A Mediterranean Undercurrent Seeding Experiment (AMUSE):
Part II: RAFOS Float Data Report
May 1993 - March 1995

by

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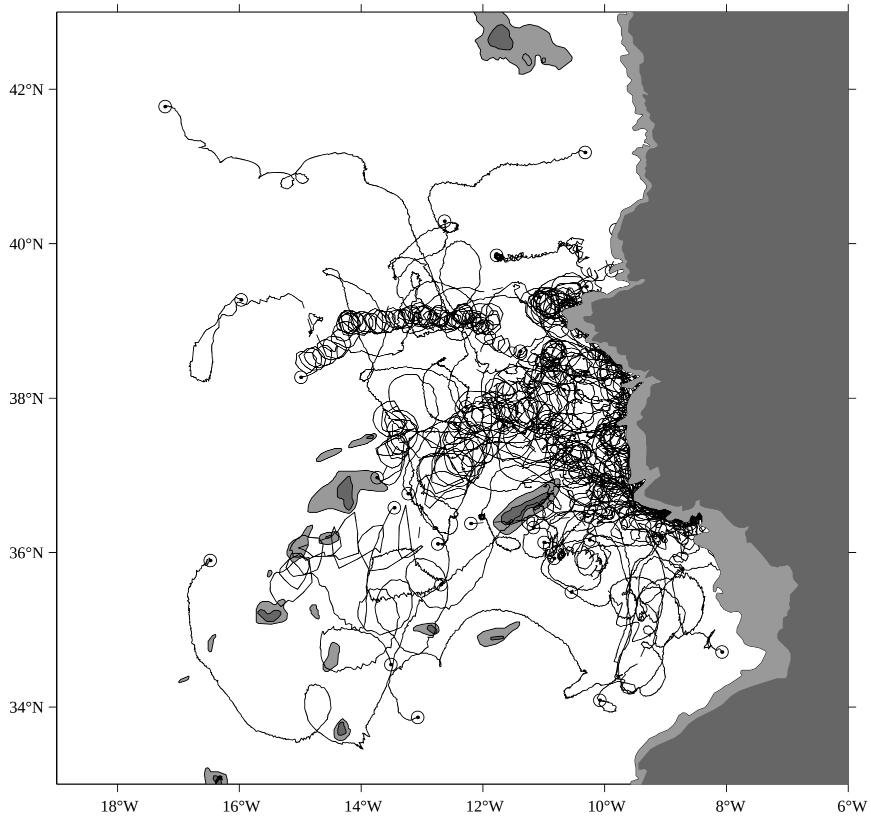

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Abstract

This is the final data report of all acoustically tracked RAFOS data collected in 1993-1995 during A Mediterranean Undercurrent Seeding Experiment (AMUSE). The overall objective of the program was to observe directly the spreading pathways by which Mediterranean Water enters the North Atlantic. This includes the direct observation of Mediterranean eddies (meddies), which is one mechanism that transports Mediterranean Water to the North Atlantic. The experiment was comprised of a repeated high-resolution expendable bathythermograph (XBT) section and RAFOS float deployments across the Mediterranean Undercurrent south of Portugal near 8.5°W. A total of 49 floats were deployed at a rate of about two floats per week on 23 cruises on the chartered Portuguese-based vessel, Kialoa II, and one cruise on the R/V Endeavor. The floats were ballasted for 1100 or 1200 decibars (db) to seed the lower salinity core of the Mediterranean Undercurrent. The objectives of the Lagrangian float study were (1) to identify where meddies form, (2) to make the first direct estimate of meddy formation frequency, (3) to estimate the fraction of time meddies are being formed, and (4) to determine the pathways by which Mediterranean Water which is not trapped in meddies enters the North Atlantic.

Table of Contents

List of Figures

List of Tables

1. Introduction

This is the final data report of all acoustically tracked Ranging and Fixing of Sound (RAFOS) float data collected in 1993-1995 during A Mediterranean Undercurrent Seeding Experiment (AMUSE). Principal investigators for the project were Amy Bower of the Woods Hole Oceanographic Institution, Laurence Armi of the Scripps Institution of Oceanography, and Isabel Ambar of the University of Lisbon. The overall objective of the program, funded by the National Science Foundation and by the Luso-American Foundation for Development (FLAD), was to observe directly the spreading pathways by which Mediterranean Water enters the North Atlantic. This includes the direct observation of Mediterranean eddies (meddies), which is one mechanism that transports Mediterranean Water into the North Atlantic. The experiment was comprised of high-resolution expendable bathythermograph (XBT) and RAFOS float deployments in a

