TECHNICAL REPORT

TEXAS TOWER
OCEANOGRAPHIC OBSERVATIONAL PROGRAM
SPRING AND SUMMER 1956

Applied Oceanography Branch
Division of Oceanography

OCTOBER 1956

U. S. NAVY HYDROGRAPHIC OFFICE
WASHINGTON, D. C.
A B S T R A C T

In April 1955 the Hydrographic Office initiated the coordination of the oceanographic requirements of all government agencies involving the use of the Texas Towers as observational platforms. The first oceanographic instruments were installed aboard the Georges Shoal Texas Tower in April 1956. Observations made during the months of April, May, June, August, and September provide the basis for a preliminary evaluation of the Texas Tower as an observational platform and of the adaptability of the instruments tested. The tower, thus far, has proven to be an excellent platform from which to conduct observations difficult to perform on shipboard. All instruments tested are considered feasible, with various degrees of modification.

REPORT PREPARED BY
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A. Wayne Magnitzky
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and
Robert J. Farland
FOREWORD

The installation of the Texas Towers off the east coast of the United States provides new facilities for measuring oceanographic parameters heretofore difficult to perform aboard a pitching ship. The Hydrographic Office recognizes the potentialities of these stable platforms and plans to exploit them to the maximum extent by coordinating the efforts of all government agencies to obtain data and knowledge from the oceans. This publication is a preliminary evaluation of the tower as an observational platform and the adaptability of various instruments.

Additional reports will be published as this program develops.

H. C. Daniel
Rear Admiral, U. S. Navy
Hydrographer
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The idea of constructing "radar islands" along the east coast of the United States for early aircraft warning resulted from the Lincoln Project at the Massachusetts Institute of Technology. The Tower, operated by the U. S. Air Force, was constructed and installed by commercial construction companies under the guidance of the U. S. Navy Bureau of Yards and Docks and under the direct supervision of Captain J. J. Albers, Officer in Charge of Construction, Texas Towers. The installation of the first offshore radar station was accomplished during July and August 1955. During the critical period of installation, the U. S. Navy Hydrographic Office provided wave forecasting services.

The Hydrographic Office is charged with the mission of collecting, disseminating, and applying oceanographic data concerning military operational problems. In carrying out this mission aboard the Georges Shoal Texas Tower, the cooperation of the Air Defense Command and the Bureau of Yards and Docks, the logistic support provided by the 762nd AC&W Squadron, and the guidance of Captain J. J. Albers, recent recipient of the Moreell Medal, during the planning phases of the program is gratefully acknowledged.
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TEXAS TOWER OCEANOGRAPHIC OBSERVATIONAL PROGRAM

PROGRESS REPORT - No. 1

I. INTRODUCTION

The first oceanographic instruments were installed aboard Georges Shoal Texas Tower in April 1956. Observations made during the months of April, May, June, August, and September provide the basis for a preliminary evaluation of the Texas Tower as an observational platform and of the adaptability of the instruments tested. The tower has thus far proven to be an excellent platform from which to conduct observations impossible on shipboard. All instruments tested are considered feasible, with varying degrees of modification.

II. HISTORY

Announcement in September 1954 of the Air Force's plans to install five offshore Texas Towers, promulgated the idea within the Hydrographic Office of investigating the feasibility of adapting these platforms for the collection of oceanographic data. In the application to Navy problems, such data would have the following important advantages:

a. The data would be an important part of a widespread data collection program now carried out in support of the Undersea Warfare Program assigned to this Office.

b. The data would have direct application to many environmental problems now confronting the Navy, such as, the prediction of sonar ranges, various mine countermeasures problems, a better understanding of actual physical processes in the ocean and its boundary media, and many others.

c. The data would be unique in that they combine the advantages of a stable platform, relatively free of artificial boundary interference, capable of obtaining synoptic time series data at several locations. Such data would provide insight into the behavior and eventual prediction of many oceanographic variables.

d. The data could be acquired at a fraction of the cost of data taken from aboard ship.

Authorization for deck space on the five USAF programmed Texas Towers to house recording equipment required to collect oceanographic data was granted by the Air Force in November 1954.
On 10 February 1955, a conference was held at the Hydrographic Office at which all interested government agencies had representation. The purpose of this conference was to investigate the feasibility of establishing a cooperative observational program whereby each participating agency would furnish funds, instrumentation, or personnel according to its needs.

