REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
March 27, 2009

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*
7 April 2007 – 31 December 2008

4. TITLE AND SUBTITLE
DURIP: Broadband Multichannel Source-Receive Nodes

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-07-1-0716

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Hodgkiss, WS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Marine Physical Laboratory of the Scripps Institution of Oceanography
University of California, San Diego
291 Rosecrans Street
San Diego, California 92106

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
One Liberty Center
875 N. Randolph Street, ONR 321
Arlington, VA 22203-1995
Robert Headrick

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Two broadband multichannel source-receive nodes have been designed and fabricated for use in the investigation of both acoustic propagation perturbations caused by environmental fluctuations and acoustic data communications in the ocean.

15. SUBJECT TERMS
acoustic data communication, acoustic propagation, signal processing

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	None	10	Anne J. Footer

19b. TELEPHONE NUMBER *(Include area code)*
858-534-1802

Reset

DURIP: Broadband Multichannel Source-Receive Nodes

W.S. Hodgkiss

Marine Physical Laboratory
Scripps Institution of Oceanography
La Jolla CA 92093-0701

27 March 2009

Final Report

Contract N00014-07-1-0716

For the Period

7 April 2007 – 31 December 2008

DURIP: Broadband Multichannel Source-Receive Nodes

W.S. Hodgkiss

Marine Physical Laboratory
Scripps Institution of Oceanography
La Jolla CA 92093-0701

Abstract

Two broadband multichannel source-receive nodes have been designed and fabricated for use in the investigation of both acoustic propagation perturbations caused by environmental fluctuations and acoustic data communications in the ocean. The availability of multiple sources in the water column will facilitate the investigation of propagation fluctuations through the simultaneous probing of the waveguide at multiple depths and similarly will facilitate the exploration of new multiple-source/multiple-receiver (MIMO) acoustic data communications concepts. Each node consists of 8 source-receive transducers cabled individually to an electronics pressure case, an internal disk capacity of 2TB for data recording, and power amplifiers for arbitrary waveform transmission. The specific band of interest is 12-32 kHz. The source transmission portion of the system was tested during the ONR KAM08 (Kauai Acomms MURI 2008) experiment in June-July 2008.

Hardware Summary

The hardware components for the two source-receive nodes were acquired under the fabrication “Fabrication of Broadband Multichannel Source-Receive Node.” The following will describe these components for each array system.

The design draws on our experience with the fabrication and at-sea deployment of autonomous broadband receive array hardware that we have deployed successfully in several major experiments [1]. The source-receive nodes described here complement those receive-only arrays by adding a multichannel source transmission and receive capability (i.e. a bidirectional source-receive node). Since low drag floats, RF-telemetry buoys, and mooring hardware already exist and are available for use, just the source-receive node hardware itself was the focus of this hardware design and fabrication.

Specific characteristics of each 8-element source-receive node are the following:

- 8 source-receive transducers (ITC-1001) with arbitrary element spacing
- Bandwidth 12-32 kHz
- Individual transmit power amplifier and receive signal conditioning for each transducer
- Arbitrary waveform synthesis and transmit signal scheduling
- f_S = 100 kHz (transmit and receive)
- Internal disk recording capacity = 2TB

The source-receive elements are ITC-1001 spherical transducers which cover the band of interest (12-32 kHz). The multichannel source waveform generation and data acquisition system functions are implemented in LabVIEW on a compact PCI CPU (Kontron CP306 single slot 3U cPCI board). On transmit, the source waveforms are generated by the CPU, converted to analog signals by a multichannel D/A, and amplified by individual Class D pulse width modulated power amplifiers (APEX SA12 modulator and associated circuitry). The combined transmit response of each power amplifier and ITC-1001 transducer is illustrated in Fig. 1. On receive, the signal conditioning electronics (20, 40, or 60 dB variable gain amplifiers and filtering – 4 kHz high-pass and 40 kHz low-pass for anti-aliasing) are followed by a multichannel A/D. The receive sensitivity of the ITC-101 is shown in Fig. 2. The 8-channel A/D and D/A board is a National Instruments PXI-7833R and includes a FPGA which provides transmit/receive data buffering, low rate clock generation, and control lines. The receive data is recorded on four serial ATA 500 GB, 2.5” disk drives (2 TB total capacity). Accurate timing for waveform transmission and receive data sampling is provided by a precision real-time clock which is synchronized with GPS (Fei-Zyfer NanoSync II Model 380). The CPU includes a

1000BaseT Ethernet interface which has been made available through a bulkhead connector on the pressure case. Thus, high-speed access to the data on the internal disks is available without the need to open the pressure case. Power is supplied externally by four, 24 volt, underwater batteries.