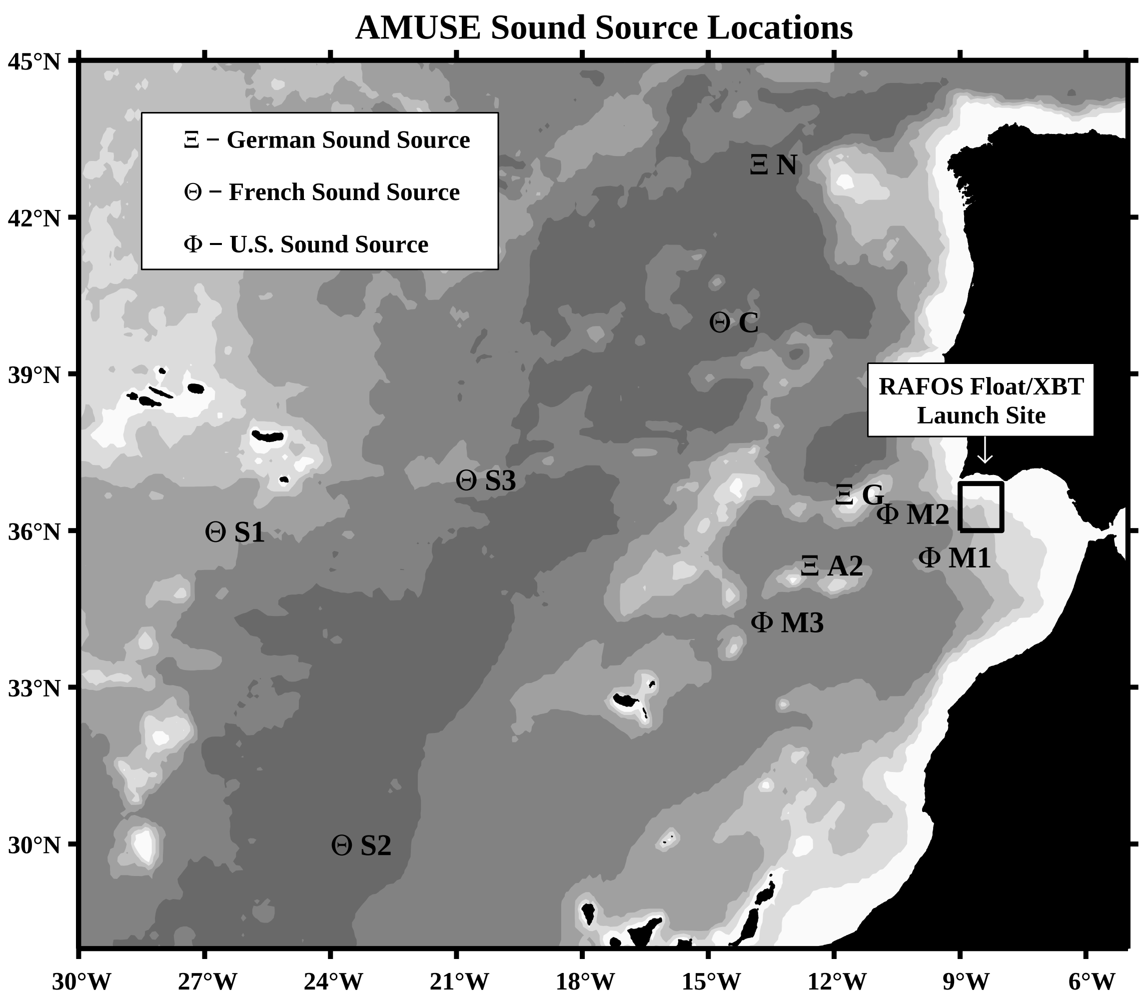

Figure 1: AMUSE float and XBT deployment and sound source locations in the eastern North Atlantic. Bathymetry intervals are every 1000 meters, shown by different shades of gray.

section across the Mediterranean Undercurrent south of Portugal (see Figure 1 and Figure 2). The objectives of the Lagrangian float study were (1) to identify where meddies form, (2) to make the first direct estimate of meddy formation frequency, (3) to estimate the fraction of time meddies are being formed, and (4) to determine the pathways by which Mediterranean Water which is not trapped in meddies enters the North Atlantic.

The Mediterranean Undercurrent is comprised of two salinity maxima. The deeper salinity core was chosen as the target for the float seeding since the water from this core is found in almost all meddies, while water from the upper core is found in only some meddies.

Figure not available.

Figure 2: An expanded view of the float and XBT launch site, shown in Figure 1. The black dots mark where the XBTs were deployed. Floats were launched between XBT launch locations 05 and 08. Bathymetric contours are shown every 200 meters.

The first two floats were launched from the R/V Oceanus in May 1993 during a preliminary CTD survey of the Undercurrent south of Portugal aimed at finding the best float launch site for the repeated seeding. Forty-seven floats were subsequently deployed at a rate of about two floats per week on 22 of 24 cruises of the Portuguese-based chartered vessel Kialoa II between July 1993 and March 1994 (see Figure 3 and Table 1). The floats were ballasted for 1100 or 1200 decibars (db). They were programmed for up to 11-month missions, and tracked using seven moored sound sources. Three of the sources were deployed specifically for AMUSE from the R/V Oceanus in May 1993, and the others had been deployed by German and French scientists for other experiments.

