Endeavor Cruise #398, leg 2

Depart: Bergen, Norway Sept 19 2004, 1000 L.
Arrive: Torshavn, Faroes, Oct. 2, 2004, 1300 L.

Scientific party:
T. Rossby, URI, Chief Scientist
M. Prater, URI, scientist
S. Fontana, URI, scientist
D. Luce, URI, scientist
H. Søiland, IMR, scientist
C. Lee, Metcalf Fellow, WBUR
W. Fanning, URI, marine technician

Tasks of the cruise:
A: To recover two moorings (at sites 1 and 2 below).
B: To deploy moorings at all 7 sites below. Some of the hardware from the first two sites will be used. Sonobuoys and a lowered hydrophone will be used to verify operation.
C: To deploy floats in the Arctic Intermediate waters north of the IFF. CTDs will be taken in conjunction with all float deployments.
D: Deploy floats over the Iceland-Faroe Ridge.
E: To operate the ADCP and TSG at all times.
F: To operate a thermistor chain in conjunction with certain ADCP sections.
G: To steam along a line (62° 17'N 7° 9'W) to (63° 13'N 6° 30'W) or vice versa. This will be done only if time permits. It is a line that cuts across the IFF in the vicinity of a cable that is being used to measure transport geo-electromagnetically. The ADCP will provide valuable calibration data.

The locations of the sound source moorings to be redeployed are as follows:

| # | lat(°N) | long(°W/°E) | depth(m)* | time(UTC) |
|---|---|---|---|---|
| 1 | 63 50.31 | 3 47.15E | 604/1504 | 0200 1400 |
| 2 | 68 53.81 | 1 18.46W | 549/1831 | 0230 1430 |
| 3 | 65 02.47 | 7 31.46W | 517/1417 | 0300 1500 |
| 4 | 62 42.55 | 14 14.64W | 610/1516 | 0230 1430 |
| 5 | 61 42.79 | 11 53.12W | 521/1176 | 0200 1400 |
| 6 | 63 30.18 | 5 58.32W | 575/1807 | 0130 1330 |
| 7 | 62 54.43 | 2 13.17W | 726/1676 | 0100 1300 |

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- The numbers show source depth/water depth. By time is meant the time at which they transmit.

As noted above, at sites 1 and 2 we also picked up the moorings deployed last summer.

The distances in km between the 7 sites are roughly:
B to 1: 480 km
1 to 2: 610 km
2 to 3: 507 km
3 to 4: 422 km
4 to 5: 165 km
5 to 6: 363 km
6 to 7: 202 km (to the last mooring)
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2749 km = 1500 NM == 6.2 days at 10 KT speed.

To recover the two moorings will require 4 hours each. To deploy the 7 moorings will require 6 hours each. This adds up to 2+ days. The remaining time is available for float work and additional ADCP sections.

Careful watch of weather will be required for mooring work. Dr. Søiland arranged for us to receive five day forecasts of winds and sea state from Mr. Magnar Reistad at the Norwegian Met. Office in Bergen. This was to prove very helpful and allowed us to plan the work more effectively.

It is appropriate to note here that all objectives of the cruise were met. As the following narrative will indicate, we were to lose much time to poor weather, but in the end everything came together very well.

Cruise Narrative

The seven sound sources deployed on this cruise serve two separate RAFOS float programs: the inflow of warm NE Atlantic waters between Iceland and the Faroes along the Iceland-Faroe Front (IFF), and the spreading of Arctic Intermediate Waters (AIW) in the southern Norwegian Sea. Floats for the first program will be deployed by fisheries research vessels in Iceland and the Faroes, while floats for the latter will all be deployed on this cruise. Figure 1 shows the cruise track, the locations of the 7 moorings and velocity vectors from the shipboard ADCP.

Preparations for the cruise in Bergen proceeded smoothly. Almost all mooring and sound source materials had been stored there since the recovery cruise on Sarsen last fall.

There is no question weather was foremost on our minds during this cruise. Late September can be very stormy, and it probably

doesn't help that we have an active hurricane year with many systems turning north and east back into the North Atlantic. Sea state conditions determine whether or not a mooring deployment can take place. Due to the forecast indicating difficult working conditions at site 1 on Sunday we made no attempt to leave early Saturday. Given a strong tail wind we decided to take our time preparing the deck and leave early Sunday.