Deployment of Source Array During KAM08

An 8-element array of ITC-1001 transducers with 7.5 m element separation (52.5 m aperture) was deployed during KAM08 (Kauai Acomms MURI 2008) off the stern A-frame while R/V Melville was in dynamic positioning mode (i.e. the source array was not anchored to the seafloor). The array dimensions are shown in Fig. 3. Note that Transducer #1 is closest to the sea surface and had a nominal depth of 30 m. Fig. 4 shows the source array and electronics pressure cases on deck of the R/V Melville prior to deployment and Fig. 5 shows the electronics pressure cases just entering the water. During KAM08, continuous transmissions from all channels simultaneously or a single channel at a time (e.g. round-robin fashion for channel impulse response measurement purposes or single channel transmissions at a selected depth) were demonstrated.

Deployment Configurations

The overall deployment concepts are shown in Fig. 6 [1]. In the autonomous configuration, the batteries are mounted in a frame along with the pressure case near the seafloor. When the surface buoy is included in the deployment configuration, power is provided by the buoy as well as RF-telemetry (802.11b) thus adding real-time access to the source-receive node over the Ethernet. The use of the RF-telemetry buoy enables updating acoustic source transmission schedules/waveforms as well as providing immediate access to receive array data without requiring recovery of the hardware.

References

[1] J.D. Skinner and W.S. Hodgkiss, “A networked/autonomous receiving array system,” Proc. OCEANS 2008 (2008).

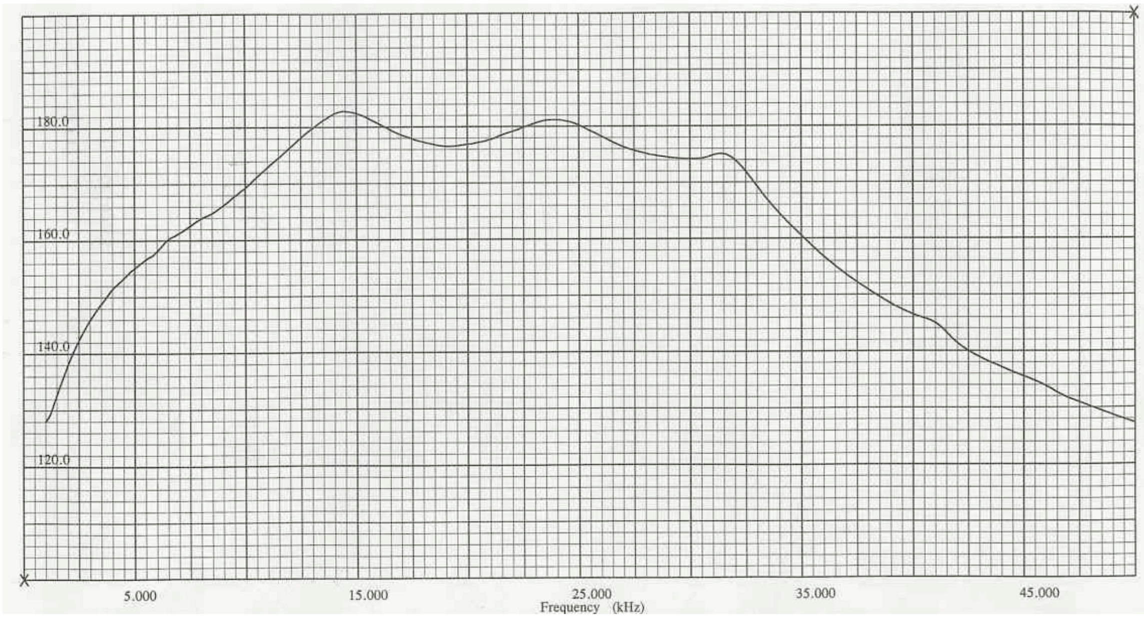

Figure 1. Transmit channel characteristics (power amplifier and ITC-1001 transducer). Transmit level is 6 dB below full-power. The nominal bandwidth of each source is 12-32 kHz with a maximum source level of 185 dB +/- 4 dB across this band.

