

# **Texas Coastal Ocean Observation Network**









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### **Texas Coastal Ocean Observation Network**

Prepared by the

Conrad Blucher Institute for Surveying and Science Texas A&M University-Corpus Christi



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All photos in this publication by Jeff Janko and Texas A&M University – Corpus Christi staff photographers unless otherwise noted.



### To the Texas Citizens,

As Texas continues to grow in population, our natural resources along the coast are becoming more important as an economic engine with expansion of port facilities, increased shipping movements, increased coastal land values, seafood production, and increased pressure from recreation and tourism. All of these activities rely on accurate scientific data of the prevailing coastal sea state. The Texas General Land Office and the Conrad Blucher Institute for Surveying and Science at Texas A&M University-Corpus Christi provide these data in real time or near real time.

The Texas Coastal Ocean Observation Network forms the backbone of these coastal scientific data sets and the data are made available to all on the Internet, giving users reliable access to existing coastal conditions 24 hours a day, seven days a week. The data has assisted the courts in resolving legal littoral boundary disputes. The data assists the maritime industry by providing pilots real-time data on currents, water level, wind speed, and wind direction as they direct ships into and out of port. The data is available in real time for emergency planners in the event of a hurricane threatening the Texas coast. The data assists windsurfers and recreational sports fishing enthusiasts in planning safe, fun filled good times.

The Conrad Blucher Institute along with the Texas General Land Office forms a team of dedicated researchers, professionals, technicians, and managers that keep this vital scientific data available to our vast number of users. We look forward to continuing to provide this valuable data to assist in the sustainable development of Texas' coastal resources.

**Professor Gary Jeffress** Director, Conrad Blucher Institute for Surveying and Science

LaNell Actor

**Ms. LaNell Aston** Director of Special Programs Texas General Land Office



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## Overview

The Texas Coastal Ocean Observation Network, or TCOON, is a unique network of scientific data collection platforms used to amass critical data pertaining to wind and water — essential data to anyone who lives or works near the Gulf coast. A confluence of federal, state and local governmental entities in partnership with academia, TCOON is that rare amalgam of tax dollars at work to provide a service that benefits



Packery Channel Station – Corpus Christi, TX

all sectors of society, including commercial interests, recreational wind surfers and anglers, research scientists, and public officials.

TCOON currently consists of 26 active stations along the Texas Gulf Coast, with the primary mission of monitoring water levels. In addition, wind speed and direction, barometric pressure, air temperature, and water temperature are also monitored, and some stations provide water current, salinity, pH, and dissolved oxygen data. Data is collected in near real time using a combination of cellular devices, as well as internal satellite transmitters. All the data collected are accessible via TCOON's website, and via Wind-Info, an automated phone system that provides the general public with wind and water conditions for any station in the network. (http://lighthouse.tamucc.edu/TCOON/HomePage) and Wind-Info phone # (361-992-WIND)

Because the TCOON stations are designed to meet the rigid scientific guidelines of the National Oceanic and Atmospheric Administration (NOAA), the data collected is admissible in court and is used to establish littoral boundaries (those legal boundaries along the seashore separating privately owned land from state owned, submerged land). Moreover, detailed records provide an audit trail

TCOON data aren't confined to the scientific lab. Station information is continuously used by the public, including anglers, wind surfers and sailors looking for the perfect conditions to get out on the water. of all of the steps used in the collection and production of data products emanating from the TCOON, assuring the accuracy and reliability of these products. In addition to the critical function of the production of tidal datums, TCOON data are essential to



public officials charged with hurricane preparedness, meteorologists providing storm forecasts, and research scientists monitoring the environmentally sensitive bays and estuaries along the Gulf of Mexico in Texas. The data are also accessible to the general public, and are frequently accessed by recreational and commercial users such as wind surfers, sailors, anglers, and surfers.