AMUSE Float Duration Chart

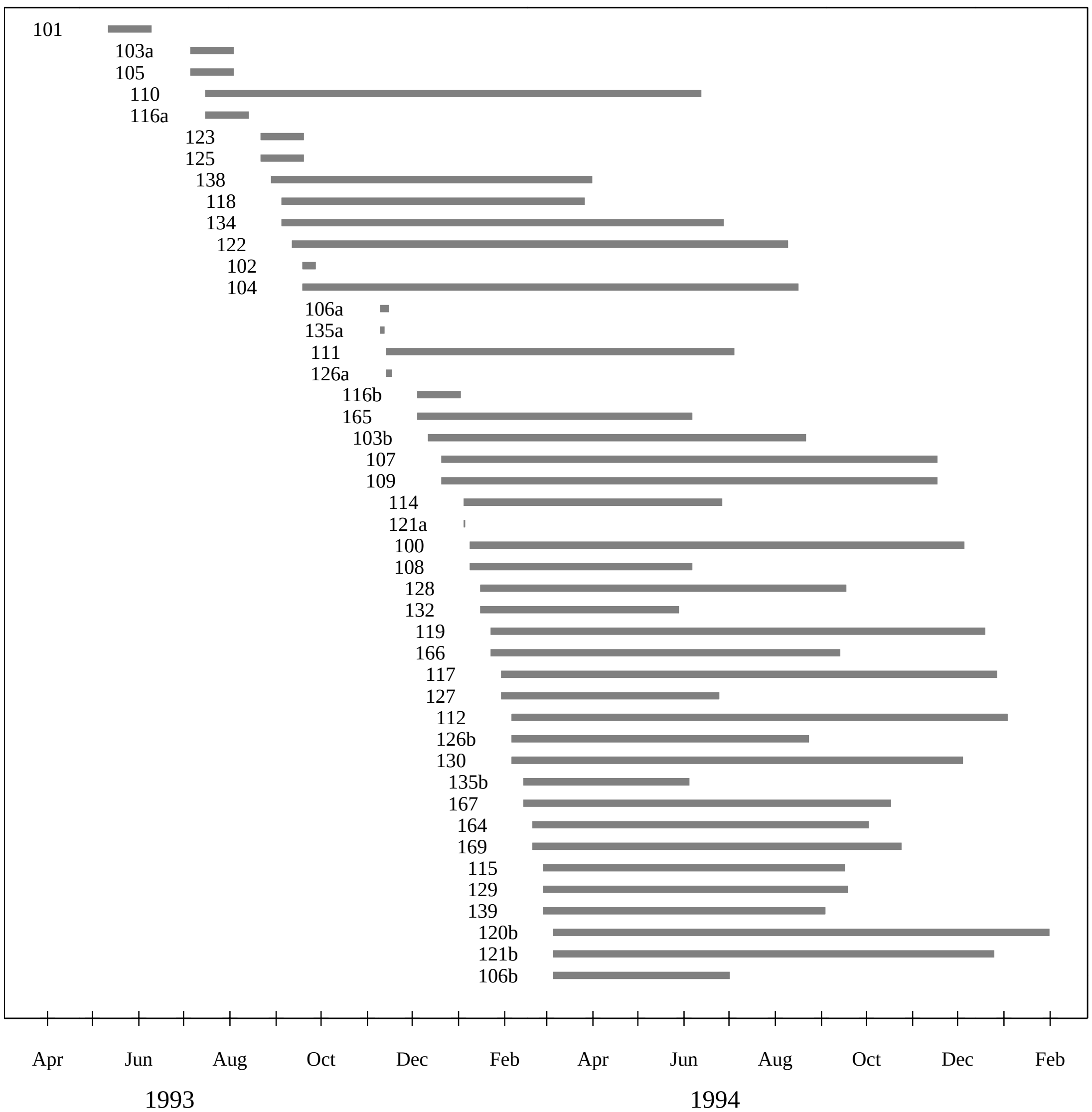

Figure 3: Float duration chart showing the periods that the floats were in the water. Float numbers are marked on the left. Floats are listed in order of launch date from top to bottom.

2. Description of the RAFOS Floats

The RAFOS float is an acoustically tracked subsurface Lagrangian drifter (see Rossby *et al*. (1986) for a complete description of the RAFOS system), which is programmed to listen for signals from moored sound sources. The RAFOS float determines the time-of-arrival (TOA) of these signals, from which, given the speed of sound in water, its position can be determined. The TOA of the acoustic signals, as well as temperature and pressure measurements are stored in the float's micro-processor memory. Also stored in the float's memory are correlation heights for each TOA, which indicate the quality of the TOA signal heard. The sound sources in this experiment were programmed to transmit an 80 second long continuous wave tone, which linearly increases its frequency from 259.375 Hz to 260.898 Hz. The individual sound sources broadcast this tone three times a day, and broadcast at different times (beginning at 0030, 0100, and 0130 UTC, and every eight hours thereafter). The floats in this experiment listened for these signals once every eight hours (beginning at 0025 UTC). The float temperature sensors were built by Yellow Springs Instrument Company and were calibrated to ±0.01°C. These thermistors were mounted on the main float board and logged manually. Float pressure sensors were built by Data Instruments and calibrated to ±1% at 2000 psi.