Immediately after leaving the intracoastal waters and entering the open sea we got our first and real taste of what the seas would be like on this cruise. Although we had tail winds the swell was from the west so were immediately put into a heavy roll. This lasted until during the night when the swell lined up with the winds from the south. The next morning when we arrived on station it was still too rough and decided to wait with the first deployment until the afternoon. Preparing the mooring was, in principle, straightforward but a bit awkward; the deck was crowded, with two anchors claiming space in the A-frame port. We finally proceeded to deploy, with the Argos beacon and balls first. The electronics module was to be eased over the side, but a yank from the balls pulled it into A-frame foundation with a hard whack. It sounded very worrisome, but a visual inspection over the side (not easy to do) seemed to suggest everything was OK so we proceeded with the rest of the mooring deployment, which went without further surprise. The absence of a first pong at 2 AM UTC (4 AM local) indicated trouble, however. No signal on the sonobuoy, the lowered array or the Benthos phone. Knowing that it had taken quite a hit, we retrieved the mooring right after breakfast and we saw immediately that the power cable to the resonator pipe had been yanked from the module. The good news a few moments later was that the electronics module did not suffer any damage: its clock was on time and power output normal, and no problem with RS-232 communications. Also, the internal air pressure was as expected (~-500mm Hg). The unit did reveal a huge dent in the battery endplate, but it was limited in extent. This, incidentally, is the unit that had been in operation for 3 months in Bergen fjord. After lunch we deployed another unit under tighter deck control and it went with incident. An excellent signal was received on the lowered array and a low-quality signal on the replacement sonobuoy (the first one failed).

Late in the afternoon we recovered the mooring deployed in July 2003. Visually the pipe and module were both in excellent condition, very little rust or corrosion. The vacuum in the module was fine (500 mm). At the time of writing we have not opened it. Nor have we attempted to communicate with it, assuming that the computer battery most likely is dead.

Tuesday Sept 20 at site 1 was a very busy day with two recoveries and one deployment. But all three operations went very well. The question at that point was whether to go to site 2 or to forgo it due to the steaming time involved. The long-range wind and sea-state forecasts from the Norwegian Met Office indicated marginal conditions for Thursday depending upon the exact course of a gale (it turned out to be a strong gale, below). Friday looked good so we set course for site 2 at the end of the recovery operations at site 1.

Wednesday Sept 21 was spent in transit during which time some preparations were made for the mooring deployment there.

Thursday Sept 22, when we should have deployed the mooring, was spent in a gale to strong gale just south of site 2. By this time we had lost over two days due to weather and given the generally poor conditions around us it became increasingly doubtful that we could complete the remaining mooring deployments within the scheduled cruise time. We transmitted our concern to the GSO Marine Office on Friday morning. Figure 2 shows the barometric pressure and windspeeds during the cruise. While sea state and especially swell matters a lot, any wind above 30 KT pretty much precludes any mooring deployment or recovery operations.

Friday Sept 24 the weather improved substantially so preparations were completed during the morning for mooring deployment immediately after lunch. A simple bathymetric check identified a spot for deployment and the ship was positioned ~2NM downwind thereof. Deployment went well although for some reason the module was quick-released too soon and it made quite a splash. The biggest surprise was that the bathymetry did not shoal as much as expected so the source is about 200 m (at 800 m) deeper than intended. We then moved to the mooring to be recovered (2 NM away) and listened first to the source at site 1 (2 PM UTC) but did not hear it. (At 600 km range, with much ship noise and with heavy winds in the area of the source, we were not surprised.) We then listened for both the new source and the old one (just about to be recovered) and established that they were both(!) working. The lowered hydrophone captured the signals far better than the sonobuoy. (Again we had to deploy a second sonobuoy, this time because the first unit’s antenna didn’t open.) Release and recovery of the old site 2 mooring proceeded smoothly. After completion of the recovery we took advantage of the calmest seas we had seen so far to move two anchors back close to the stern, put the next reel of rope in

position to be reeled onto the Scanfish winch during transit the next day.

Saturday Sept 25 in transit to site 3. Generally good weather but with head winds.

