

# Long Range Acoustic Communications Experiment 2010

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## Objectives

Experimentally confirm that robust coherent synthetic aperture communications (SAC) is feasible between a source and a receiving array at speed and depth at long ranges in deep water with separations as much as 1,000 km.

## Background

Analysis of deep-water data collected as part of the ONR Acoustic Thermometry of Ocean Climate (ATOC) program has suggested that coherent acoustic communications is feasible at long ranges. By treating the tomography signals (m-sequence transmissions) as BPSK communication signals, successful recovery of the sequence of bits has been demonstrated. One example is from the ATOC Acoustic Engineering Test (AET) in November 1994 where 1023-digit m-sequences were transmitted at a 75 Hz center frequency to a 20-element (700 m aperture) vertical array at approximately 3250 km range in the NE Pacific Ocean. An information rate of 37.5 bits/s was achieved. For additional details about this test, see: H.C. Song, W.A. Kuperman, and W.S. Hodgkiss, "Basin-scale time reversal communications," *J. Acoust. Soc. Am.* 125(1): 212-217 (2009).

While initial feasibility of long-range acoustic communications has been demonstrated as discussed above, the transmissions in the September 2010 experiment will be carried out at a higher center frequency (~100-300 Hz) and will explore larger bandwidths and higher order constellations with signals designed appropriate for deep-water, long-range synthetic aperture communications, rather than for acoustic tomography experiments. Thus, our intent is to understand the limiting characteristics of long-range acoustic communications in deep water.

## Location and Participating Ships

The long range acoustic communications (LRAC) experiment will be carried out 8-21 September 2010 off the southern California coast. Two SIO (Scripps Institution of Oceanography) ships will participate – the R/V New Horizon will be the source ship and the R/V Melville will be the receiving array ship.

For marine mammal mitigation purposes, the source ship will need to transit ~1100 km (~600 nmi) west of San Diego for an appropriate operational area. The source ship will tow the sound source at relatively low speed (2-5 knots) within its operational area.

The receiving array ship will tow a horizontal line array (HLA) at distances 100-1000 km (55-540 nmi) from the source. The HLA will be towed at relatively low speed (~5 knots) during this period. Although some of the towed array operation will be carried out with the array broadside to the source, most of the tow time will be spent in an endfire configuration with the HLA traversing roughly a radial path with respect to the source position.

In both cases, the source and receiving array ships will traverse tracks roughly aligned with the prevailing wind and seas.

### **Acoustic Transmissions**

The R/V New Horizon is the source ship.

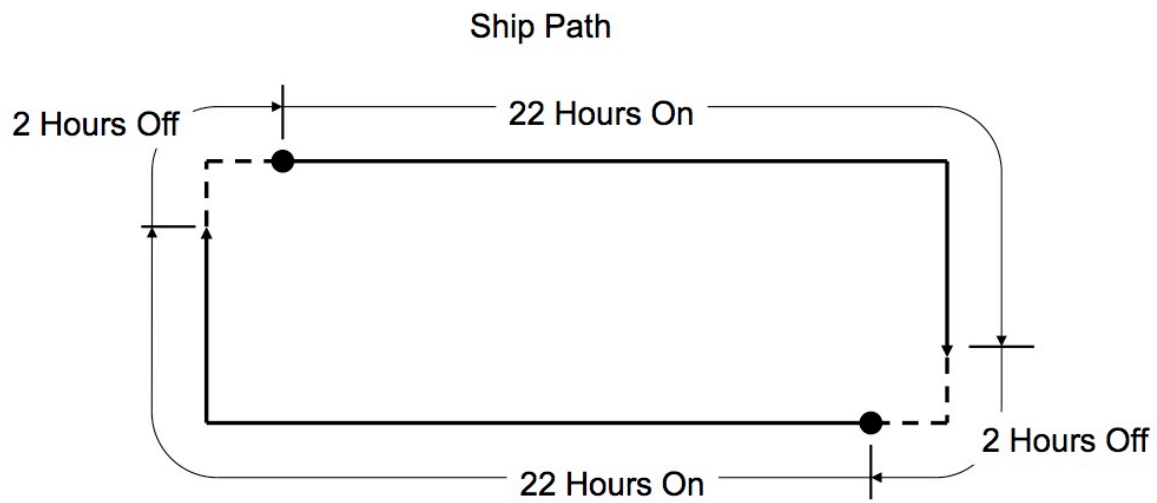
The acoustic transmissions primarily will be continuous transmissions of a phase modulated carrier (PSK) as well as multicarrier (OFDM) transmissions in the 100-300 Hz band. Some linear frequency modulated (LFM) chirps also will be transmitted in the same band.