Table 1. RAFOS Float Summary – launch and surface data

Float ID	*Launch Site*	*LAUNCH*			*SURFACE*			*Length of Mission (days)*
		Date (yymmdd)	*Latitude (°N)*	*Longitude (°W)*	*Date (yymmdd)*	*Latitude (°N)*	*Longitude (°W)*	
101	OCctd110	930511	36.556	8.438	930610	37.692	10.064	30
113	OCctd111	930511	36.536	8.458	930512	36.533	8.447	1
103a	K0106	930705	36.561	8.442	930804	36.276	11.179	30
105	K0107	930705	36.539	8.462	930804	37.636	11.675	30
110	K0207A	930715	36.525	8.480	940613	38.014	15.150	333
116a	K0205	930715	36.577	8.429	930814	37.621	11.516	30
123	K0306	930821	36.564	8.442	930920	36.524	8.340	30
125	K0307	930821	36.542	8.460	930920	37.085	9.385	30
124	K0405A	930828	36.571	8.432	no show			
138	K0407	930828	36.540	8.465	940401	39.623	9.912	216
118	K0506	930904	36.561	8.443	940327	39.654	12.967	204
134	K0507	930904	36.542	8.460	940628	36.686	13.435	297
120a	K0606A	930911	36.549	8.453	930914	36.498	8.827	3
122	K0607A	930911	36.533	8.471	940810	37.891	12.311	333
102	K0706	930918	36.561	8.446	930928	36.965	9.850	10
104	K0707A	930918	36.531	8.471	940817	40.481	9.856	333
106a	K0906	931109	36.562	8.446	931116	36.689	9.313	6
135a	K0907A	931109	36.532	8.470	933113	36.476	8.566	5

Table 1. RAFOS Float Summary (continued)

Float ID	Launch Site	LAUNCH			SURFACE			Length of Mission (days)
		Date (yymmdd)	*Latitude (°N)*	*Longitude (°W)*	*Date (yymmdd)*	*Latitude (°N)*	*Longitude (°W)*	
111	K1006	931113	36.561	8.444	940705	35.209	10.266	235
126a	K1007	931113	36.542	8.463	931118	36.490	8.558	5
116b	K1205A	931204	36.572	8.437	940103	36.963	10.101	30
165	K1208	931204	36.522	8.482	940607	38.106	10.689	185
103b	K1306	931211	36.563	8.445	940822	37.663	11.103	254
170	K1307A	931211	36.531	8.470	940905	33.010	19.273	269
107	K1406	931220	36.562	8.444	941118	35.924	10.894	333
109	K1407A	931220	36.532	8.471	941118	41.803	17.204	333
114	K1505A	940104	36.572	8.434	940627	39.210	10.223	174
121a	K1506A	940104	36.551	8.453	940106	36.481	8.737	3
100	K1606	940108	36.561	8.445	941206	34.032	10.156	333
108	K1608	940108	36.521	8.480	940607	36.135	11.081	151
128	K1705A	940115	36.568	8.435	940918	40.340	12.760	246
132	K1706A	940115	36.550	8.452	940529	36.377	12.197	134
119	K1806A	940122	36.549	8.454	941220	41.272	10.487	333
166	K1807A	940122	36.531	8.470	940914	35.622	12.707	245
117	K1905A	940129	36.573	8.434	941228	39.351	15.716	333
127	K1907A	940129	36.534	8.472	940625	39.968	9.977	148
112	K2005A	940205	36.571	8.433	950104	36.007	16.478	333
126b	K2006A	940205	36.551	8.453	940824	36.666	13.236	201
130	K2007A	940205	36.530	8.471	941205	38.648	11.350	303
135b	K2105A	940213	36.570	8.434	940605	39.229	10.288	112
167	K2106A	940213	36.560	8.443	941018	39.312	11.057	247
164	K2205A	940219	36.572	8.434	941003	36.149	10.317	226
169	K2207	940219	36.541	8.460	941025	33.889	13.091	249
115	K2305A	940226	36.572	8.435	940917	34.373	13.501	203
129	K2307A	940226	36.532	8.467	940919	36.874	13.427	206
139	K2307	940226	36.542	8.460	940904	36.116	12.780	190
120b	K2406	940305	36.562	8.444	950201	37.881	12.102	333
121b	K2406A	940305	36.552	8.452	941226	35.022	7.555	297
106b	K2407	940305	36.542	8.461	940702	37.695	12.598	119