# Background & History

In 1989, the Conrad Blucher Institute for Surveying and Science (CBI) at Texas A & M University-Corpus Christi installed a state of the art water level measurement system for the city of Corpus Christi. This system was designed to be a source of real time water level data to be used in hurricane preparedness. Soon, other state agencies, including the Texas General Land Office and the Texas Water Development Board, contracted with the CBI to provide coastal observation data. In 1991, the Texas legislature mandated that water level data be collected along the entire Texas Gulf Coast following federal standards, and the TCOON became an official state program. The Texas General Land Office entered into a Memorandum of Agreement with NOAA for technology transfers and oversight. CBI was chosen to manage the network and to provide all the data collected by the network to the various TCOON sponsors. As the network grew, other agencies recognized the benefits of TCOON and became sponsors, as well. These include the U.S. Army Corps of Engineers-Galveston District, who utilize the data during channel dredge operations, and the Texas Water Development Board, who use data to study bay and estuarine circulations. By 1998, the network had grown to more than 40 stations.

The CBI continues its close collaboration with NOAA to ensure federal standards are being maintained, assuring the quality of the scientific data collected. All TCOON stations use the Next Generation Water Level Measurement System (NGWLMS), designed by NOAA. NOAA also continues to provide oversight and technical assistance to TCOON as well as participating in the annual TCOON planning meetings.

TCOON is truly a unique program in that the funds used to support the network are derived from a consortium of federal, state, and local agencies. The pooling of resources and funding to support TCOON reduces the financial burden of a single sponsor, while making the most of available tax dollars.



The instrument configuration at each station mirrors that of NOAA's National Water Level Observation Network (NWLON) stations so that data collected can be utilized by many scientists and researchers, as well as the sponsors of the TCOON.

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## **TCOON Stations**

TCOON is comprised of different types of monitoring stations, seven of which are long-term control stations owned by NOAA. These stations are under contract to CBI for operation, service, maintenance and repairs. These seven NOAA stations are: Sabine Pass North, Galveston Pier 21, Galveston Pleasure Pier, US Coast Guard Freeport, Rockport, Corpus Christi (Bob Hall Pier), and Port Isabel.





Map of TCOON Stations (NOAA Stations are in red)

Each TCOON station has sensors for measuring the various environmental parameters. Each station also has a data collection computer for controlling the sensors, storing data, formatting data for transmission, and one or more devices for data transmission or retrieval. The data collection computer and sensors are powered by solar panels and batteries. The instrument configuration at each station mirrors that of NOAA's National Water Level Observation Network (NWLON) stations so that data collected can be utilized by many scientists and researchers, as well as the sponsors of the TCOON. Other types of station installations are dependent on purpose and local conditions. For example, the instruments used to measure water current or water quality parameters are maintenance intensive and costly, so there are currently fewer of these stations. Structures of opportuni-

ty, such as existing piers, wharfs, or docks, are utilized whenever and wherever possible, reducing the cost of a station installation.

The sensors used to measure environmental parameters include acoustic transducers and pressure sensors for measuring water levels, anemometers for wind speed and direction, acoustic Doppler current profiling instruments for water current, and multiparameter probes for water quality. Each sensor is interfaced to the data collection computer using various types of cables. All station computers are equipped with multiple data control and conversion processes allowing for the storage and transmission of



data in formats specified by NOAA. The CBI's Division of Nearshore Research has an operations staff that performs service, routine maintenance, and repair of the TCOON stations and sensors.

## **Data Collection & Management**

### **Collecting the Data**

All the stations in the TCOON measure environmental parameters at six minutes, or some multiple of six-minute, intervals. For example, water level, wind, and water current measurements are averaged and reported every six minutes. Other sensors such as water quality parameters are reported at thirty minute intervals, while water temperature, air temperature, and atmospheric pressure are reported hourly. The data are stored in the data collection computer at the station and then transmitted to the CBI by one or more communications methods including satellite, spread-spectrum packet radio, or internet modem.

The primary choice of communication used for any station depends on the availability of communication capabilities and/or need for real time observations. At stations where radio or modem communications are not available, satellite transmissions are used to transmit data at hourly intervals.



Thus, the time from measurement to acquisition at CBI depends on the measurement interval and the communications medium used. The data arrive at CBI somewhere between six and sixty minutes after measurements are recorded.

#### CBI's Data Management Design Principles

- 1. Preserve source data and annotate data instead of modifying or deleting.
- 2. Automate as much as possible.
- 3. Maintain a standard data interchange format.
- 4. Avoid complex or proprietary components.
- 5. Emphasize long-term reliability over short-term costs.
- 6. Provide easy access to data.

