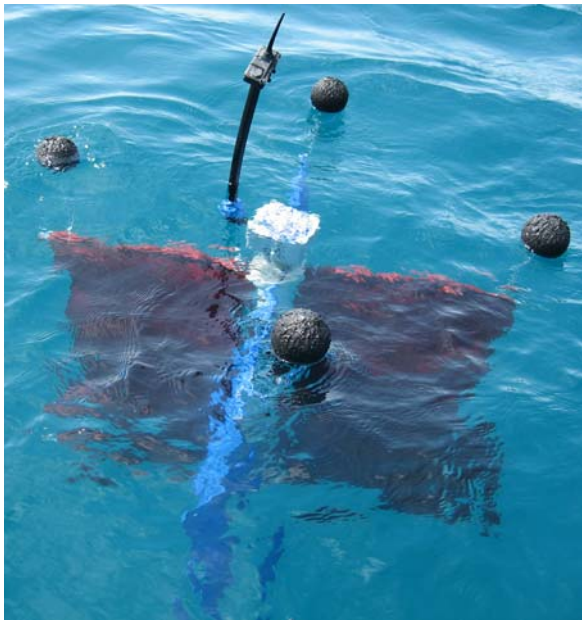

Drifter dispersion experiments in the vicinity of the Gulf of La Spezia (Ligurian Sea) in June 2007: Data report

by

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Approved for release by: ……

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1. Introduction

Surface drifters were deployed in the Gulf of La Spezia (GSP) in June 2007 in the framework of the MREA07 and LASIE07 experiments. The objective of this drifter program was twofold: 1) to measure the surface circulation in the GSP and to study the related dispersion of particles; and 2) to provide ground truth for VHF coastal radar measurements of the surface currents. The drifter data described in this report were collected in conjunction with several other oceanographic measurements mainly conducted by the NATO Undersea Research Centre (NURC) as part of their Maritime Rapid Environment Assessment (MREA) program, in and outside of the GSP, including hydrographic surveys, measurements with bottom-mounted ADCPs (BARNYS), with SEPTRs, waveriders, meteorological buoys, etc. All these oceanographic and meteorological observations were also complemented by numerical simulations using models of ocean circulation by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) and the U.S. Naval Research Laboratory (NRL). The drifter operations were mainly conducted by OGS, in collaboration with colleagues from the Consiglio Nazionale della Ricerca (CNR), the University of Toulon and NURC.

This report provides details on the hardware and software of the drifters used (Section 2). The drifter deployment and recovery operations are described in Section 3. The drifter data processing is explained in Section 4, along with a presentation of the data collected. Preliminary conclusions are drawn in Section 5.

2. Drifter Systems

2.1 Coastal drifter designs

The drifters used in the dispersion experiments are similar to the ones used in the Coastal Dynamics Experiment (CODE) in the early 1980's (Davis, 1985). They consist of a slender, vertical, 1-m-long negatively buoyant PVC tube with four drag-producing nylon sails extending radially from the tube over its entire length and four small spherical surface floats attached to the upper extremities of the vanes to provide buoyancy (Poulain, 1999). Comparison with current meter measurements (Davis, 1985) and studies using dye to measure relative water movements (D. Olson, Personal Communication) showed that the CODE drifters follow the surface currents to within 3 cm/s, even during strong wind conditions. Recent studies on the water-following capabilities of the CODE-type drifters showed that they follow the surface current within 2 cm/s and that there is no significant slip in the down-wind direction, while they slip with 0.1-0.2 % of the wind speed in the direction perpendicular to the wind (to the right).

Therefore the CODE-type drifter can be considered an efficient instrument to measure surface currents in the first meter of the water column with 1-3 cm/s accuracy.

The mechanical parts of the drifters were manufactured by Technocean, Cape Coral, Florida, USA. Instead of the common electronics and antennas for satellite Argos/GPS positioning and satellite Argos data telemetry, the drifters were fitted with a waterproof container of dimension 12 cm x 12 cm x 9 cm on top of the vertical tubular haul and with a PVC tube protruding over the sea surface to host, respectively, the electronics and antennas of the GPS receiver and the GSM cellular modem (see Figures 1, 3 and 4). One drifter was also equipped with Nortek Aquadopp acoustic currentmeters to measure the horizontal relative flow (Figure 2). The integration of these instruments was made without changing significantly the hydro-dynamical characteristics (e.g., size, buoyancy and drag area) of the drifters. Photographs of the prototype CODE-type drifters are displayed as Figures 3 to 5.

The electronics in the container includes the new GM862-GPS module of Telit (see Figure 1) which includes a Quad-Band GSM/GPRS modem and a 20 channel high sensitivity SiRFstarIII Single Chip GPS receiver. This module has 3 MB of NV memory for the storage of user's scripts and data, and 1.5 MB RAM for the Python engine usage. As interfaces, the module has a maximum of 13 I/O ports, one analog audio and one A/D converter (11 bits). These will be used in future upgrades to collect sea surface temperature or other oceanographic data. Both the GSM and GSM/GPRS have normal commercial antennas.

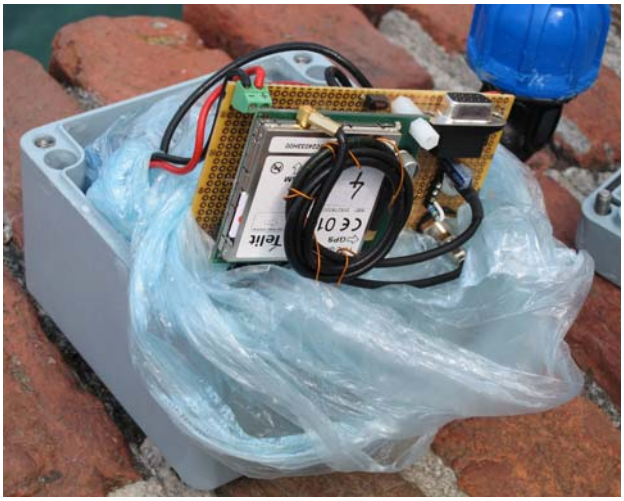

Figure 1. Telit GPS and GSM/GPRS module, electronic circuit, and batteries (in plastic bag) included in the waterproof container.

The Nortek Aquadopp currentmeters (Figures 2, 3 and 4) measure the relative water flow at 2 levels (~30 and 130 cm under the surface) near the body of the drifter with an accuracy of about 1 cm/s and with sampling frequency of 1 Hz. The Aquadopp uses the Doppler effect to measure current velocity by transmitting a short of pulse of sound, listening to its echo and measuring the change in frequency of the echo. These measurements were made with three custom-made transducer heads pointing in directions separated by 120° and perpendicular to the Aquadopp, that is, perpendicular to the main body of the drifter. Acoustic signals (at 2 MHz) in beams of 1.7° width emitted by the three transducers are reflected by particles suspended in the water in the measurement cell centered at 1.1 m from the transducer head. The radial velocities obtained from each beam are combined by the Aquadopp software to produce the two components of the relative flow velocity perpendicular to the drifter. The Aquadopp currentmeters include ancillary sensors such as tilt meters to measure its pitch and roll, a compass to record its orientation, a pressure sensor to measure the depth of the instrument and a thermistor. All data were sampled at 1 Hz for all the drifter tests performed.

Pictures of the drifters floating at the sea surface in the GSP are shown in Figure 5. The electronics container is about 20 cm under the surface, whereas the dual GSM/GPS antenna protrudes, depending on the drifter, 25-50 cm above sea level.

Figure 2. Photograph showing how the two Nortek Aquadopp currentmeters were fitted inside the tubular body of the CODE drifter.

Figure 3. Pictures of CODE drifters equipped with GSM/GPS electronics (in cubic container) and dual antenna: regular drifter (left) and drifter fitted with Nortek Aquadopp currentmeters (right).

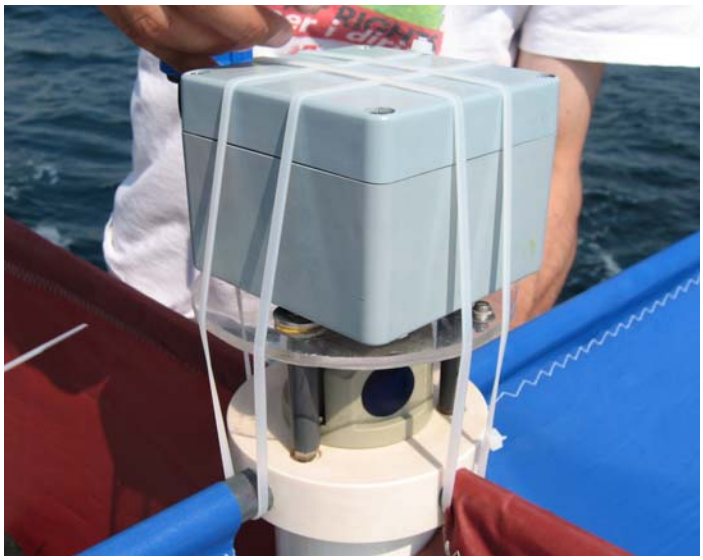

Figure 4. Expanded view of the Nortek Aquadopp currentmeter and the container with the GSM/GPRS and GPS electronics at the top of a CODE drifter.