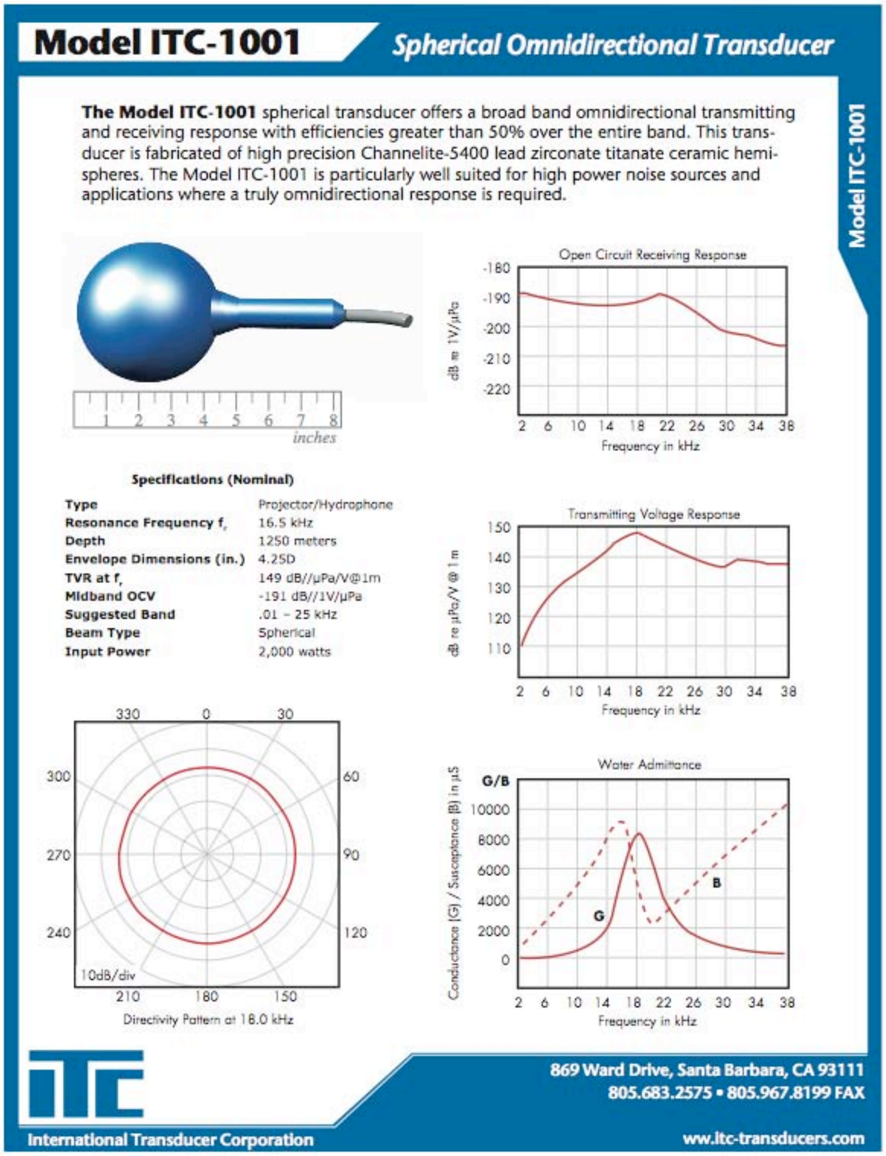

Figure 2. ITC-1001 receiving sensitivity and transmit voltage response.

