Investigating Eddies in North Atlantic RAFOS Float Data

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Contents

List of Figures

List of Tables

List of Appendices

1 INTRODUCTION

Sub-surface eddies are an important ocean phenomenon, but one we know relatively little about due to the difficulty of finding, tracking and measuring them. The aim of this study is to investigate eddies using data from RAFOS floats deployed as part of the WOCE Atlantic Circulation and Climate Experiment (ACCE; Bower et al., 2000). Specific objectives are to determine the geographical distribution of cyclonic and anticyclonic eddies and whether there is any order to this distribution; calculate the proportion of cyclonic to anticyclonic eddies in different regions, determine their prevalence and discover any differences between them; investigate eddy interactions; and determine eddy translation mechanisms for the observed features.

2 DATA

Woods Hole Oceanographic Institution (WHOI) and the University of Rhode Island (URI) between them launched over 100 RAFOS floats at intermediate depths in the North Atlantic between November 1996 and July 1998 (Figure 1). WHOI floats were deployed on three separate cruises in the Mediterranean Water at the eastern boundary (November 1996 and November 1997) and at the sub-polar front (to the west of the Mid Atlantic Ridge; June 1997 and October 1997). Apart from four floats deployed at 34.8ºW (two at 46.3ºN and two at 52.8ºN) in early summer 1997, the URI floats were deployed to the west of the Mid Atlantic Ridge along 37ºW between 49ºN and 54ºN in early November 1997 and July 1998. The launch (and surface) positions and dates for each float analyzed in this study are listed in Table 1.

The floats measure pressure, temperature and times of arrival (TOAs) from moored sound sources. The distinct advantage of RAFOS floats over other types of float is that they record TOAs once per day, therefore we have daily positions for them and they can be used to look at flows/features with periods of just a few days. Figure 2 shows the trajectories of all the floats, with URI floats in blue, WHOI eastern boundary floats in green and WHOI sub-polar front floats in red.

2.1 Versions of data used

WHOI float data version 'G' were used, the only edit made was to remove record number 456 from float track 377. URI 'final' float tracks were used, recovered from ftp site <po.gso.uri.edu>, directory

<pub/downloads/sandy/ACCE> on the 7th December 2000. No adjustments were made to the URI data. All the individual float tracks can be seen in Appendix 1.

3 METHODS

An eddy is defined by two or more consecutive loops in the same direction within the float trajectory, and it is assumed that each looping trajectory measures a discrete eddy. Cusps are counted as being due to eddy motions as long as they are in a part of the trajectory which has at least two full loops. These looping trajectories, "loopers", reveal quasi-circular eddy features containing trapped fluid, which have periods of rotation of up to 50 days.

Each float trajectory was visually examined for eddies. This is obviously a subjective process, allowing the possibility that loops were mischaracterised. It should also be noted that floats may have been in an eddy, but not show any looping or cusps in the track. If, for example, the float is positioned in the center of the eddy, then the float trajectory will show only the direction of propagation of the eddy with no loops in it; if the eddy is propagating rapidly (with respect to its period of rotation) then you might just see cusps, rather than loops; if the propagation speed is very fast compared to the rotation then the float trajectory could even be a straight line.

Once the individual looping trajectories were identified (see Appendix 2), they were checked to determine whether any were actually looping in the same eddy. Eddies were separated into cyclonic and anticyclonic and then numbered in order of decreasing number of loops (eddies with the same number of loops were ordered by decreasing number of days spent looping). For each looping trajectory, the number of loops was estimated visually, and then used to calculate the period of rotation. This is not necessarily the period of rotation of the core of the eddy because the period varies with radius. The period of looping is the same as the period of rotation of the eddy at the same radius. Details of all anticyclonic and cyclonic looping trajectories are given in tables 2a and 2b respectively.

To make a meaningful estimation of the proportion of cyclones to anticyclones in different regions, as well as counting the number of individual eddies observed, the number of looping records as a percentage of the total number of records in each area was calculated and are shown in table 3. The results are given in the following section.

4 RESULTS

Of the 113 ACCE floats analyzed, 69 (61%) were caught in eddies at some point in time. The entire data set represents 159.1 float years of data, of which 24.8 years are looping records, therefore 15.6% of the data set is characterized by "loopiness". This is the same percentage as found by Richardson (1993) in his census of eddies in North Atlantic SOFAR float data. Figures 3 and 4 show all the anticyclonic and cyclonic looping trajectories, or "loopers"; the beginning of each track is marked with a circle and labeled with the eddy ID and float number (details for which are given in Table 2). Approximately half (51%) of the loopers are anticyclonic, and half (49%) are cyclonic.

From the 108 individual loopers identified (Table 2), there are 96 unique eddies; 49 anticyclonic and 47 cyclonic. There are several eddies (4 anticyclonic and 3 cyclonic) with more than one float caught in them (shown in figure 5). Some of these occurrences are due to the fact that floats were launched very close together in both space and time (e.g. eddies ac6, ac9 and ac12).

An interesting multiple-float-eddy is c4. URI floats 537, 544 and 558 were all launched on 25th July 1998, and although they didn't follow the same exact pathways (in fact, URI-558 went a completely different route from the other two floats), they all ended up making their way through the Charlie Gibbs Fracture Zone and started looping in eddy c4 between the 8th and 20th February 1999 (approximately 200 days into their mission). From figure 6 it can be seen how the floats simultaneously loop cyclonically with different radii depending on the distance of the float from the centre of the eddy. The floats all looped with periods of between 14.5 and 15.5 days, suggesting that the part of the eddy sampled is in solid body rotation.

Table 3 shows the geographical differences in the number of cyclones and anticyclones observed in four different regions in the North Atlantic. In the Iceland Basin and Rockall Trough (Area 2), where nearly 40% of the eddies are found and the highest percentage of records that loop are also found (20.4%), again roughly half of these eddies are anticyclonic (51.4%) and half are cyclonic (48.6%). The smallest number of eddies is found in the Irminger Basin (Area 1), just under 15% of the total number, and 57% of them are anticyclones. A higher percentage of anticyclones (63.2%) is also found in the West European Basin (Area 3), where 20% of the total eddies are observed. The only region that has a higher proportion of cyclones is the Newfoundland Basin (Area 4), where there are a relatively high number of eddies (27% of the total) and over 60% of them are cyclonic.

It should be noted that the number of eddies found in each region is strongly linked to the number of records in that region. The majority of the floats were launched in Area 4 (Newfoundland Basin and Mid Atlantic Ridge), and most floats made their way through the Iceland Basin (Area 2), resulting in far more records in these areas. However, it is the ratio of cyclones to anticyclones that is the most interesting result in Table 3, and this doesn't depend on the number of float records in a particular area.

There are both stationary and translating eddies observed in this data set; the longest record for a stationary eddy is 251 days (eddy ac6, WHOI floats 413, 418 and 420, just to the west of the Mid-Atlantic Ridge), and for a translating eddy is 502 days (eddy ac3, float WHOI-326, at the eastern boundary). Most of the loopers characterized as stationary have very few loops, which could explain why they don't seem to be translating; the record isn't long enough. There are, however, a few exceptions (e.g. ac6, ac15, c12, c15). These eddies could be constrained by the topography or perhaps by the ambient flow.

4.1 Eddy trajectories

We are interested in determining what governs eddy translation; is it the eddy rotation direction, the mean currents or the topography for example? An eddy can self advect due to its rotational velocity and the value of f/H (Nof, 1981; Cushman-Roisin et al., 1990); anticyclones in a south-westward direction and cyclones north-westward (assuming that f/H contours are aligned zonally).

Figure 7 shows vectors connecting start and end points of the looping trajectories, for records of at least 30 days length and containing at least 3 loops. There are three anticyclonic eddies (ac3, ac9 and ac31) that move southwestward from the Goban Spur. This is the direction that anticyclones would be expected to travel purely due to their rotation direction. Eddy ac3 was identified as a meddy by Bower et al. (1999) due to its high heat and salt content. Although its heat and salt content are not as high as those of a classic meddy generated near Cape St Vincent or west of Lisbon (Bower et al., 1997), we will assume that this identification is correct and continue to refer to this feature as a meddy. It is possible that the other two features are also meddies, their properties and pathways being indicative of these eddies.

The other anticyclones and many of the cyclones appear to be travelling in directions consistent with the general circulation pattern: northwestward in the northern Bay of Biscay (c16); northwestward across the southern Rockall-Hatton Plateau (ac8); northward along the western edge of the Rockall-Hatton Plateau (c13); anticlockwise around the Iceland Basin (ac24, ac19, ac2, ac4, ac11, ac13, c14, c3); anticlockwise around the Irminger Basin (ac18, ac17, ac16, ac10, c7); and eastward through the Charlie Gibbs and Faraday Fracture Zones (ac27, ac5, c5, c17, c19, c21, c12, c22).

Eddy c1 crosses the southern Irminger Basin north-westward, which is consistent with eddy propagation due to its cyclonic rotation, but perhaps surprising when one considers the flow patterns in this area. The path of this eddy may indicate a "shortcut" of the subpolar circulation across the entrance of the Irminger Basin. The mechanism for propagation of cyclonic eddies in the West European Basin (c9, c11, c20) is more difficult to fathom. It seems possible that c9 is advected southwestward by recirculation of the boundary flow that may separate at the Goban Spur, or possibly linked to an anticyclone that was formed at the Goban Spur, while c20 appears to be following the topography along the western edge of the Basin. In general, the motion of many of the eddies seems to be consistent with the general flow field, whilst some appear to be self-advecting. It seems likely that a combination of these mechanisms is involved in eddy propagation, however, we have insufficient information to determine the individual contributions of each to the final eddy velocity.

4.2 Eddies in the Iceland Basin

The time sequence for the year-long anticyclone (ac1) in the Iceland Basin is shown in Figure 8. WHOI float 389 became trapped in an eddy (ac1) in October 1998 and remained looping anticyclonically at the same location (56.5ºN, 28.5ºW) for over three months. In mid-December 1998, URI float 569 became caught by a separate anticyclone at 57ºN, 26ºW, which then traveled towards ac1 and appears to have merged with it in January 1999. This eddy, whilst remaining in the same general vicinity, propagated in an apparently random fashion. In August 1999 another URI float (576) became caught by the eddy, but evidently much further from the center than float 569. It would also seem that at this distance from its center, the eddy was not in solid body rotation as the looping period is much longer (16 days, rather than 7 days for float 569). The entire record of this particular anticyclone is over 13 months long.

Figure 9 shows the time sequence of all float trajectories as well as highlighting the looping trajectories (anticyclonic in red and cyclonic in blue) in the Iceland Basin. It is interesting to note how many of the floats follow the topography of the region; floats drifting into the region from the south split either side of higher topography and propagate up the deeper channels into the Iceland Basin; floats can also be seen closely following the contours of the Rockall-Hatton Plateau.

There appear to be several instances of anticyclones co-existing alongside cyclones, forming dipoles. In March/April 1999, ac2 and c15 (59ºN, 20ºW) appear to be a dipole, although ac2 does move away from c15 after a short while. Another dipole occurs in the same month at 55ºN, 30ºW (c6 and ac13). In May 1999, ac38 and c47 form a dipole at 60ºN, 24ºW. Both eddies have a period of around 5 days.

The floats illustrate other instances of eddy/flow interaction. In August 1998 a float made a single loop around c41, and in May to August 1999, several floats passing by ac1 were deflected from their pathways and translated around the eddy, some making a complete loop before carrying on northeastwards. By looking at these occurrences more closely, we estimate that anticyclone ac1 is roughly 90 km in diameter.

4.3 Eddies upstream of the Charlie Gibbs and Faraday Fracture Zones

The area just upstream (i.e. to the west) of the Charlie Gibbs and Faraday Fracture Zones (at 52ºN and 50ºN respectively) is abundant with eddies (see figures 3 and 4). A time sequence of the looping trajectories in this area is shown in figure 10. By the end of October 1997, 3 floats have become trapped in an anticyclone (ac6; at 50ºN, 35ºW) which lasts for at least 9 months, positioned over slightly higher topography than its surroundings. During these 9 months, floats are trapped in a number of cyclones surrounding ac6. In March 1998, 2 of the cyclones (c2 and c5) which have been relatively stationary for the preceding 2 months, propagate eastwards around the perimeter of ac6, as though they are being advected by the larger eddy. The cyclone c2 comes to a halt just to the northeast of ac6 and remains at that location for the following few months, even acquiring one of the floats that was previously in ac6, showing just how close these two eddies are. In late July 1998, eddies ac12 and c19 form a dipole at 52ºN, 37ºW. In September 1998 c19 and another cyclone, c21, propagate southeastwards in the same way that c2 did six months earlier. Although there are no floats left in ac6 to verify it, it looks from the background float trajectories (figure 11) as though ac6 could still be present, which also explains the movement of the cyclones (c19 and c21) once they come within close proximity of the large, stationary anticyclone (ac6).

The float trajectories shown in figure 11 give a very good sense of what the flow is doing in this region. The timings of the different float deployments can clearly be seen (pre-July '97, Oct '97, Nov '97, July '98) and the fact that many floats were deployed very close together gives an excellent view of the circulation at these times. Throughout the sequence, floats can be seen heading for and going through the Charlie Gibbs and Faraday Fracture Zones, showing these as preferred routes for flow crossing the Mid Atlantic Ridge. These background floats highlight how flow passing close to an eddy can get deflected by that eddy (e.g.

flow to the north and south of ac6 in November 1997). They also indicate the continuing presence of eddies in spite of the fact that no floats remain in the eddy (e.g. flow around ac6 and c2).

It appears that some of these eddies occur when the flow becomes constrained by the topography, for example c12 and ac15 are stationary eddies pressed up against the western flank of the Mid Atlantic Ridge. It is unclear why ac6 remains at its location; the eddy is over slightly higher topography surrounded by channels (figure 11, July/August 1998). It could be hypothesised that the deep flow is constrained to pass through the restricted channels of the fracture zone which constrains the shallower flow to follow a similar path; these enforced meanders then trap embedded eddies which thus appear to be trapped by the topography. So the eddies could actually be trapped by the flow, locked by a downstream feature. Alternatively, the reverse situation may occur, where an eddy becomes trapped by the topography and impacts on the ambient flow to force the flow around it. It is really a question of cause and effect.

4.4 Anticyclones in the West European Basin

Anticyclones near the Goban Spur are shown in figure 12. As already mentioned, float 326 (eddy ac3) has been identified as a meddy (Bower et al., 1999), a possible formation mechanism for which is the sharp direction change the flow undergoes as it rounds the Goban Spur. Two other WHOI floats (352 and 358) were caught in a very similar eddy, ac9, at exactly the same position as float 326, but a year later. The floats had looping periods of 18 and 14 days for approximately seven loops, they then split off from each other, propagating in a southwestward direction still looping, but float 358 had a period of 60 days. Float 319 was caught for 3 loops in eddy ac31, at the same position as the long period looping of float 358, but months earlier. Another anticyclone, ac36, was discovered by float 331 on the northern edge of the Goban Spur; the float only remained in this eddy for two and a half loops. It is possible that some of these anticyclones are also meddies. To corroborate this (or otherwise), hydrographic sections at the deployment position could be examined.

As can be seen in figure 3, the West European Basin is a very anticyclone-rich area, with over 60% of the eddies and looping records being anticyclonic (see Table 3). It also has the highest prevalence of eddies; over 20% of the records are looping. Perhaps this is due to the northward flowing, subsurface, eastern boundary current and the associated formation of anticyclones, similar to the formation of Meddies.

4.5 Eddy temperatures

The temperature record of float 326 in eddy ac3 is shown in figure 13. The float was deployed directly into the core of the meddy, as can be seen from the high temperature and small radius loops. After a few loops the meddy propagated southwestward, and the float may have then moved away from the center slightly, as shown by the larger radius loops and the decrease in temperature. After 375 days, the meddy moved very rapidly southward. It is assumed that the float is still in the same eddy because there are a couple of small cusps in the trajectory, and the temperature remains constant. At day 430, the meddy slowed down again and the float temperature increased, reaching temperatures equal to those at the start of the record. After day 502, the float temperature dropped and the trajectory became smooth, and it is assumed that the float left the meddy. Around day 585, the temperature increased dramatically whilst the float described a single loop, and it seems likely that another anticyclone was encountered. As the float only looped once this wasn't counted as an eddy, but it is interesting to note the increase in temperature that occurred. In general, floats record warmer temperatures and deeper pressures on entering anticyclones, and vice versa when leaving these eddies; the reverse is true for floats entering and leaving cyclones.

As a very quick attempt to determine whether there are any differences in temperature between cyclones and anticyclones, the mean temperature of each eddy was calculated and plotted in a histogram (figure 14). It can be seen that there are more anticyclones at higher temperatures, and more cyclones at lower temperatures. This suggests, as expected, that anticyclones are generally warmer than cyclones.

If time allowed, it would be useful to undertake this type of analysis for other properties, such as angular velocity, size and period, to determine whether there are any other differences between cyclones and anticyclones.

5 SUMMARY

ACCE RAFOS float data were analyzed to investigate eddies in the North Atlantic. 15.6% of the data set were in loopers (two or more consecutive loops in a float trajectory), of which 108 were observed. There were several occasions when floats were found to be looping in the same eddy. In most regions, between 14% and 15% of the data records were in loopers, however, in the West European Basin eddies seem to be more prevalent, with 20.4% of the records characterized as loopers.

Roughly half of the 96 eddies observed were anticyclonic (51%) and half were cyclonic (49%). This ratio varies by geographical region: over 60% of the eddies observed in the Irminger and West European Basins are anticyclones, while less than 40% of those found west of 27ºW and south of 54ºN (Newfoundland Basin and Mid Atlantic Ridge) are anticyclones. In the Iceland Basin and Rockall Trough, the ratio is roughly 50:50. In the mean, anticyclones were found to have higher temperatures than cyclones.

There are a number of observations of eddy interactions; smaller eddies being advected by larger ones and eddies touching and merging; as well as observations of flow and eddy interaction. With just a few exceptions, eddies with more than 3 loops were observed propagating through the ocean. Eddy translation appears to be governed mostly by currents, and therefore indirectly by topography, although there are a few instances (mainly the anticyclones in the West European Basin) where eddy rotation seems to be the controlling factor. It is likely that both mechanisms play a role in determining the eddies' propagation, but it is unfeasible with this data set to determine the relative contributions of each. The longer-lived stationary eddies are generally either topographically constrained or constrained by the surrounding flow.

6 FURTHER WORK

A few further calculations of eddy properties such as translation speed, azimuthal velocity, size and eddy kinetic energy would provide a more complete picture of the eddies in the ACCE RAFOS float data. These could then be used to find further similarities and differences between cyclones and anticyclones, for example, is one type of eddy more energetic than another? It would also be interesting to look at the temperature and pressure records to determine changes that occur as floats start to loop in a particular eddy.

Eddies that trapped more than one float, if looked at in detail, might provide some information on the horizontal structure of eddies. These floats could also be used, along with any floats that moved radially within an eddy, to investigate how rotational velocity varies with distance from the center of an eddy.

Temperature and salinity sections at float deployments, especially those deployments that were directly into eddies, can be used to determine the properties of those eddies. Later studies could look at correlations between surface drifters and the ACCE floats. It would also be interesting to see if any of the eddies can be seen in satellite altimetry. The combination of hydrography, RAFOS floats, drifters and satellite altimetry would be very powerful in furthering our knowledge of eddies.

Acknowledgements

This work was made possible through an exchange between the School of Ocean and Earth Science (SOES), Southampton University, UK and Woods Hole Oceanographic Institution (WHOI), USA, and was funded by SOES. Many thanks are due to Phil Richardson and Amy Bower at WHOI who were the hosts and advisors for my visit. They provided the office space, computing facilities, data, advice, support, encouragement and friendly working environment that made the work possible and enjoyable. Thanks to Tom Rossby from the University of Rhode Island for allowing us to use his float data, and so greatly augmenting the data set. Thanks also to Heather Furey at WHOI for answering my many Matlab questions and dealing with computing problems so quickly.