Sunday Sept 26. The weather for the deployment at site 3 was fine. A simple linear survey showed the bottom to be quite flat in the direction of motion during payout of the mooring. Between the good weather and increasing confidence in the operations this deployment was the smoothest to date. After anchor release preparations for the next mooring were initiated. The sound source ponged on schedule at 1500 UTC. This time it was the sonobuoy that captured the transmission. The lowered hydrophone data capture crashed due to memory overflow in Matlab.

We then proceeded towards site 4, but deteriorating weather forced us to come to a stop and hold the bow into the winds. This blow with 40+ KT gusts kept us immobile for over 24 hours. Although we had already alerted the marine office of our very slow progress and need for additional time to complete the basic objectives of the cruise, a firm decision was needed. A formal request was sent to NSF on Monday AM asking for 2 additional days, allowing us to arrive the Faroes on Sunday Oct.3 instead. This was approved by NSF the same day, a quick response for which we are most grateful.

Late on Monday evening we started up again with following seas, which subsided during the night. By Tuesday AM the winds had vanished. In fact, conditions were calm enough (there was quite a bit of swell, but it was a following sea) that we could lay out the entire mooring on deck while in transit and thus be ready for deployment immediately upon arrival at site 4.

Deployment of the moorings south of the ridge at sites 4 and 5 (early on Wednesday the 29$^{th}$) went very smoothly. The only hiccup was that the winch wouldn't operate, but the relief engineer Dan Alexander got it back to life within a half hour. To save time we did not bother to remain at these sites until the first pong. The deployments had gone very smoothly and with three moorings verified working we felt confident about the sources. The final checkout of the electronics just prior to launch had been routine. Starting at site 5 the bos'n used a different type of quick-release hook that worked far more smoothly.

During the long transit back north Wednesday (Sept 29) to site 6 we deployed two IFF floats (ballasted for 200 m) just south of the ridge crest and six floats (ballasted for 800 m) over the

northern slope of Iceland-Faroe ridge. The checkout and deployment of the sound sources at the last two sites, 6 (Sept 29) and 7 (Sept 30), went completely smoothly. At site 7 a sonobuoy captured the first pong just as the anchor was released.

Focus now shifted to the deployment of the remaining 22 AIW floats. Time was tight so it was decided to limit CTD operations and focus on optimizing the float deployment pattern. Two square boxes each 13.9 km on the side were defined, both over relatively flat bottom 2600 and 3400 m deep, respectively. At three of the corners a single float was released and at the fourth corner two floats were released and a CTD to 10000 dbars was taken. Five pairs of floats were deployed along the northern slope of the Iceland-Faroe ridge and a CTD taken at the shallowest site (~1100m). Two floats were not deployed due to leaking batteries. The locations of all float deployments are shown in Figure 3.

Finally, at the end of the cruise and during the trip to Torshavn, we took an ADCP section to provide calibration data for an ongoing program to measure transports electromagnetically using a cable that extends north from the Faroes into deep water in the Norwegian Sea. Prof. Peter Lundberg and Dr. Peter Sigray at the University of Stockholm are in charge of this activity. Figure 4 gives a sample overview of the ADCP velocity data from the IFF area. These have not yet been adjusted for final compass corrections, but the vectors indicate the magnitude of the velocities and degree of eddy variability.

ADCP operations

Throughout the cruise the 75 kHz RDI Surveyor ADCP was in operation in the narrowband mode. Very high quality data were obtained to 600-700 m in good weather. These data will be useful to the float program by providing information on eddy scales and energy levels in various regions. Three complete or nearly complete sections across the northern slope of the Iceland-Faroe ridge will also give helpful snapshot information on the dynamical structure of the IFF.

CTD profiles

Due to the limited time available we had to limit the number of casts to 4.

XBT drops A total of 21 T-7 and 4 T-6 XBTs were taken during the last day of operations.

Towed temperature measurements

This past summer we developed a simple technique for collecting temperatures along a towed CTD cable pulled down with the help of a V-fin depressor. We wanted to get information on the thermal structure of the Iceland-Faroe Front without having to stop the vessel – both to save time and to prevent discontinuities in the ADCP velocity field. The idea was to clamp small industrial temperature recorders (ibutton thermochrons) to the cable; kind of a simple 'thermistor chain'. However, the shortness of time prevented us from putting this technology to work, and we had to limit ourselves to collecting data for estimating the shape of the towed cable. For this we used a Sea-Bird SBI-39 pressure-temperature recorder to get the depth of the depressor. This information will come in handy for future efforts. We did test a thermochron in the brass-housing clamped to the wire and it worked perfectly.