By April 1955 the Hydrographic Office had undertaken the function of coordinating the oceanographic requirements of all government agencies involving the use of Texas Towers as observational platforms. It was believed that only through a carefully coordinated program would it be possible to obtain maximum benefit from these towers for research in the fields of oceanography and undersea warfare. The first tower of this system is to serve as a pilot installation for testing and evaluating the performance of various oceanographic instruments.

III. OBSERVATORY

The tower is located at $41^\circ41'16.3''N$, $67^\circ45'36.2''W$ in a water depth of about 56 feet, and the bottom deck of the tower is about 61 feet above the sea surface. The tower is shaped like an equilateral triangle with sides 185 feet long. The west side of the tower is oriented north-south and the opposite angle points east. It is supported by 3 caissons 10 feet in diameter situated at the apex of each angle. Figure 1 shows an aerial view of the tower.

The superstructure and radomes house the radar and operational facilities. The hull consists of three decks. The main deck serves as a helicopter pad. The middle deck is composed primarily of living quarters, recreation, and messing facilities. The bottom deck consists mainly of the power plant, boilers, fuel and water tanks, and storage space. The oceanographic observatory is situated on the bottom deck midway between the north and south caissons. This compartment is 16x20 feet and approximately half of this space is devoted to instrument lowering facilities while the other half is used for recording and maintenance facilities. A plan view of the compartment is shown in figure 2. Recorders are shown in figure 3.

Instruments are lowered through deck holes 2 feet in diameter, each of which have a 1-inch steel hawser passing through their center. These guide cables are attached to springs on an overhead beam and to an 18-ton block on the bottom. All instruments and signal wires are attached to the guide cables by special instrument mounts or cable clips and are raised and lowered with five thirty-seconds inch wire rope halyards. The guide cables prevent lateral movements of the instruments due to wind, waves, or currents.
Two manually operated winches with a capacity of 500 pounds each are mounted to accommodate the south and middle hatches. A manually operated BT reel is mounted over the north hatch for use with a bathythermograph and other small oceanographic instruments. The maximum capacity of this reel is approximately 50 pounds. A smaller winch constructed of a wooden spool is located over the north hatch. This winch is intended for use with instruments weighing up to 20 pounds, such as water samplers and reversing thermometers. Figure 4 shows the arrangement of heavier winches and the upper ends of guide cables.

Table I shows instruments installed prior to 6 September 1956.

**TABLE I**

Instruments Installed Aboard Texas Tower No. 2
as of 6 September 1956

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Levels</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN/UMQ-5B Bendix-Friez</td>
<td>(3) 10, 50, and 175 ft.</td>
<td>Winds</td>
</tr>
<tr>
<td>Roberts current meter</td>
<td>(3) 5 and 55 ft. depth</td>
<td>Currents</td>
</tr>
<tr>
<td>Bathythermograph</td>
<td>-----------------------------</td>
<td>Thermal structure</td>
</tr>
<tr>
<td>H.O. wave staff</td>
<td>-----------------------------</td>
<td>Waves</td>
</tr>
<tr>
<td>NRL Mk IX pressure recorder</td>
<td>20 and 50 ft. depth</td>
<td>Pressure</td>
</tr>
<tr>
<td>USC&amp;GS portable tide gage</td>
<td>-----------------------------</td>
<td>Tides</td>
</tr>
<tr>
<td>Foerst sampler</td>
<td>-----------------------------</td>
<td>Salinity</td>
</tr>
</tbody>
</table>

All instruments except the bathythermograph and the Foerst sampler are automatically recording and may be programmed to sample at any desired interval. Table II shows the sampling schedules that have been employed.