# Managing the Data & Quality Control

In order to manage the large volume of data collected from all TCOON stations, a database management system has been developed and continues to be improved. Intel based workstations running UNIX are responsible for collecting, archiving, and decoding all source data received from the remote stations. The data are supplied to sponsors and the public via the Internet at the Division of Nearshore Research website (*http://lighthouse.tamucc.edu/TCOON/HomePage*) and through voice telephone systems.

#### **Data Management: Mission Critical**

The Conrad Blucher Institute for Surveying and Science has placed data management as a "mission critical" component of its observation networks, recognizing that the success of its observation network depends on the quality of the end product this network produces – data. Because many Conrad Blucher Institute products are used to determine property boundaries, support engineering designs, for scientific research, for response and restoration activities, and in forecast models, it's possible that these data products will need to be defended in a court of law. Therefore, the CBI maintains detailed records of all activities related to TCOON stations and the data collected and used in the creation of its data products. Electronic data management and highly automated systems have been the keys that allow the CBI to achieve these results within limited budgets.

Each morning, one or more CBI personnel perform additional quality control checks by visually inspecting recently received data in the online database. This is facilitated by a web-based interface that automatically graphs recent data for each station in the network. An analyst detecting a potential problem with a sensor or station uses the same interface to post "quality-control messages" – messages that will be distributed automatically to operations staff and management, who then arrange for necessary repairs and recovery of missing data. Operators also have the ability to suppress distribution of erroneous data that may not have been detected by the automated quality-control systems.

CBI's extensive use of automated processes has resulted in a cost-effective, reliable, and flexible data management program. A CBI staff member can generally perform a complete inspection of data from all stations in less than two hours. Data acquisition, archiving, and distribution take place continuously and autonomously with only occasional operator intervention in cases of mal-functions or data transmission errors. The daily data inspection results in timely platform repairs and excellent data quality. Furthermore, the use of automated systems for the majority of the data processing tasks makes it possible to provide environmental data to end-users in near real time. Observations that pass the automated quality control features of the system are generally made available to end-users within seconds of the data's arrival at CBI. For stations equipped with radio transmission capabilities, this means that data are typically available to end-users within fifteen minutes of the actual time of measurement.



# **Applications of TCOON Data**

### **Tidal Datums**

In order to navigate the seas, complete engineering projects along the shore, or to forecast weather events along the coast, it is necessary to know the depth of the water at any stage of the tide. A datum is an elevation of water used to establish navigational charts, coastal land boundaries, and elevations for construction of coastal structures. A *tidal* datum identifies these water level elevations relative to a fixed point on land called a *benchmark*.



Benchmarks can be installed in many forms but essentially fulfill the same task, a point maintaining a stable elevation on land.

Benchmarks are installed in various forms, including a brass disc set in a concrete block, a brass disc set atop a stainless steel rod driven into the ground, a brass disc set into a concrete slab, sidewalk, or driveway, or a single stainless steel rod driven into the ground, as illustrated below.



#### How Tidal Datums are Calculated at TCOON Stations

Each TCOON station is assigned an arbitrary station "zero" upon installation. This station's "zero" is set such that the water level measurements will never be below this "O" point. Commonly referred to as *"Station Datum,"* all sensors, components, and benchmarks are referenced to this local elevation. Once the sensors are installed, their elevations are measured through the use of a digital level survey



9th Ward in New Orleans post-Katrina Photo Courtesy: USACE

#### Why Tidal Datums are Critical

Federal studies conducted in the aftermath of Hurricane Katrina revealed inaccuracies in the measurements of elevations used in the design, construction and maintenance of hurricane protection systems surrounding New Orleans by as much as one to three feet. These inaccuracies were a significant factor in the levee failures that caused the devastating flooding in the city.

and referenced back to one benchmark designated as the "Primary Benchmark" (PBM). The elevation of the acoustic water level sensor is then calculated relative to the PBM. As data are collected over a period of months or years, the data are processed and datums are produced. All datums produced are relative to the benchmarks and the *Station Datum*. To calculate water level measurements, the elevation of the acoustic sensor above the station's PBM is measured and entered as a coefficient in the data collection platform. Once collected, all water level readings are internally

referenced to this coefficient and reported accordingly. For stability reasons, each station actually has five to ten benchmarks installed near each data collection platform. The Primary Bench Mark is assigned an elevation relative to the Station *Datum*, which is held constant for the life of the station.