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Figures

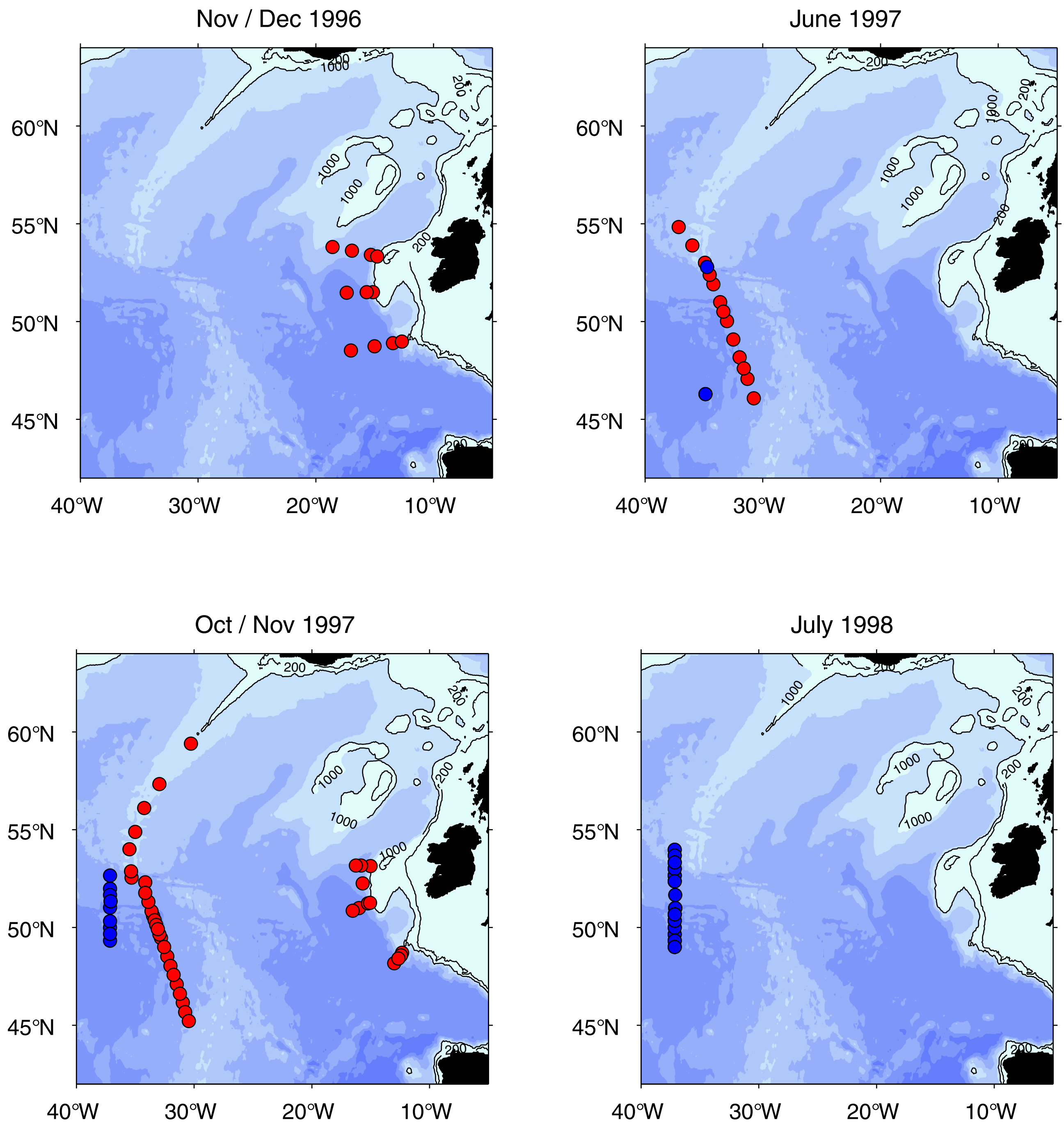


Figure 1
ACCE float launch positions and dates. WHOI floats are in red, URI floats are in blue.
The details (float number, launch date and position) are listed in table 1.

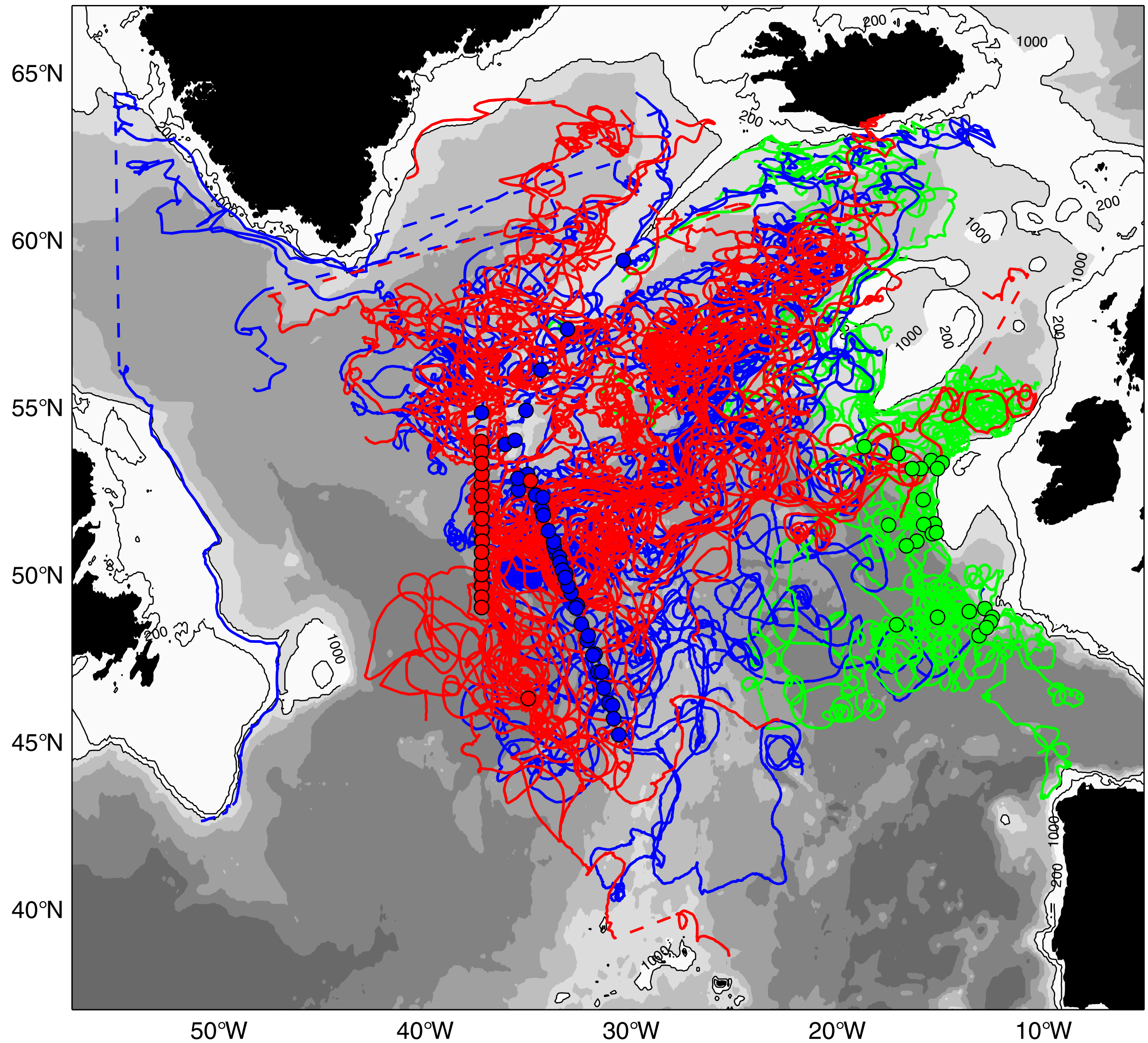


Figure 2
ACCE float trajectories. URI floats are in red, WHOI Subpolar Front floats are in blue, WHOI eastern boundary floats are in green. Circles mark the float launch positions, dashed lines indicate where tracking was lost.

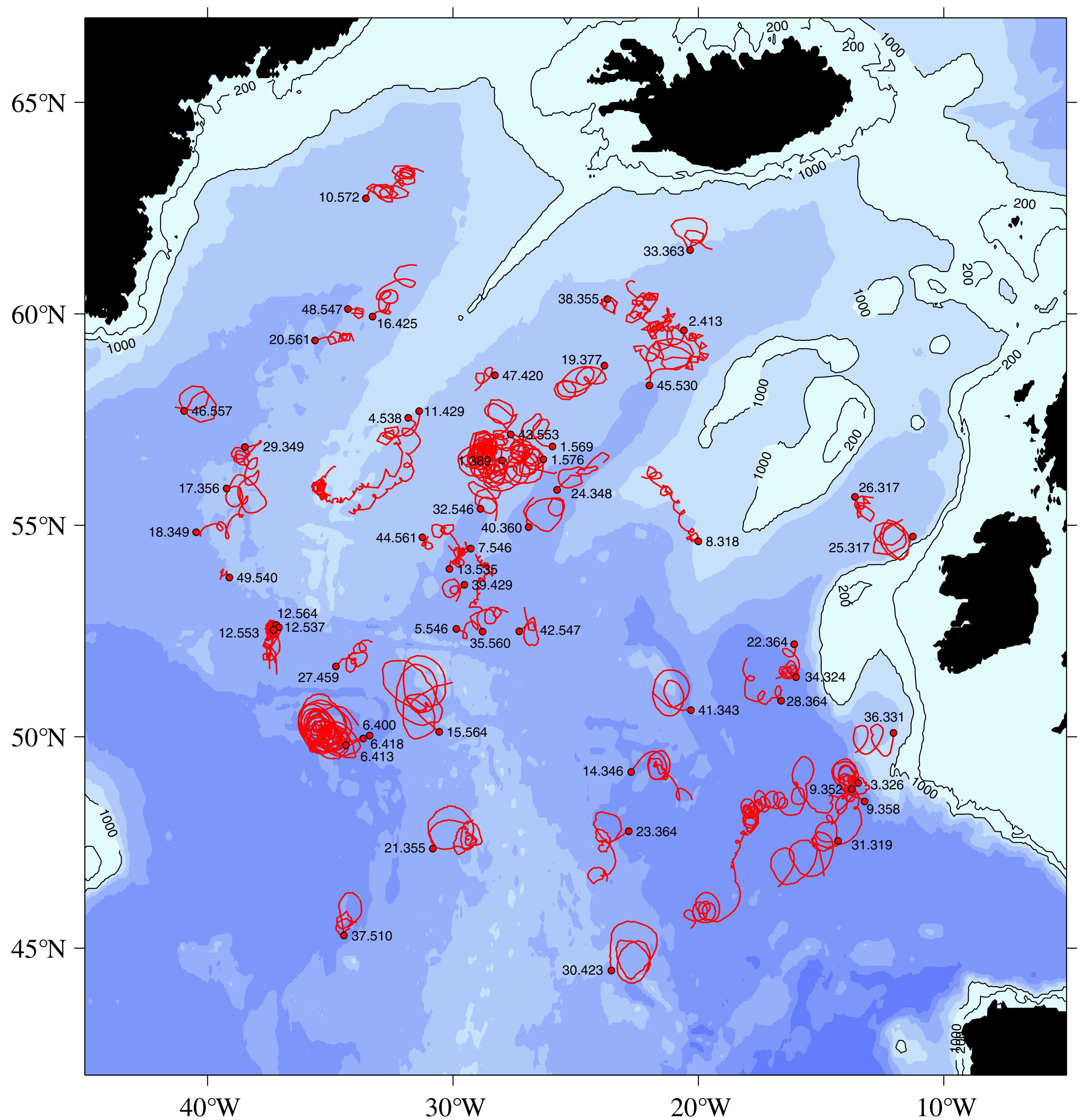


Figure 3
ACCE floats anticyclonic looping trajectories. The beginning of each track is marked with a circle and labelled with the eddy ID and float number (e.g. 30.423 = eddy 30, float 423).

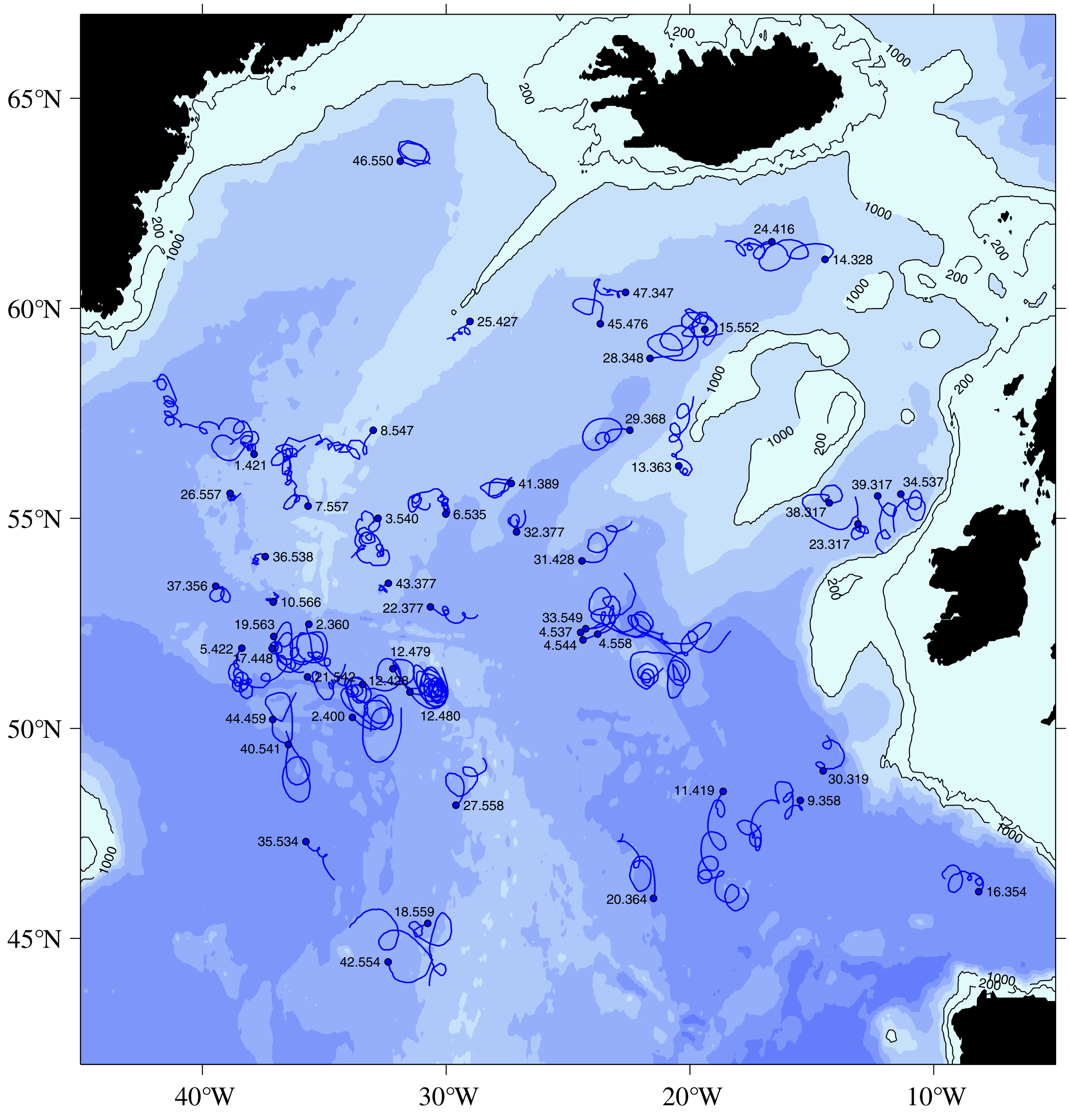


Figure 4
ACCE floats cyclonic looping trajectories. The beginning of each track is marked with a circle and labelled with the eddy ID and float number (e.g. 11.419 = eddy 11, float 419).

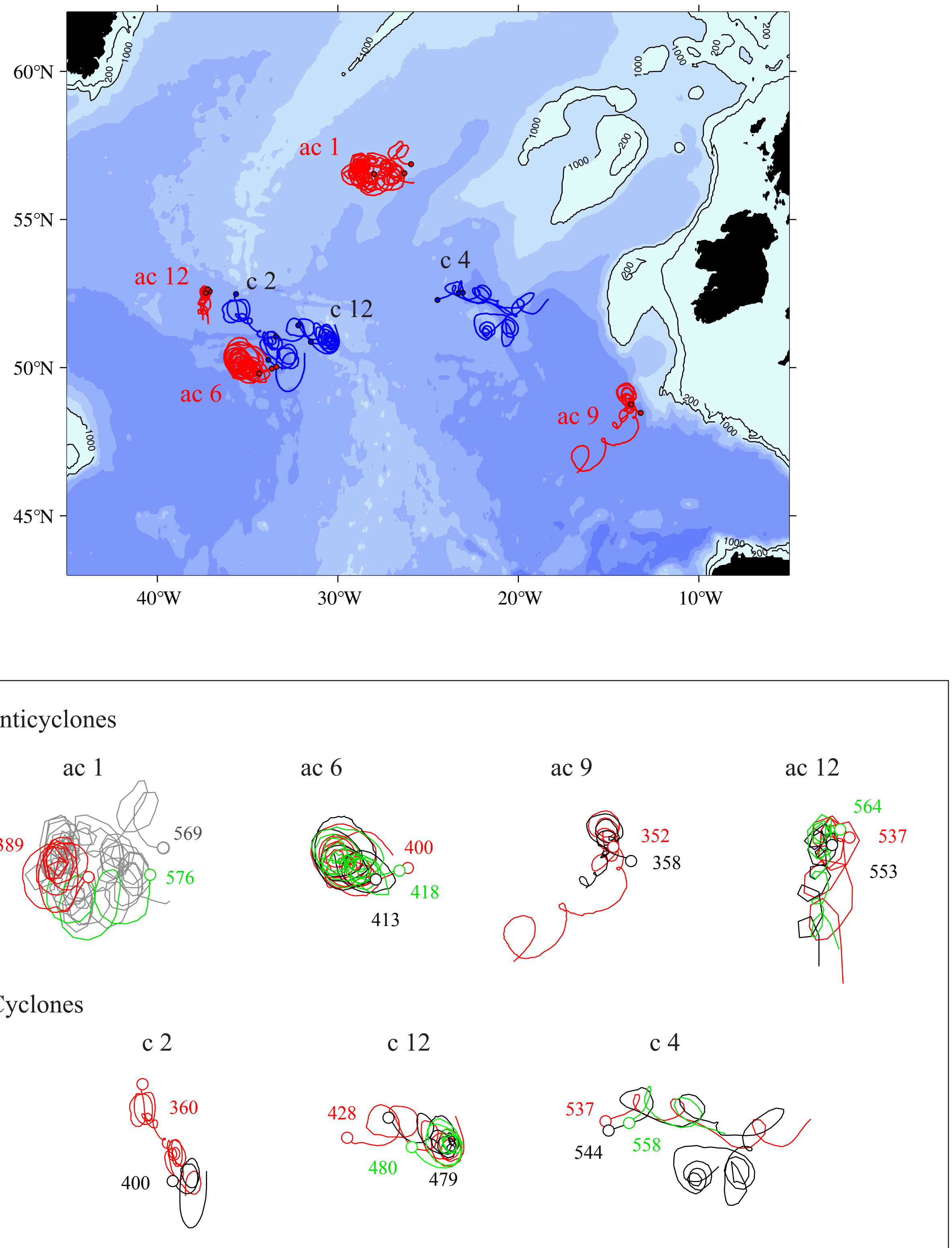


Figure 5
Eddies containing more than one float.
Top figure shows the location of eddies containing more than one float; eddy IDs are shown.
Lower figures show the floats in each eddy and their individual tracks.