Acknowledgments

We wish to thank Capt. Rhett McMunn, bos'n Jay St. Germain and the entire crew for an unqualified very successful cruise. In particular we want to thank the deck crew who went beyond the call of duty to assist us with the rope work for each of the 7 moorings. Not only do we appreciate their efforts, it was a real pleasure working with them. Mr. Bill Fanning cheerfully provided solid support in the laboratory, shipboard instrumentation and communications. The weather (four days lost due to heavy seas) was a significant challenge to completing the cruise objectives, and NSF was gracious to grant our request for two additional days. We thank Mr. Magnar Reistad of the Norwegian Met. Office for the 5-day forecasts of winds and sea state conditions. We also thank Messrs. John Kemp and Jim Valdes of WHOI for the sonobuoys and lowered hydrophone, which proved quite helpful in verifying sound source performance. The United States National Science Foundation and the Norwegian Research Council are supporting the research activities associated with this cruise.

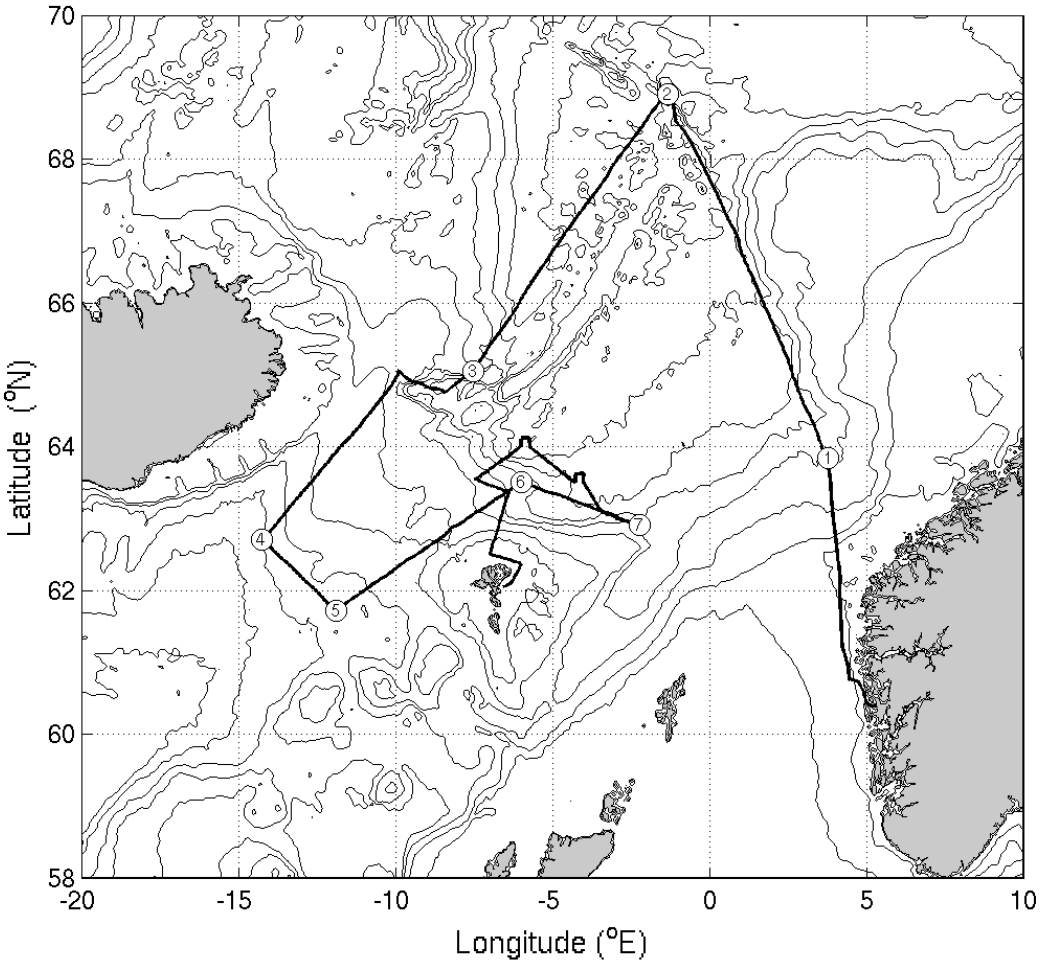


Figure 1. Plot of ship's track and location of the seven sound sources. The average depth of the sources is 600 m.