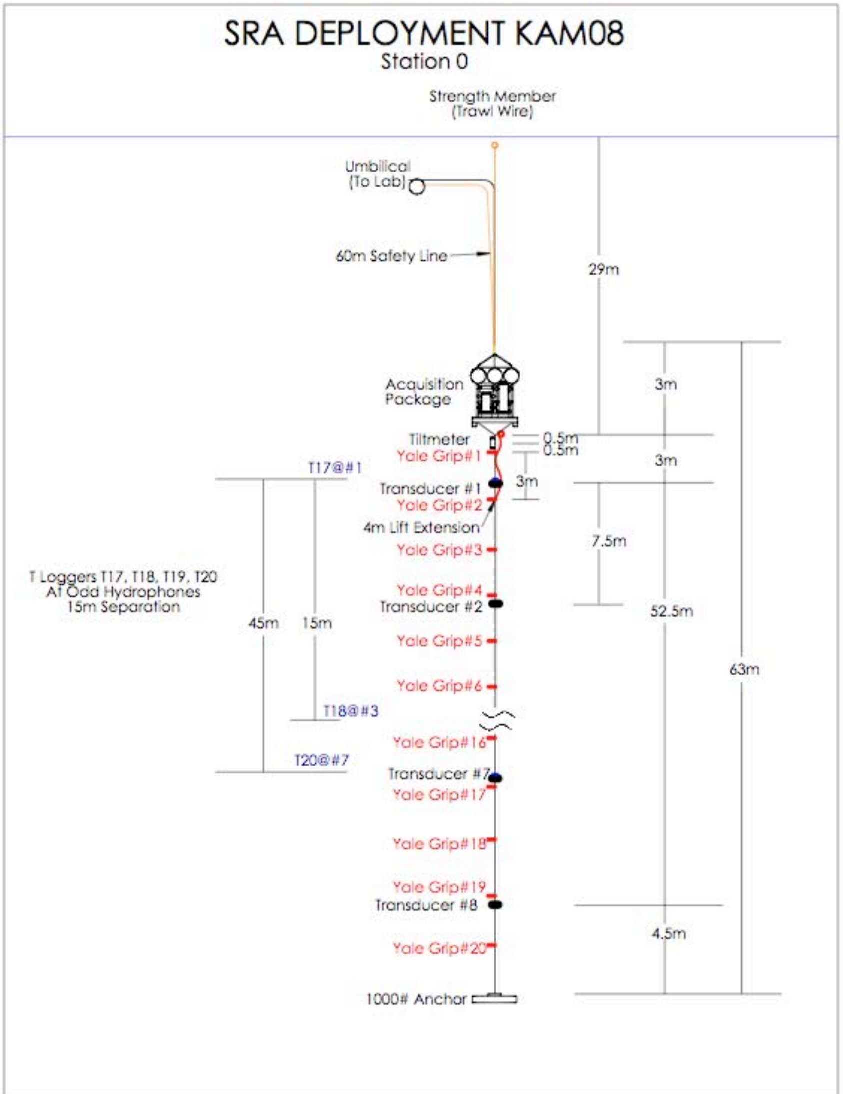

Figure 3. Source array deployed from the R/V Melville in dynamic positioning mode during KAM08.

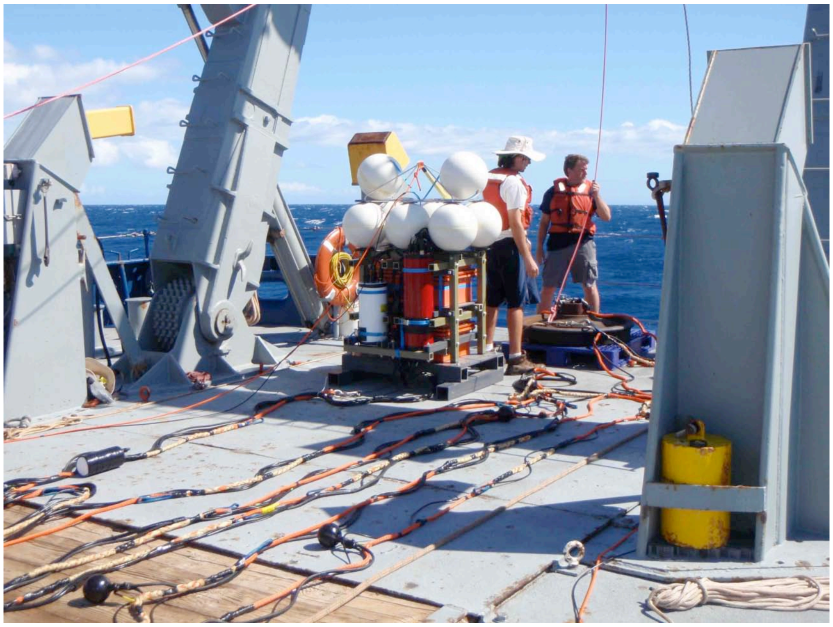

Figure 4a. Source array on deck of R/V Melville prior to deployment during KAM08.