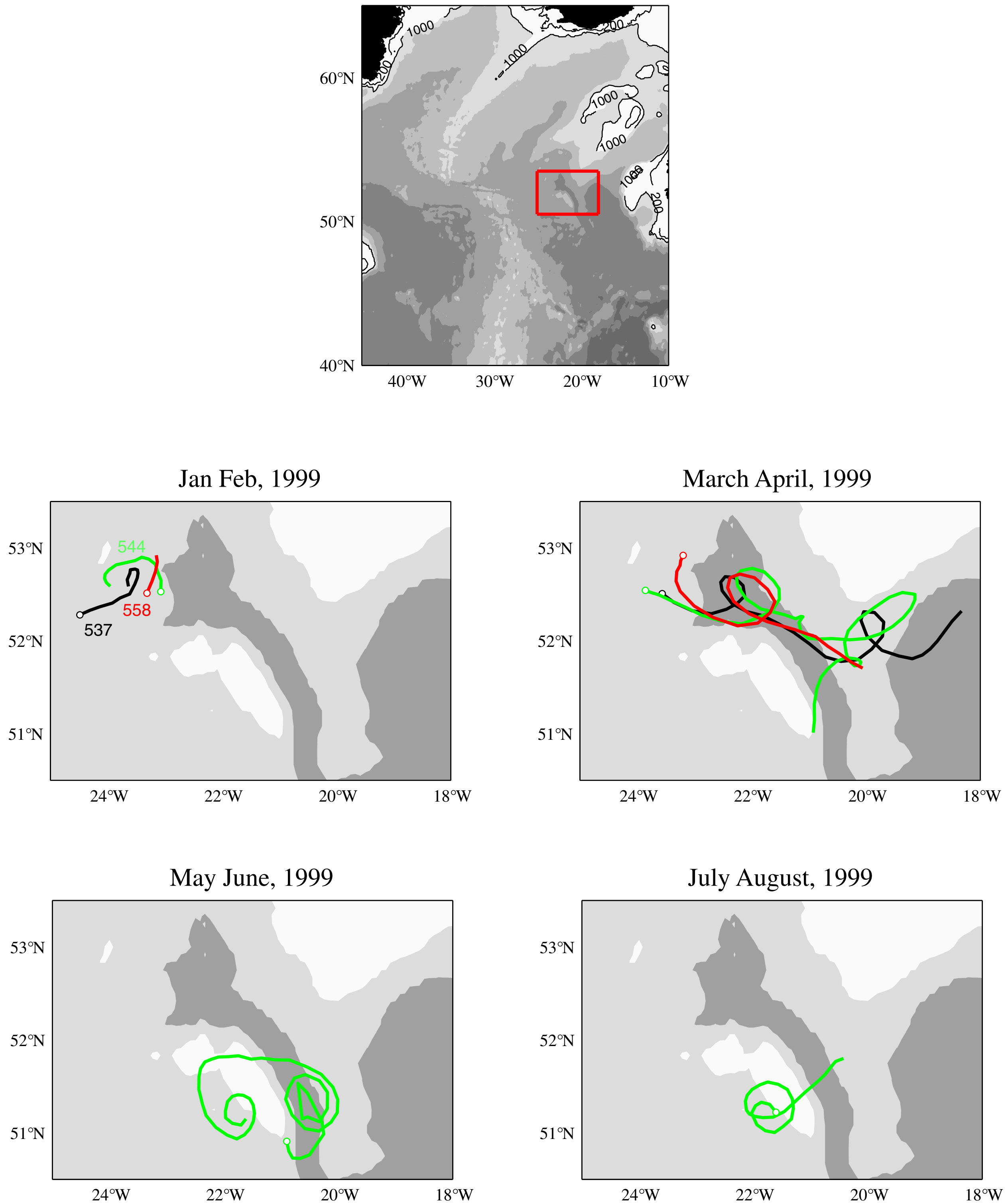


Figure 6
Time frames showing 3 floats (537 in black, 544 in green and 558 in red) in eddy c4.

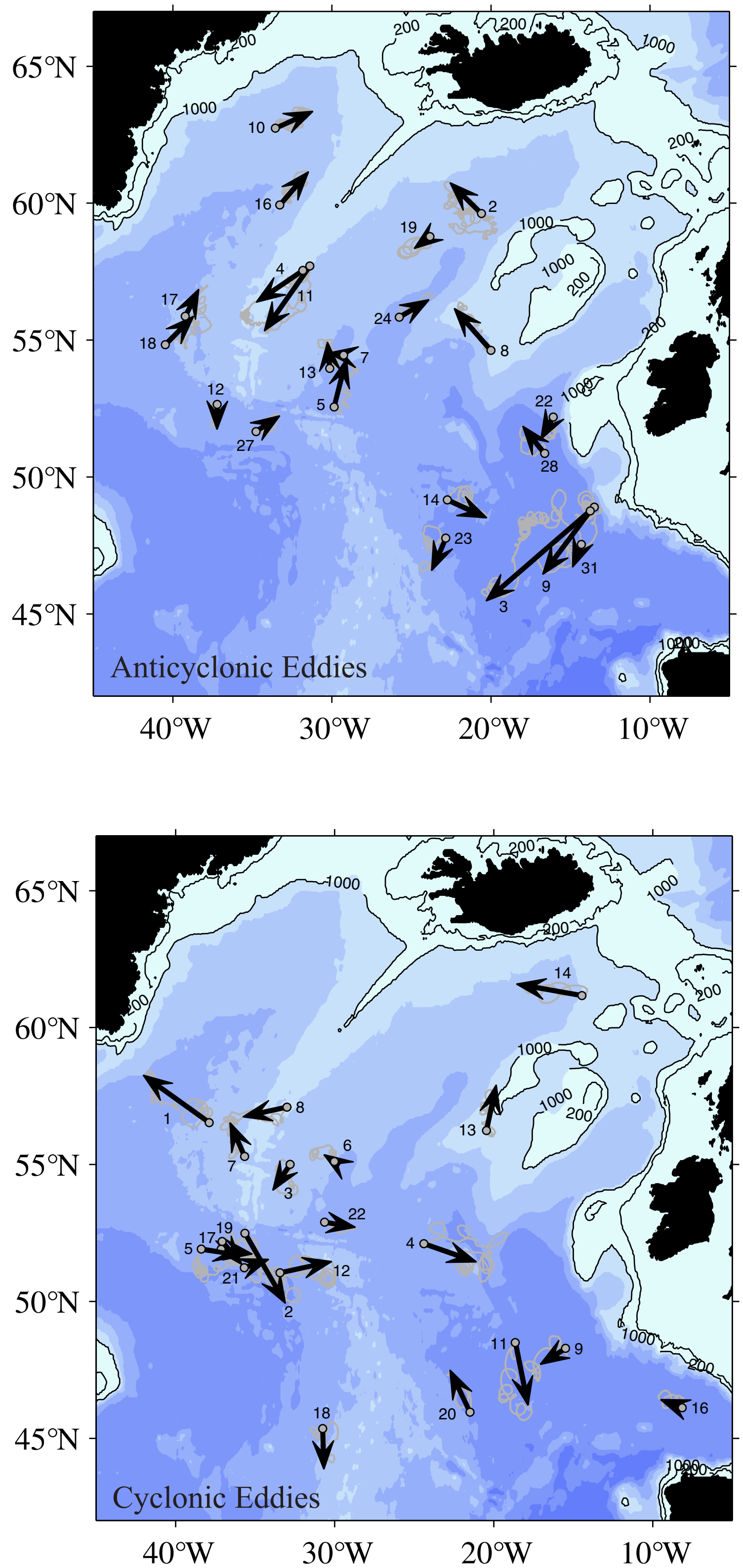


Figure 7
Vectors showing overall translation direction of anticyclonic eddies (top figure) and of cyclonic eddies (lower figure) for records of at least 30 days and 3 loops. Each vector is labelled with the eddy ID.

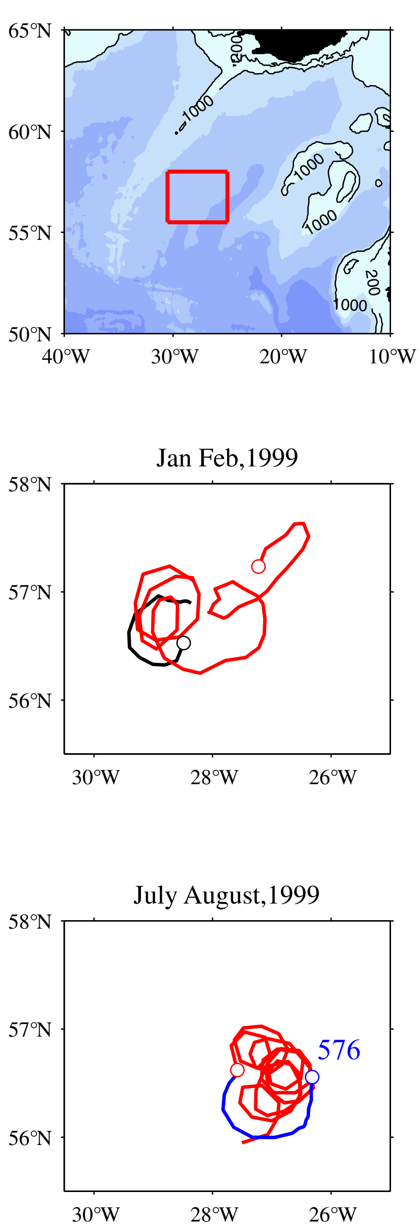


Figure 8
Time frames showing 3 floats (389 in black, 569 in red and 576 in blue) in an anticyclonic eddy in the Iceland Basin. The eddy ID is ac1. The beginning of each track is marked with a circle.

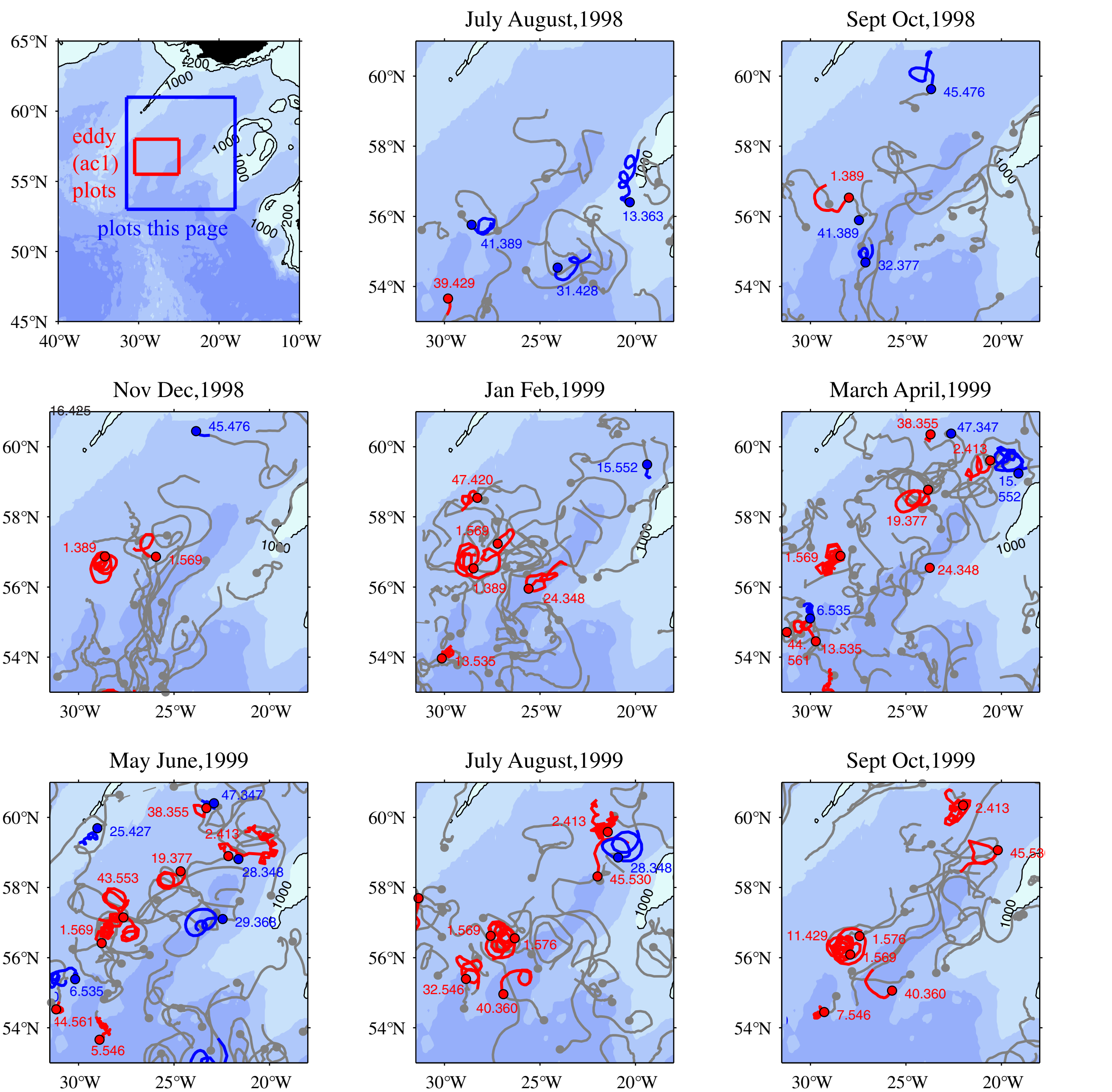


Figure 9
Time frames showing all trajectories (in grey) as well as looping trajectories (anticyclonic in red and cyclonic in blue) of floats in the Iceland Basin. The beginning of each track is marked with a circle.

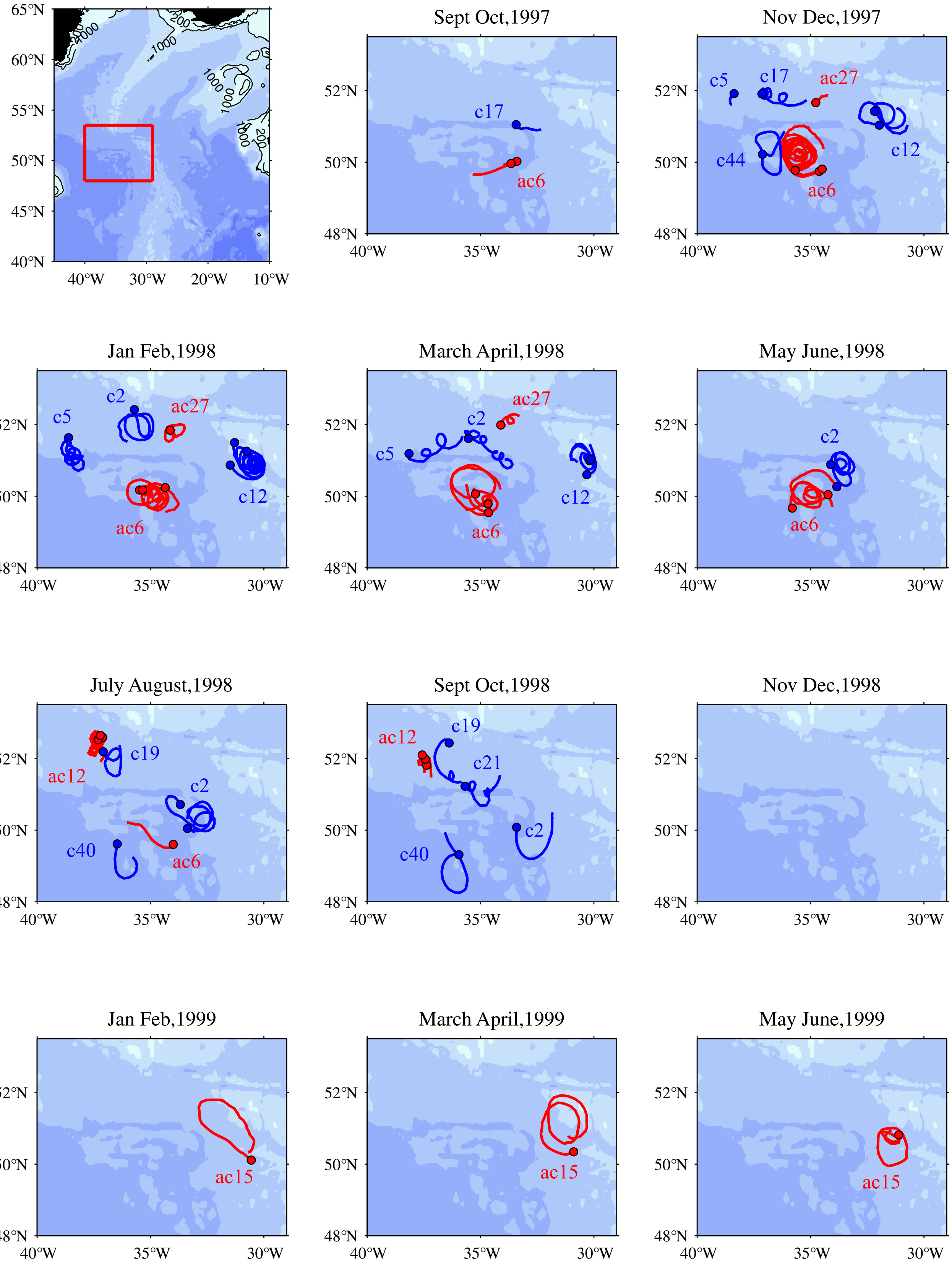


Figure 10
Time frames showing looping trajectories (anticyclonic in red and cyclonic in blue) of floats in an area just to the west of the Mid-Atlantic-Ridge. The beginning of each track is marked with a circle. Each individual eddy is labelled with its ID number.

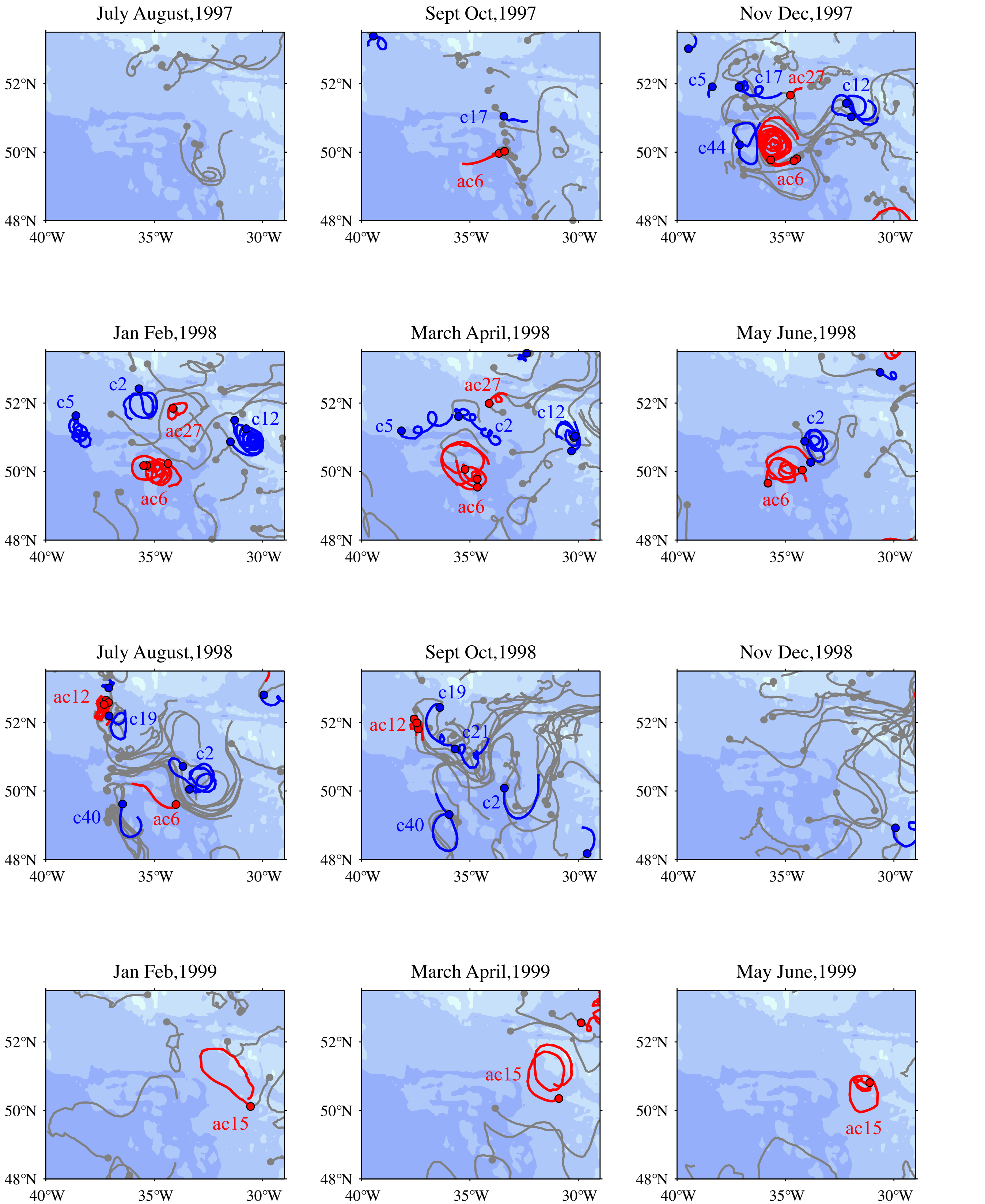


Figure 11
Time frames showing all trajectories (in grey) as well as looping trajectories (anticyclonic in red and cyclonic in blue) of floats in an area just to the west of the Mid-Atlantic-Ridge. The beginning of each track is marked with a circle. The individual eddies of interest are labelled with their ID numbers.