The source will be a J15-3 (plus a spare). The source has a maximum depth of 100 m and the typical tow depth will be 75 m. The frequency transmitting current response (TCR) roughly is flat 50-300 Hz and gradually rolls off to 600 Hz. The maximum source level is ~180 dB re  $\mu\text{Pa}$  @ 1 m.

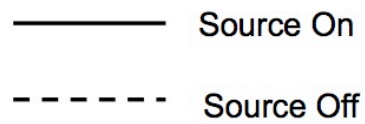
For marine mammal impact mitigation purposes, the acoustic source transmissions will be restricted to be within the box given by the following SE and NW coordinates:

30 deg 00' N, 125 deg 10' W  
35 deg 00' N, 130 deg 00' W

The source transmissions will be at a depth of 75 m with the source being towed slowly at a speed of 2-3 knots. The transmissions will have the duty cycle illustrated in the figure below (22 hours on and 2 hours off). The exact tow direction is not critical and should be at a heading most convenient for ship handling (e.g. NW and SE).



Track Separation ~5 nm



Duty cycle of acoustic transmissions.



## Schedule

The experiment period is 8-21 September 2010 (14 days) for the R/V New Horizon and 8-19 September 2010 (12 days) for the R/V Melville. The experiment schedule somewhat is driven by the source ship transit to its operational area. The assumption is that a little over 6 days will be devoted to data collection, 1 day to hardware testing, and 4-6 days devoted to transit to/from the deep water operational area of both ships.

The overall schedule roughly will be as follows (see Appendix with ship track map and chart of the NE Pacific operational area):

Date	Operation
07Sep10	Mobilize
08-11Sep10	Transit to beginning of source/receive array operations (34°N, 129°W)
11Sep10	Deploy source and FORA towed array – operational checks
12-18Sep10	Data collection
18-19Sep10	Transit to port (R/V Melville)
18-21Sep10	Transit to port (R/V New Horizon)
20Sep10	Demobilize – R/V Melville
22Sep10	Demobilize – R/V New Horizon

Notes:

(1) The source will be deployed to 75 m depth and towed at ~2 knots. What is indicated on the map is the center point of the desired source tow track with its length being ~50 nmi (24 hour straight tow approximately into or away from the prevailing NW wind).

The reason for selecting the upper-left-hand corner of the permitted box is to stay away from the seamounts in the 31-32°N, 126-128°W region. This also achieves the largest range possible between the source and towed array.