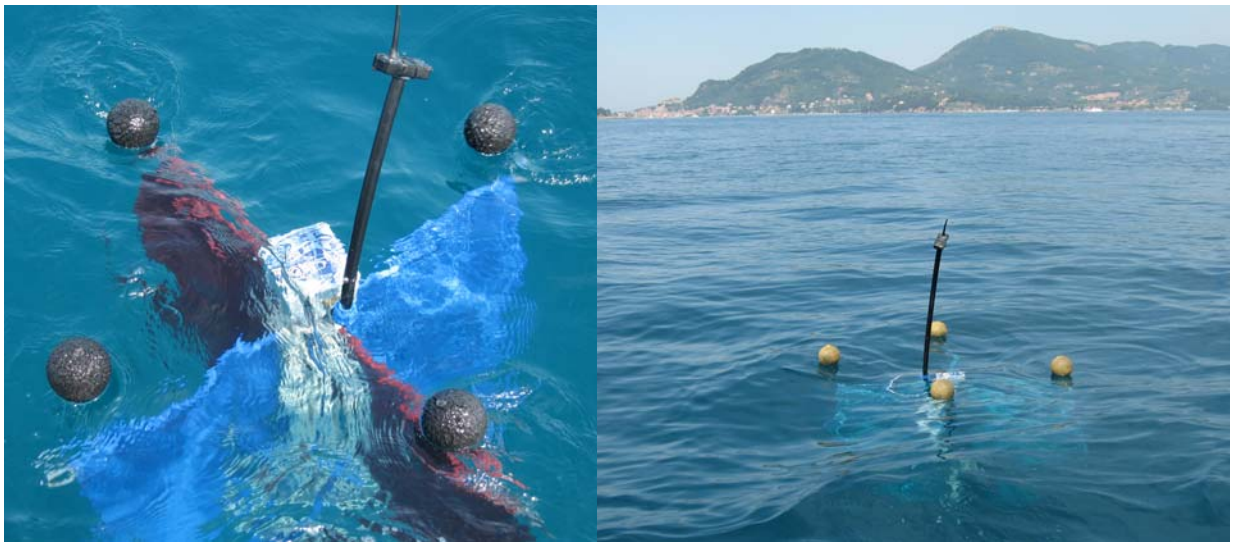

Figure 5. Pictures of CODE drifters deployed in the GSP. The electronics container is about 20 cm under the surface, whereas the dual GSM/GPS antenna extends, depending on the drifter, 25-50 cm above sea level.

2.2 Localization and data telemetry

For the experiment in the GSP, we programmed the Telit module to save the GPS positions every 5-10 min on the internal memory, and to send them as SMS messages via GSM to several cellular phones and to a dedicated computer every 15 min. The strength of the GSM coverage was telemetered along with the position data in order to monitor it in near-real time and eventually organize recovery operations in case the signal was becoming weak. The GSM coverage for all the drifters during their operation at sea and transportation by boats/cars is illustrated in Figure 6. Interruption of the signal along some tracks corresponds to data loss due to low coverage at the position of the receiving phones and their saturation/congestion by the numerous SMS messages received. It can be seen that the GSM coverage in the GSP is relatively good (signal strength of mostly 3 and 4, expect close to the eastern coast in the vicinity of Fiascherino). Low strength is also evident off the Cinque Terre (south of Riomaggiore). The drifters transmitted data via GSM as far as four nautical miles from the coast, in the area southwest of the Cinque Terre in the Ligurian Sea. No significant variation was observed in the signal strength among the drifters with antennas of different length.

The GPRS capability was not exploited in these first tests. It is planned to do so in the future in order to have bi-directional interactivity between the drifters and land stations (computers or cellular phones).

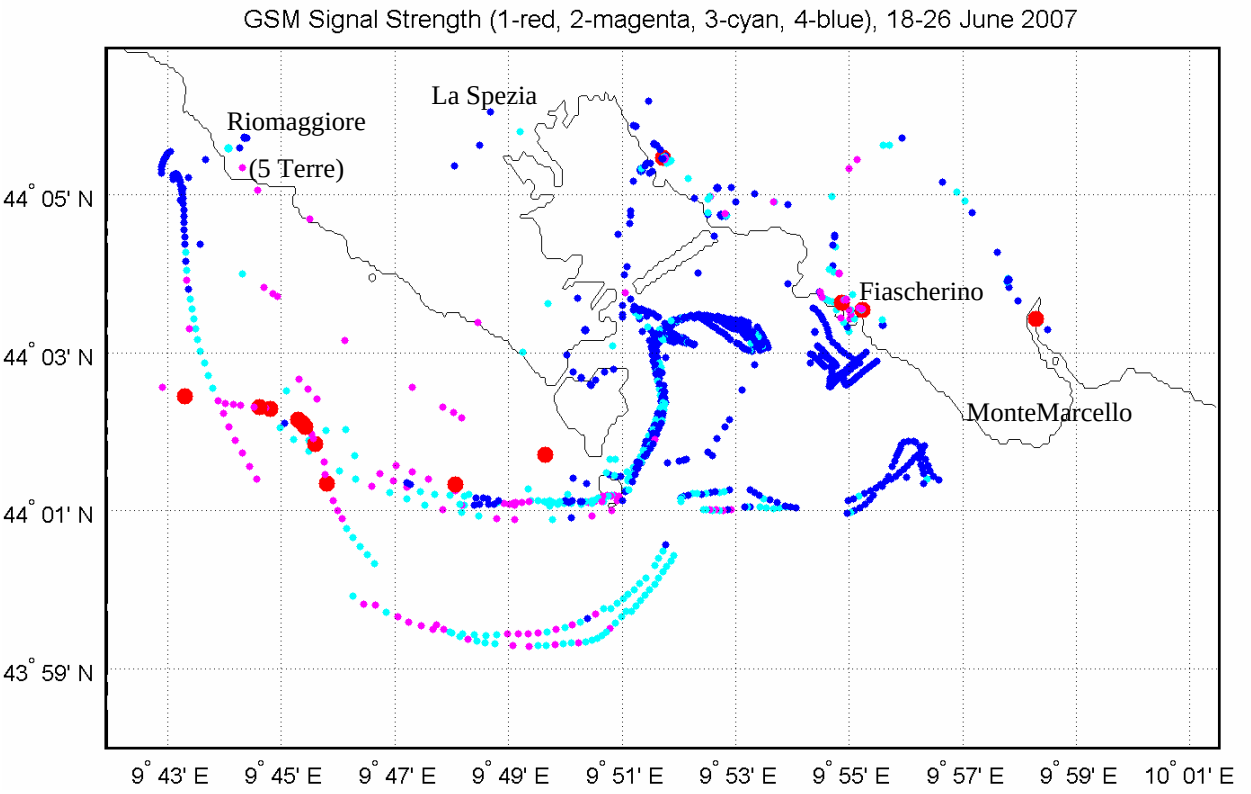

Figure 6. Coverage of the GSM signal strength in the area of the GSP as measured by drifters (in water and in boats/cars during transport). The weakest signal (enlarged red circles) was found in the coastal area near Fiascherino in the GSP, and off the Cinque Terre in the Ligurian Sea.

3. Drifter Dispersion Experiments

3.1 Experiment #1

Five drifters were deployed on 18 June 2007 by NURC (using a rubber boat) about 1 nm off Fiascherino in the GSP (see Figure 7 for geographical location and Table 1 for deployment details). The planned deployment geometry was a cross-shape with 125-m-long legs extending in the North, East, South and West directions. The drifters were recovered by NURC the next morning, on 19 June 2007, using R/V Leonardo, as all the drifters were escaping the Gulf to the west (in the direction of the Cinque Terre). All drifters were successfully retrieved after about 20 hours of drift.

Figure 7. GSP with approximate deployment positions (triangle symbols) of the Drifter Dispersion Experiments 1 to 5.

3.2 Experiment #2

A cluster of six drifters were deployed on 20 June 2007 by OGS (using a rented rubber boat) about 1 nm off Fiascherino in the GSP, at approximately the same positions as in Experiment #1 (see Figure 7 for geographical location and Table 2 for deployment details). The planned deployment geometry was a cross-shape with 125-m-long legs extending in the North, East, South and West directions. The sixth unit (11), the drifter equipped with the two Aquadopp currentmeters, was deployed in the vicinity of the other drifters. It was recovered the same day in the evening using the rented rubber boat, after operating about 8 hours in the water. One drifter (unit 07) was picked-up around 5:46 GMT the next morning and was returned to NURC. It provided about 21 hours of data. Another drifter (unit 04) ended up on the seawall in the northern part of the Gulf on 20 June at 22:52 GMT after 14 hours of operation. This drifter was safely recovered near the seawall by OGS using a rented rubber boat on 21 June morning, after the normal recovery of units 01, 08 and 09 which operated for about 23 hours.

3.3 Experiment #3

Three drifters were released by NURC (using a rubber boat) near the eastern entrance of the GSP (off Montemarcello, see Figure 7) on 22 June 2007 (see details in Table 3). The planned configuration for these drifters was a triangle with 250-m sides. One of these drifters (unit 09) was recovered late in the evening of the same day by OGS (using a rubber boat) because no data was obtained from it. It was later diagnosed that a water leakage caused the electronics to malfunction. The other two drifters moved to the west and were found off Tino Island (south of Palmaria) the next day on 23 June. Sea conditions prevented the OGS team to recover these units in the open sea (using a rented boat from Porto Venere). The drifters were followed until Monday (25 June) early morning in front of the Cinque Terre. One unit (04) stranded on the seawall protecting the small port of Riomaggiore on Sunday 24 June by 14:50 GMT. It was recovered the next day without problems. Mechanical damages were observed on the sails and harms due to the waves slashing on the drifter. A small amount of water was found in the container with the electronics but not damage was evidenced. The other drifter stopped transmitting positions on Monday 25 June. Search operations for this unit organized in front of the Cinque Terre on Monday around noon time with the help of the ecological boat of the "Riserva Marina delle Cinque Terre" administered by the "Ministero dell'Ambiente e della Tetula del Territorio" resulted unsuccessful. Therefore, this unit was considered as lost. However, about a month later on 25 July 2007, we were informed that the drifter had been recovered by the Coast Guards in Santa Margherita Ligure about 40 nm to the northwest of La Spezia. We recovered this unit, and despite the presence of some water in the container, we were able to download the data from the Telit module.

3.4 Experiment #4

A cluster of 4 drifters were released by NURC (using a rubber boat) in the western part of the Gulf (about 1 nm east of Porto Venere; see Figure 7) on 22 June 2007. Deployment details are listed in Table 4. The planned configuration for these drifters was a triangle with 250-m sides, with the drifter fitted with the Aquadopp instruments (unit 11) localized in its center. The latter drifter was recovered by OGS (using a rented rubber boat) after about 4 hours, along with unit 01 which had failed transmitting after some time. Drifter 01 was found with the antenna bended down and with some damage on one of the sails, presumably caused by a propeller. The box containing the electronics resulted entirely flooded. Units 06 and 07 were picked-up by seafarers and returned to NURC. They provided 11-16 hours of drift data.

3.5 Experiment #5

A cluster of 3 drifters were released by OGS (using a rented rubber boat) off Fiascherino (see Figure 7) on the evening of 25 June 2007 (see details in Table 5). The planned configuration for these drifters was a triangle with 250-m sides. All drifters were recovered by NURC (with the rubber boat) the next day (26 June) near the coast between Fiascherino and Lerici. Sea state was increasing and forecasts called for worst seas for the following days. Hence, it was decided to terminate the MREA07-LASIS07 coastal drifter operations with these recoveries on 26 June by 10:30 GMT. The three drifters were operated for about 16 hours.