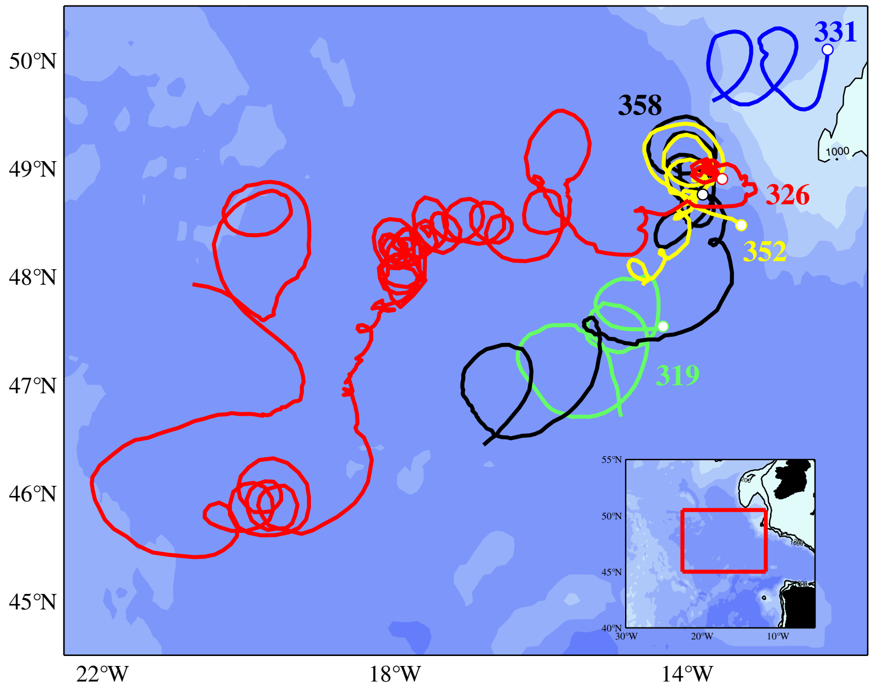


Figure 12
Anticyclonic looping float trajectories at the eastern boundary, labelled with float numbers.

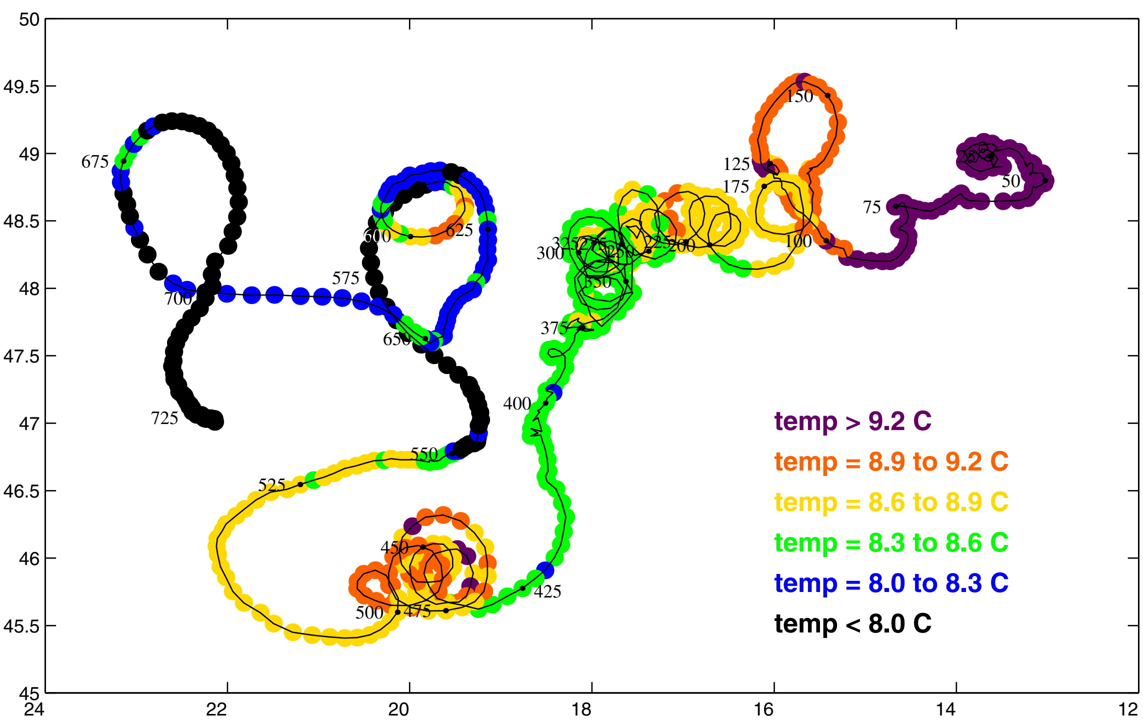
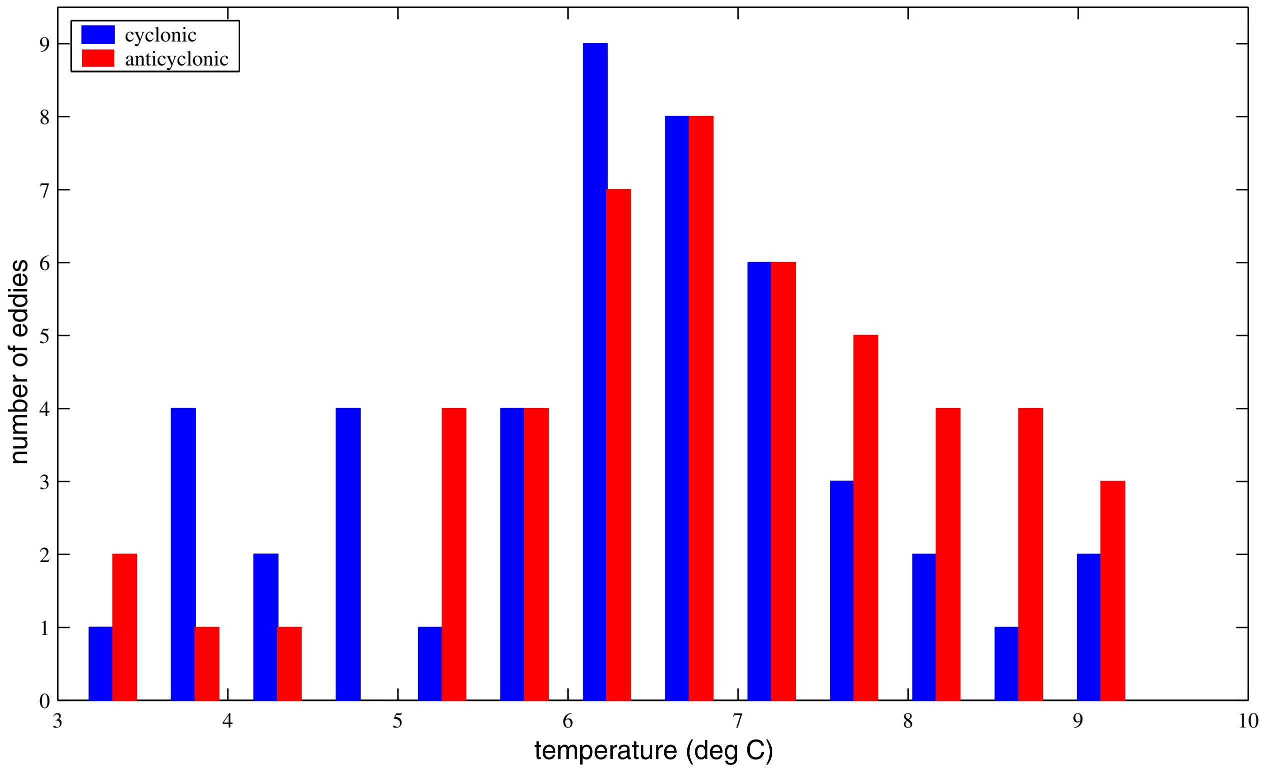


Figure 13
Temperature along the trajectory of float 326. Numbers denote days from float deployment.



Number of eddies in each bin:

bin centre	#cyclonic eddies	#anticyclonic eddies
3.3	1	2
3.8	4	1
4.3	2	1
4.8	4	0
5.3	1	4
5.7	4	4
6.2	9	7
6.7	8	8
7.2	6	6
7.7	3	5
8.2	2	4
8.7	1	4
9.1	2	3

Number of cyclonic eddies = 47
Number of anticyclonic eddies = 49

Percentage of eddies that are anticyclonic = 51 %

Figure 14
Histogram of mean temperature of each eddy (cyclonic in blue, anticyclonic in red)

Tables

Table 1a. WHOI ACCE floats launch and surface positions and dates.
Organised by float number within 3 separate cruise groups.

Float	Launch					Surface				
	Date			Lat	Lon	Date			Lat	Lon
317 *	11	26	1996	53.42	-15.33	11	26	1998	55.00	-10.59
318 *	11	26	1996	53.82	-18.57	11	26	1998	57.32	-29.22
319 *	12	1	1996	48.72	-15.02	12	1	1998	49.95	-15.38
320 *	12	1	1996	48.51	-17.01	12	1	1998	44.68	-10.31
322 *	11	25	1996	53.34	-14.80	11	25	1998	54.91	-17.34
323 *	11	30	1996	51.51	-15.16	2	28	1997	51.82	-15.37
324 *	11	29	1996	51.49	-15.68	2	27	1997	50.95	-16.77
326 *	12	2	1996	48.90	-13.46	12	2	1998	47.00	-22.12
328 *	11	26	1996	53.62	-16.91	11	26	1998	61.18	-25.76
330 *	11	29	1996	51.48	-17.38	11	29	1998	57.29	-33.64
331 *	12	3	1996	48.98	-12.71	12	3	1998	50.87	-21.43
349	6	21	1997	54.84	-37.13	6	21	1999	59.19	-37.16
356	6	22	1997	53.88	-36.00	6	22	1999	53.74	-40.66
359	6	24	1997	48.18	-31.97	6	24	1999	50.95	-29.35
365	6	24	1997	49.09	-32.50	6	24	1999	45.29	-27.80
367	6	25	1997	46.09	-30.79	6	25	1999	45.04	-28.67
368	6	23	1997	50.04	-33.04	6	23	1999	56.78	-23.60
369	6	23	1997	50.98	-33.63	6	23	1999	56.84	-28.43
377	6	23	1997	51.92	-34.21	6	23	1999	57.69	-22.51
378	6	22	1997	53.00	-34.90	6	22	1999	52.38	-27.32
380	6	23	1997	50.52	-33.35	8	22	1997	49.50	-32.56
381	6	25	1997	47.62	-31.63	6	25	1999	47.29	-25.28
382	6	23	1997	52.38	-34.50	8	21	1997	52.64	-29.97
325	10	21	1997	54.90	-35.00	8	10	1999	54.99	-48.77
341	10	17	1997	46.15	-30.97	10	17	1999	48.79	-26.87
342	10	19	1997	50.60	-33.49	10	19	1999	53.33	-18.24
343	10	18	1997	48.51	-32.29	10	18	1999	54.92	-18.76
344 *	11	2	1997	53.16	-15.00	11	2	1999	58.66	-30.41
346	10	18	1997	48.04	-32.01	10	18	1999	49.63	-12.74
347	10	19	1997	50.83	-33.61	10	19	1999	60.79	-27.38
348	10	17	1997	47.10	-31.50	10	17	1999	62.56	-22.05
350 *	11	3	1997	52.25	-15.70	11	3	1999	62.01	-25.81
351 *	11	5	1997	48.72	-12.35	4	14	1998	48.82	-11.73
352 *	11	5	1997	48.59	-12.43	11	5	1999	45.67	-6.57
354 *	11	4	1997	51.00	-16.01	11	4	1999	46.89	-9.02
355	10	17	1997	46.62	-31.20	10	17	1999	60.19	-28.39
357 *	11	5	1997	48.18	-12.99	11	5	1999	50.18	-11.72
358 *	11	5	1997	48.40	-12.63	11	5	1999	47.79	-16.89
360	10	19	1997	52.54	-35.34	10	19	1999	58.39	-23.91
361 *	11	4	1997	51.22	-15.26	11	4	1999	54.83	-10.74
362 *	11	2	1997	53.17	-15.83	10	2	1999	57.00	-17.83
363 *	11	2	1997	53.17	-16.25	11	2	1999	62.08	-23.40
364 *	11	4	1997	50.87	-16.53	11	4	1999	50.30	-21.47
389	10	18	1997	50.36	-33.34	10	18	1999	61.24	-33.69
400	10	18	1997	50.13	-33.22	10	18	1999	54.65	-27.53
413	10	18	1997	49.45	-32.81	10	18	1999	60.67	-22.00
414	10	18	1997	47.59	-31.75	10	18	1999	57.55	-20.56
415	10	19	1997	52.30	-34.17	10	19	1999	57.39	-39.20
416	10	18	1997	49.00	-32.55	10	18	1999	62.75	-22.50
418	10	18	1997	49.66	-32.94	6	16	1999	47.94	-36.22
419 *	11	4	1997	51.27	-15.06	11	4	1999	46.35	-18.18
420	10	18	1997	49.91	-33.08	10	18	1999	52.54	-33.26
421	10	21	1997	56.11	-34.25	10	21	1999	63.02	-53.66
422	10	18	1997	54.00	-35.50	10	18	1999	60.98	-17.61
423	10	17	1997	45.69	-30.75	10	17	1999	42.75	-24.56
424	10	16	1997	45.22	-30.47	10	16	1999	46.20	-24.81
425	10	22	1997	57.33	-32.96	10	22	1999	63.77	-55.44
426	10	23	1997	59.39	-30.26	10	23	1999	43.24	-52.17
427	10	20	1997	52.87	-35.38	10	16	1999	64.47	-30.14
428	10	19	1997	51.31	-33.89	10	19	1999	57.76	-21.64
429	10	19	1997	51.78	-34.14	10	19	1999	55.25	-34.15

* denotes floats launched at the eastern boundary

Table 1b. URI ACCE floats launch and surface positions and dates.
Organised by float number within 3 separate cruise groups.

Float	Launch					Surface				
	Date			Lat	Lon	Date			Lat	Lon
431	5	28	1997	46.30	-34.86	6	25	1997	45.76	-37.69
432	6	24	1997	52.80	-34.75	7	22	1997	52.74	-33.04
433	5	28	1997	46.30	-34.86	9	23	1997	44.84	-33.63
434	6	24	1997	52.80	-34.75	10	20	1997	54.56	-30.52
440	11	5	1997	51.01	-37.15	8	10	1998	45.44	-39.69
448	11	5	1997	52.00	-37.14	5	9	1998	52.75	-19.74
453	11	5	1997	50.00	-37.13	12	14	1997	51.05	-32.96
459	11	5	1997	50.33	-37.14	8	30	1998	54.57	-34.28
466	11	6	1997	52.67	-37.15	12	19	1997	52.71	-37.94
469	11	4	1997	49.33	-37.13	8	27	1998	46.29	-30.40
475	11	5	1997	51.67	-37.13	8	27	1998	54.14	-42.79
476	11	5	1997	51.33	-37.12	12	26	1998	59.04	-20.17
479	11	5	1997	51.34	-37.12	4	2	1998	50.84	-30.54
480	11	5	1997	49.67	-37.14	3	30	1998	50.82	-30.87
502	7	25	1998	49.33	-37.14	1	10	2000	46.86	-33.91
510	7	25	1998	49.33	-37.14	1	10	2000	38.69	-25.03
530	7	26	1998	49.01	-37.14	1	9	2000	60.39	-19.62
531	7	25	1998	50.67	-37.13	1	6	2000	56.88	-31.07
534	7	26	1998	49.65	-37.13	1	9	2000	57.51	-24.35
535	7	24	1998	52.36	-37.13	12	11	1999	56.95	-34.04
536	7	24	1998	53.33	-37.13	8	26	1999	59.38	2.57
537	7	25	1998	52.67	-37.14	10	10	1999	54.40	-12.66
538	7	25	1998	50.34	-37.14	1	8	2000	53.99	-36.96
539	7	24	1998	53.67	-37.14	2	27	1999	62.00	-7.48
540	7	25	1998	51.00	-37.11	1	10	2000	53.60	-39.08
541	7	25	1998	49.99	-37.13	11	19	1999	56.81	-11.90
542	7	26	1998	51.00	-37.11	1	9	2000	57.77	-22.48
544	7	25	1998	51.00	-37.11	1	10	2000	51.60	-16.73
546	7	25	1998	53.00	-37.13	1	10	2000	54.47	-29.44
547	7	25	1998	50.34	-37.14	12	4	1999	60.38	-28.04
548	7	25	1998	49.99	-37.13	1	10	2000	54.23	-21.86
549	7	21	1998	51.00	-37.11	1	9	2000	59.52	-20.89
550	7	24	1998	53.98	-37.16	11	3	1999	64.50	-33.51
552	7	21	1998	50.67	-37.13	8	22	1999	63.98	-16.17
553	7	25	1998	52.67	-37.14	1	10	2000	54.82	-37.55
554	7	21	1998	49.33	-37.14	1	10	2000	46.50	-32.05
557	7	24	1998	53.33	-37.13	1	5	2000	56.48	-36.91
558	7	25	1998	50.34	-37.14	1	7	2000	60.74	-18.07
559	7	21	1998	49.01	-37.14	1	10	2000	45.62	-22.70
560	7	25	1998	50.67	-37.13	12	14	1999	60.79	-32.62
561	7	21	1998	50.34	-37.14	11	4	1999	62.93	-39.28
563	7	25	1998	52.36	-37.13	11	22	1999	64.87	-30.70
564	7	24	1998	52.67	-37.14	1	9	2000	55.98	-31.52
566	7	24	1998	53.00	-37.13	12	30	1998	61.94	0.55
569	7	21	1998	50.67	-37.13	1	9	2000	57.39	-25.00
570	7	24	1998	53.00	-37.13	3	4	1999	59.76	-5.01
571	7	24	1998	53.98	-37.16	8	7	1999	63.70	-40.47
572	7	24	1998	53.67	-37.14	10	15	1999	60.49	-46.26
573	7	24	1998	53.33	-37.13	1	15	1999	65.53	9.19
574	7	21	1998	52.36	-37.13	12	25	1999	61.71	-31.87
575	7	26	1998	49.01	-37.14	1	20	1999	47.80	-31.83
576	7	21	1998	51.67	-37.13	1	9	2000	58.76	-26.07

Table 2a. Details of all ACCE floats anticyclonic looping trajectories (in eddy ID order)

eddy ID[x]	float		start rec #	end rec #	days tracked	no. of loops	mean period (days)	dates tracked					
								start date			end date		
ac1	569	URI	150	485	336	46	7.3	12	16	1998	11	16	1999
ac1 [#2]	389	WHOI	350	455	106	8	13.25	10	3	1998	1	16	1999
ac1 [#3]	576	URI	392	436	45	2.8	16	8	15	1999	9	28	1999
ac2	413	WHOI	540	720	181	43	4.2	4	11	1999	10	8	1999
ac3	326	WHOI	1	502	502	42	12	12	3	1996	4	18	1998
ac4	538	URI	222	370	149	36	4	3	2	1999	7	28	1999
ac5	546	URI	237	340	104	22	4.6	3	17	1999	6	28	1999
ac6	418	WHOI	10	280	271	15	18	10	28	1997	7	25	1998
ac6 [#2]	400	WHOI	3	253	251	13	19.3	10	21	1997	6	28	1998
ac6 [#3]	413	WHOI	13	146	134	4.5	29.8	10	31	1997	3	13	1998
ac7	546	URI	417	487	71	11	6.5	9	13	1999	11	22	1999
ac8	318	WHOI	305	405	101	10.5	10	9	27	1997	1	5	1998
ac9	352	WHOI	13	273	261	10	26 (18, 60) *	11	18	1997	8	5	1998
ac9 [#2]	358	WHOI	10	133	124	9	14	11	15	1997	3	18	1998
ac10	572	URI	318	388	71	9.75	7.3	6	5	1999	8	14	1999
ac11	429	WHOI	662	730	69	9.5	7	8	12	1999	10	19	1999
ac12	564	URI	1	50	50	8	6.25	7	24	1998	9	10	1998
ac12 [#2]	537	URI	1	47	47	7	6.7	7	25	1998	9	8	1998
ac12 [#3]	553	URI	1	46	46	8	5.8	7	25	1998	9	7	1998
ac13	535	URI	196	246	51	7.5	6.7	2	3	1999	3	25	1999
ac14	346	WHOI	392	507	116	6.5	17.5	11	14	1998	3	9	1999
ac15	564	URI	180	348	169	6	28	1	18	1999	7	5	1999
ac16	425	WHOI	309	380	72	5.5	13	8	27	1998	11	6	1998
ac17	356	WHOI	346	480	135	5	27	6	3	1998	10	15	1998
ac18	349	WHOI	86	179	94	5	18.6	9	15	1997	12	17	1997
ac19	377	WHOI	645	700	56	5	11.2	3	30	1999	5	24	1999
ac20	561	URI	399	420	22	4.7	4.7	8	22	1999	9	12	1999
ac21	355	WHOI	10	229	220	4.5	49	10	27	1997	6	3	1998
ac22	364	WHOI	122	166	45	4.5	10	3	6	1998	4	19	1998
ac23	364	WHOI	360	501	142	4	35.5	10	30	1998	3	20	1999
ac24	348	WHOI	440	502	63	4	16	12	31	1998	3	3	1999
ac25	317	WHOI	633	681	49	4	12	8	21	1998	10	8	1998
ac26	317	WHOI	524	548	25	4	6	5	4	1998	5	28	1998
ac27	459	URI	52	139	88	3.5	25	12	25	1997	3	22	1998
ac28	364	WHOI	1	58	58	3.5	16.6	11	5	1997	1	1	1998
ac29	349	WHOI	586	632	47	3.3	14	1	28	1999	3	15	1999
ac30	423	WHOI	419	554	136	3	45	12	10	1998	4	24	1999
ac31	319	WHOI	211	316	106	3	35	6	30	1997	10	13	1997
ac32	546	URI	359	402	44	3	14.3	7	17	1999	8	29	1999
ac33	363	WHOI	499	529	31	3	10	3	16	1999	4	15	1999
ac34	324	WHOI	2	30	29	3	9	12	1	1996	12	29	1996
ac35	560	URI	122	145	24	2.7	9.5	11	22	1998	12	15	1998
ac36	331	WHOI	94	175	82	2.5	32.4	3	7	1997	5	27	1997
ac37	510	URI	119	183	65	2.5	25.5	11	19	1998	1	22	1999
ac38	355	WHOI	557	569	13	2.5	5.2	4	27	1999	5	9	1999
ac39	429	WHOI	200	271	72	2.3	31	5	7	1998	7	17	1998
ac40	360	WHOI	643	698	56	2.3	24	7	24	1999	9	17	1999
ac41	343	WHOI	451	511	61	2.2	27	1	12	1999	3	13	1999
ac42	547	URI	100	160	61	2	30	10	31	1998	12	30	1998
ac43	553	URI	290	333	44	2	20	5	9	1999	6	21	1999
ac44	561	URI	281	311	31	2	15.5	4	26	1999	5	26	1999
ac45	530	URI	395	420	26	2	12	8	23	1999	9	17	1999
ac46	557	URI	292	315	24	2	12	5	10	1999	6	2	1999
ac47	420	WHOI	462	480	19	2	10	1	23	1999	2	10	1999
ac48	547	URI	485	495	11	2	5.5	11	20	1999	11	30	1999
ac49	540	URI	525	534	10	2	5	12	30	1999	1	8	2000

[x] ac stands for anticyclonic, so ac1 is anticyclonic eddy 1. [#2] denotes second float in the eddy etc.