As illustrated in the accompanying schematic, because the Station Datum is set low enough to always be below any water level reading, all water level values are positive numbers.





A wealth of tidal datum information is available for each TCOON station. The website where users access the data provides instructional material regarding how these data are collected and how to understand the computation and measurement of tidal datums. The acronyms and datums used are identified below:

- AQLP Aquatrak Level Point The point on the acoustic water level sensor used to establish elevation
- **PBM -** Primary Bench Mark The benchmark used to hold a reference elevation for all components
- **MHHW-** Mean High High Water The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch
- MHW- Mean High Water The average of all high water heights observed over the National Tidal Datum Epoch
- **MSL-** Mean Sea Level The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch
- MTL Mean Tide Level The arithmetic mean of Mean High Water and Mean Low Water
- MLW Mean Low Water The average of all the low water heights observed over the National Tidal Datum Epoch
- MLLW Mean Lower Low Water The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch
- STND Station Datum A fixed base elevation at a tide station to which all water level measurements are referenced

Finally, calculating tidal datums along the Texas Gulf coast presents its own sets of challenges. At many locations along the Texas coast, the astronomical tide is often masked by local meteorological conditions and long-term trends in the Gulf of Mexico. These conditions increase the degree of labor required to produce a datum. Scientists at the Conrad Blucher Institute have developed web based software that automates the computations of datums from water level data stored in the CBI database. This software and the daily quality control procedures allow the CBI to quickly produce tidal datums with little manual intervention.

### **Littoral Boundary Definition**

Tidal datums are the basis for establishing boundaries between privately owned upland, state owned submerged land, and economic zones along the coast. Because the ramifications of these measurements are significant, it is essential that the data collected and used to produce tidal datums are as accurate as humanly possible, and capable of withstanding a legal challenge.

Benchmark leveling is performed annually at each TCOON station to ensure station stability and to relate water level information to referenced benchmarks on land. The CBI publishes benchmark elevation sheets on its web site which indicate the elevation of the marks relative to the tidal datums established; surveyors then use these elevations for precisely locating littoral boundaries.

#### **Marine Navigation & Safety**

The near real time collection and availability of TCOON data has great value to navigation interests. Information provided by TCOON stations is augmented with current metererological data from other systems to provide near real time reports of conditions in heavily trafficked shipping channels in several Texas ports. One of these systems is known as the Corpus Christi Real-Time Navigation System (CCRTNS). The CCRTNS is sponsored by the Port of Corpus Christi and was established by the CBI. The system includes two sidelooking acoustic Doppler current



profilers (ADCP). These instruments are installed at key locations along the Corpus Christi Ship Channel and collect real time water current data. This data, coupled with TCOON station data, are provided to ship pilots who use the information to better navigate large vessels in and out of Corpus Christi Bay. Access to the near real time data is provided via automated voice systems running on CBI computers. Pilots call a local telephone number to receive a digitized voice summary of the latest water current, water-level, and meteorological conditions for the stations in Corpus Christi Bay.

### **Physical Oceanographic Real-Time System (PORTS®)**



**Physical Oceanographic Real-Time System (PORTS®)** 

NOAA's Houston/Galveston Physical Oceanographic Real-Time System (PORTS®) makes similar use of two TCOON stations in Galveston Bay. The data collected from two TCOON stations, two NOAA NWLON stations, and a single ADCP are collected and the data provided to the US Coast Guard Vessel Traffic Safety (VTS) Office in Houston. The VTS then provides the information to ship pilots during passage in the Houston Ship Channel.

#### Forecasting

The Conrad Blucher Institute's Division of Nearshore Research and TCOON, as well other observation networks, provide an increasing amount of real time data. As part of its research, personnel at the CBI take advantage of this information to develop and implement real time predic-



tive models. Predictive models help decision makers and anyone looking for coastal forecasts. The models are developed in collaboration with faculty members of the Texas A&M - Corpus Christi's College of Science and Technology and Center for Water Supply Studies (CWSS), along with the Corpus Christi Weather Forecasting Office.