The RAFOS float electronics were built by Sea Scan, Inc. The WHOI float group (Jim Valdes, Bob Tavares, and Brian Guest) assembled the floats and ballasted them in the ballasting tank at Webb Research Corporation. A few floats were ballasted by the WHOI float group at the University of Rhode Island for comparison purposes. Isobaric floats were initially ballasted with a hollow drop weight that forces the floats to be neutrally buoyant at a desired pressure surface. More detail on the ballasting procedure can be found in the report by Anderson-Fontana *et al*., 1996. It became apparent, after several floats sank, registered overpressure, and then surfaced early, that the hollow drop weights were susceptible to leaking and corrosion. The hollow weights were replaced early in the field program with solid drop weights, solving these problems. The floats were placed in the Mediterranean Undercurrent off Cape St. Vincent to follow the 1100 or 1200 db pressure surface.

After the float completes its mission, it is programmed to drop its external ballast, rise to the ocean surface, and telemeter its data to Service Argos receivers aboard the NOAA Polar Orbiting Environmental Satellites. Through Service Argos, the data are relayed to a ground station and transferred to a Global Processing Center. There, the data are processed and then transferred via the Internet to WHOI. The raw float data, including temperature, pressure, TOAs and respective correlations, are converted from hexadecimal to decimal, and are then ready for advanced processing, editing, and tracking.

3. Sound Source Deployment

Seven sound sources were used to track the AMUSE floats (locations shown in Figure 1). Three of these (M1-M3) were deployed specifically for AMUSE during the May 1993 CTD survey. Their placement was designed to provide maximal coverage along the south coast of Portugal and around Cape St. Vincent, a potential site of meddy formation and float dispersal. The other four sources, deployed by IFREMER (C) and IfM/Kiel (N, G, A2) for other experiments provided valuable coverage once the AMUSE floats moved away from the continental slope and into the Iberian Basin. The relatively large number of sources was needed to minimize topographic shadowing due to the rugged Horseshoe Seamounts and the Estremadura Promontory.

The vital statistics for each source are given in Table 2. All the sources were built by Webb Research Corporation and signaled every eight hours, beginning at 00:30, 01:00, 01:30, or 01:32 (pong times). Two sources, M3 and G, had clock failures within a year of activation. The clock of sound source N jumped 16 seconds 20 months after activation.

4. Float Deployment

To choose a suitable launch site for the floats, the seeding experiment was preceded by a detailed CTD survey of the Undercurrent in the western Gulf of Cadiz in May, 1993 from the R/V Oceanus OC258 (Bower *et al*., 1997). In choosing a float deployment site, we tried to balance three basic criteria. The launch site had to be (1) downstream of the region in the eastern Gulf of Cadiz where the Mediterranean Water is being carried in a bottom-trapped gravity current; (2) upstream of all potential meddy formation sites that had been suggested in the literature; and (3) close to a suitable port for easy access. Based on the results of the CTD survey, a site was chosen south of Portugal in Portimao Canyon near 36° 30’N, 8° 00’W (Figures 1 and 2). To launch floats and XBTs on a weekly basis,

Table 2. Sound Source Moorings

Source Site & No.	*Pong Time (GMT)*	*Launch Date (yymmdd)*	*Recovery Date (yymmdd)*	*Depth (meters)*	*Latitude (° W)*	*Longitude (° N)*	*Drift Rate (seconds/ day)*	*Comments*
M1, 01	00:30	930503		1500	35.505	10.000	0	
M2, 02	01:30	930502		1500	36.334	11.000	0	
M3, 03	01:32	930501		1500	34.263	13.991	0*	Clock failed on 930926
N, 04	00:30	930101	940900	800	43.027	14.015	0	+16 sec on 940328
A2, 05	01:00	930101	940900	800	35.349	12.808	0	
G, 06	01:00	930101		800	36.707	11.988	0*	Clock failed on 931215
C, 07	01:30	930101	940501	1500	40.008	14.993	0	

* Drift rates for these sources are unknown, and assumed zero for this experiment.

it was necessary to engage the services of a chartered vessel because conventional research vessels could not accommodate this type of schedule. The 72-foot motor-sailing yacht Kialoa II, owned and operated by Dr. Frank Robben, was chartered for the experiment, and the port of Vilamoura, on the south coast of Portugal, was chosen as the base of operations. Rita Klabacha from Scripps Institution of Oceanography managed the operations in Vilamoura and on the float/XBT deployment cruises on board Kialoa II. She was assisted by members of the Oceanography Group at the University of Lisbon.