Drifter ID (phone #)	Deployment Date/Time(GMT)	Latitude	Longitude	Recovery Date/Time(GMT)	Latitude	Longitude	Drift Time (hours)	Delta-t (min)	Comments
09 (433)	18 June 07 / 14:24	44N 3.298	9E 53.477	19 June 07 / 09:48	44N 1.344	9E 48.320	19.3	5	
08 (908)	18 June 07 / 14:16	44N 3.330	9E 53.675	19 June 07 / 09:47	44N 1.344	9E 48.320	19.4	5	
04 (765)	18 June 07 / 14:13	44N 3.382	9E 53.541	19 June 07 / 10:50	44N 2.319	9E 45.106	20.5	5	
01 (279)	18 June 07 / 14:20	44N 3.319	9E 53.747	19 June 07 / 10:33	44N 3.220	9E 45.220	20.1	5	
07 (140)	18 June 07 / 14:10	44N 3.330	9E 53.604	19 June 07 / 10:00	44N 1.77	9E 46.838	19.8	5	

Table 1. Details of the Drifter Dispersion Experiment #1.

Drifter ID (phone #)	Deployment Date/Time(GMT)	Latitude	Longitude	Recovery Date/Time(GMT)	Latitude	Longitude	Drift Time (hours)	Delta-t (min)	Comments
09 (433)	20 June 07 / 08:40	44N 3.291	9E 53.483	21 June 07 / 08:21	44N 1.818	9E 52.998	23.7	5	
08 (908)	20 June 07 / 08:50	44N 3.330	9E 53.671	21 June 07 / 08:40	44N 2.658	9E 52.998	23.8	5	
04 (765)	20 June 07 / 08:51	44N 3.391	9E 53.531	20 June 07 / 22:52	44N 4.770	9E 52.698	14.0	5	Seawall
01 (279)	20 June 07 / 08:45	44N 3.325	9E 53.742	21 June 07 / 10:33	44N 2.772	9E 51.498	23.3	5	
07 (140)	20 June 07 / 08:52	44N 3.328	9E 53.605	21 June 07 / 05:46	44N 3.132	9E 52.902	20.9	5	Picked-up
11 (443)	20 June 07 / 09:35	44N 3.402	9E 53.605	20 June 07 / 17:39	44N 4.349	9E 53.581	8.1	5	Aquadopp

Table 2. Details of the Drifter Dispersion Experiment #2.

Drifter ID (phone #)	Deployment Date/Time(GMT)	Latitude	Longitude	Recovery Date/Time(GMT)	Latitude	Longitude	Drift Time (hours)	Delta-t (min)	Comments
04 (765)	22 June 07 / 10:23	44N 1.637	9E 56.796	24 June 07 / 14:50	44N 5.808	9E 44.298	52.5	10	Riomaggiore
08 (908)	22 June 07 / 10:32	44N 1.637	9E 56.593	25 June 07 / 03:58	44N 7.645	9E 40.712	65.4	10	Sta Margherita L.
09 (433)	22 June 07 / 10:39	44N 1.776	9E 56.689	22 June 07 / 18:30	-	-	-	-	Leakage (no data)

Table 3. Details of the Drifter Dispersion Experiment #3.

Drifter ID (phone #)	Deployment Date/Time(GMT)	Latitude	Longitude	Recovery Date/Time(GMT)	Latitude	Longitude	Drift Time (Hours)	Delta-t (min)	Comments
06 (387)	22 June 07 / 13:01	44N3.416*	9E51.809*	22 June 07 / 23:48	44N 3.636	9E 51.498	10.8	5	Picked-up
01 (279)	22 June 07 / 13:04	44N 3.428	9E 51.966	22 June 07 / 17:32	44N 3.354	9E 52.505	-	-	Flooded, damaged sail (no data)
07 (140)	22 June 07/12:47**	44N 3.519	9E 51.842	23 June 07 / 04:16	44N 3.876	9E 51.198	15.5	5	Picked-up
11 (443)	22 June 07 / 12:53	44N 3.462	9E 51.886	22 June 07 / 17:06	44N 3.390	9E 52.454	4.2	5	Aquadopp

*Not from deployment log but from closest position in track.
** Time advanced by 10 min with respect to log to have better match with track.

Table 4. Details of the Drifter Dispersion Experiment #4.

Drifter ID (phone #)	Deployment Date/Time(GMT)	Latitude	Longitude	Recovery Date/Time(GMT)	Latitude	Longitude	Drift Time (Hours)	Delta-t (min)	Comments
05 (548)	25 June 07 / 17:54	44N 3.246	9E 54.698	26 June 07 / 10:33	44N 3.826	9E 54.500	16.6	10	
06 (387)	25 June 07 / 17:58	44N 3.253	9E 54.496	26 June 07 / 09:56	44N 4.042	9E 54.600	16.0	10	
07 (140)	25 June 07 / 18:02	44N 3.380	9E 54.603	26 June 07 / 09:55	44N 3.950	9E 55.100	15.9	10	

Table 5. Details of the Drifter Dispersion Experiment #5.

4. Drifter data

4.1 Position data: Downloading and editing

In most cases, the data were downloaded from all the drifters after each dispersion experiment. They comprise the date, GMT time, latitude and longitude at 5 or 10 minute sampling intervals. They were organized in ASCII files named as drifter##_n, where ## is the drifter identification number and n is the dispersion experiment number. The data were edited to exclude records when the drifters were not in the water, using deployment/recover information when available, or after manual inspection of the trajectories. The trajectories off all the drifters for all the dispersion experiments are shown in Figures 8 to 34. Data are missing for drifter 09 during the 3rd dispersion experiment and drifter 01 during the 4th experiment.

For some unknown reason, the latitude of drifters 04 and 08 during the 3rd dispersion experiment was shifted southward by a fixed offset of 0.8335° when the drifters went south of 44°N (see Figures 21 and 23). The trajectories were corrected (Figures 22 and 24) by simply adding back this offset to the latitude time series during the time period for which the problem occurred. A spike in the trajectory of drifter 08 during the 3rd dispersion experiment (see Figure 23) was also removed. This is the only editing that was performed on the drifter data.

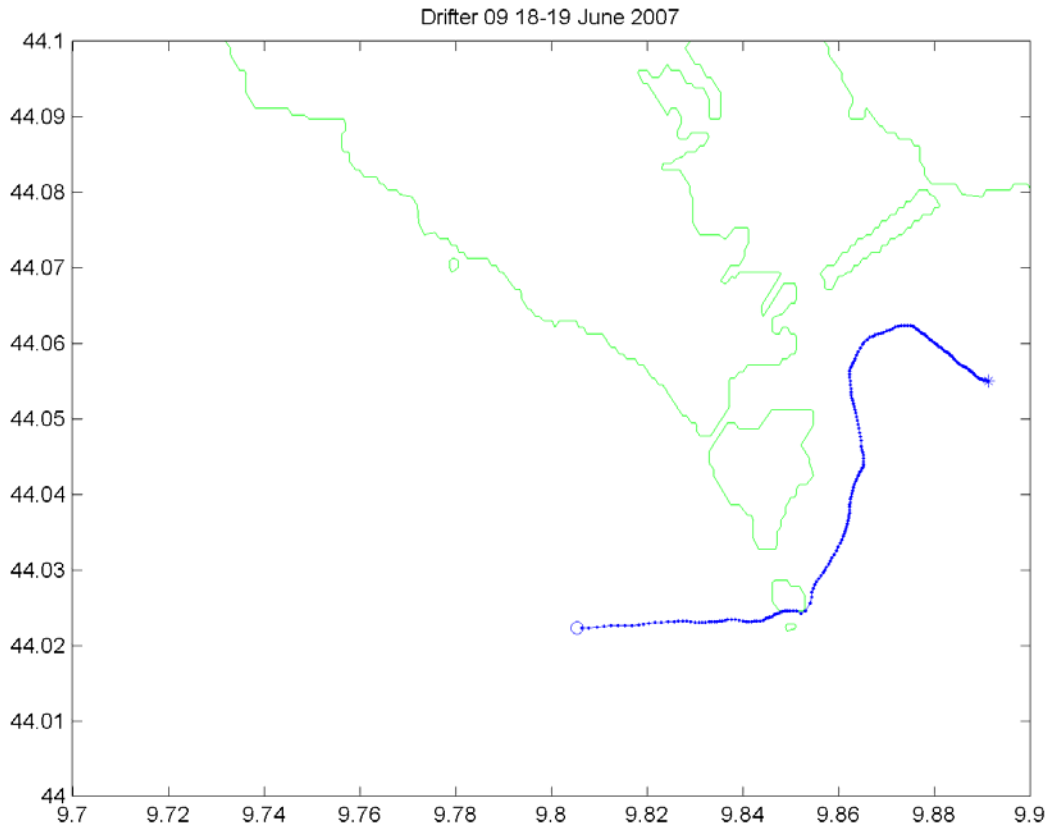

Figure 8. Raw trajectory of drifter 09 during the 1st dispersion experiment (18-19 June 2007). The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 5 min.