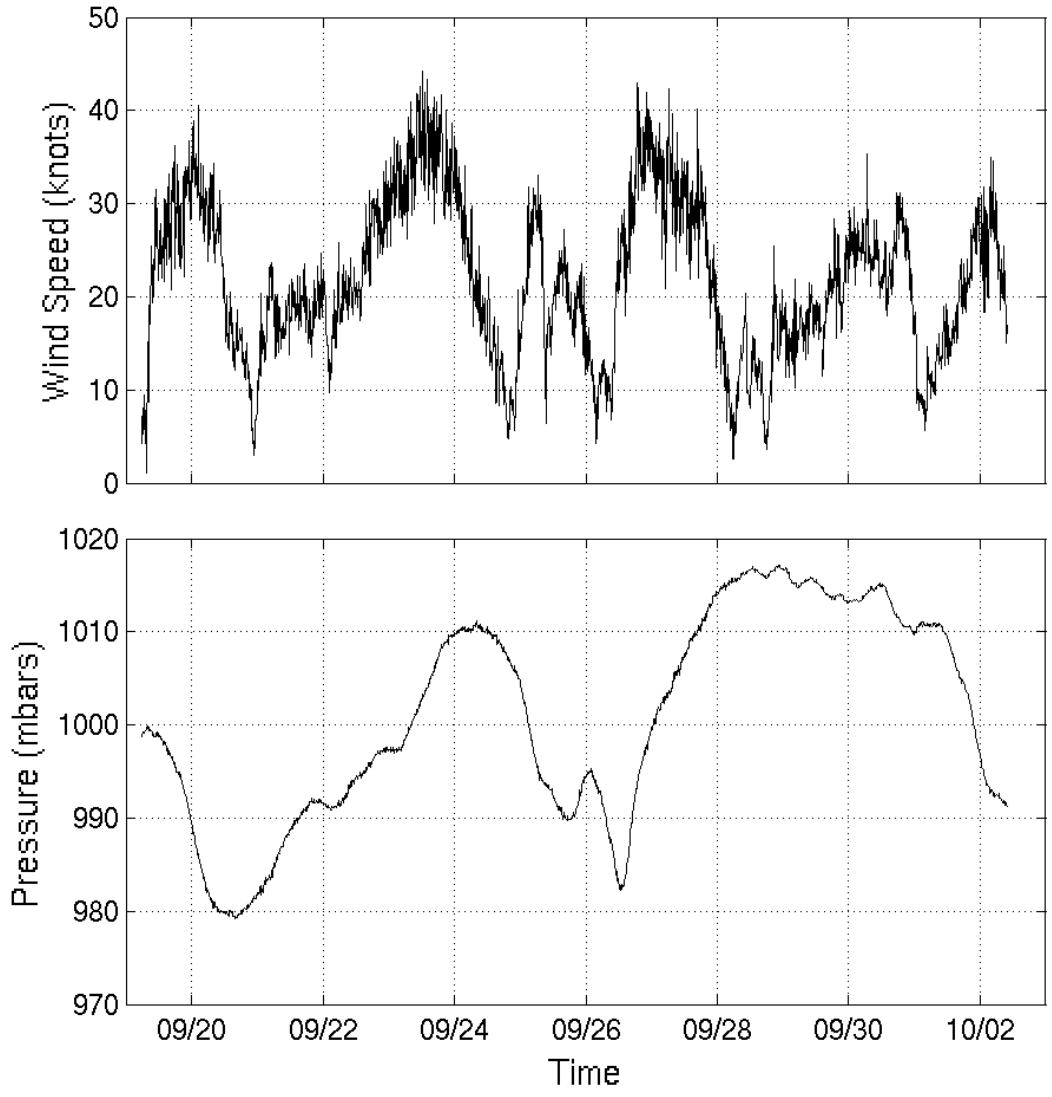


Figure 2: Plot of windspeed and barometric pressure during the cruise. These data are collected automatically by the ship's environmental sampling system, which includes many other parameters such as solar radiation and underway sea surface temperature and salinity.