Water level forecasting is another application for TCOON data. Scientists at Texas A&M University – Corpus Christi have developed a set of models to predict water levels as an aid to navigation in the coastal waters of the Gulf of Mexico and as a tool for emergency management. In Texas, tidal predictions do not meet NOAA's acceptance criteria for tides because of other more dominant non-tidal factors such as wind stress and atmospheric pressure. The graph above shows comparisons of tidal predictions, persistence and Artificial Neural Network model forecasts, and actual water level data. As indicated by the graph above, the predictions in blue did not perform so well, at least in Texas.

#### **Hurricane and Storm Preparation**

At its genesis, the initial two stations installed by the CBI were designed to provide timely water level and meteorological data and information to City of Corpus Christi and local weather service office personnel. The information from these two stations was used in support of public safety decisions before, during, and after the passage of a hurricane or tropical storm. With the expansion of TCOON, this critical mission is now performed along the entire Texas Gulf Coast. Local officials



use TCOON data as when making decisions regarding inundation of evacuation routes, low lying areas, community infrastructure, and public safety. Software has been developed to allow the local National Weather Service Office to seamlessly integrate near real time observations into its weather forecasting systems to better predict the effects of an incoming storm.

#### **Channel Dredging and Maintenance**

The United States Army Corps of Engineers Galveston District uses TCOON data to plan and execute its maintenance of federally authorized channels and waterways along the Texas coast, including ship channels and the Gulf Intracoastal Waterway. Navigation, channel maintenance and operation activities require precise knowledge of water level, tidal datums, and other environmental parameters before, during, and after dredging. Convenient access to real time and historical data is needed in order to conduct these activities.



Aerial view of Pelican Island, an island off the northeastern end of Galveston Island. Pelican Island was largely built up by material dredged from the Galveston Ship Channel and the Houston Ship Channel by the U.S. Army Corps of Engineers.

#### **Healthy Bays & Estuaries**

Estuaries are areas along the coast where fresh water from streams and rivers mix with salt water from the ocean. These environmentally rich habitats are vital to both the environmental and commercial well-being of coastal communities. Estuaries provide nurseries for marine life, important

filtration vital for clean water, and natural protection from storm surges. Imbalances in salinity and/or oxygen levels are harmful to these critical coastal areas, and are therefore monitored closely.

Part of Cayo del Oso Creek which empties into Corpus Christi Bay

> Courtesy: NOAA Nueces Bay Salinity Project



#### **Nueces Bay Salinity Project**

The City of Corpus Christi and the Conrad Blucher Institute have been monitoring salinity levels in the Nueces River Delta since November 1991 to study the effects of water management of the Nueces River. In 1985, the Choke Canyon Reservoir was built along the Nueces River, and with its construction, the City of Corpus Christi and the State of Texas entered into a water management agreement. The mix of freshwater with salt water is incredibly sensitive to environmental habitats. Saline monitoring is critical in order to ensure water flowing from the Nueces River watershed into Nueces Bay approximates what would occur in nature without man-made intervention of the reservoir.



#### **Oil Spill Response**

As the impact of the devastating BP oil disaster has shown, rapid response to oil spills in the Gulf is critical. Being able to forecast where a devastating spill is headed is one of the first steps in disaster response. TCOON's near real time data is used when calibrating circulation and oil spill trajectory models. The Texas Water Development Board has developed an automated system that models water currents in Corpus Christi Bay and Galveston Bay using TCOON data. The Texas General Land Office Oil Spill Division also models oil spill trajectory in preparation for a response. Each night, the latest water level measurements are automatically downloaded from the TCOON Web site via the Internet. These measurements are used to generate a new set of calculation models that predict the currents for the following three days. These current predictions are then fed as input to a trajectory model called SpillSim that predicts where oil will move if a spill occurs in these bays. Oil spill emergency response teams use information from these models to deploy cleanup teams and other resources to minimize a spill's impact.