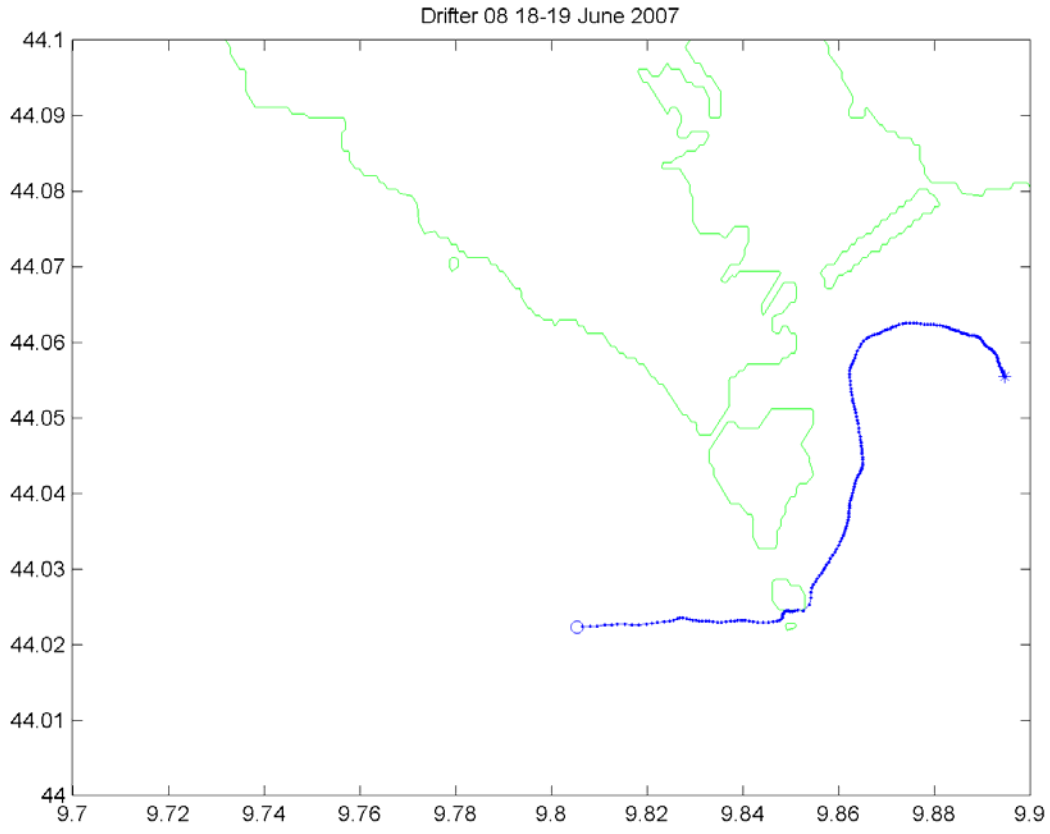

Figure 9. Same as Figure 8 but for drifter 08.

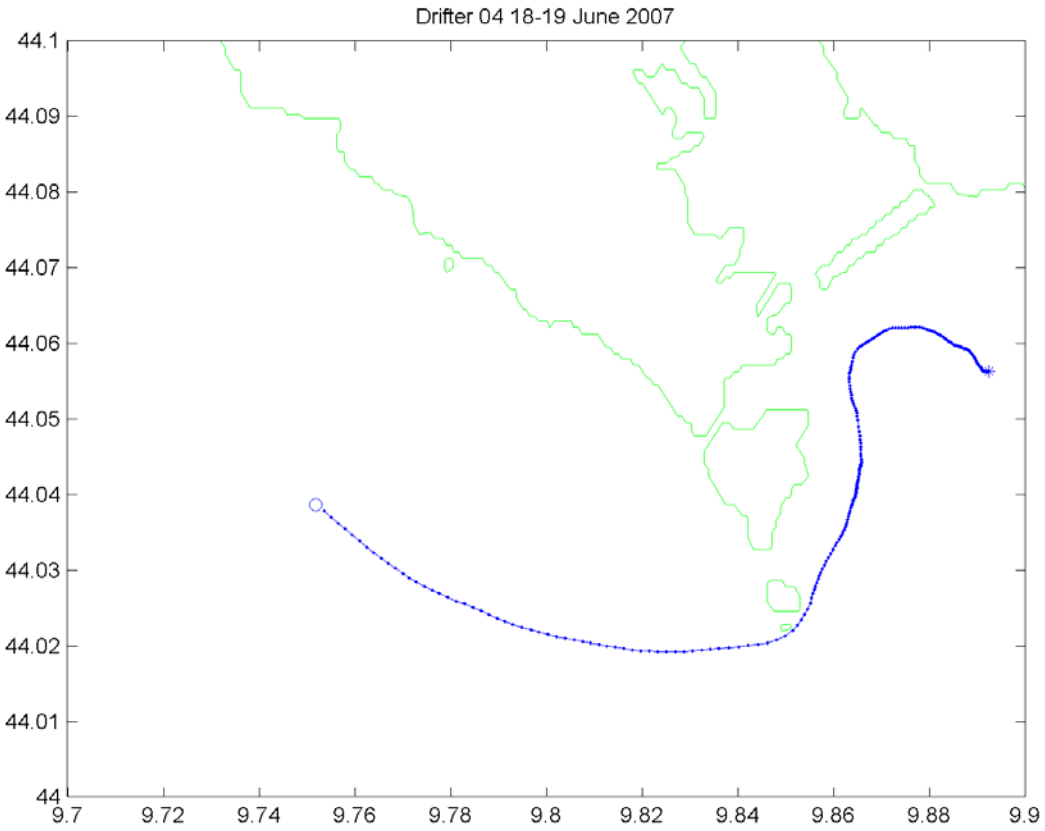

Figure 10. Same as Figure 8 but for drifter 04.

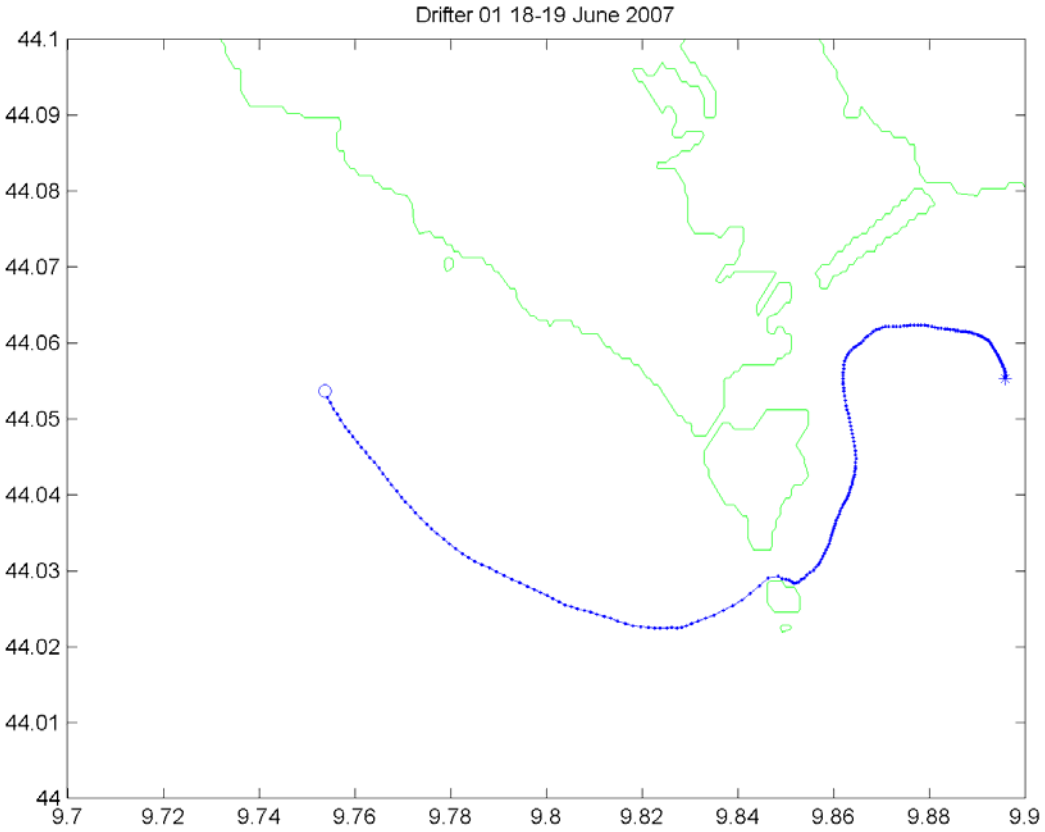

Figure 11. Same as Figure 8 but for drifter 01.

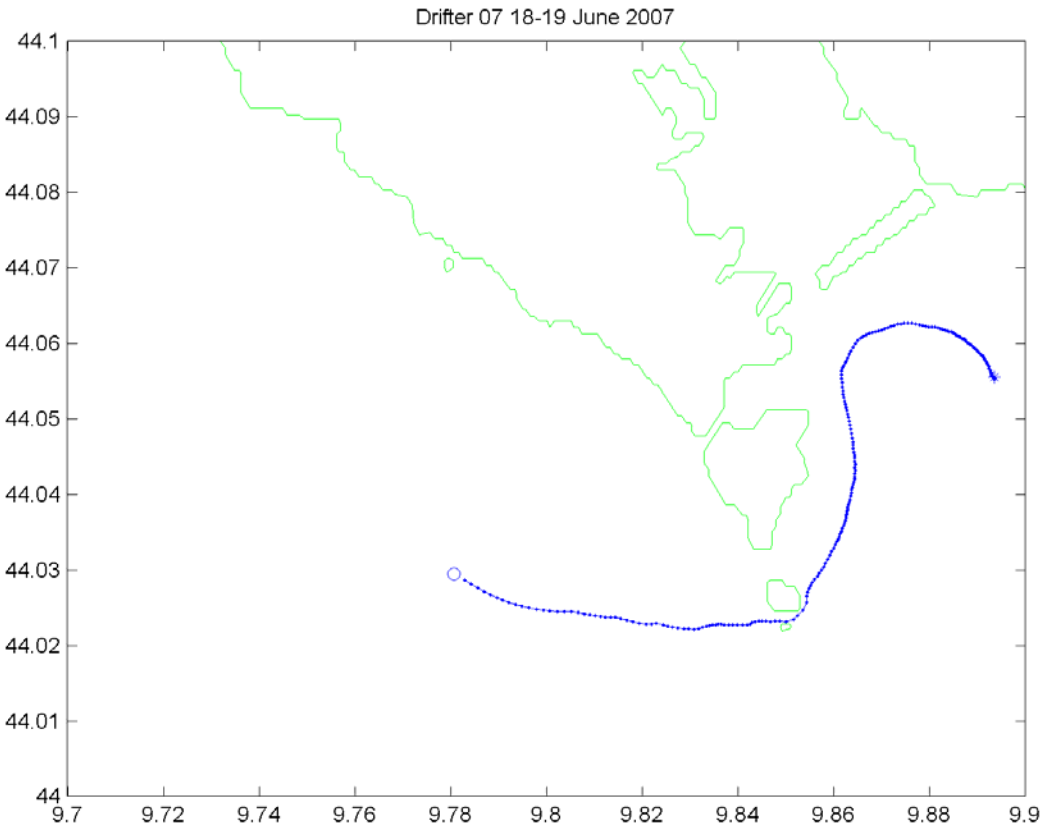

Figure 12. Same as Figure 8 but for drifter 07.