**TABLE II**

Sampling Schedules Employed on Texas Tower No. 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sampling Period</th>
<th>Duration of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winds</td>
<td>continuous</td>
<td>continuous</td>
</tr>
<tr>
<td>Currents</td>
<td>hourly</td>
<td>5 min.</td>
</tr>
<tr>
<td>Thermal structure</td>
<td>daily</td>
<td>---</td>
</tr>
<tr>
<td>Waves</td>
<td>every 6 hours</td>
<td>30 min.</td>
</tr>
<tr>
<td>Pressure</td>
<td>every 6 hours</td>
<td>30 min.*</td>
</tr>
<tr>
<td>Tides</td>
<td>continuous</td>
<td>continuous</td>
</tr>
<tr>
<td>Salinity (surface)</td>
<td>daily</td>
<td>---</td>
</tr>
<tr>
<td>(bottom)</td>
<td>weekly</td>
<td>---</td>
</tr>
</tbody>
</table>

*Remainder of the time, pressure maximums and minimums are obtained at slow chart speed.
IV. INSTRUMENTS AND DATA

Most instruments are designed for suspension beneath the lower deck of the tower and are attached to the guide cables. Figure 6 shows a typical arrangement of instruments on the guide cables. The arrangement is flexible and all instruments are easily lowered and retrieved from the compartment above.

The guide cable vibration resulting from current and wave motion was one of the principle causes of instrument failure. The amplitude and frequency of these vibrations were not measured; however, on one occasion an instrument mount was dismembered which would require a distortion of at least 3 inches from the plumb line. The fundamental frequency of vibration was not measured but is estimated to be somewhat higher than 5 cycles per second.

As a result of this vibration it has been necessary to employ various means of isolating each instrument from the vibrating cable.

A summary of the data obtained to date is shown on table III. While much of these data remain in the raw form, efforts are being made to process them to more usable form. These data are available from the Hydrographic Office on a loan basis and in some cases certain processing can be arranged.

1. Winds

The anemometers now in use are Bendix-Friez type AN/UMQ-5B. They automatically record speed and direction and operate continuously while rigged. One anemometer is mounted atop the radio tower, 175 feet above the sea surface. Two other anemometers are available for lowering beneath the tower at various levels. The latter instruments are mounted to instrument mounts in an inverted position and are suspended by special rubber bushings to absorb the cable vibrations. Corrosion of these instruments resulting from salt spray is a major problem. Figure 5 shows two anemometers being lowered on guide cables.

While the boundary interference to instruments at the guide cables appears to be small it is detectable under certain conditions. Figure 7 shows wind turbulence experienced in the lee of the north caisson, 74 feet away. This turbulence appears to introduce a possible error of ±30° when the wind is from the north or the south. There has been no noticeable interference from the east caisson, 152 feet away. Corresponding caisson interference to current and wave measurements has not been detectable with existing instruments.

2. Currents

Roberts radio current meters (Mod. II) are used exclusively. They are lowerable to any depth and record set and drift every hour. As many as three may be lowered on the same cables to obtain simultaneous data at various depths.
TABLE III
Summary of Oceanographic Observations Made Aboard
Texas Tower No. 2 Between 5 April and 6 September 1956

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Winds 175' (hrs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>72</td>
</tr>
<tr>
<td>40' (hrs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>369.5</td>
<td>114</td>
</tr>
<tr>
<td>20' (hrs.)</td>
<td>9</td>
<td>290</td>
<td>205</td>
<td>0</td>
<td>408</td>
<td>114</td>
</tr>
<tr>
<td>10' (hrs.)</td>
<td>0</td>
<td>43</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wave staff (obs.)</td>
<td>12</td>
<td>66</td>
<td>131</td>
<td>0</td>
<td>39</td>
<td>23</td>
</tr>
<tr>
<td>Current 10' (obs.)</td>
<td>26</td>
<td>194</td>
<td>0</td>
<td>0</td>
<td>439</td>
<td>93</td>
</tr>
<tr>
<td>25' (obs.)</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>50' (obs.)</td>
<td>16</td>
<td>164</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pressure 20' (hrs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>424</td>
<td>134.5</td>
</tr>
<tr>
<td>50' (hrs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>270.5</td>
<td>0</td>
</tr>
<tr>
<td>BT (obs.)</td>
<td>16</td>
<td>4</td>
<td>12</td>
<td>0</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Water samples (surface)</td>
<td>6</td>
<td>13</td>
<td>14</td>
<td>0</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Water samples (bottom)</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Tide record (hrs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>156.5</td>
<td>40.0</td>
</tr>
</tbody>
</table>