* the first 8 loops have an 18 day period, the last 2 each have a 60 day period

Table 2b. Details of all ACCE floats cyclonic looping trajectories (in eddy ID order)

eddy ID[x]	float		start rec #	end rec #	days tracked	no. of loops	mean period (days)	dates tracked: start date			end date		
c1	421	WHOI	458	625	168	17.5	9.5	1	22	1999	7	8	1999
c2	360	WHOI	73	313	241	13.5	18	12	31	1997	8	28	1998
c2 [#2]	400	WHOI	253	340	88	2.6	33.8	6	28	1998	9	23	1998
c3	540	URI	258	418	161	12.5	13	4	7	1999	9	14	1999
c4	544	URI	200	369	170	11.5	14.5	2	8	1999	7	27	1999
c4 [#2]	537	URI	206	257	52	3.5	14.6	2	14	1999	4	6	1999
c4 [#3]	558	URI	212	244	33	2.2	15.5	2	20	1999	3	24	1999
c5	422	WHOI	67	166	100	11	9.7	12	24	1997	4	2	1998
c6	535	URI	251	338	88	10.5	8	3	30	1999	6	25	1999
c7	557	URI	422	522	101	10	10	9	17	1999	12	26	1999
c8	547	URI	366	421	56	9	6	7	24	1999	9	17	1999
c9	358	WHOI	478	712	235	8	29.4	2	26	1999	10	18	1999
c10	566	URI	3	32	30	7.5	4	7	25	1998	8	23	1998
c11	419	WHOI	510	727	218	7	31	3	29	1999	11	1	1999
c12	428	WHOI	4	145	142	6.7	21.2 (30, 16.3) **	10	23	1997	3	13	1998
c12 [#2]	479	URI	45	150	106	8.2	13	12	18	1997	4	2	1998
c12 [#3]	480	URI	64	150	87	5	17.4	1	6	1998	3	30	1998
c13	363	WHOI	227	295	69	6.5	10.5	6	17	1998	8	24	1998
c14	328	WHOI	520	602	83	4.5	18.4	4	30	1998	7	21	1998
c15	552	URI	218	269	52	4.5	11.6	2	22	1999	4	14	1999
c16	354	WHOI	550	678	129	4	32.25 (25, 40) ***	5	8	1999	9	13	1999
c17	448	URI	1	40	40	4	10	11	5	1997	12	13	1997
c18	559	URI	263	360	98	3.5	28	4	8	1999	7	14	1999
c19	563	URI	1	68	68	3.5	19.5	7	25	1998	9	29	1998
c20	364	WHOI	570	660	91	3	30	5	28	1999	8	26	1999
c21	542	URI	48	92	45	3	15	9	10	1998	10	24	1998
c22	377	WHOI	354	397	44	3	14	6	12	1998	7	25	1998
c23	317	WHOI	47	87	41	3	13	1	12	1997	2	21	1997
c24	416	WHOI	442	466	25	3	8.3	1	3	1999	1	27	1999
c25	427	WHOI	592	611	20	3	6	6	4	1999	6	23	1999
c26	557	URI	370	384	15	3	4.5	7	27	1999	8	10	1999
c27	558	URI	89	156	68	2.7	25	10	20	1998	12	26	1998
c28	348	WHOI	620	662	43	2.7	16	6	29	1999	8	10	1999
c29	368	WHOI	691	730	40	2.6	15.4	5	15	1999	6	23	1999
c30	319	WHOI	490	568	79	2.5	31.6	4	5	1998	6	22	1998
c31	428	WHOI	238	297	60	2.5	23.5	6	14	1998	8	12	1998
c32	377	WHOI	450	490	41	2.5	16	9	16	1998	10	26	1998
c33	549	URI	297	335	39	2.5	16	5	12	1999	6	19	1999
c34	537	URI	371	398	28	2.5	11	7	29	1999	8	25	1999
c35	534	URI	17	39	23	2.5	9.2	8	10	1998	9	1	1998
c36	538	URI	517	530	14	2.5	5.6	12	22	1999	1	4	2000
c37	356	WHOI	106	137	32	2.3	14	10	6	1997	11	6	1997
c38	317	WHOI	317	351	35	2.25	15.6	10	9	1997	11	12	1997
c39	317	WHOI	553	571	19	2.25	8.5	6	2	1998	6	20	1998
c40	541	URI	27	70	44	2.1	21	8	19	1998	10	1	1998
c41	389	WHOI	245	321	77	2	38.5	6	20	1998	9	4	1998
c42	554	URI	70	145	76	2	38	9	27	1998	12	11	1998
c43	377	WHOI	253	299	47	2	23	3	3	1998	4	18	1998
c44	459	URI	1	37	37	2	18.5	11	5	1997	12	10	1997
c45	476	URI	332	366	35	2	17	10	1	1998	11	4	1998
c46	550	URI	366	391	26	2	12	7	23	1999	8	17	1999
c47	347	WHOI	557	567	11	2	5.5	4	29	1999	5	9	1999

[x] c stands for cyclonic, so c1 is cyclonic eddy 1. [#2] denotes second float in the eddy etc.

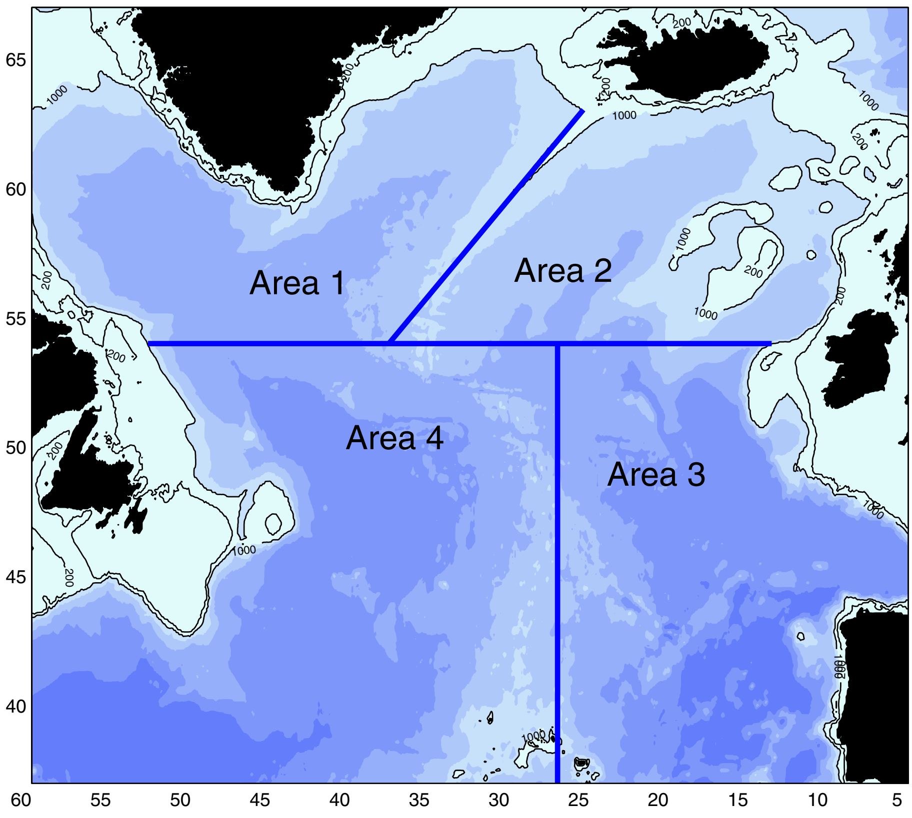
** the first 3 loops have a 30 day period, the rest have a 16.3 day period

*** the first 2 loops have a 25 day period, the last two have a 40 day period

Table 3: Rotation direction of records and eddies in four areas in the North Atlantic.
(the areas are illustrated in the figure below)

	Area 1 North of 54N and west of MAR* **Irminger Basin**		Area 2 North of 54N and east of MAR **Iceland Basin and Rockall Trough**		Area 3 South of 54N and east of 27W **West European Basin**		Area 4 South of 54N and west of 27W **Newfoundland Basin, MAR and area just to east of CGFZ****		**Entire Area**	
No. of records	5980		17674		13550		20875		58079	
% of records that are looping	15.0%		13.9%		20.4%		14.2%		15.6%	
% of looping records that are **anticyclonic** / cyclonic	**60.2%**	39.8%	**62.2%**	37.8%	**61.9%**	38.1%	**51.9%**	48.1%	**58.5%**	41.5%
Number of eddies that are **anticyclonic** / cyclonic	**8**	6	**19**	18	**12**	7	**10**	16	**49**	47
% of eddies that are **anticyclonic** / cyclonic	**57.1%**	42.9%	**51.4%**	48.6%	**63.2%**	36.8%	**38.5%**	61.5%	**51.0%**	49.0%
Number of eddies as a % of total number in data set	14.6%		38.5%		19.8%		27.1%		100%	

* MAR = Mid Atlantic Ridge
** CGFZ = Charlie Gibbs Fracture Zone
N.B: Areas 1 and 2 have as their common east/west boundary a line running down the centre of the Mid Atlantic Ridge, described by the equation y = (0.741*x) + 81.85, where y is latitude and x is longitude, which intersects 54ºN at 37.6ºW, see figure below.

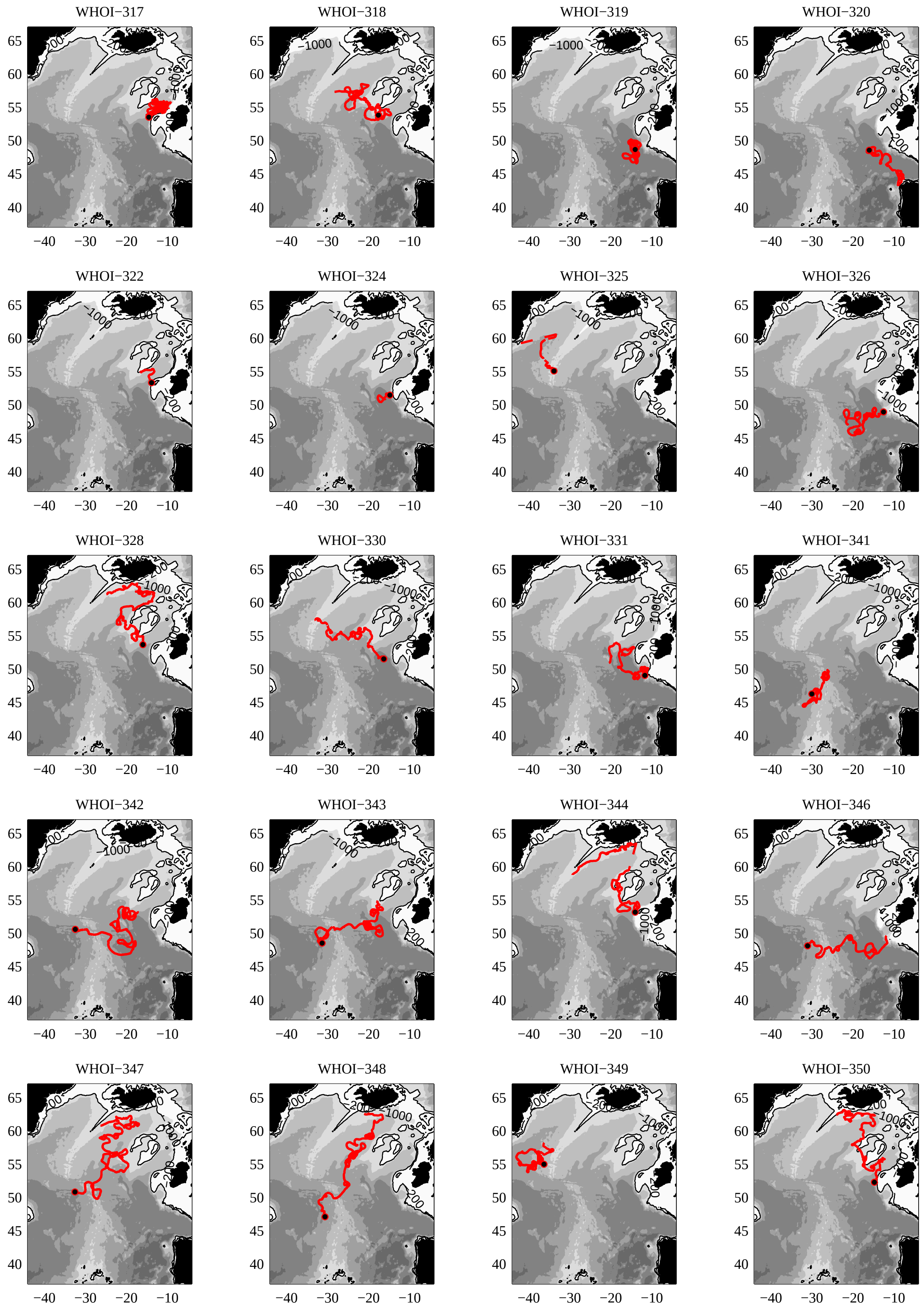


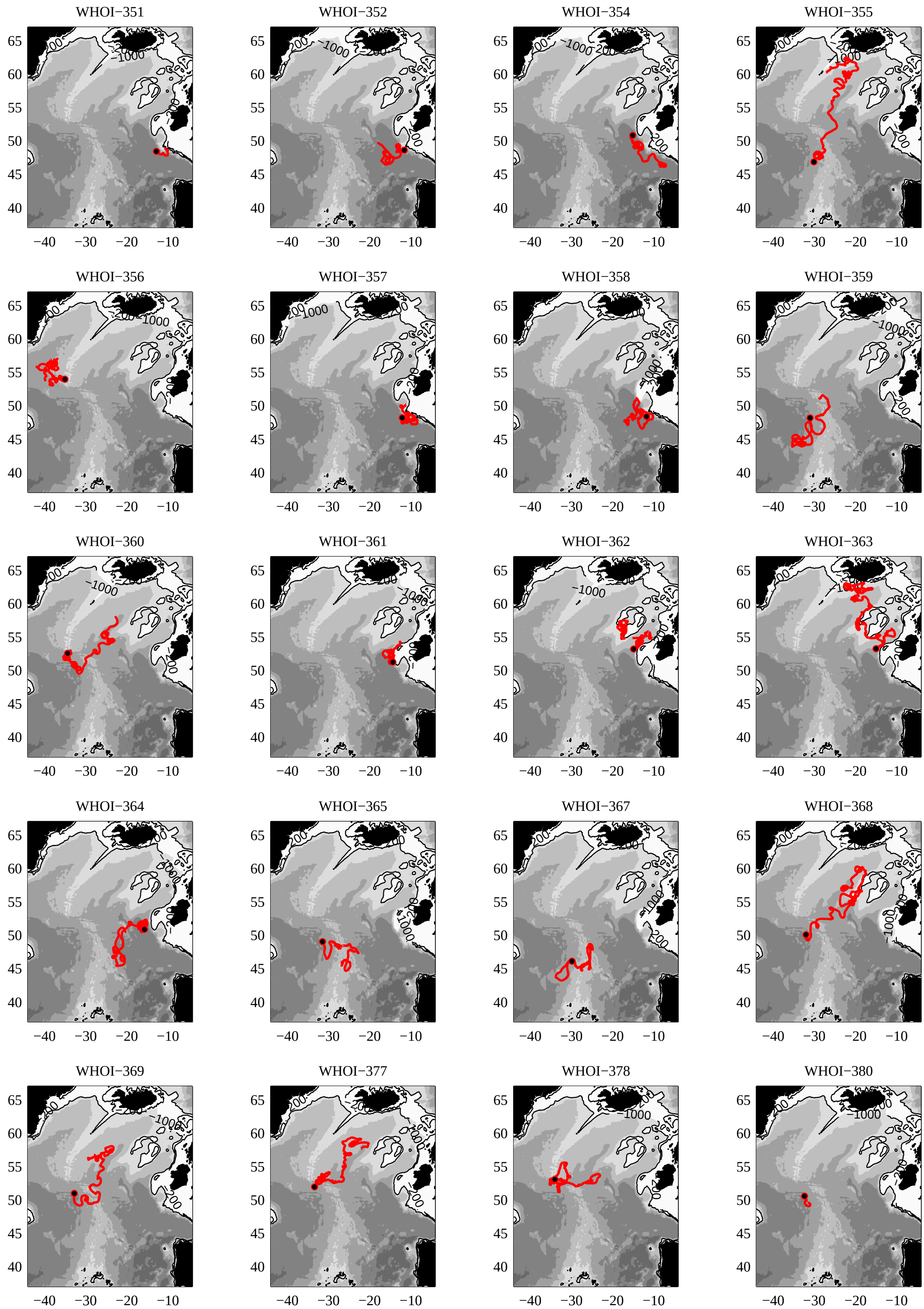
Appendix 1

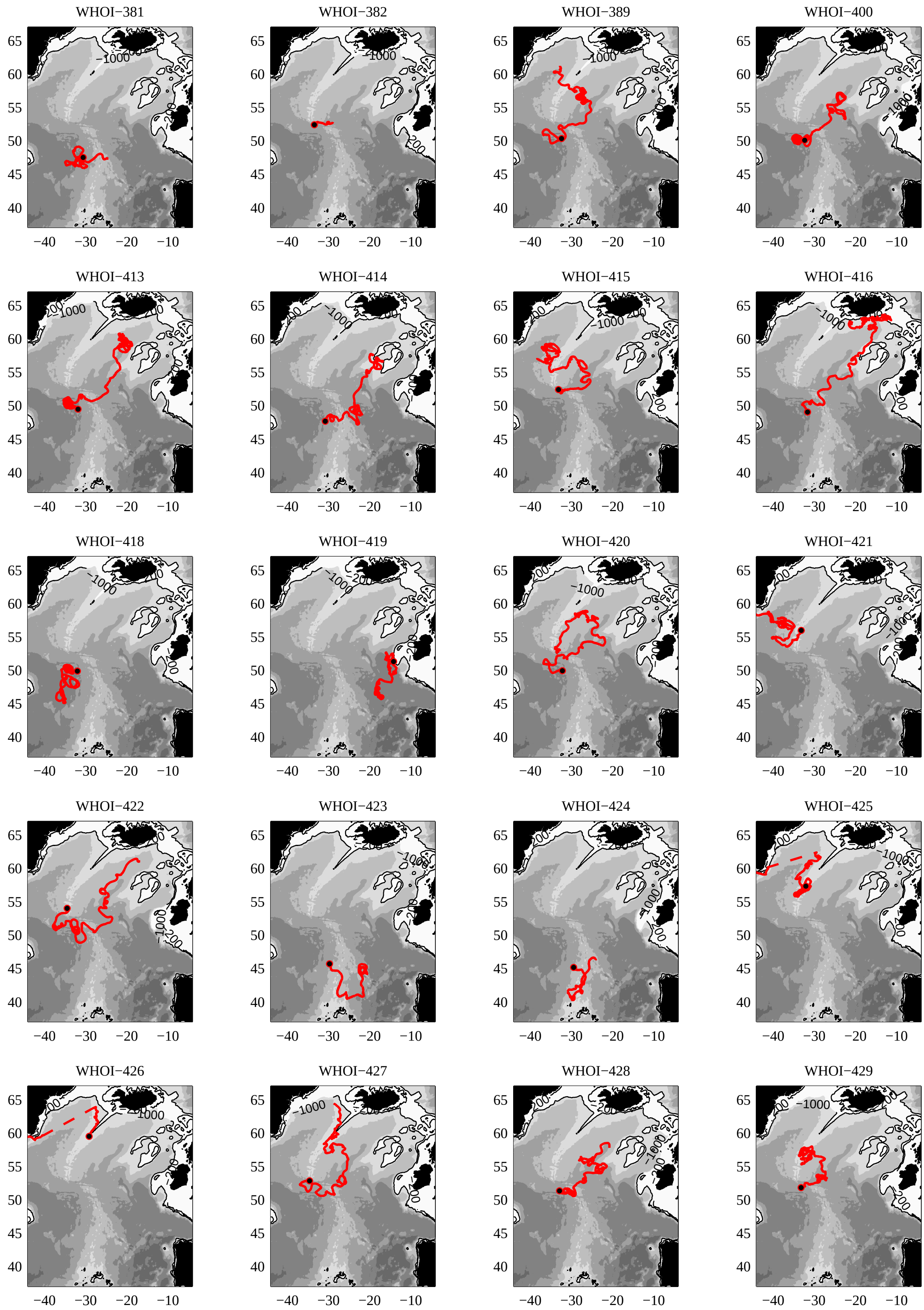
Individual ACCE RAFOS float tracks for WHOI and URI floats