The float observational strategy was to survey the Undercurrent with XBTs along a section perpendicular to the slope (Figure 2), and launch a pair of floats in the deeper of the two salinity maxima in the Undercurrent every week. The time between float seedings was chosen to be slightly shorter than the indirect estimate of the time for a typical meddy to form of 10-20 days (Armi and Zenk, 1984). The floats were initially ballasted for 1100 db to seed the lower salinity core, but the first XBT profiles showed that the highest temperatures associated with this core were found at 1200 db, so the target pressure was changed shortly into the float seeding experiment.

The deployment plan called for the release of 40 floats on 20 cruises made once a week for five months. A number of technical problems with the floats forced us to make several breaks in the weekly deployment strategy (see Table 1 and Figure 3). Some floats were recovered to help diagnose the technical problems (explained in the next section), and these floats were refurbished and deployed for a second mission. These floats are indicated by ‘a’ and ‘b’ in Table 1. As a result, we made a total of 49 float deployments on 22 Kialoa cruises and one Oceanus cruise between May, 1993 and March, 1994. Ten floats were programmed for a 30-day mission, 38 for a 333-day (11-month) mission, and one float for a 119-day mission. The 30-day float missions were set so that the float and sound source performance could be checked early in the experiment. The 119-day mission was set to test the performance of a new seal on the end cap of the glass float housing. All floats were programmed to collect temperature, pressure and acoustic tracking data every eight hours.

5. Float Performance

Table 1 lists the launch and surface data for each float, as well as the actual length of each float’s mission, and Table 3 documents the technical performance of each float Two main problems led to the premature surfacing of many of the floats: sinking caused by a leak in the glass housing or the hollow drop weight, which caused the floats to release their ballast weight and surface (eight floats), and unexplained loss of the ballast weight, probably due to fishbite or corrosion (21 floats). The first problem was corrected early in the experiment by replacing the hollow weights with solid stainless steel and removing the hardcoat from the aluminum endplate (thought to be compromising the glued seal). The cause (and cure) of the second problem was never determined, although some recovered floats showed significant corrosion of the endplate, suggesting that may have been a factor. Also, no floats lost their weights unexpectedly until they had been in the water for at least three months, which would not be consistent with fishbite (should be more random). Floats that surfaced early still transmitted the data they had collected up to that point. In addition to these two failure modes, one float surfaced early due to low battery voltage and one float never surfaced and/or transmitted any data. Eighteen of the 49 floats completed their missions.

In spite of these technical problems, 48 of the 49 floats launched returned to the surface, and 44 floats returned some useful data. Of the five floats that returned no useful data, two sank and surfaced within two days, one did not surface/transmit, one returned corrupted data, and one returned pressure and temperature data but no tracking data. Of the 48 floats that returned to the surface, the average percent of the mission accomplished was 70%.

6. Float Data Processing and Tracking

Service Argos satellites received the transmissions of the RAFOS floats and Service Argos forwarded them to WHOI via FTP. The floats transmitted the data in random order so that the entire mission of the float would be represented even if the float stopped transmitting before all the data messages were received. The messages were put in order, converted from hexadecimal to decimal, and the times-of-arrival (TOAs), correlation heights, temperatures and pressures were extracted. At this stage, the temperatures and pressures were converted from counts to engineering units, using the coefficients in Table

4 and the algorithms described below. The clock-drift of the float was calculated at this step by averaging the difference between the expected and actual reception times (using the Argos clock) of up to 25 messages received in the first twelve hours.

Table 3. Float Performance

Float ID	*% Mission Completed*	*% Messages Received*	*Temp Corrected (Y/N)*	*Pressure (db)*			*Comments*
				Mean	*Minimum*	*Maximum*	
101	100	100	Y	1275	1219	1335	
113	3	100	Y	1124	1124	1124	a,g
103a	100	100	Y	1141	1102	1174	
105	100	100	Y	1071	1044	1100	
110	100	96	Y	1237	1100	1367	
116a	100	100	Y	1065	1039	1104	
123	100	44	Y	826	773	850	
125	100	93	Y	757	719	781	
124	0	-	-	-	-	-	h
138	65	100	Y	1074	1032	1109	b
118	61	100	Y	1005	961	1036	b
134	89	96	Y	724	456	917	b, d
120a	1	100	Y	1142	881	1415	a, g
122	100	100	Y	569	373	795	
102	3	100	Y	1342	1212	1395	a
104	100	100	Y	1208	1160	1265	
106a	23	100	Y	1202	1163	1379	a
135a	13	100	Y	1173	1155	1232	a
111	70	17	Y	1318	1200	1407	a
126a	1.5	100	Y	1240	1206	1379	a
116b	100	100	Y	1155	1130	1179	
165	56	100	Y	1112	1016	1204	b
103b	76	99	Y	1133	1094	1175	b
170	80	00	N	1131	1131	1131	c, f
107	100	94	Y	806	624	924	
109	100	100	Y	724	496	908	
114	52	100	Y	814	497	874	b
121a	1	100	Y	1360	1319	1391	a
100	100	100	Y	1091	1038	1142	50-day on baseline gap
108	45	100	Y	1100	1031	1147	b
128	74	100	Y	1118	1079	1153	b
132	40	100	Y	1112	1052	1158	b, e
119	100	100	Y	1105	1017	1166	
166	73	99	N	1185	1160	1223	1st 27 recs pre-launch, b
117	100	42	Y	1094	1054	1148	
127	44	100	Y	1179	1077	1230	b