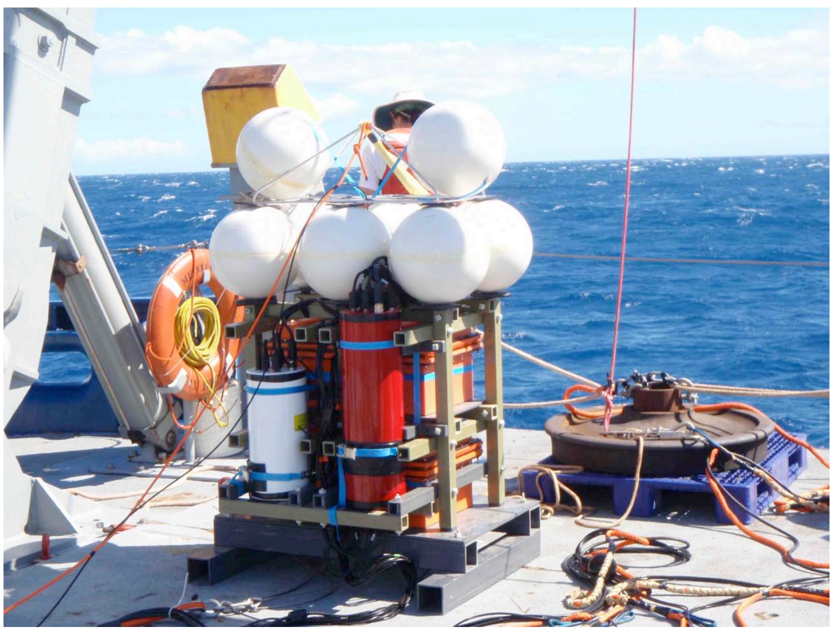

Figure 4b. Source array electronics. Power amplifiers are in the red pressure case (right) and remaining electronics (CPU, timing, and D/A) are in the white pressure case (left).