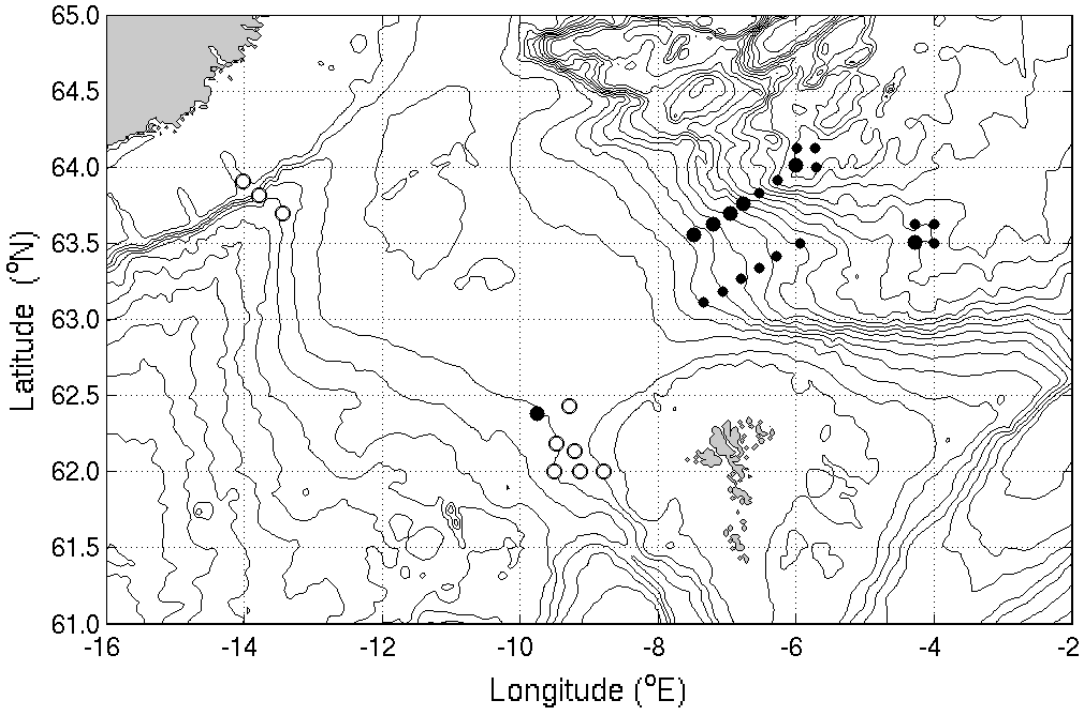


Figure 3. Solid circles show the locations of all float deployments on this cruise. The larger circles indicate two floats deployed at the same site. The open circles near 64°N, 14°W show the proposed locations for the floats to be deployed by the Marine Research Institute in Reykjavik, Iceland. The open circles west of the Faroes show the corresponding deployment sites for the floats to be deployed by the Marine Research Institute in Torshavn, Faroes.