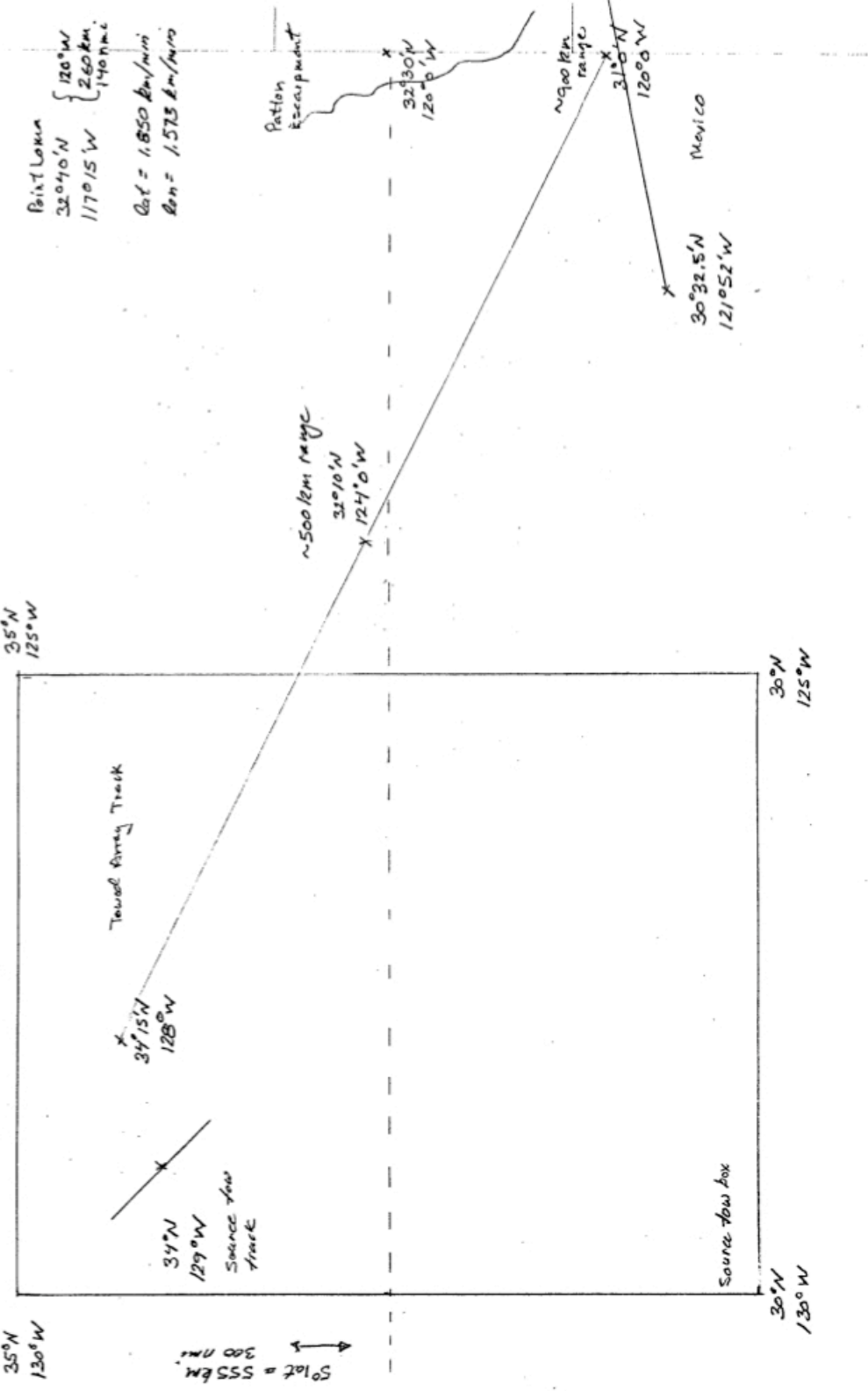
(2) The towed HLA is ~280 m long in aperture and will be towed at ~200 m deep. Since it is just a receiver, there are no restrictions on where it can be deployed other than any navy operational area considerations and any navigation hazards (surface and subsurface moorings).