Table 3. Float Performance (continued)

Float ID	*% Mission Completed*	*% Messages Received*	*Temp Corrected (Y/N)*	*Pressure (db)*			*Comments*
				Mean	*Minimum*	*Maximum*	
112	100	100	Y	1152	1084	1223	
126b	60	99	Y	1176	1140	1212	b
130	91	99	Y	1070	1011	1148	b
135b	34	100	Y	1202	1142	1240	b
167	74	49	N	1066	992	1173	b
164	68	100	N	1144	1103	1188	b
169	75	100	N	1119	1075	1171	b
115	61	100	Y	1088	1004	1159	b
129	62	87	Y	1170	1139	1201	b
139	57	100	Y	1126	1101	1160	b
120b	100	99	Y	1085	1025	1136	
121b	89	100	Y	1129	981	1181	b
106b	100	100	Y	1164	1141	1196	

Key to Comments:
a – surfaced early due to overpressure
b – surfaced early due to lost ballast weight
c – surfaced early due to low battery voltage
d – sampled every 16 hours
e – no acoustics
f – float reset at surface; no useful data
g – float surfaced immediately after launch; no useful data
h – never heard

For floats with the data stored in compressed format, pressure and temperature are stored in the last three bytes of the message (the middle byte is split between them). WHOI takes care of the 1000 counts that have been subtracted from the pressure by the float in the calibration step. The pressure counts are divided by 1000, then linear coefficients are applied, and the result is divided by 10. If the result is more than 500 db from the target pressure, a rollover is assumed, 4096 is added to the raw counts and pressure recomputed. Raw counts are output as well as the result.

$$P = (pc1 + pc2 \times praw) \div 10$$
$$\text{where } praw = pcounts[+4096] \div 1000$$

Temperature raw counts initially have 1000 added to them, for output as well as subsequent processing. Then logarithmic coefficients are applied. The result is divided into 1000, then 273.16 is subtracted. If the result is more than 5 degrees from the target temperature, a rollover is assumed, 4096 is added to the raw counts and the temperature is recomputed.

$$T = [1000 \div (tc1 + tc2 \times traw^2 + tc3 \times traw^3)] - 273.16$$
$$\text{where } traw = \log((tcounts+1000[+4096])\div 1000)$$

Table 4. Float Clock Net Offsets and Temperature and Pressure Coefficients

Float No.	Net Offset (seconds)	Temperature Coefficients (logarithmic)			Pressure Coefficients (linear)	
100	-35.98	3.1504	0.2683	0.0072	94.0	2783.0
101	0.12	3.1510	0.2669	0.0074	0.0	2774.0
102	0.00	3.1502	0.2717	0.0069	74.0	2783.0
103a	0.00	3.1483	0.2675	0.0074	9.0	2730.0
103b	0.00	3.1483	0.2675	0.0074	9.0	2730.0
104	-6.88	3.1498	0.2690	0.0072	-23.0	2789.0
105	0.00	3.1473	0.2707	0.0069	81.0	2757.0
106a	0.00	3.1460	0.2695	0.0067	102.0	2741.0
106b	1.19	3.1460	0.2695	0.0067	-20.0	2750.0
107	-3.88	3.1502	0.2686	0.0071	93.0	2774.0
108	-0.58	3.1535	0.2651	0.0079	84.0	2784.0
109	-0.38	3.1504	0.2685	0.0071	46.0	2763.0
110	-10.60	3.1507	0.2700	0.0070	19.0	2771.0
111	-6.50	3.1507	0.2688	0.0071	212.0	2781.0
112	-13.80	3.1497	0.2682	0.0071	273.0	2764.0
114	-1.34	3.1513	0.2674	0.0073	105.0	2782.0
115	-22.84	3.1505	0.2686	0.0071	111.0	2773.0
116a	0.60	3.1509	0.2686	0.0072	193.0	2757.0
116b	3.69	3.1509	0.2686	0.0072	193.0	2757.0
117	-5.81	3.1510	0.2698	0.0070	55.0	2745.0
118	9.40	3.1508	0.2676	0.0074	7.0	2745.0
119	1.00	3.1515	0.2673	0.0073	110.0	2785.0
120b	-19.31	3.1502	0.2690	0.0070	73.0	2796.0
121b	-12.71	3.1516	0.2647	0.0076	-18.0	2784.0
122	15.12	3.1507	0.2682	0.0071	34.0	2782.0
123	0.12	3.1341	0.2859	0.0044	-49.0	2754.0
125	1.10	3.1499	0.2678	0.0071	114.0	2792.0
126a	0.00	3.1507	0.2688	0.0071	212.0	2781.0
126b	-11.58	3.1507	0.2713	0.0067	-3.0	2785.0
127	10.30	3.1484	0.2690	0.0069	253.0	2726.0
128	-5.46	3.1544	0.2671	0.0074	118.0	2757.0
129	-2.46	3.1485	0.2685	0.0070	31.0	2792.0
130	1.54	3.1480	0.2716	0.0064	154.0	2762.0
132	0.00	3.1516	0.2681	0.0073	60.0	2775.0
134	7.66	3.1479	0.2704	0.0070	12.0	2778.0
135a	0.00	3.1527	0.2648	0.0078	196.0	2778.0
135b	-1.00	3.1527	0.2648	0.0078	72.0	2787.0
138	8.40	3.1492	0.2695	0.0071	-5.0	2866.0
139	-20.30	3.1506	0.2679	0.0074	84.0	2776.0
164	-15.46	3.1312	0.2885	0.0039	4.0	2790.0
165	4.54	3.1144	0.3079	0.0400	76.0	2775.0
166	-10.48	3.1271	0.2903	0.0032	205.0	2761.0
167	-0.46	3.1314	0.2847	0.0046	194.0	2773.0
169	-14.58	3.1465	0.2702	0.0074	228.0	2767.0