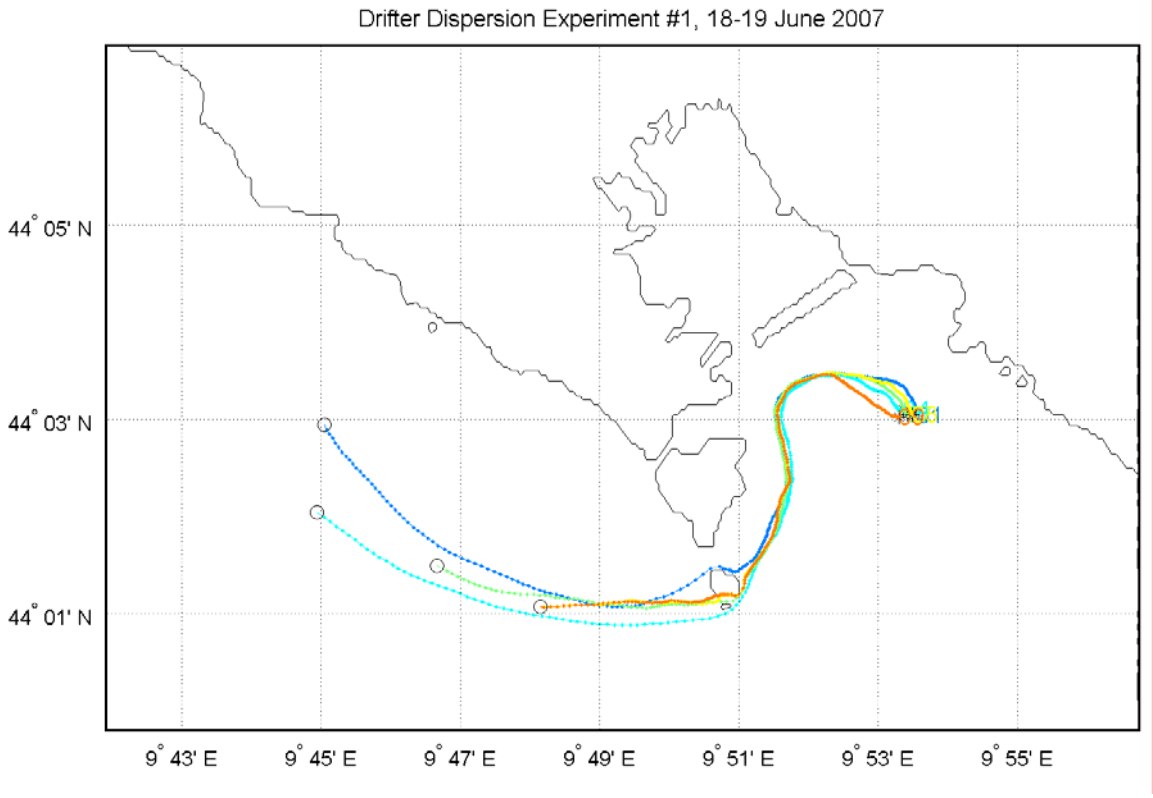

Figure 13. Composite plot with raw trajectories of drifters released during the 1st dispersion experiment (18-19 June 2007).

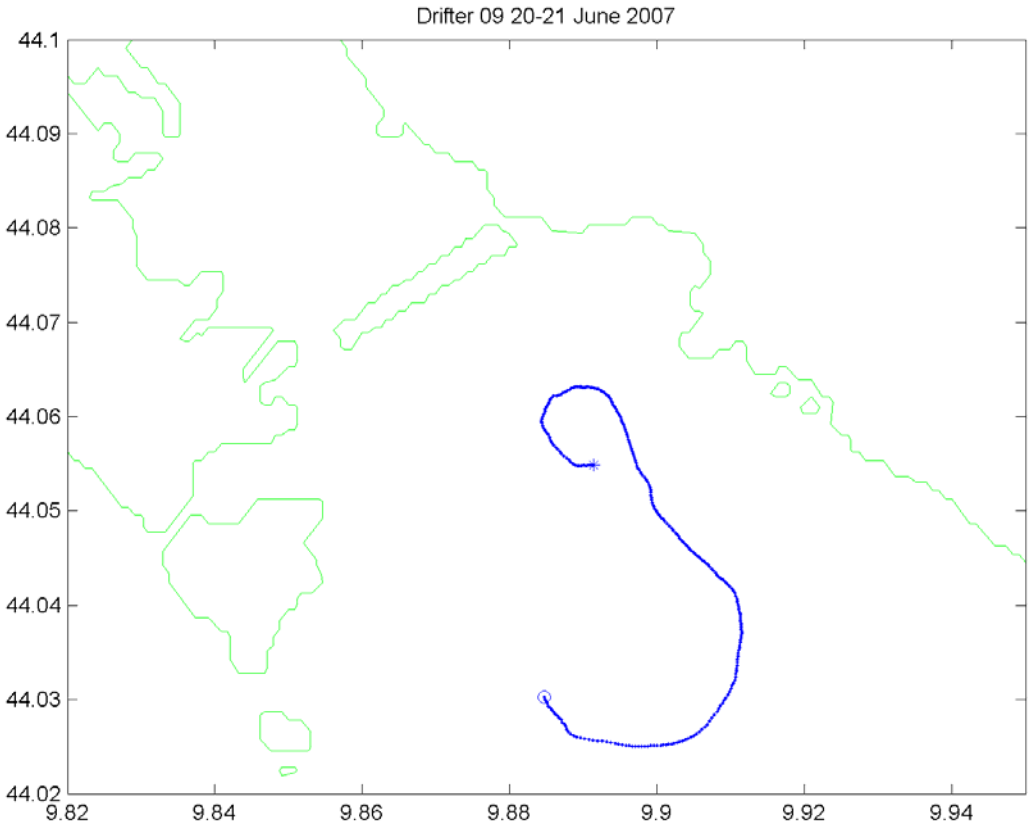

Figure 14. Raw trajectory of drifter 09 during the 2nd dispersion experiment (20-21 June 2007). The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 5 min.

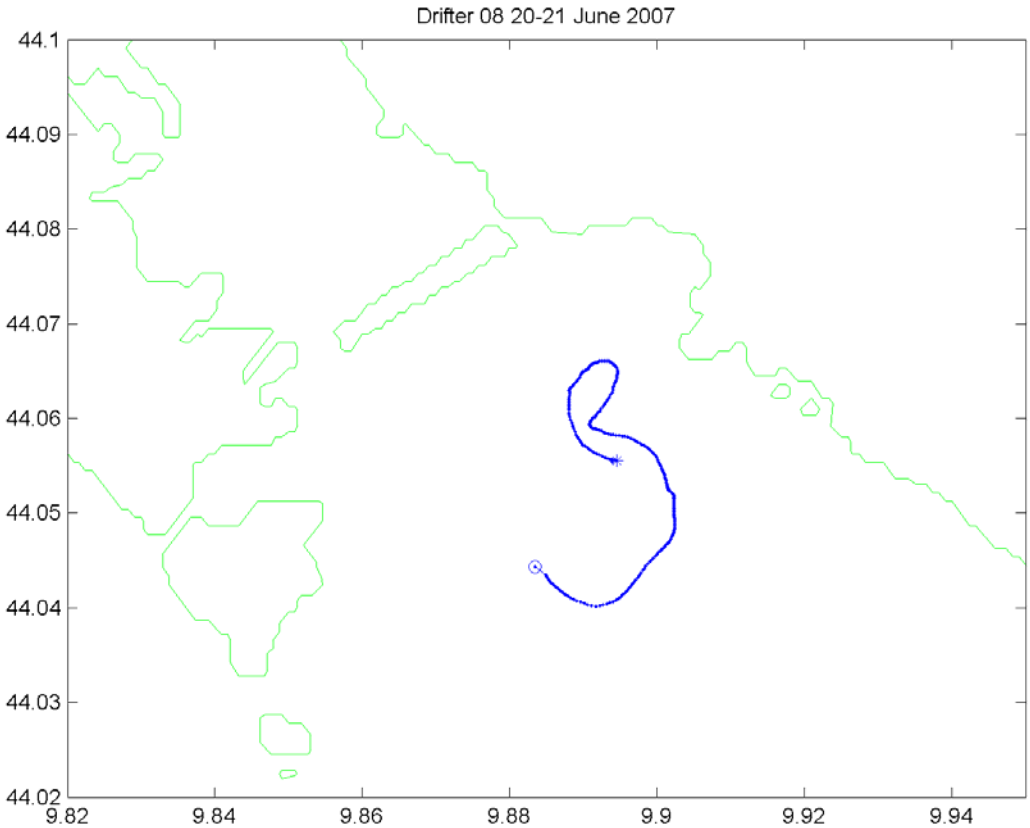

Figure 15. Same as Figure 14 but for drifter 08.

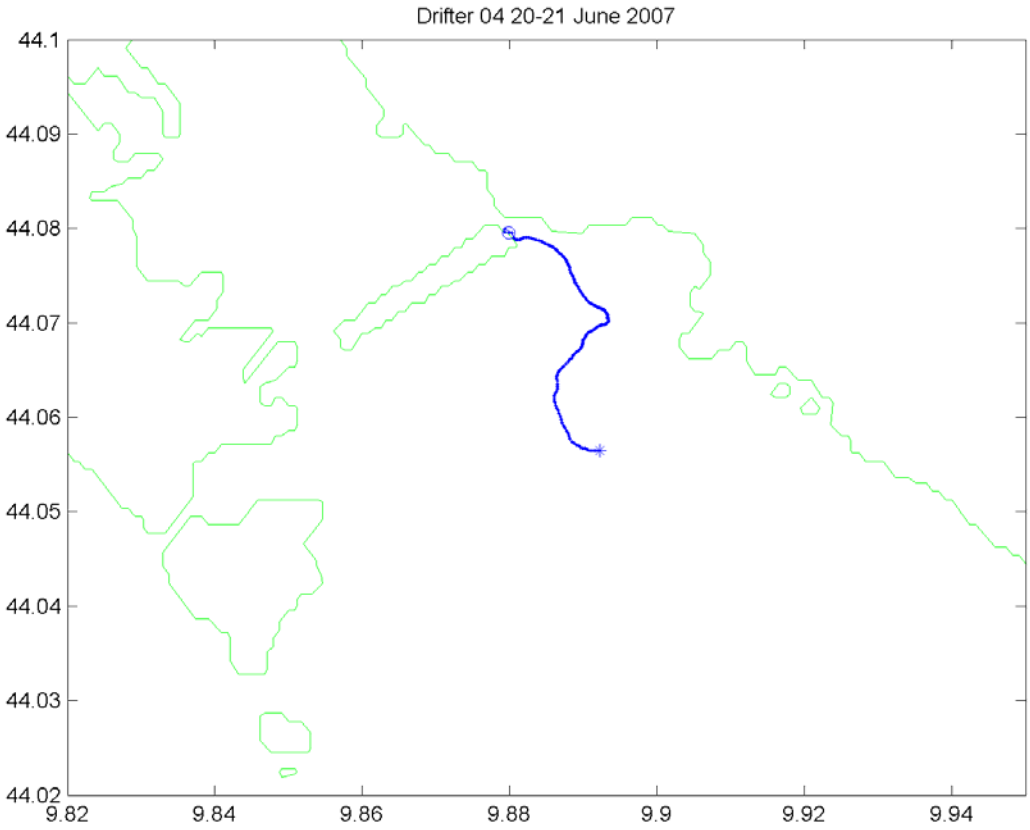

Figure 16. Same as Figure 14 but for drifter 04.