#### Disaster Averted: TCOON Data Aid Oil Spill Response Crews

So long as the U.S. continues to transport and refine crude oil, the threat of oil spills, especially in and around the Gulf of Mexico, is persistent. That's why the Texas General Land Office inputs TCOON data daily in preparation for an accident. The use of TCOON data during a potentially catastrophic oil spill in the Port Arthur, Texas ship channel in January of 2010 is one example of how this data was used by spill response crews to best determine how to battle the dangerous crude. As a result, cleanup crews were able to keep the 462,000 gallons of crude oil away from the environmentally sensitive J.D. Murphree Wildlife Management Area, home to endangered species and one of the most pristine estuarine reserves in the state of Texas.

The accident happened at 9:30 in the morning on January 23 when an 800 foot oil tanker, the Eagle Otome, collided with one of two barges being pulled by a tugboat. The collision tore a 15 by 8 foot hole in the side of the tanker, and ultimately, 450,000 gallons of crude oil escaped into the Sabine-Neches Waterway. Responders from the U.S. Coast Guard and the Texas General Land Office's Oil Spill Prevention and Response Team quickly worked to lay containment booms, their primary mission to keep the toxic crude out of the marsh lands in the ship channel, and even more importantly, keep the oil from travelling to the Keith Lake Cut, a passageway to Keith Lake in the J.D. Murphree Wildlife Management Area. In all, the crews laid out 11 miles of containment boom and deployed 27 skimmers to trap and contain the oil. An accident of this size could have been an environmental catastrophe; however, disaster was averted and the environmental impact was reduced significantly thanks to swift action and the use of technology. Using near real time TCOON data to determine tide, currents, and other conditions was essential and proved to be an important factor in this success story.











The U.S. Coast Guard Readies Containment Boom





### **Recreational Users**

TCOON's data is critical to research scientists, engineers, and meteorologists, but it is most often used by the general public. Wind surfers, commercial and recreational anglers, and sailors who enjoy the beautiful Texas Gulf Coast all rely on TCOON data. One reason is that all TCOON data are easily accessible via the internet. Wind-Info, a telephone voice-response system (361-992-WIND) also provides the general public with wind and water conditions for any station in the CBI's observation network. In 1993, WindInfo received over 60,000 calls from windsurfers, sailors, fishermen, and other recreational enthusiasts desiring near real time information along the coast.

With the advances in technology, new methods of transmitting TCOON data to users are being developed. Currently, social media such as Facebook and Twitter are being explored as an additional means of transferring current environmental and meteorological data to all users.



### **Operational TCOON Stations** (as of July, 2010)

DNR ID	Abbr.	Name	Field ID
003	RINCON	Rincon del San Jose	87778121
005	PACKER	Packery Channel	87757921
006	INGLES	Ingleside	87752831
008	AQUARI	Texas State Aquarium	87752961
009	PTARAN	Port Aransas	87752371
O11	WHITEP	White Point	87751881
013	BIRDIS	S. Bird Island	87761391
014	BOBHAL	Bob Hall Pier	87758701
015	ROCKPO	Rockport	87747701
016	SABINE	Sabine Pass	87705701
017	PTMANS	Port Mansfield	87784901
018	PTISAB	Port Isabel	87797701
021	GALVPL	<b>Galveston Pleasure Pier</b>	87715101
022	PIER21	Galveston Pier 21	87714501
031	SEADRI	Seadrift	87730371
033	PTLAVA	Port Lavaca	87732591
036	COPANO	Copano Bay	87745131s
051	SPICGS	S. Padre Island Coast Guard Sta.	87797481
057	PTOCON	Port O'Connor	87737011
068	BAFFIN	Baffin Bay	87766041
126	TEXASP	Texas Point	87708221
152	USCGFP	USCG Freeport	87724471
181	REALPN	Realitos Peninsula	87792801
185	NUEBAY	Nueces Bay	87752441
503	MORGAN	Morgans Point	87706131
504	RAINBO	Rainbow Bridge	87705201
507	EAGLEP	Eagle Point	87710131
513	MANCHE	Manchester Houston	87707771
524	PTARTH	Port Arthur	87704751
526	SANLUI	San Luis Pass	87719721

Stations in red are NOAA stations





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