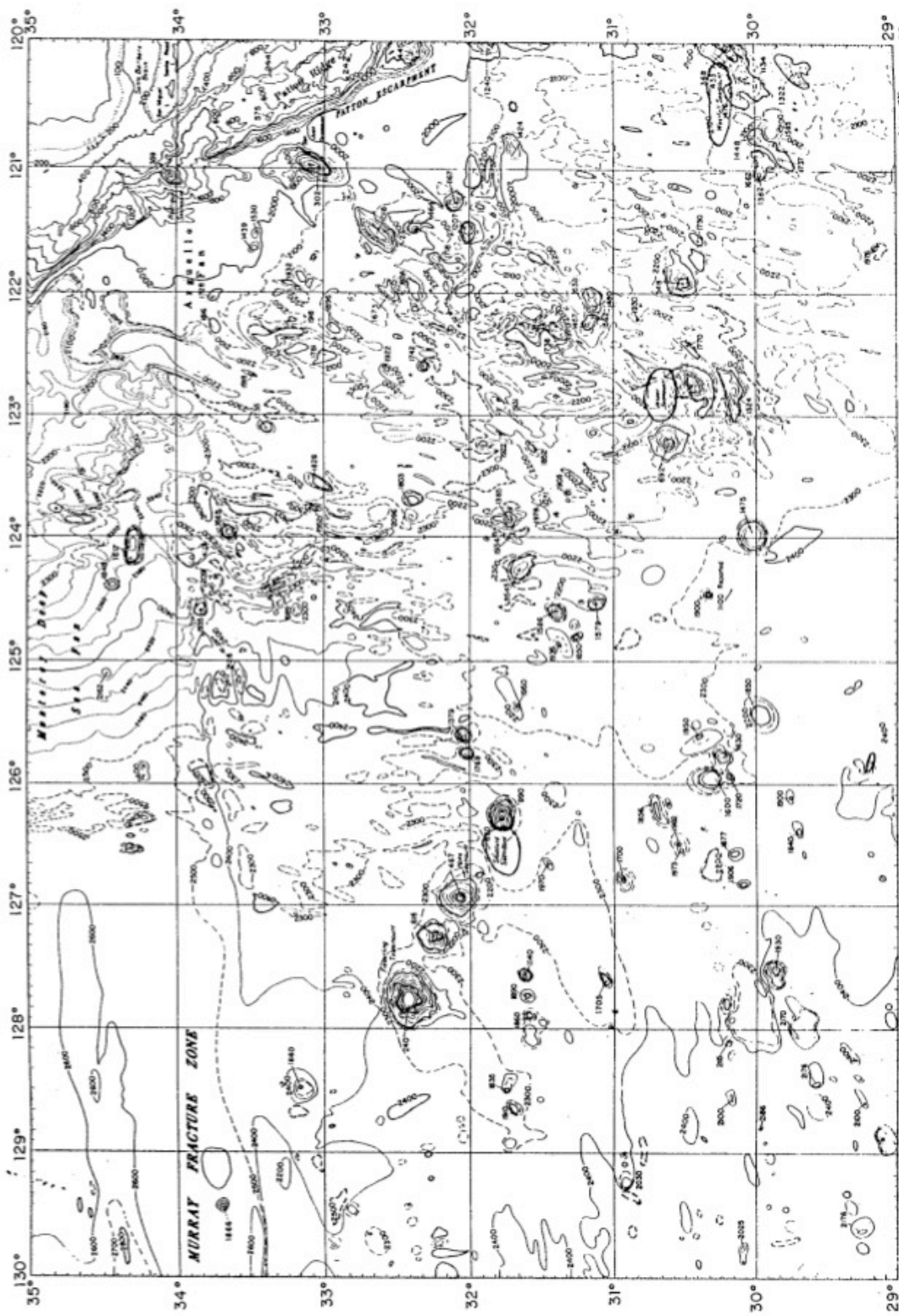
The intent is to start the data collection at relatively short source-receiver range (~100 km) and let the range open from there until the end of the experiment. The HLA will be towed at ~4-5 knots (~100 nmi/day or ~185 km/day).

If the HLA was towed straight without stopping, the track shown is ~432 nmi or ~800 km in length and this would take ~4.3 days. Likely, extra time (~1-2 days) will be spent going back and forth around the point that is at ~500 km range. All towed array operations are in deep water (~4 km or deeper).

Scale = 100 kms/in

5° lon = 472 km  
255 nmi





129° 128° 127° 126° 125° 124° 123° 122° 121° 120°

35° 34° 33° 32° 31° 30° 29°

**MURRAY FRACTURE ZONE**

**PATTON ESCARPMENT**

1:10,000 Scale

NO. 1306N

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with 100 fathom contour interval