Dates tower occupied by oceanographers:
5 Apr. - 10 May  
26 May - 14 June  
1 Aug. - 6 Sept.
Oceanographers:
Q. H. Carlson  
A. J. Barther  
R. J. Farland  
B. A. Kunkel
The major problem encountered with the current meters was the rapid disintegration of the lignum-vitae bearings due to molar agents in the sea water. Average bearing life was approximately 3 days. Bearings constructed of polytetrafluoroethylene (Teflon) were used during the month of August with excellent results. By the end of the month none of the original bearings showed any appreciable wear. One meter had 409 hours of operation. A current-meter problem was caused by the rotary currents which resulted in the twisting of the cables leading to the recorders. A swivel containing slip rings to conduct the electrical pulses was developed and proved successful during August tests. Figure 8 shows three current meters being lowered on the guide cables.

Since the installation of current instruments, 755 hourly observations were made at the 10-foot depth, 86 at the 50-foot depth, and 27 at the 25-foot depth. The raw data are in tape form as shown on figure 10. These data are tabulated as soon as practical and eventually punched on the specially designed IBM card shown in figure 11.

Currents are rotary and generally range from 0.8-1.8 knots in speed at the surface. Bottom currents are slightly weaker, about 0.3-1.2 knots.

The strongest current observed at the surface was 1.9 knots and at the bottom, 1.5 knots. An example of a typical tidal cycle is shown on figure 12 where surface and bottom currents are plotted over a 24-hour period.

Previous reports of 3-5 knot currents in the area have not been verified by observations taken from the tower. A conspicuous current rip is a semi-permanent feature running NW-SE, passing about 200 yards NE of the tower. Stronger currents may very likely occur over this shoal area.

3. Thermal Structure

Thermal structure is presently being measured by means of the bathy-thermograph. No thermal stratification has been observed at any time between April and September. It is believed that mixing is primarily due to currents since several extended periods of low wave heights were observed with no change in thermal gradient. The prospect of studying thermal structure from this tower is therefore limited.

4. Waves

Two flexible step-gage resistance wave staffs were used. A detailed description of this system will be found in H.O. Pub. 607, Instruction Manual for Oceanographic Observations, U. S. Navy Hydrographic Office, Washington, D. C., 1955. One staff is 12 feet long with 4-inch step intervals and the other is 36 feet long with 1-foot step intervals. Figure 9 shows a wave staff being lowered on guide cables.
Figure 13 shows the form in which raw wave data is recorded. Thirty-minute wave records are generally taken every six hours. Records may be recorded directly on magnetic tape also if required. Prior to 5 September 1956, 94 3/2-hour records and 194 15-minute records have been taken. Waves are primarily due to local winds. Long period swell is very rare.

5. Underwater Pressure

Two pressure pickups (Mk IX) are mounted semipermanently to a guide cable at depths of 20 and 50 feet. Impulses from the pressure pickups are recorded on graphic tape. Pressure records are programmed for 30 minutes every 6 hours at fast tape speeds. The remainder of the time they are run at slow tape speeds to record the pressure of the maximum wave heights. The pressure recorders were provided and installed by the Naval Research Laboratory and are of the University of California Mk IX type.

Figure 14 is a pressure record taken at a depth of 20 feet during the passage of hurricane Betsy. The track of Betsy is shown on figure 15.

6. Tides

A portable U. S. Coast and Geodetic Survey type tide gage was installed in August at the water level, within the seaward caisson. This gage is only provisional until a remote recording gage is available.

Approximately 10 days of tide records were obtained in the latter part of August. While the data are not numerous enough to draw definite conclusions, they illustrate the general magnitude of the tidal variations. The mean tide range, 19 August to 29 August, was 3.6 feet. It is interesting to compare this value with the U. S. Coast and Geodetic Survey tide predictions for Georges Shoal (41°40'N, 67°14'W) corresponding to times of observations.