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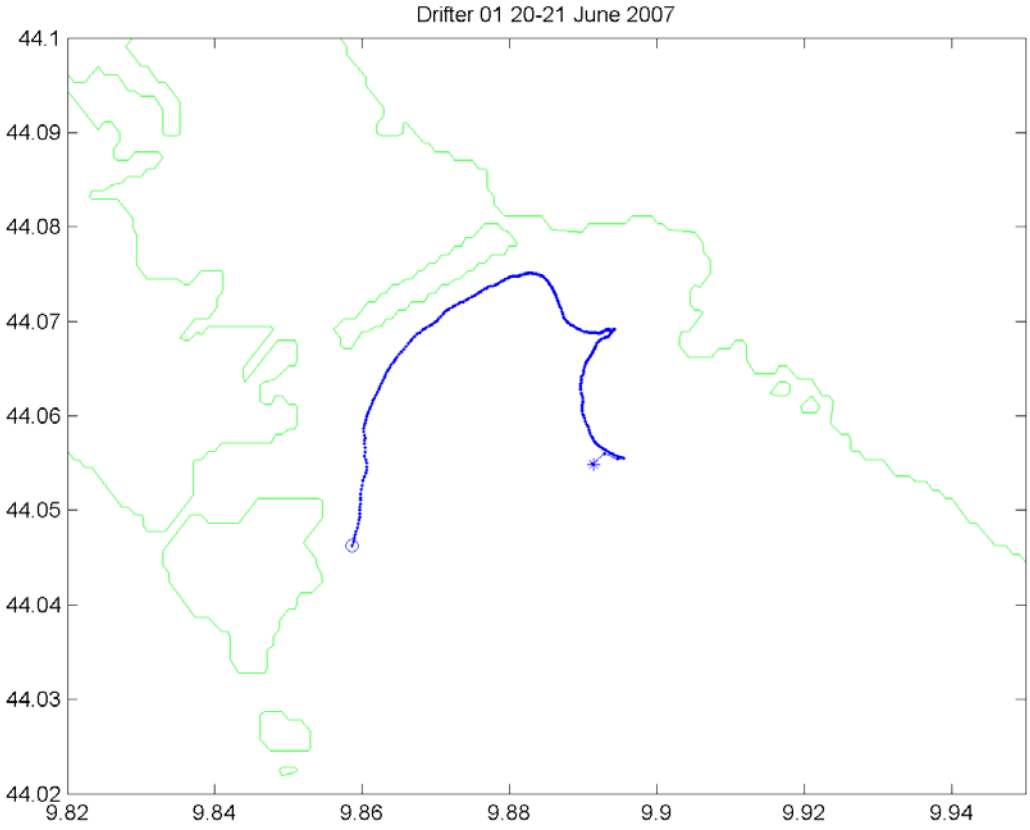

Figure 17. Same as Figure 14 but for drifter 01.

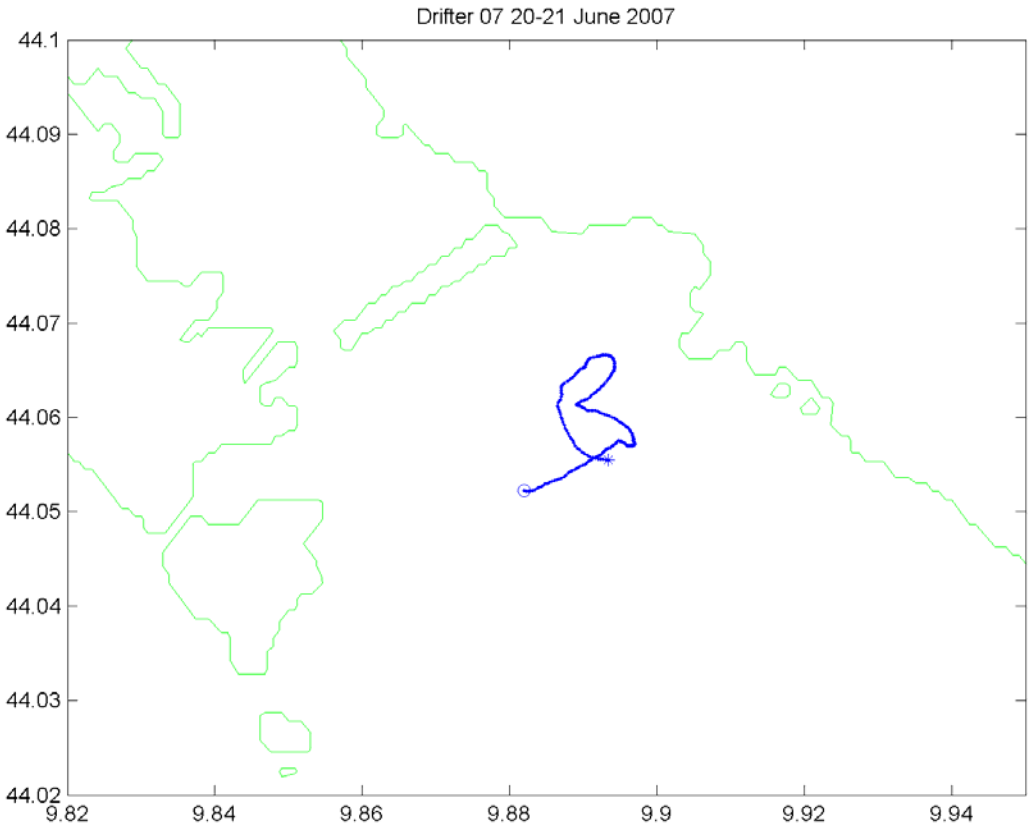

Figure 18. Same as Figure 14 but for drifter 07.

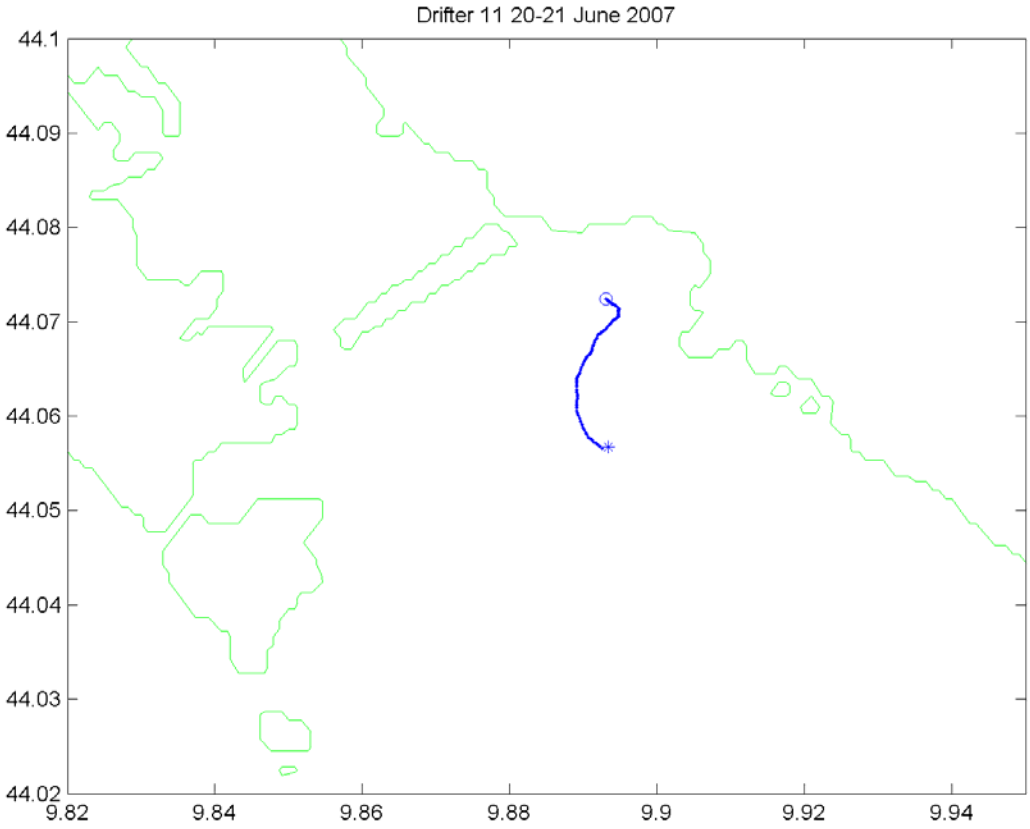

Figure 19. Same as Figure 14 but for drifter 11 (with Aquadopp).