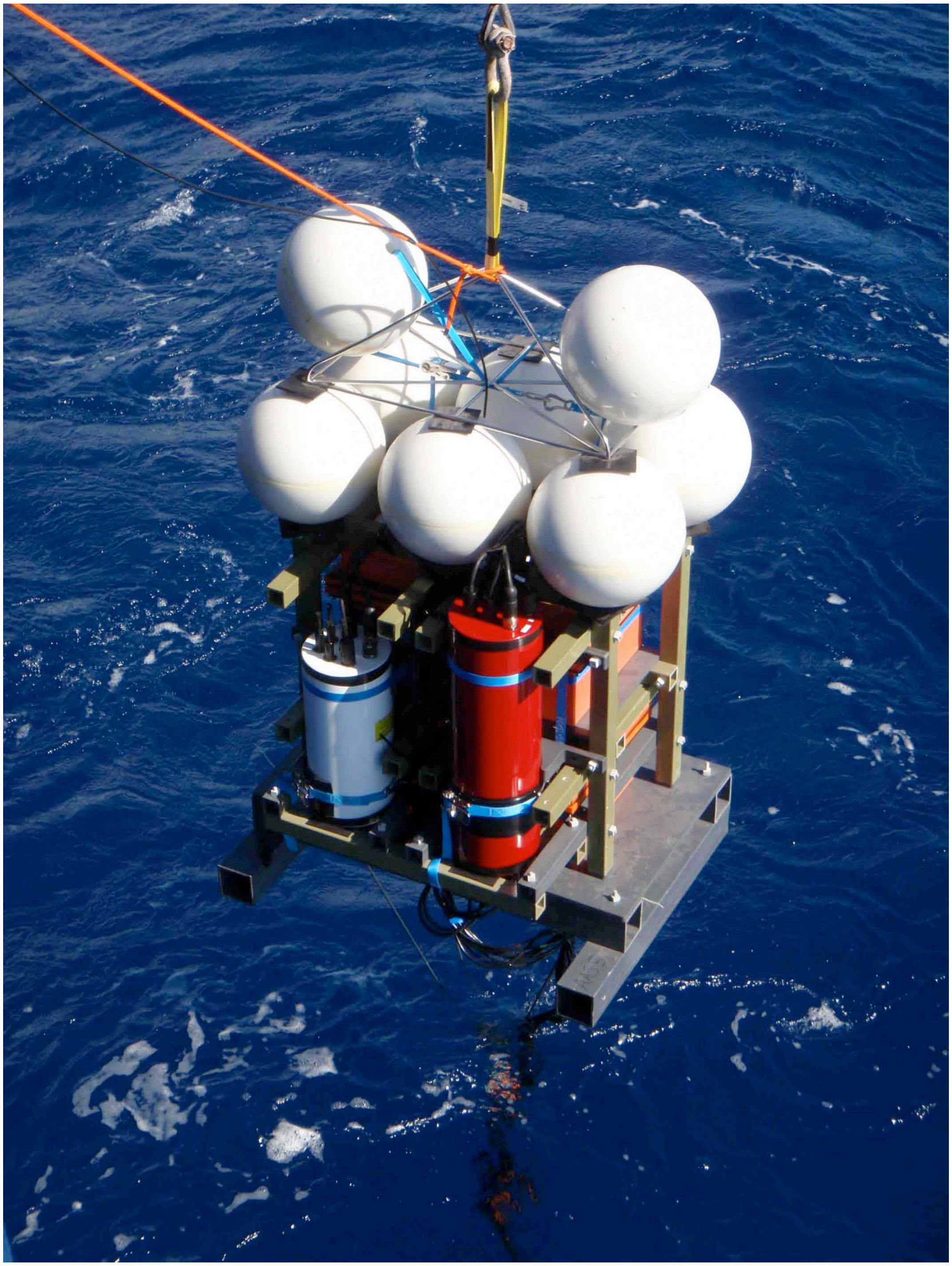

Figure 5. Source array being lowered into the water during KAM08.

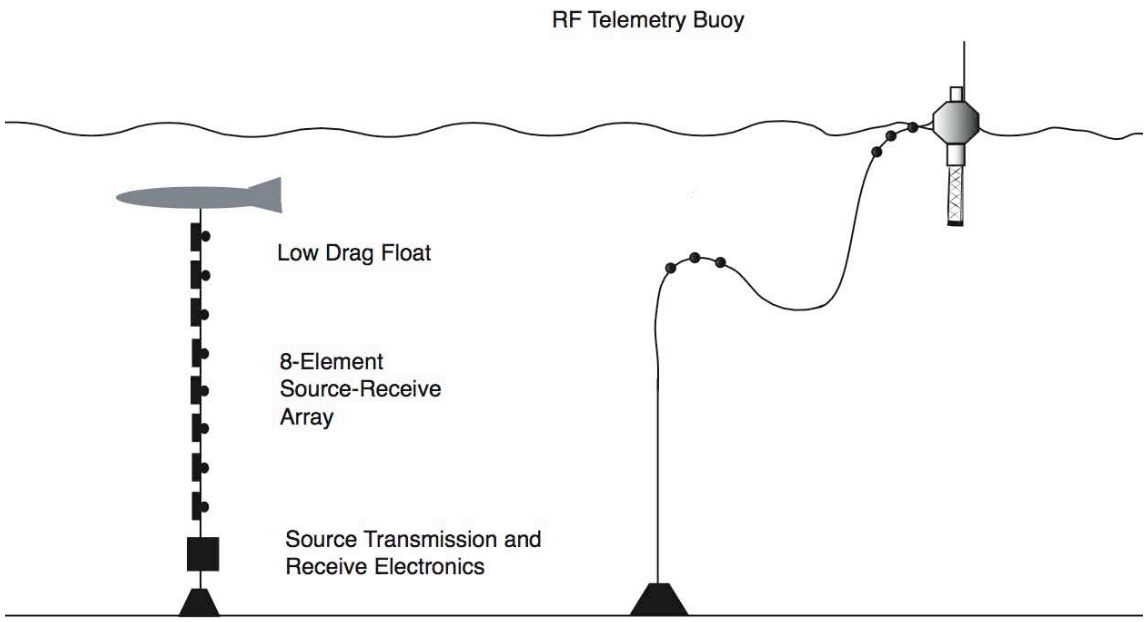

Figure 6. Source-receive node deployment concepts. A low-drag buoyant float at the top of the source-receive array helps minimize array motion. The source transmission and receive electronics are in a pressure case at the bottom of the array. Four underwater batteries mounted in a frame along with the pressure case provide power for autonomous operation (left side only). Although requiring a more complicated deployment, the addition of a RF-telemetry buoy (left and right sides together) adds a real-time access capability to the source-receive node thus enabling the ability to update acoustic source schedules/waveforms as well as to provide immediate access to receive array data without requiring recovery of the hardware. In addition, power for the source-receive electronics is provided by the buoy.