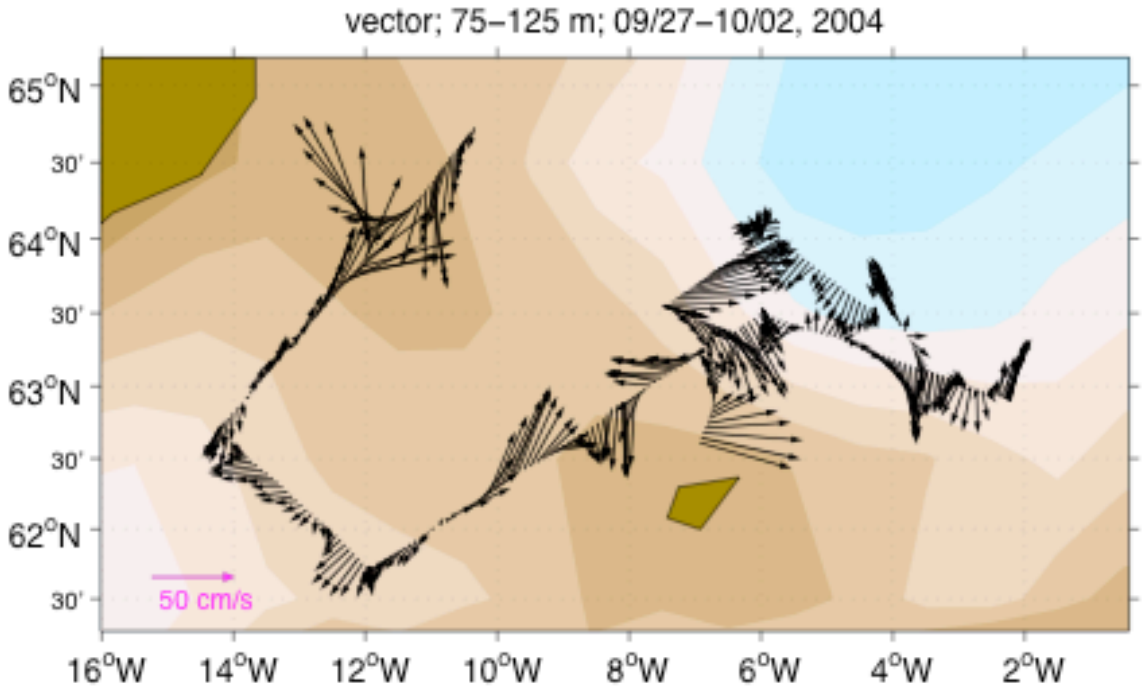


Figure 4. Preliminary plot of all shipboard ADCP data collected near the Iceland-Faroe Front. Note the considerable eddy activity throughout the region. While the ADCP reaches much deeper, this shallow depth is chosen to include the velocities just north of the Faroes on the shelf. The arrow in the lower left corner indicates 50 cm/s ~ 1 KT. For detailed bathymetry information see Figure 3.

Table 1: Sound source moorings

| Site | latitude | longitude | Pong-UTC | date | depth(m)[1] |
|---|---|---|---|---|---|
| 1 | 63° 51.49’N | 3° 37.74’E | 02:00:00 | Sept 21 | 600/1533 |
| 2 | 68° 54.57’N | 1° 23.75’W | 02:30:00 | Sept 24 | 800/2192 |
| 3 | 65° 02.97’N | 7° 33.06’W | 03:00:00 | Sept 26 | 524/1424 |
| 4 | 62° 42.74’N | 14° 13.39’W | 02:30:00 | Sept 28 | 600/1497 |
| 5 | 61° 43.26’N | 11° 54.18’W | 02:00:00 | Sept 29 | 600/1221 |
| 6 | 63° 30.55’N | 5° 57.48’W | 01:30:00 | Sept 29 | 675/1875 |
| 7 | 62° 54.33’N | 2° 14.14’W | 01:00:00 | Sept 30 | 750/1688 |

1: The two numbers refer to transducer and water depth.

Table 2: Transducer and release information

| | Sound source | | | Acoustic release and Argos ID | | |
|---|---|---|---|---|---|---|
| Site | pipe-# | ITC-# | module-# | Ser.-# | ARM-code[1] | Argos ID |
| 1 | 7 | 166 | 102 | 142 | 04B6 | 35518 |
| 2 | 3 | 167 | 13 | 137 | 04B1 | 8195 |
| 3 | 9 | 164 | B002 | 136 | 04B0 | 9257 |
| 4 | 4 | 170 | 104 | 140 | 04B4 | no xmitter |
| 5 | 5 | 165 | 101 | 143 | 04B7 | 1756 |
| 6 | 8 | 168 | 111 | 144 | 04B8 | 35516 |
| 7 | 6 | 169 | 106 | 145 | 04B9 | 35517 |

1: All units have release code 0455.