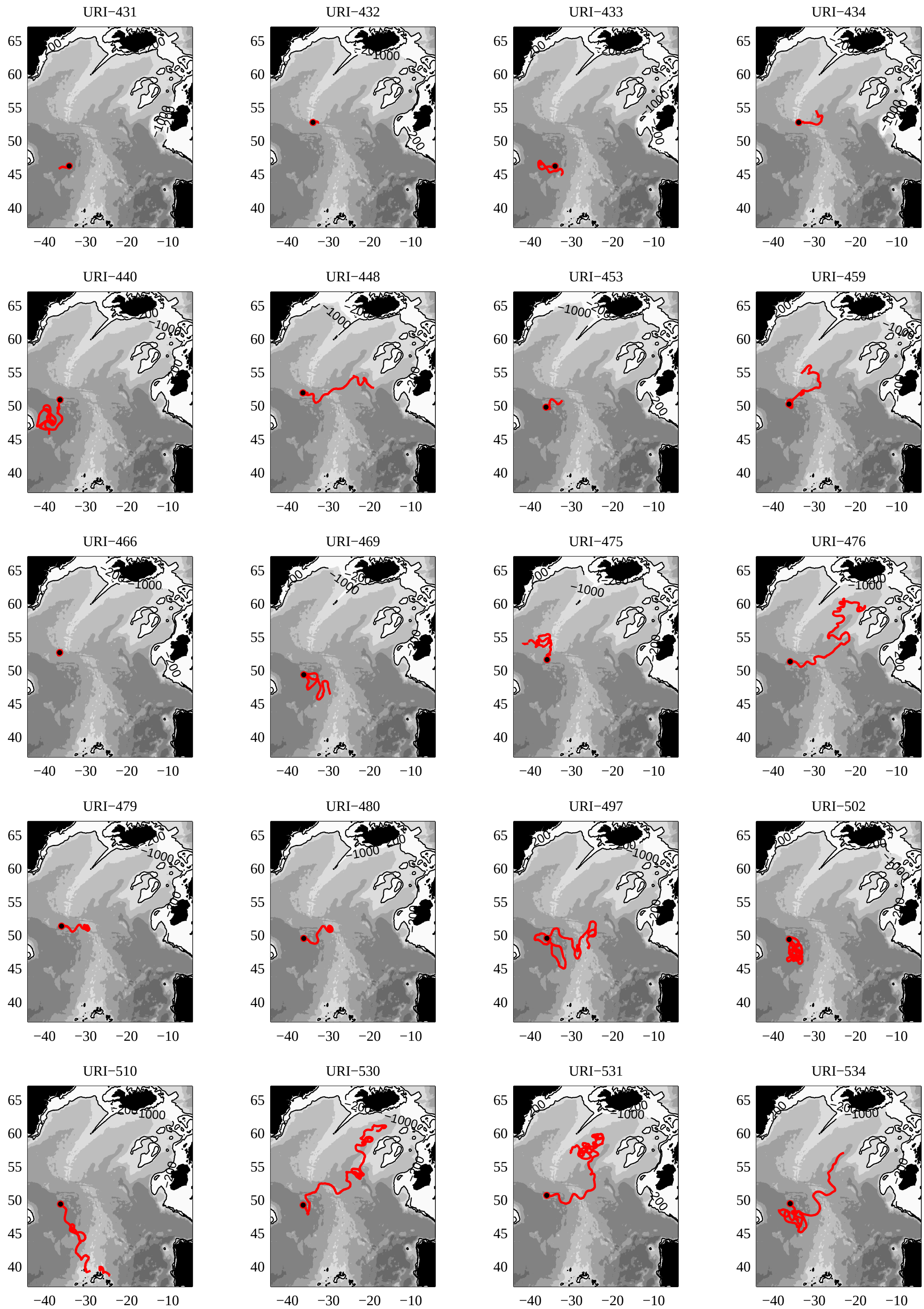
Each plot shows a different float track overlying bathymetry.
Float number is given in the plot title.
A dot is drawn at the beginning of the track.

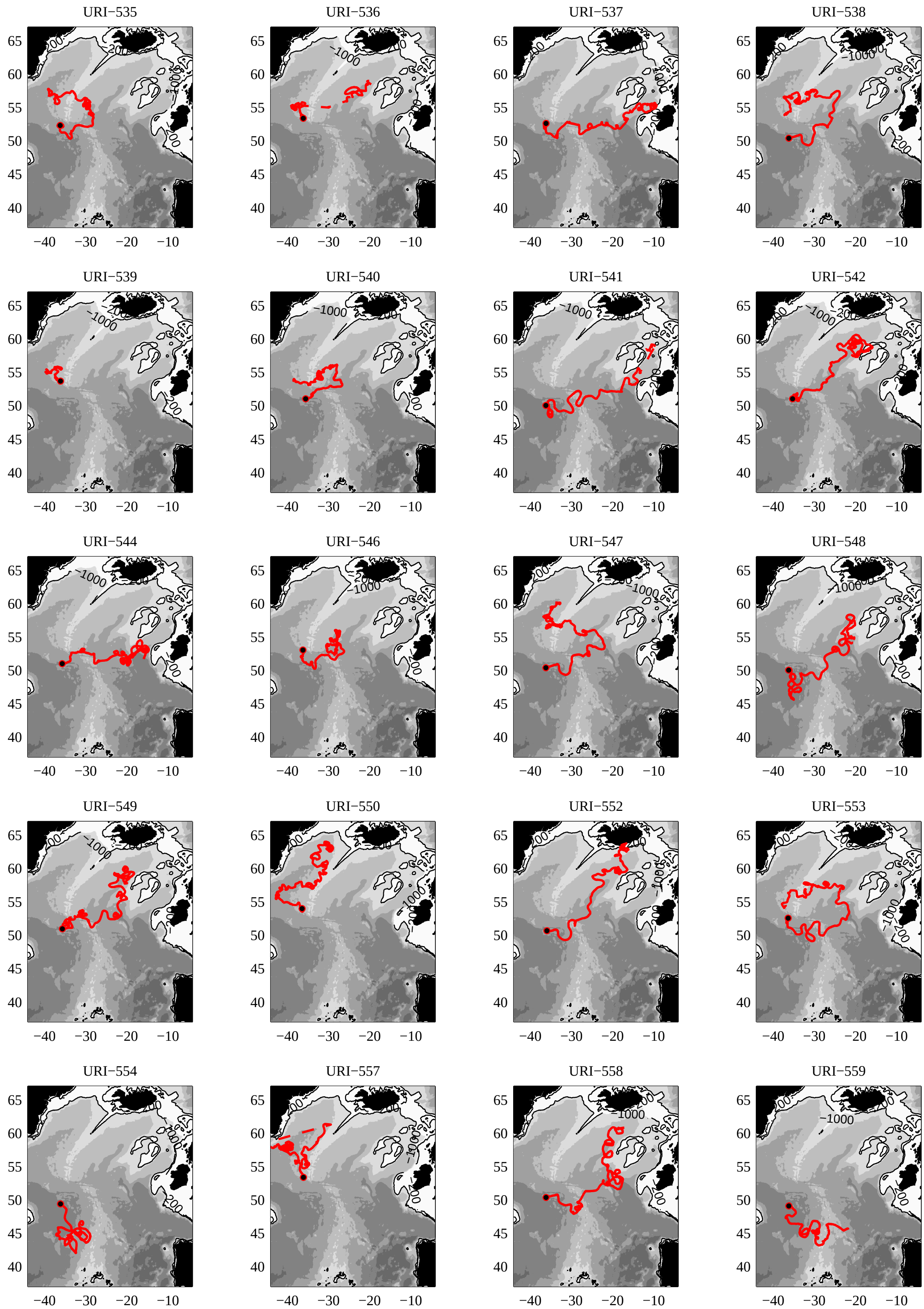
Please note: These plots are for reference only, to make finding particular tracks easier. They are not intended to be used to make out any details of the track!


WHOI−317
WHOI−318
WHOI−319
WHOI−320
WHOI−322
WHOI−324
WHOI−325
WHOI−326
WHOI−328
WHOI−330
WHOI−331
WHOI−341
WHOI−342
WHOI−343
WHOI−344
WHOI−346
WHOI−347
WHOI−348
WHOI−349
WHOI−350


WHOI−351
WHOI−352
WHOI−354
WHOI−355
WHOI−356
WHOI−357
WHOI−358
WHOI−359
WHOI−360
WHOI−361
WHOI−362
WHOI−363
WHOI−364
WHOI−365
WHOI−367
WHOI−368
WHOI−369
WHOI−377
WHOI−378
WHOI−380
65
60
55
50
45
40
−40
−30
−20
−10


WHOI−381
WHOI−382
WHOI−389
WHOI−400
WHOI−413
WHOI−414
WHOI−415
WHOI−416
WHOI−418
WHOI−419
WHOI−420
WHOI−421
WHOI−422
WHOI−423
WHOI−424
WHOI−425
WHOI−426
WHOI−427
WHOI−428
WHOI−429
65
60
55
50
45
40
−40
−30
−20
−10


URI−431
URI−432
URI−433
URI−434
URI−440
URI−448
URI−453
URI−459
URI−466
URI−469
URI−475
URI−476
URI−479
URI−480
URI−497
URI−502
URI−510
URI−530
URI−531
URI−534


URI−535
URI−536
URI−537
URI−538
URI−539
URI−540
URI−541
URI−542
URI−544
URI−546
URI−547
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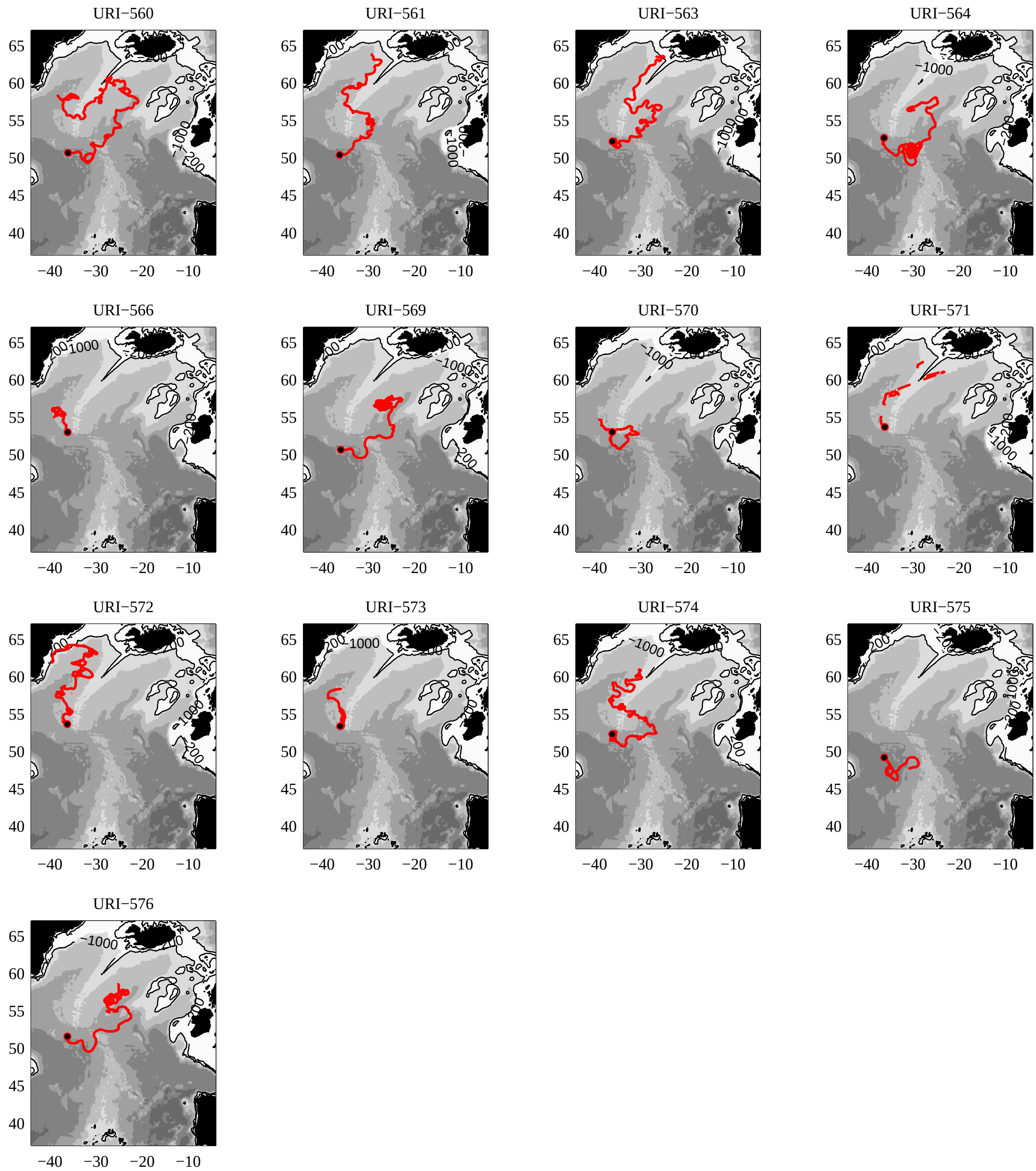
URI−549
URI−550
URI−552
URI−553
URI−554
URI−557
URI−558
URI−559
65
60
55
50
45
40
−40
−30
−20
−10

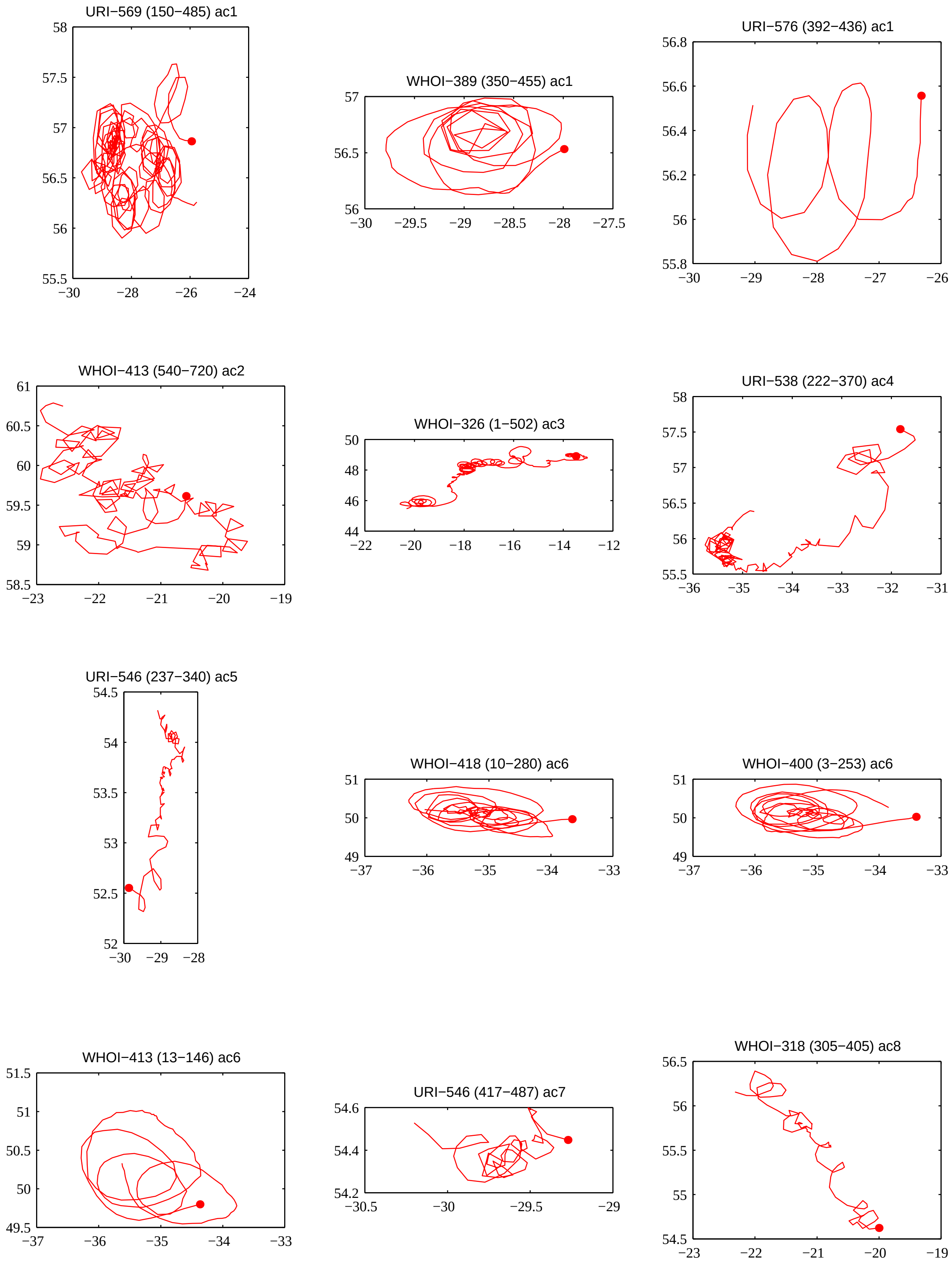

URI−560
URI−561
URI−563
URI−564
URI−566
URI−569
URI−570
URI−571
URI−572
URI−573
URI−574
URI−575
URI−576
65 60 55 50 45 40
−40 −30 −20 −10