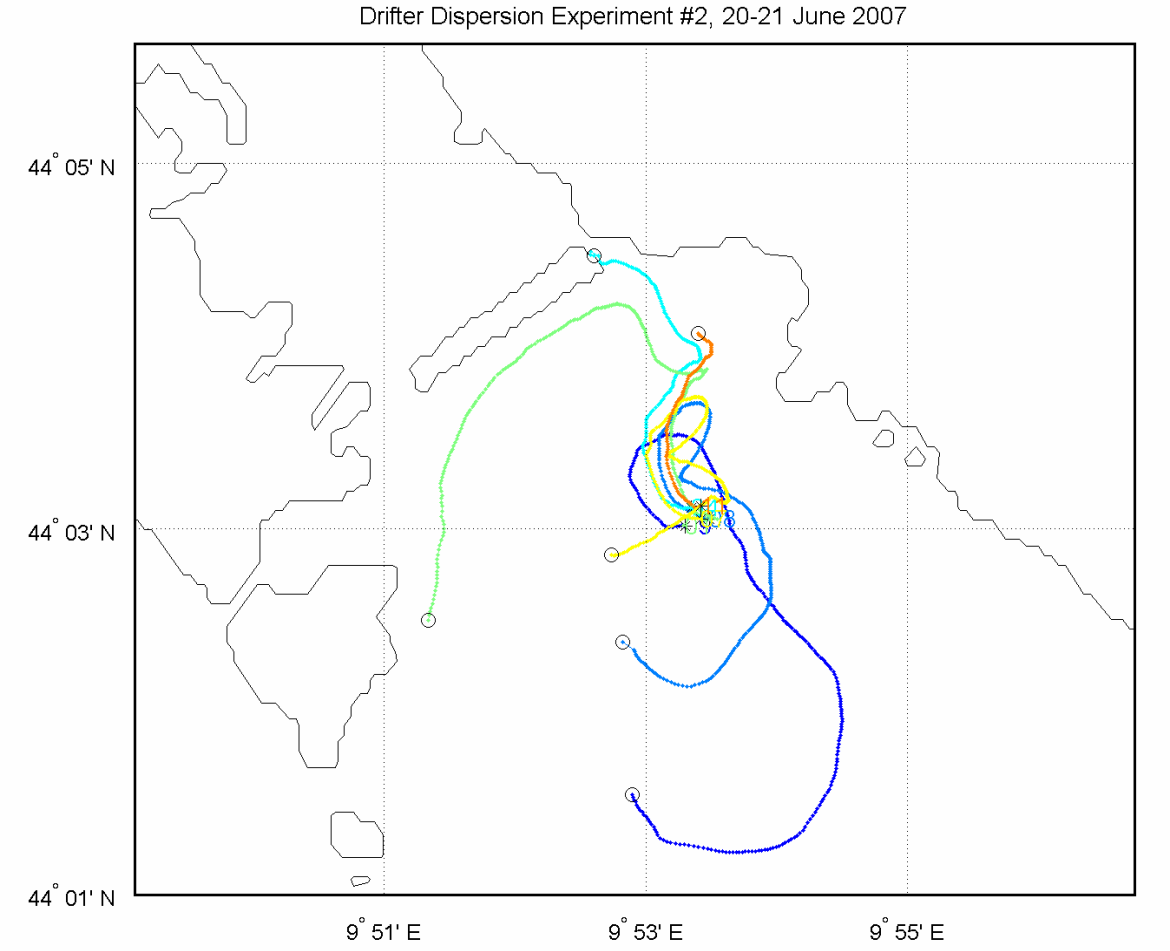

Figure 20. Composite plot with raw trajectories of drifters released during the 2nd dispersion experiment (20-21 June 2007).

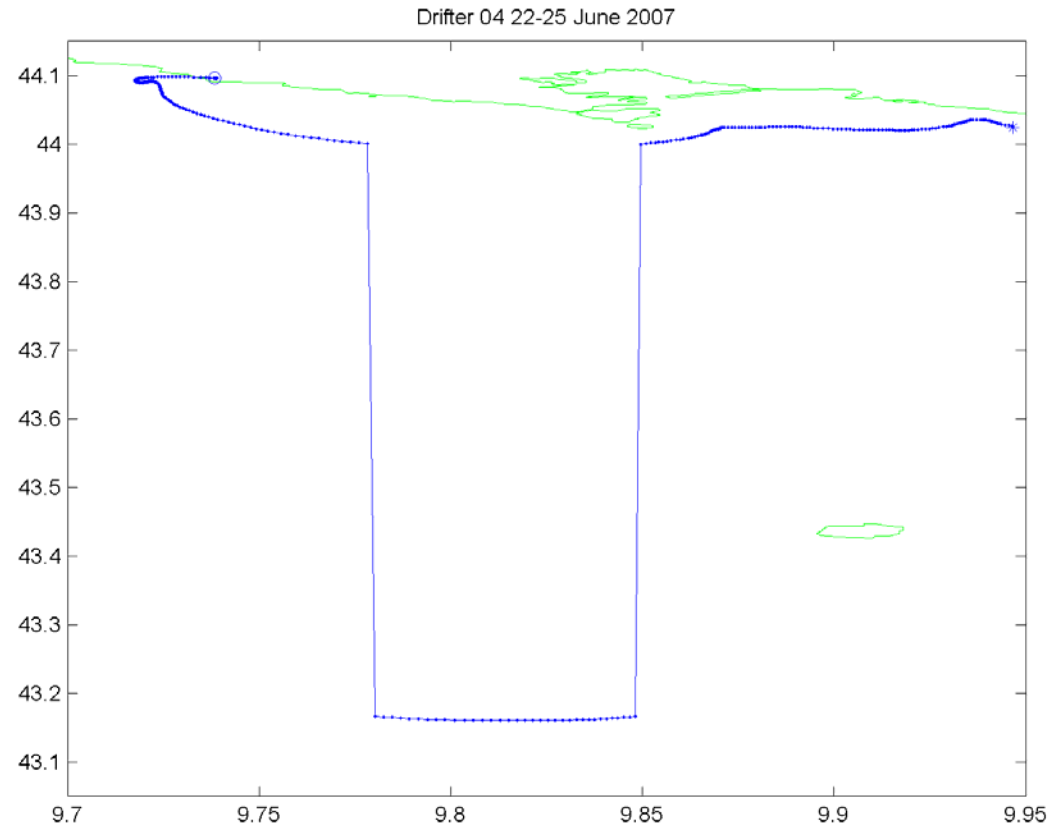

Figure 21. Raw trajectory of drifter 04 during the 3rd dispersion experiment (22-25 June 2007). The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 10 min.

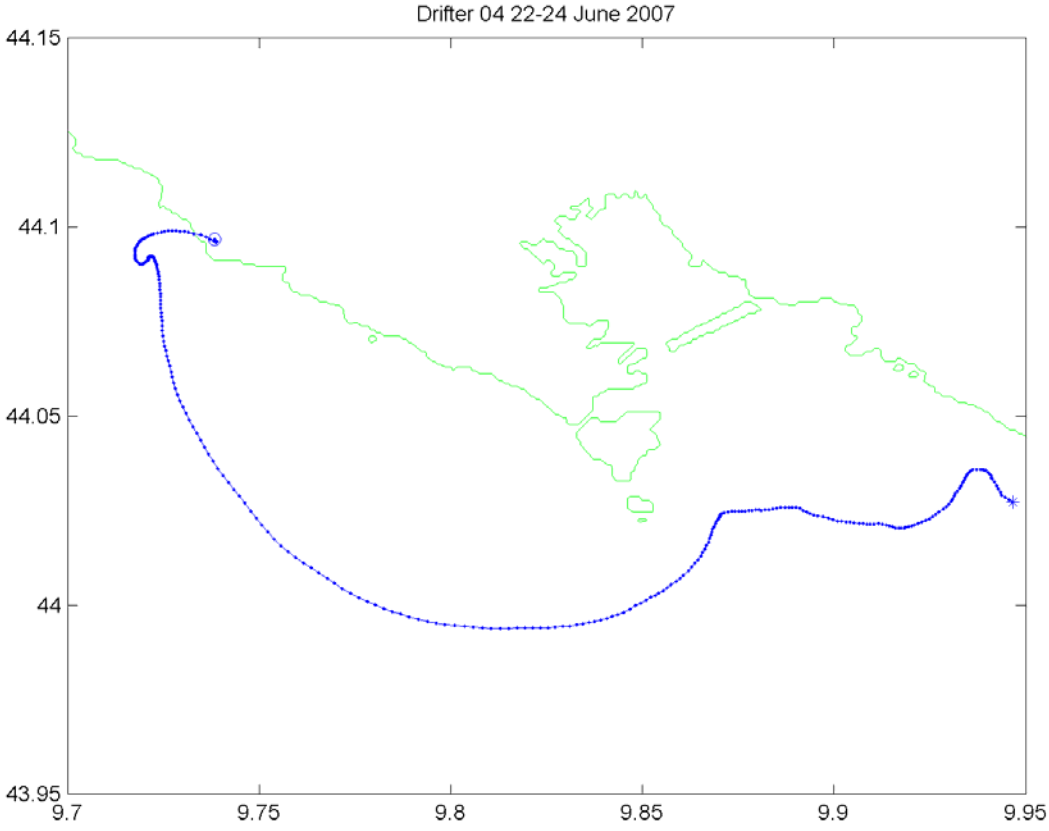

Figure 22. Same as Figure 21 but with corrected trajectory.

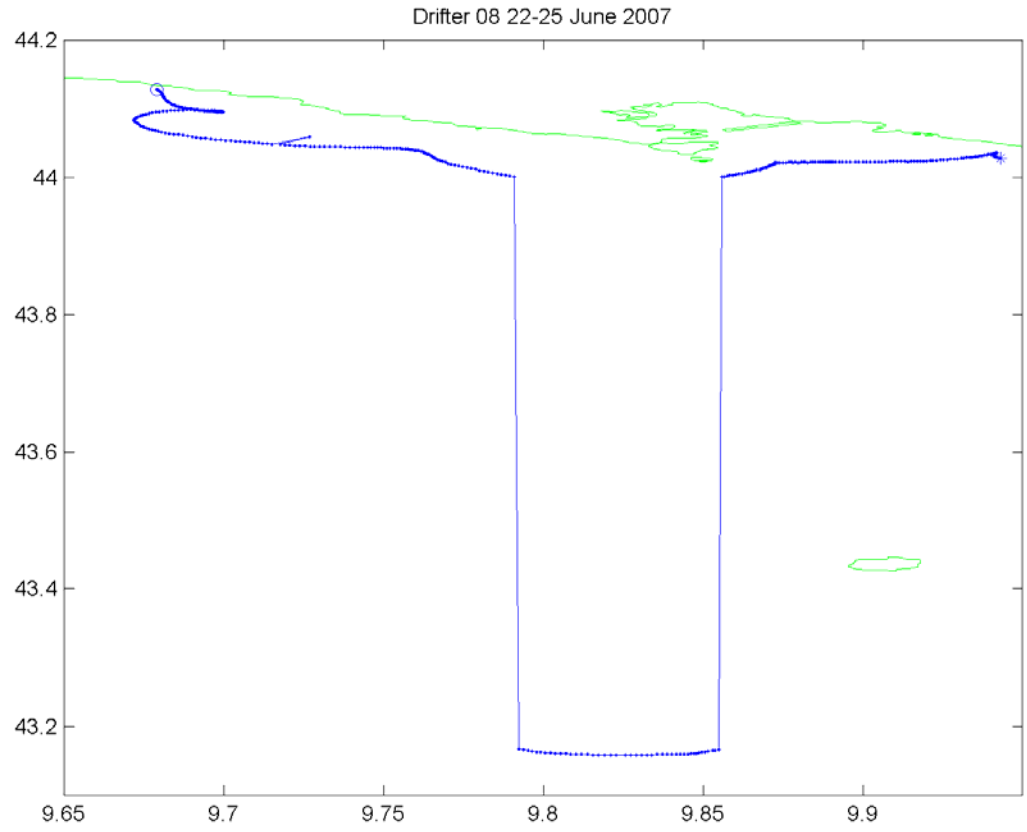

Figure 23. Raw trajectory of drifter 08 during the 3rd dispersion experiment 22-25 June 2007. The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 10 min.