## Table 3: Float deployments

Iceland Faroe Front / PathMix Project
RAFOS Launch Summary - EN398 - 2004

| | Float | Date | Mission (UTC) | Launch (UTC) | Latitude (deg,min N) | Longitude (deg,min W) | Depth (m) | Cycles/Days | CTD XBT |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *531 | Sep 29 | 09:00 | 09:11 | 62 22.74 | 09 45.51 | 616 | 120 / 60 | - |
| 2 | *530 | Sep 29 | 09:01 | 09:13 | 62 22.74 | 09 45.51 | 616 | 360 / 180 | - |
| 3 | 547 | Sep 29 | 16:28 | 16:40 | 63 06.61 | 07 20.76 | 1037 | 1080 / 540 | - |
| 4 | 546 | Sep 29 | 17:25 | 17:37 | 63 10.80 | 07 04.02 | 1224 | 1080 / 540 | - |
| 5 | 558 | Sep 29 | 18:07 | 18:33 | 63 16.08 | 06 47.95 | 1401 | 240 / 120 | - |
| 6 | 553 | Sep 29 | 19:21 | 19:27 | 63 20.39 | 06 31.92 | 1519 | 1080 / 540 | - |
| 7 | 552 | Sep 29 | 20:03 | 20:16 | 63 24.70 | 06 17.41 | 1606 | 1080 / 540 | - |
| 8 | 549 | Sep 29 | 22:18 | 23:05 | 63 30.07 | 05 57.02 | 1855 | 1080 / 540 | - |
| 9 | 539 | Sep 30 | 21:25 | 22:08 | 63 29.83 | 03 59.73 | 2737 | 1080 / 540 | C01 |
| 10 | 538 | Sep 30 | 21:26 | 23:03 | 63 37.65 | 04 00.10 | 2700 | 1080 / 540 | - |
| 11 | 536 | Sep 30 | 23:18 | 23:59 | 63 37.40 | 04 16.69 | 2685 | 1080 / 540 | - |
| 12 | 537 | Oct 01 | 00:15 | 02:02 | 63 30.45 | 04 16.81 | 2624 | 1080 / 540 | C02 |
| 13 | 556 | Oct 01 | 00:16 | 02:04 | 63 30.45 | 04 16.81 | 2624 | 1080 / 540 | C02 |
| 14 | 540 | Oct 01 | 06:22 | 06:53 | 63 59.76 | 05 43.02 | ~3530 | 1080 / 540 | - |
| 15 | 543 | Oct 01 | 07:30 | 07:46 | 64 07.60 | 05 43.22 | ~3560 | 1080 / 540 | - |
| 16 | 554 | Oct 01 | 07:50 | 08:58 | 64 07.49 | 05 59.59 | ~3520 | 1080 / 540 | - |
| 17 | 555 | Oct 01 | 08:47 | 10:16 | 64 00.58 | 06 00.59 | 3467 | 1080 / 540 | C03 |
| 18 | 542 | Oct 01 | 08:48 | 10:18 | 64 00.58 | 06 00.59 | 3467 | 1080 / 540 | C03 |
| 19 | 550 | Oct 01 | 11:04 | 11:19 | 63 54.87 | 06 16.19 | 3278 | 1080 / 540 | - |
| 20 | 533 | Oct 01 | 11:38 | 12:12 | 63 49.72 | 06 32.08 | 2628 | 1080 / 540 | X03 |
| 21 | 532 | Oct 01 | 12:22 | 13:00 | 63 45.62 | 06 46.25 | 2076 | 1080 / 540 | X05 |
| 22 | 557 | Oct 01 | 12:21 | 13:02 | 63 45.62 | 06 46.25 | 2076 | 1080 / 540 | X05 |
| 23 | 534 | Oct 01 | 13:26 | 13:42 | 63 41.79 | 06 57.69 | 1735 | 1080 / 540 | X07 |
| 24 | 535 | Oct 01 | 13:27 | 13:44 | 63 41.79 | 06 57.69 | 1735 | 1080 / 540 | X07 |
| 25 | 551 | Oct 01 | 13:55 | 14:32 | 63 37.74 | 07 12.09 | 1406 | 1080 / 540 | X09 |
| 26 | 559 | **Oct 01 | 19:18 | 14:34 | 63 37.74 | 07 12.09 | 1406 | 600 / 300 | X09 |
| 27 | 544 | Oct 01 | 14:23 | 16:23 | 63 33.12 | 07 28.90 | 1120 | 1080 / 540 | C04 |
| 28 | 545 | Oct 01 | 14:24 | 16:24 | 63 33.12 | 07 28.90 | 1120 | 1080 / 540 | C04 |

* Two floats (530 and 531) were ballasted for 200 m to tag North Atlantic water, while all other floats were ballasted for 800 m, nominally the depth of the AIW (Arctic Intermediate Water).

** All floats were launched on the same day that their missions were started, except for number 26 (Float 559), which was started on Sep 29.

One float (543) did not display any message on the LCD after many attempts with a magnet, but was able to communicate via the SAIL box, and was initialized and placed into mission through software. Another float (556) took many attempts with a magnet (about 10) before a startup message was displayed on the LCD.

Two floats (541 and 548), when removed from their shipping boxes, were found with severely corroded battery packs, and were not deployed.