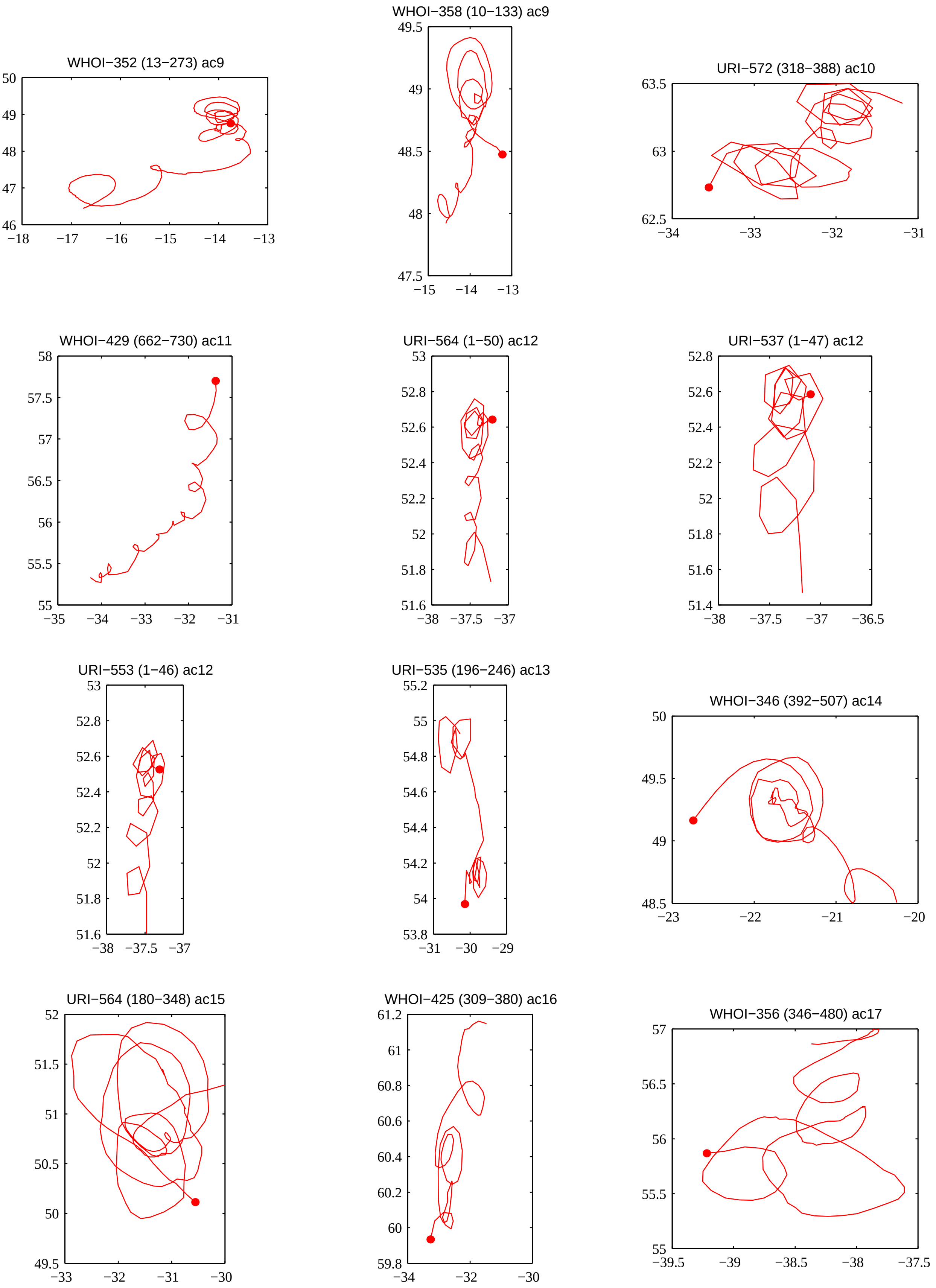
Appendix 2

Individual ACCE RAFOS float track loops; anticyclonic in red, cyclonic in blue.
A dot is drawn at the beginning of the track.

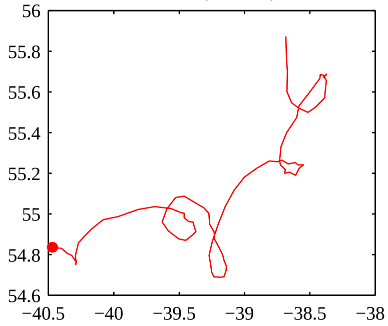
The float number is given in the plot title, along with record numbers in brackets and then the eddy ID (ac is for anticyclonic eddies, c is for cyclonic eddies).

For example:
WHOI-421 (458-625) c1 = WHOI float 421, records 458 to 625, cyclonic eddy no. 1
URI-459 (52-139) ac27 = URI float 459, records 52 to 139, anticyclonic eddy no. 27

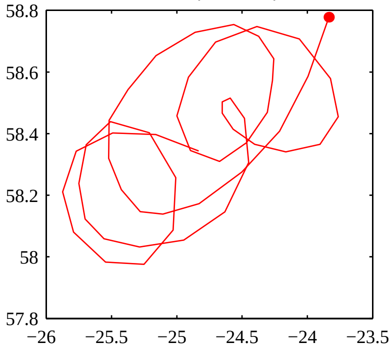

URI−569 (150−485) ac1
58
57.5
57
56.5
56
55.5
−30 −28 −26 −24
WHOI−389 (350−455) ac1
57
56.5
56
−30 −29.5 −29 −28.5 −28 −27.5
URI−576 (392−436) ac1
56.8
56.6
56.4
56.2
56
55.8
−30 −29 −28 −27 −26
WHOI−413 (540−720) ac2
61
60.5
60
59.5
59
58.5
−23 −22 −21 −20 −19
WHOI−326 (1−502) ac3
50
48
46
44
−22 −20 −18 −16 −14 −12
URI−538 (222−370) ac4
58
57.5
57
56.5
56
55.5
−36 −35 −34 −33 −32 −31
URI−546 (237−340) ac5
54.5
54
53.5
53
52.5
52
−30 −29 −28
WHOI−418 (10−280) ac6
51
50
49
−37 −36 −35 −34 −33
WHOI−400 (3−253) ac6
51
50
49
−37 −36 −35 −34 −33
WHOI−413 (13−146) ac6
51.5
51
50.5
50
49.5
−37 −36 −35 −34 −33
URI−546 (417−487) ac7
54.6
54.4
54.2
−30.5 −30 −29.5 −29
WHOI−318 (305−405) ac8
56.5
56
55.5
55
54.5
−23 −22 −21 −20 −19


WHOI−352 (13−273) ac9
50 49 48 47 46
−18 −17 −16 −15 −14 −13
WHOI−358 (10−133) ac9
49.5 49 48.5 48 47.5
−15 −14 −13
URI−572 (318−388) ac10
63.5 63 62.5
−34 −33 −32 −31
WHOI−429 (662−730) ac11
58 57.5 57 56.5 56 55.5 55
−35 −34 −33 −32 −31
URI−564 (1−50) ac12
53 52.8 52.6 52.4 52.2 52 51.8 51.6
−38 −37.5 −37
URI−537 (1−47) ac12
52.8 52.6 52.4 52.2 52 51.8 51.6 51.4
−38 −37.5 −37 −36.5
URI−553 (1−46) ac12
53 52.8 52.6 52.4 52.2 52 51.8 51.6
−38 −37.5 −37
URI−535 (196−246) ac13
55.2 55 54.8 54.6 54.4 54.2 54 53.8
−31 −30 −29
WHOI−346 (392−507) ac14
50 49.5 49 48.5
−23 −22 −21 −20
URI−564 (180−348) ac15
52 51.5 51 50.5 50 49.5
−33 −32 −31 −30
WHOI−425 (309−380) ac16
61.2 61 60.8 60.6 60.4 60.2 60 59.8
−34 −32 −30
WHOI−356 (346−480) ac17
57 56.5 56 55.5 55
−39.5 −39 −38.5 −38 −37.5

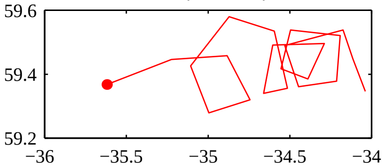
WHOI−349 (86−179) ac18



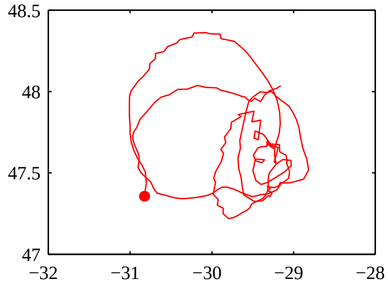
WHOI−377 (645−700) ac19



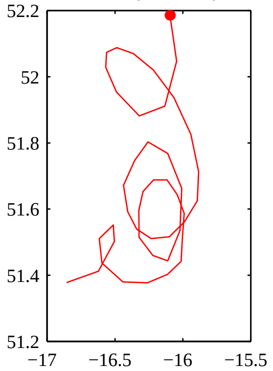
URI−561 (399−420) ac20



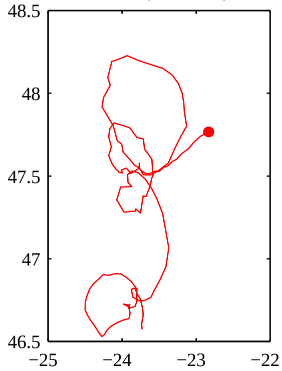
WHOI−355 (10−229) ac21



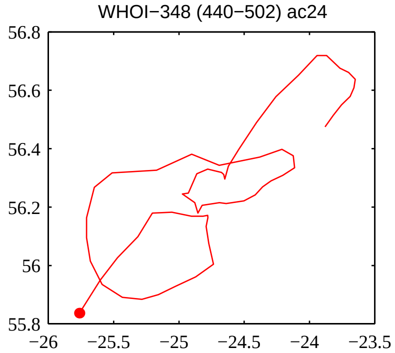
WHOI−364 (122−166) ac22



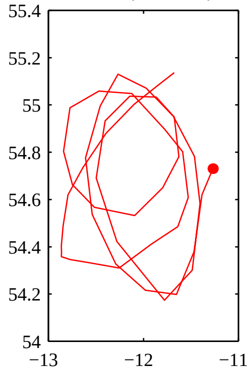
WHOI−364 (360−501) ac23



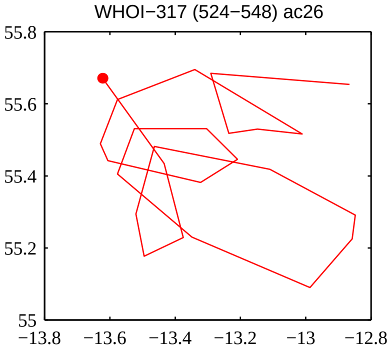
WHOI−348 (440−502) ac24



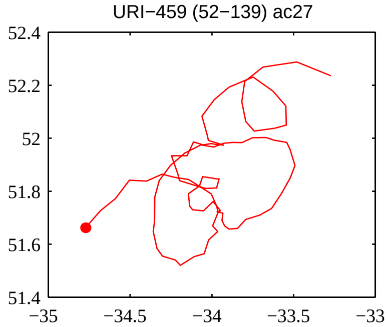
WHOI−317 (633−681) ac25



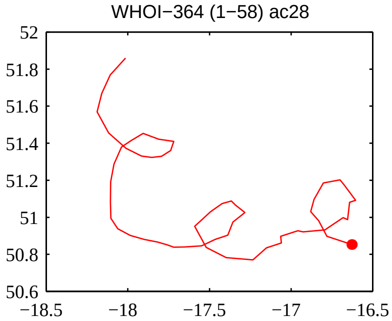
WHOI−317 (524−548) ac26



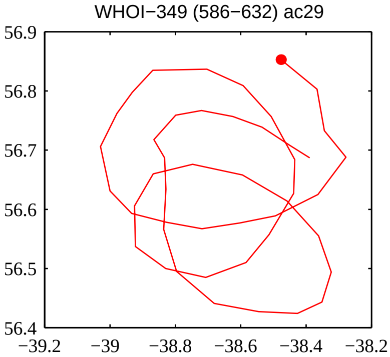
URI−459 (52−139) ac27



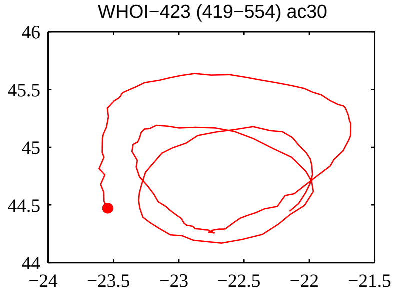
WHOI−364 (1−58) ac28



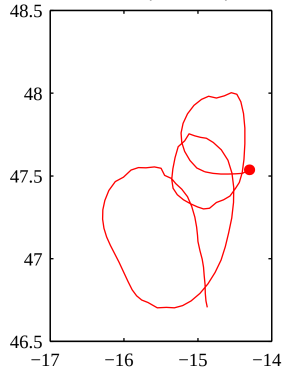
WHOI−349 (586−632) ac29



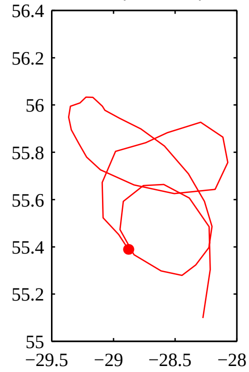
WHOI−423 (419−554) ac30



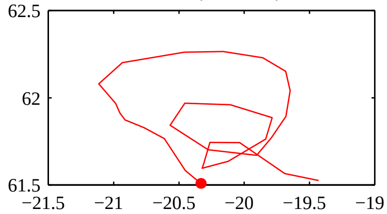
WHOI−319 (211−316) ac31



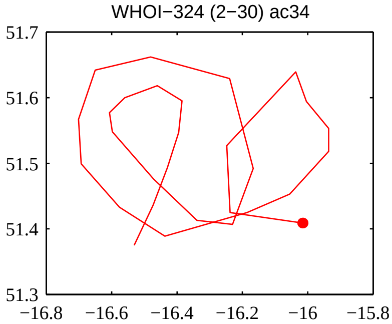
URI−546 (359−402) ac32



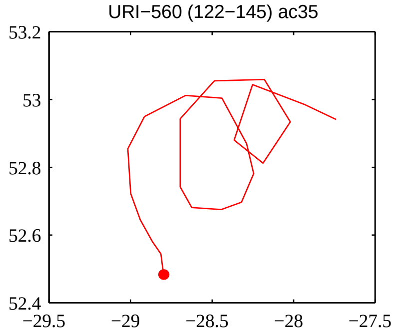
WHOI−363 (499−529) ac33



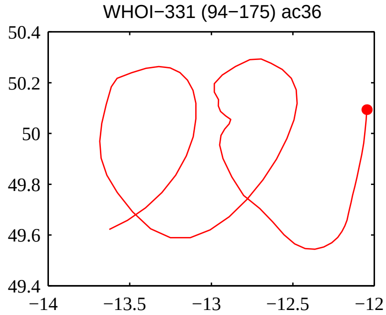
WHOI−324 (2−30) ac34



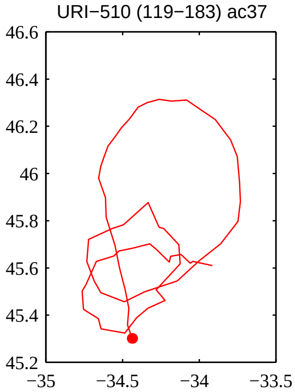
URI−560 (122−145) ac35



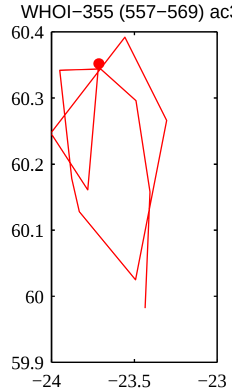
WHOI−331 (94−175) ac36



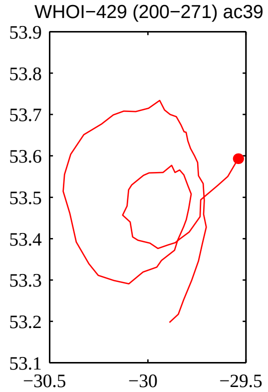
URI−510 (119−183) ac37



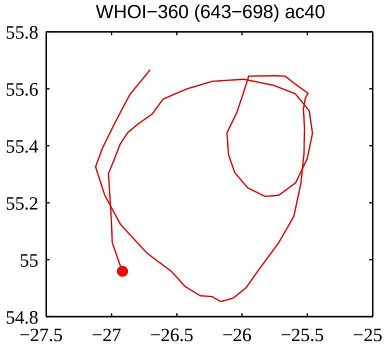
WHOI−355 (557−569) ac38



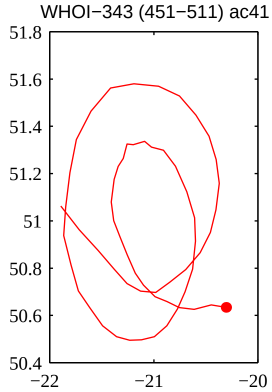
WHOI−429 (200−271) ac39

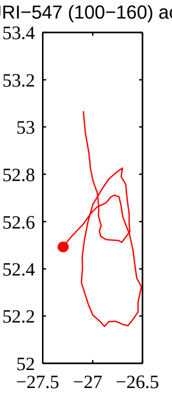


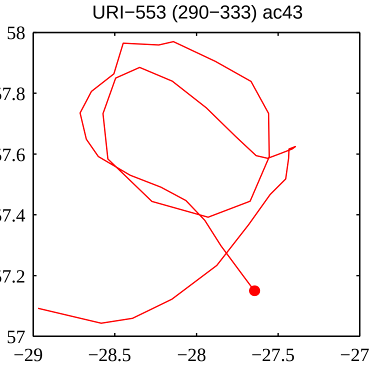
WHOI−360 (643−698) ac40

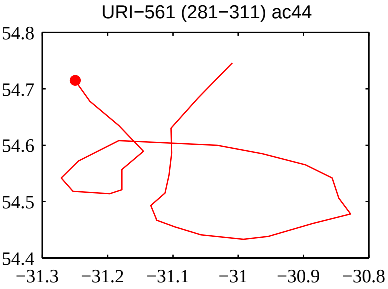


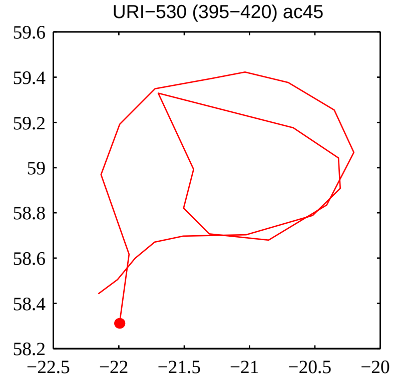
WHOI−343 (451−511) ac41

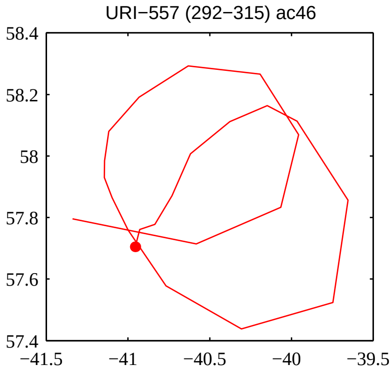


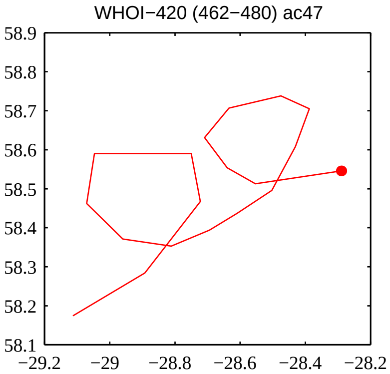

URI−547 (100−160) ac42
53.4
53.2
53
52.8
52.6
52.4
52.2
52
−27.5
−27
−26.5

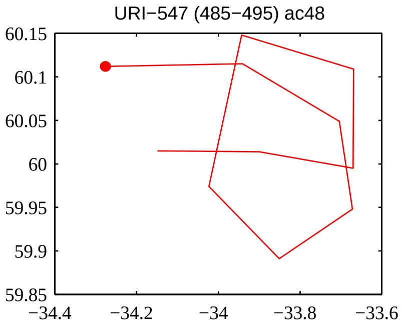

URI−553 (290−333) ac43
58
57.8
57.6
57.4
57.2
57
−29
−28.5
−28
−27.5
−27

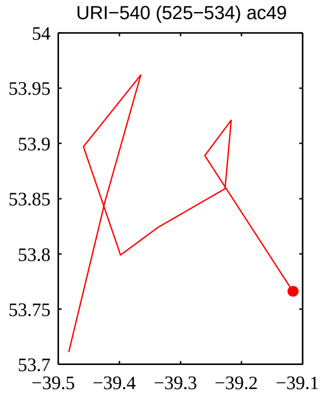

URI−561 (281−311) ac44
54.8
54.7
54.6
54.5
54.4
−31.3
−31.2
−31.1
−31
−30.9
−30.8

