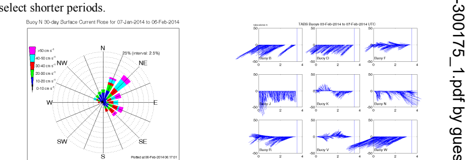
A quality controlled data set of all data collected during the TABS program is available on a DODS server at http://tabs.gerg.tamu.edu/DODSdata/. Under the current Globalstar airtime agreement, TABS buoys transmit data every 30 minutes, and data are updated hourly on the webpage The TABS website is also mirrored on a redundant Web server as well as an off site computer in the Department of Oceanography to ensure reliability in the case of a hardware or power failure. Each buoy page also contains a link that allows the user to search the TABS database and retrieve data from a buoy for a user selectable time period. The user can access up to two months of data at a time. The results of each database search can be viewed in both graphical and tabular format.

Real time Analysis

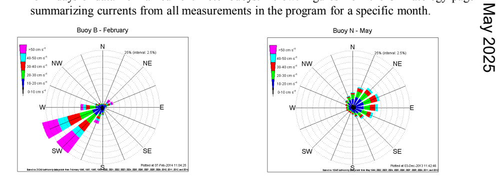
Real time analysis of the TABS data is accessed at http://tabs.gerg.tamu.edu/tglo/RTA/RTA_index.html. This product provides the user multiple views of the quality-controlled oceanographic, meteorological, and engineering data. For example, the current vectors and current roses are provided in one-, two-, four-, seven-, fourteen-, and 30-day time slices in order to enhance oil spill response. These products represent the end result of a process that begins when the telemetered data from each of the buoys (raw data) are received in College Station. Once daily, at 3 am, real-time analysis of the previous 30 days of data commences. The first step is the quality control of each data type, i.e., oceanographic, meteorological, and engineering. The second step is to determine if any of the flagged data can be replaced with an interpolated value. The third step is the preparation and presentation of the products.



Examples of plots available on web pages. Users can select plots of the last 30 days (default) but can also select shorter periods.



Above Left: Example of current rose for previous 30 day period. Above Right: Quick look plot of 4 days of data from all current meter buoys. Below: Figures from the Climatology page summarizing currents from all measurements in the program for a specific month.



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Martin, R. A., F. J. Kelly, Linwood L. Lee III, and Norman L. Guinasso, Jr., 1997: Texas Automated Buoy System: Real-time currents for oil spill response. Proceedings of the 1997 International Oil Spill Conference, April 7-10, 1997, Fort Lauderdale, FL.