<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>Predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean range (22 half cycles)</td>
<td>3.6 ft.</td>
<td>4.6 ft.*</td>
</tr>
<tr>
<td>Ratio (high and low water)</td>
<td>.41*</td>
<td>.52*</td>
</tr>
<tr>
<td>Time difference (30 highs and lows)</td>
<td>-47 min.*</td>
<td>-1 hr, 15 min.*</td>
</tr>
</tbody>
</table>

*Referred to Boston

Figure 16 illustrates a section of the tide gage chart.

7. Instrument Mounts

The original instrument mounts were made of brass and proved to be too weak to withstand prolonged cable vibration and wave action. Similar mounts have been designed for construction in stainless steel which should withstand even the most violent forces.
8. Water Samples

Water samples are analysed by Woods Hole Oceanographic Institution in conjunction with their Light Ship Program.

9. Meteorology

The Air Weather Service of the United States Air Force is collecting and disseminating synoptic meteorological and climatological data on a routine basis.

V. PERSONNEL REQUIREMENTS

Two men on continuous call are required to maintain the oceanographic instruments on the tower. Many duties such as lowering instrument mounts require two men. Since recorders are automatically programmed, split shifts have not been necessary. Quarters, messing, and recreational facilities are provided by the Air Force.

Tour of duty for oceanographers is 1 month plus travel time. Transportation to and from the tower is exclusively by helicopters from Otis AFB in Falmouth, Massachusetts via 762nd AC&W Squadron, North Truro, Massachusetts.

VI. FUTURE PLANS

Plans for the immediate future include installation of thermocouples at various levels in the sea and air to be recorded on a multipoint potentiometer. It is planned to record incident and reflected long and short wave radiation. An acoustic system (Mk 1) is scheduled for installation by NOL in the near future. This system will record bottom pressure fluctuations a quarter of a mile from the tower.

A system for recording operation of all data collecting systems is scheduled for installation very soon. Such a recorder would register the on and off times of all recorders, thus maintaining a continuous record of all data being taken. Such a system is expected to minimize manpower and errors involved in log keeping and would be a permanent reference to data available at any time.

Projected plans include the measurement of wave forces, ambient noise, wave direction, bottom seismology, atmospheric pressure rates of change, and water conductivity.

It is anticipated that data recording systems of a similar nature will be employed on subsequent Texas Towers after having proven successful on Georges Shoal. Two more towers are planned by the Air Force. Nantucket Shoals Texas Tower (No. 3) is already in position in 86 feet of water and is scheduled for completion in 1957.
FIGURE I. AERIAL VIEW OF GEORGES SHOAL TEXAS TOWER
FIGURE 2. PLAN VIEW OF OCEANOGRAPHIC OBSERVATORY COMPARTMENT
FIGURE 3. RECORDERS
FIGURE 4. WINCHES AND UPPER ENDS OF GUIDE CABLES

FIGURE 5. ANEMOMETERS BEING LOWERED ON GUIDE CABLES
FIGURE 6. TYPICAL ARRANGEMENT OF INSTRUMENTS ON GUIDE CABLES.
FIGURE 7. WIND RECORD SHOWING INTERFERENCE OF NORTH CAISSON
FIGURE 8. CURRENT METERS BEING LOWERED ON GUIDE CABLES

FIGURE 9. WAVE STAFF BEING LOWERED ON GUIDE CABLES
FIGURE 12. ROTARY TIDAL CURRENT ON 7 MAY 1956
FIGURE 13. EXAMPLE OF WAVE RECORD
FIGURE 14. PRESSURE FLUCTUATIONS AT 20 FEET DURING PASSAGE OF HURRICANE BETSY
FIGURE 15. PATH OF HURRICANE BETSY
FIGURE 16. SECTION OF TIDE GAGE RECORD
The objectives of the observational program are outlined, the observatory and its instruments are described. The data collected during Spring and Summer 1956 are summarized and future plans are outlined.

U. S. NAVY HYDROGRAPHIC OFFICE
TEXAS TOWER OCEANOGRAPHIC OBSERVATIONAL PROGRAM, SPRING AND SUMMER 1956, October 1956, 23 p., including 17 figures, 3 tables. (H. O. TR-41)

1. Texas Tower
2. Oceanography, Georges Shoal
3. Georges Shoal, Oceanography

i. title: Texas Tower Oceanographic Observational Program, Spring and Summer 1956.

ii. H. O. TR-41