Table 5. Sound Sources Used

Float No.	M1	M2	M3	N	A2	C	G
100	X	X	X	X			
101	X	X	X				
102	X	X					
103a	X	X	X				
103b	X	X	X	X			
104	X	X	X	X	X		
105	X	X	X	X	X		
106a	X	X					
106b	X	X	X				
107	X	X	X	X			
108	X	X	X	X	X		
109	X	X	X	X			
* 110	X	X	X	X	X	X	X
111	X	X					
112	X	X	X	X			
114	X	X	X	X	X	X	
115	X	X	X				
116a	X	X	X	X	X		
116b	X	X	X				
117	X	X	X	X	X		
118	X	X	X	X			
119	X	X	X	X			
120a	X	X					
120b	X	X	X	X			
121a	X	X					
121b	X	X	X				
122	X	X	X	X	X	X	X
123	X	X	X				
125	X	X	X				
126a	X	X					
126b	X	X	X	X			
127	X	X	X	X			
128	X	X	X	X	X		
129	X	X	X	X	X		
130	X	X	X				
** 134	X	X	X	X	X		
135a	X	X					
135b	X	X	X	X	X		
138	X	X	X	X	X		
139	X	X	X	X			
164	X	X	X				
165	X	X	X				
166	X	X	X				
167	X	X	X	X			
169	X	X	X	X			

* 110 may have used G until 940116
** 134 may have used G until 931223

The .dat file is produced according to the above steps. On re-examination of the calibration methods, it was found that a systematic offset had been introduced into the temperatures for the earliest floats calibrated. A value of 0.375°C was added to all temperatures except for floats 164 through 169 (see Table 3). Temperature and pressure coefficients for each float are listed in Table 4.

Plots of temperature, pressure, and TOAs in each half-hour window were made at this point. Temperatures and pressures were only edited if they were clearly outside the range of values, and were replaced using linear interpolation. The sources to be extracted were selected and the TOAs and their correlation heights for each source-float pair were transferred into a file. (See Table 5 for a list of sound sources used to track each float.) The clock-drift of the float may be applied at this time, or later. The TOAs were usually edited at this point. The next step was to linearly interpolate missing TOAs (limited to one-day gaps for some meddy floats, and three days for others), apply Doppler correction and source clock-drifts, if known, and interpolate first and third listening windows to the time of the second.

Standard processing had formerly used the five previous values of TOAs to predict a Doppler correction. This gave a poor result on curving trajectories. A new algorithm was instituted which used the previous and next TOAs to compute the correction (with extrapolation at the end of the segments).

A sound velocity of 1.501 km/s was chosen to convert TOAs to distance based on ray-tracing information supplied by Michel Ollitrault at IFREMER (personal communication). Locations were calculated using two or more sources and a routine that uses a least-squares fit. Bad track locations were detected based on plots and speed and direction information. If the error was too large, TOAs were omitted based on correlation height, and the position recalculated. Some sources were routinely avoided after clock problems were detected (M3 and G). Some floats near the end of the experiment had intervals where no computation could be made because the float was on the base line of the only source pair available. Cubic spline interpolation was used to fill in short gaps in latitude and longitude (under five days for most floats, one day for floats in some meddies). Where the cubic spline interpolation gave physically unrealistic results, those segments were cut out of the final track.

One exceptional case was float 134 for which the listening interval proved to be 16 hours, instead of the eight hours expected. This was diagnosed because it had exactly half the number of messages expected, and by comparing the timing of the sudden change in M3's clock to other floats.

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