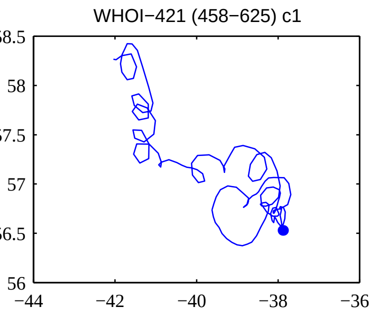

URI−530 (395−420) ac45
59.6
59.4
59.2
59
58.8
58.6
58.4
58.2
−22.5
−22
−21.5
−21
−20.5
−20

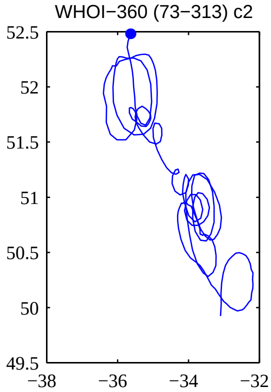

URI−557 (292−315) ac46
58.4
58.2
58
57.8
57.6
57.4
−41.5
−41
−40.5
−40
−39.5

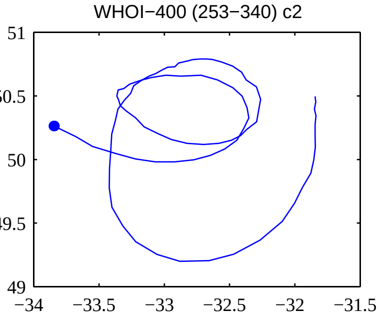

WHOI−420 (462−480) ac47
58.9
58.8
58.7
58.6
58.5
58.4
58.3
58.2
58.1
−29.2
−29
−28.8
−28.6
−28.4
−28.2

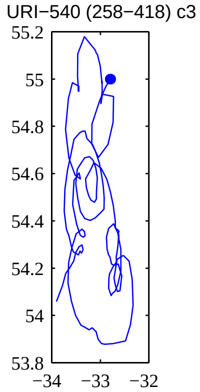

URI−547 (485−495) ac48
60.15
60.1
60.05
60
59.95
59.9
59.85
−34.4
−34.2
−34
−33.8
−33.6


URI−540 (525−534) ac49
54
53.95
53.9
53.85
53.8
53.75
53.7
−39.5
−39.4
−39.3
−39.2
−39.1


WHOI−421 (458−625) c1
58.5
58
57.5
57
56.5
56
−44
−42
−40
−38
−36


WHOI−360 (73−313) c2
52.5
52
51.5
51
50.5
50
49.5
−38
−36
−34
−32


WHOI−400 (253−340) c2
51
50.5
50
49.5
49
−34
−33.5
−33
−32.5
−32
−31.5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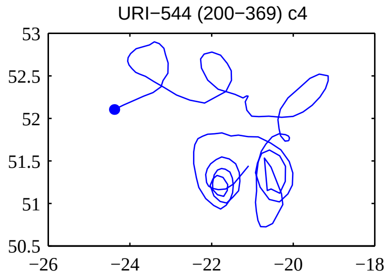
−33
−32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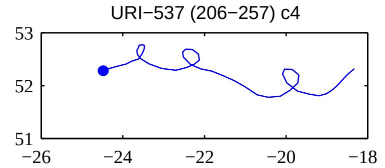
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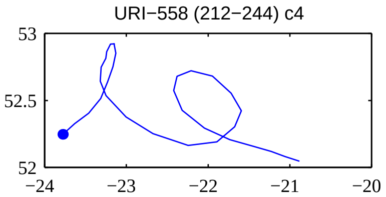
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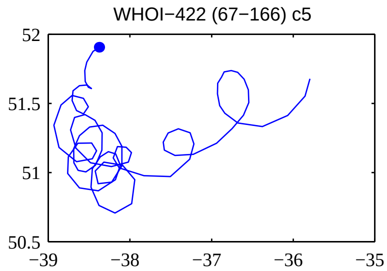
WHOI−422 (67−166) c5
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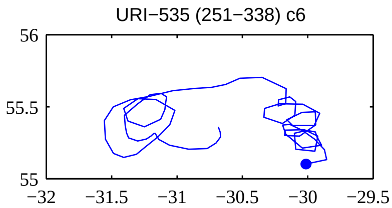
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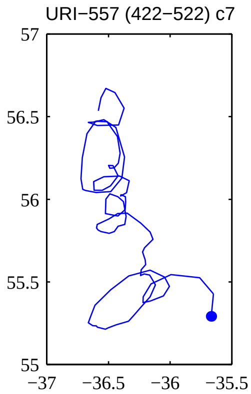
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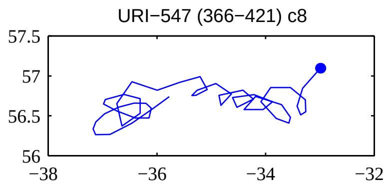
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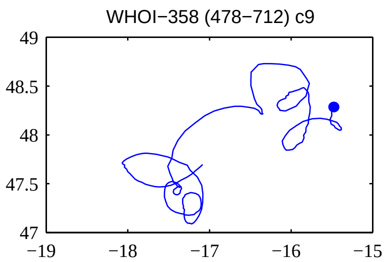
−38 −36 −34 −32


WHOI−358 (478−712) c9
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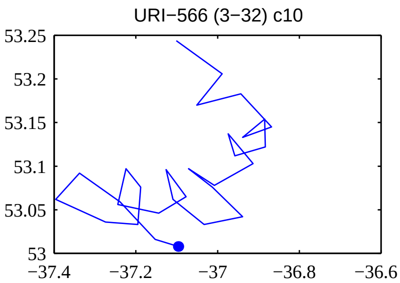
−19 −18 −17 −16 −15


URI−566 (3−32) c10
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53.1
53.05
53
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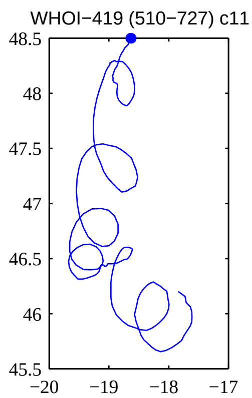
WHOI−419 (510−727) c11
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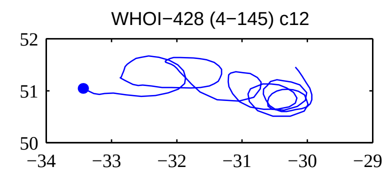
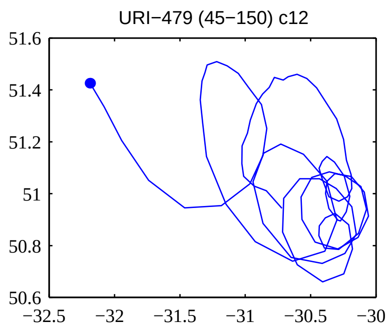
46.5
46
45.5
−20 −19 −18 −17


WHOI−428 (4−145) c12
52
51
50
−34 −33 −32 −31 −30 −29


URI−479 (45−150) c12
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50.8
50.6
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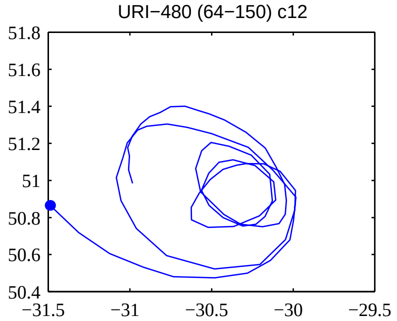
URI−480 (64−150) c12
51.8
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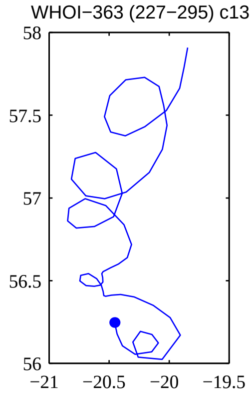
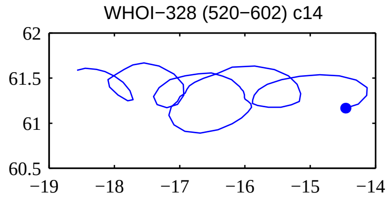
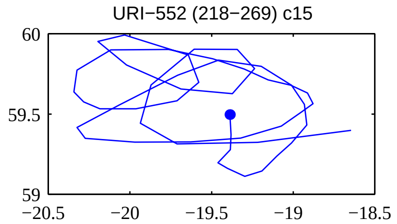
50.8
50.6
50.4
−31.5
−31
−30.5
−30
−29.5


WHOI−363 (227−295) c13
58
57.5
57
56.5
56
−21
−20.5
−20
−19.5


WHOI−328 (520−602) c14
62
61.5
61
60.5
−19
−18
−17
−16
−15
−14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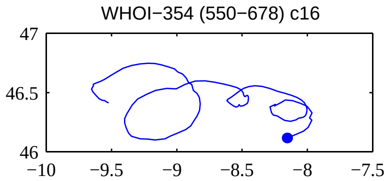
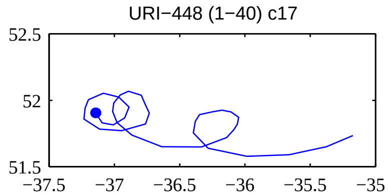
60
59.5
59
−20.5
−20
−19.5
−19
−18.5


WHOI−354 (550−678) c16
47
46.5
46
−10
−9.5
−9
−8.5
−8
−7.5


URI−448 (1−40) c17
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51.5
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−36.5
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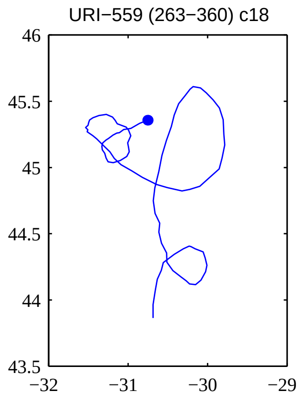
−35.5
−35


URI−559 (263−360) c18
46
45.5
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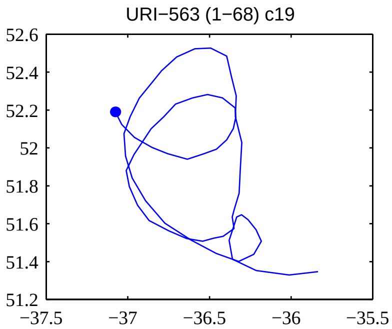
44.5
44
43.5
−32
−31
−30
−29


URI−563 (1−68) c19
52.6
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51.6
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51.2
−37.5
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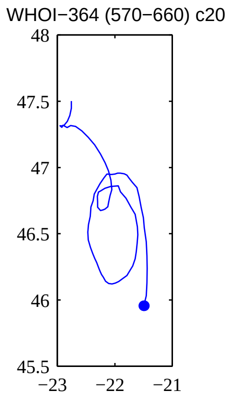
−36.5
−36
−35.5


WHOI−364 (570−660) c20
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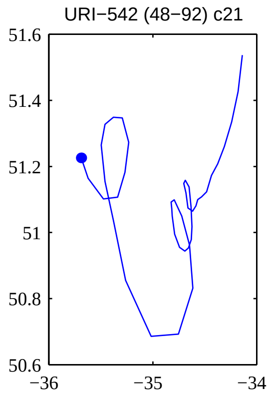
−23
−22
−21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−36
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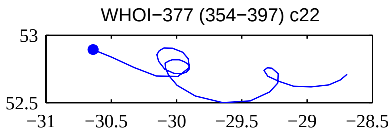
−34


WHOI−377 (354−397) c22
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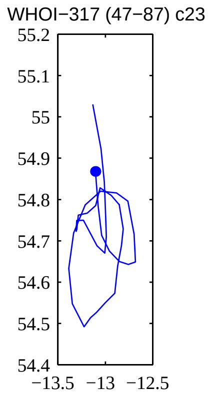
−28.5


WHOI−317 (47−87) c23
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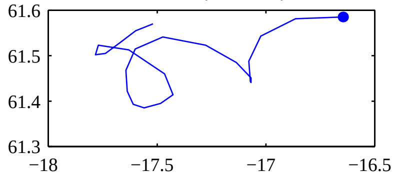
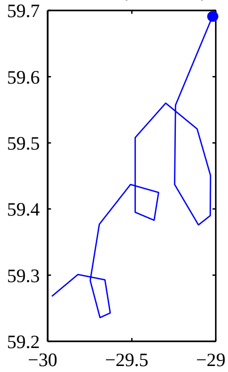
−13.5
−13
−12.5

WHOI−416 (442−466) c24



WHOI−427 (592−611) c25



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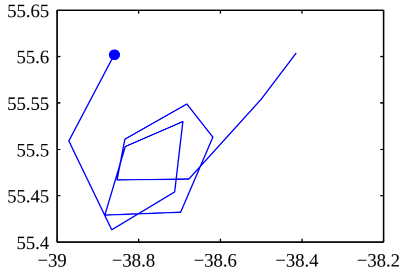

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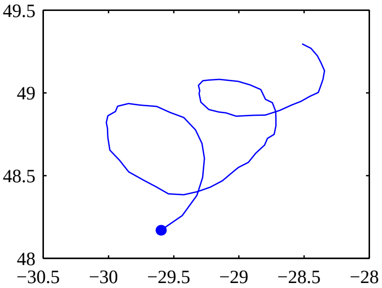
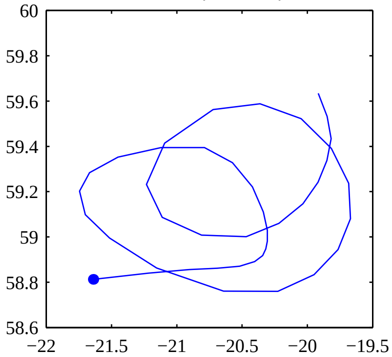
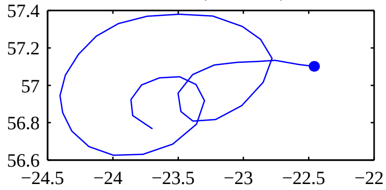


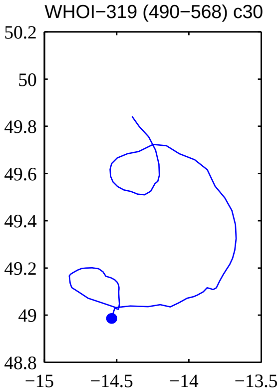
WHOI−348 (620−662) c28



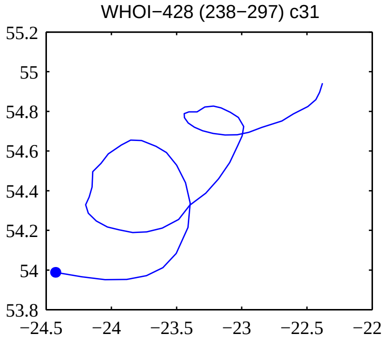
WHOI−368 (691−730) c29



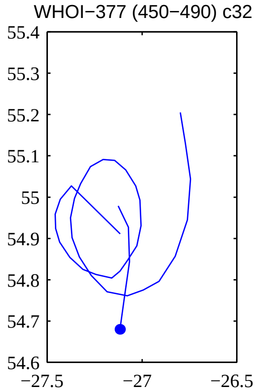
WHOI−319 (490−568) c30



WHOI−428 (238−297) c31



WHOI−377 (450−490) c32



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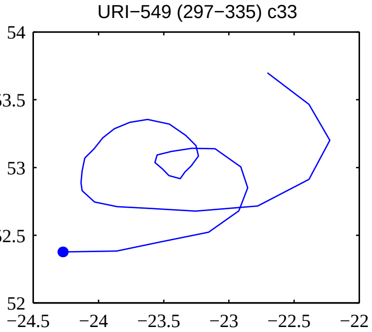

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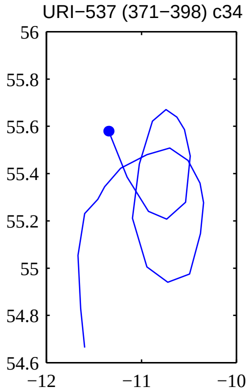
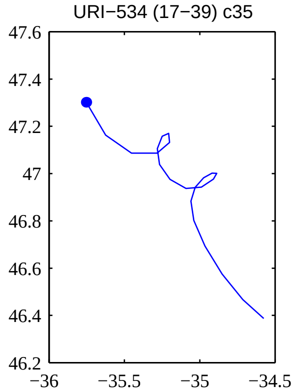
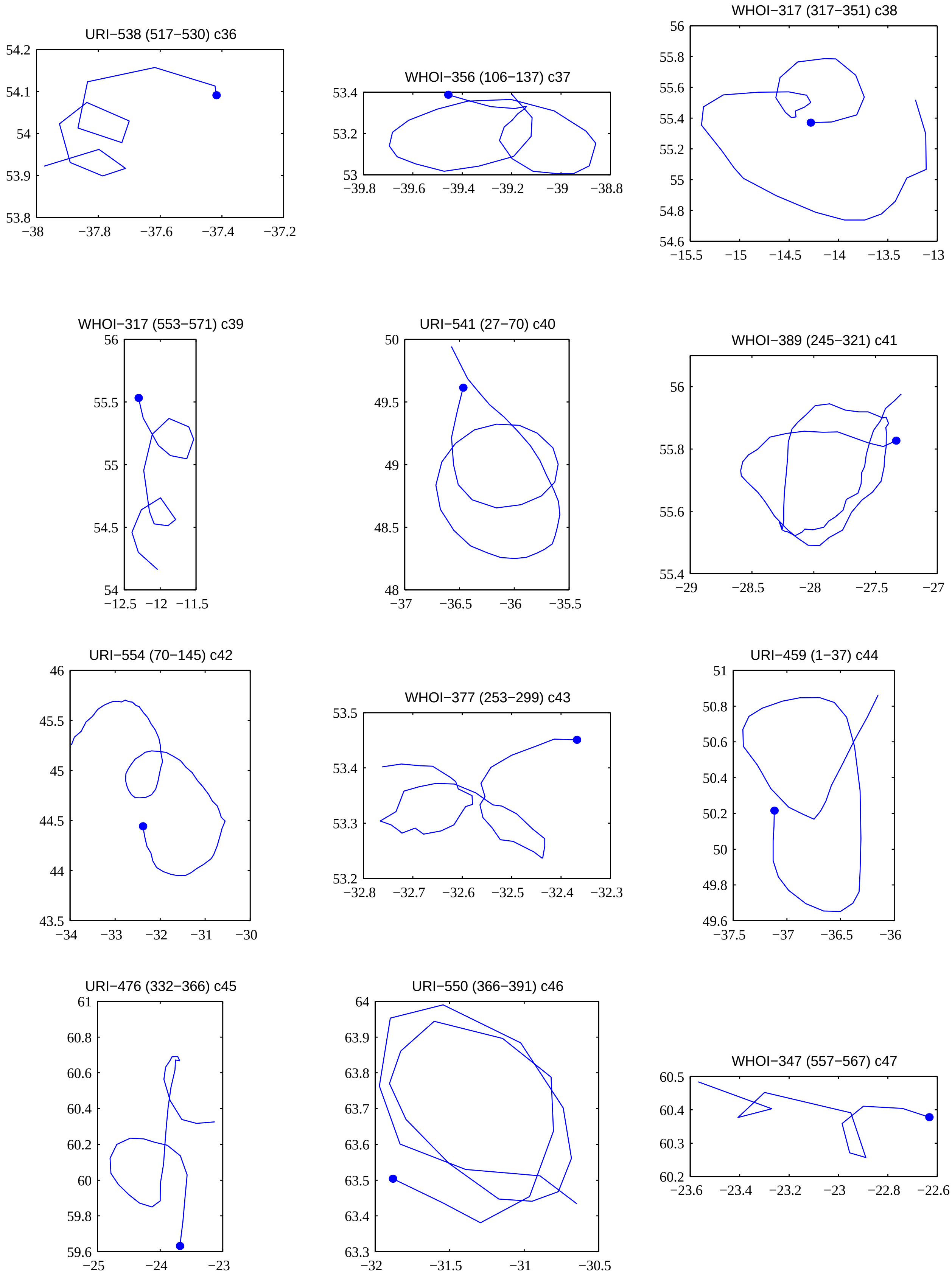


URI−534 (17−39) c35

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WHOI−356 (106−137) c37
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WHOI−317 (317−351) c38
56
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WHOI−317 (553−571) c39
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URI−541 (27−70) c40
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WHOI−389 (245−321) c41
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URI−554 (70−145) c42
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WHOI−377 (253−299) c43
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URI−459 (1−37) c44
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URI−476 (332−366) c45
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URI−550 (366−391) c46
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WHOI−347 (557−567) c47
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