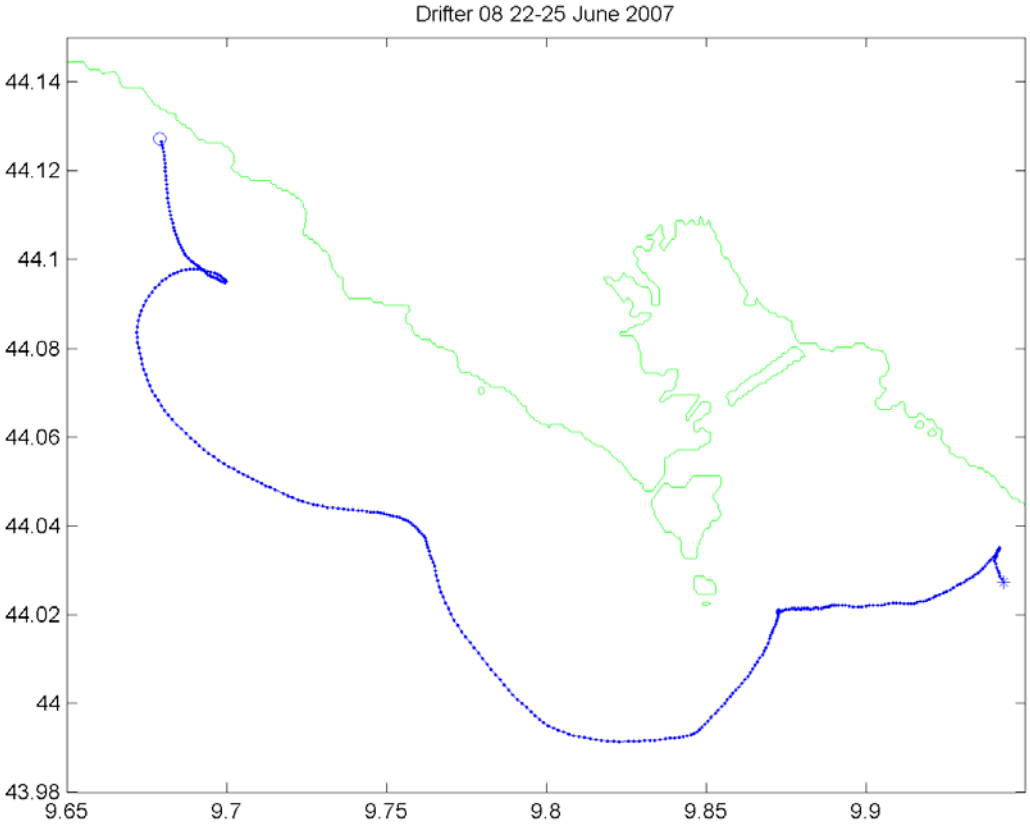

Figure 24. Same as Figure 23 but with corrected trajectory.

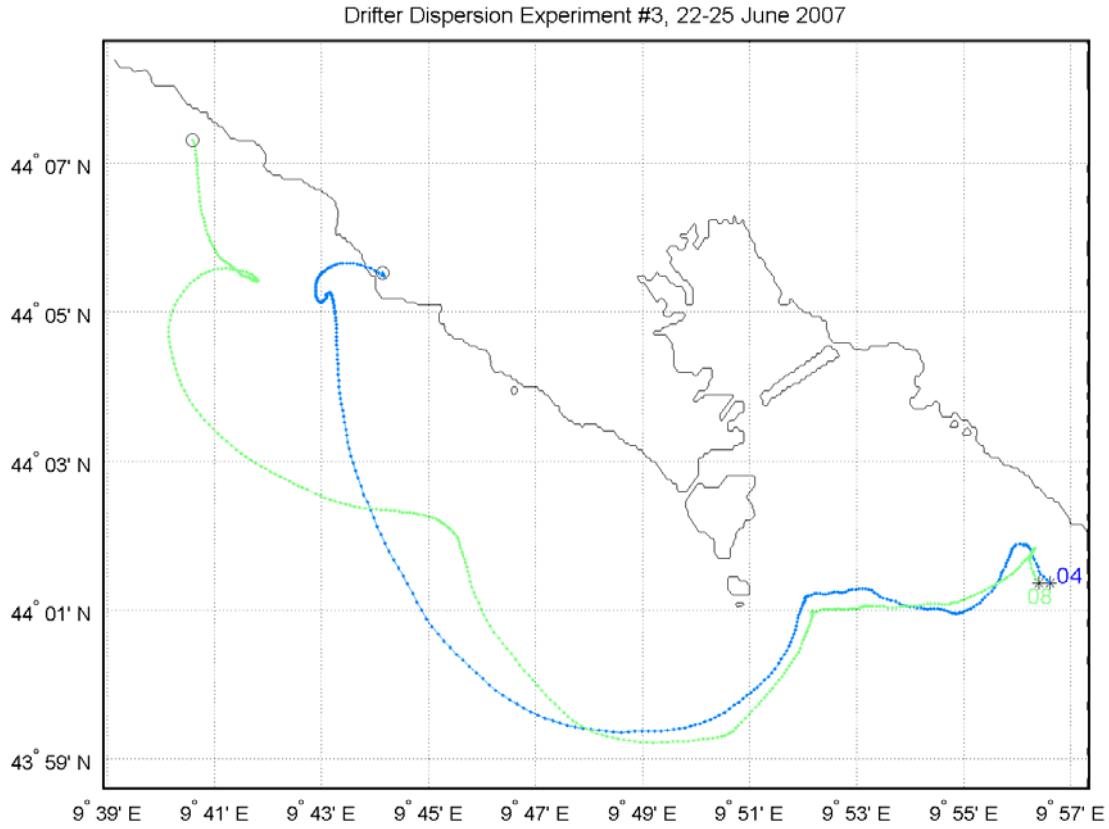

Figure 25. Composite plot with edited trajectories of drifters released during the 3rd dispersion experiment (22-25 June 2007).

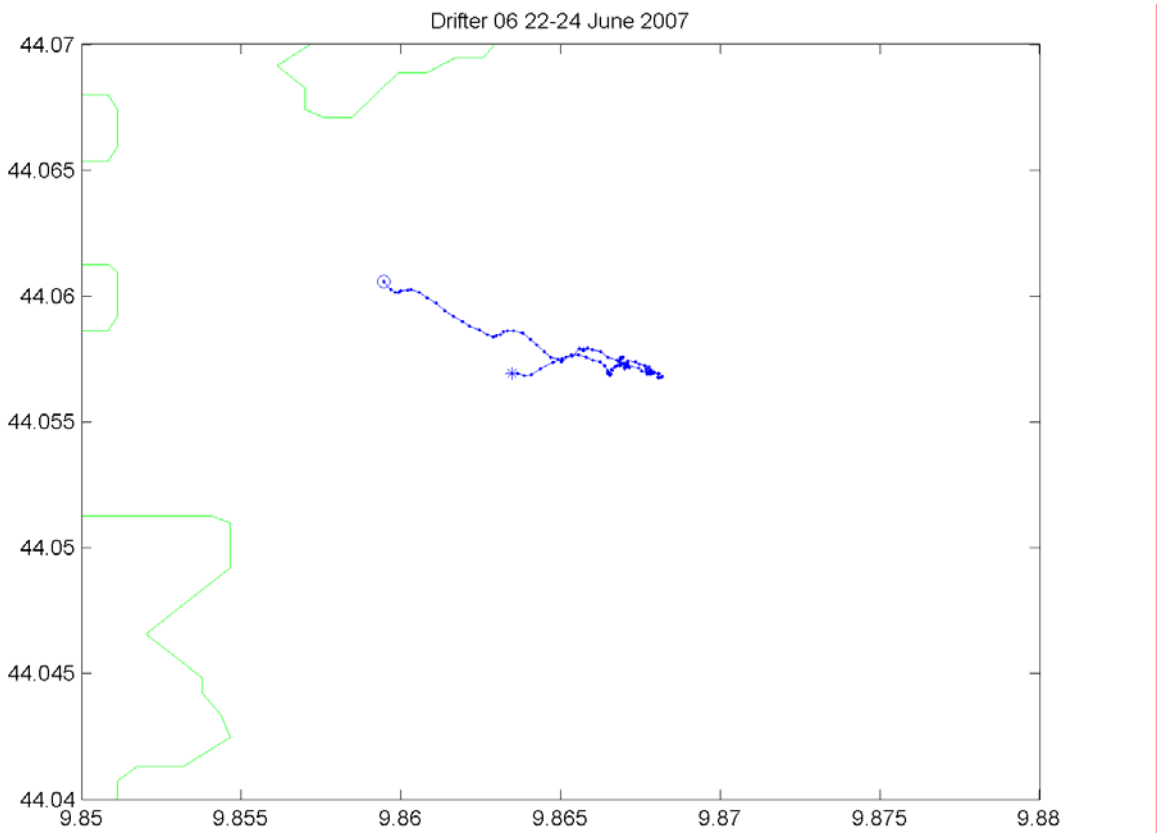

Figure 26. Raw trajectory of drifter 06 during the 4th dispersion experiment (22-23 June 2007). The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 5 min.

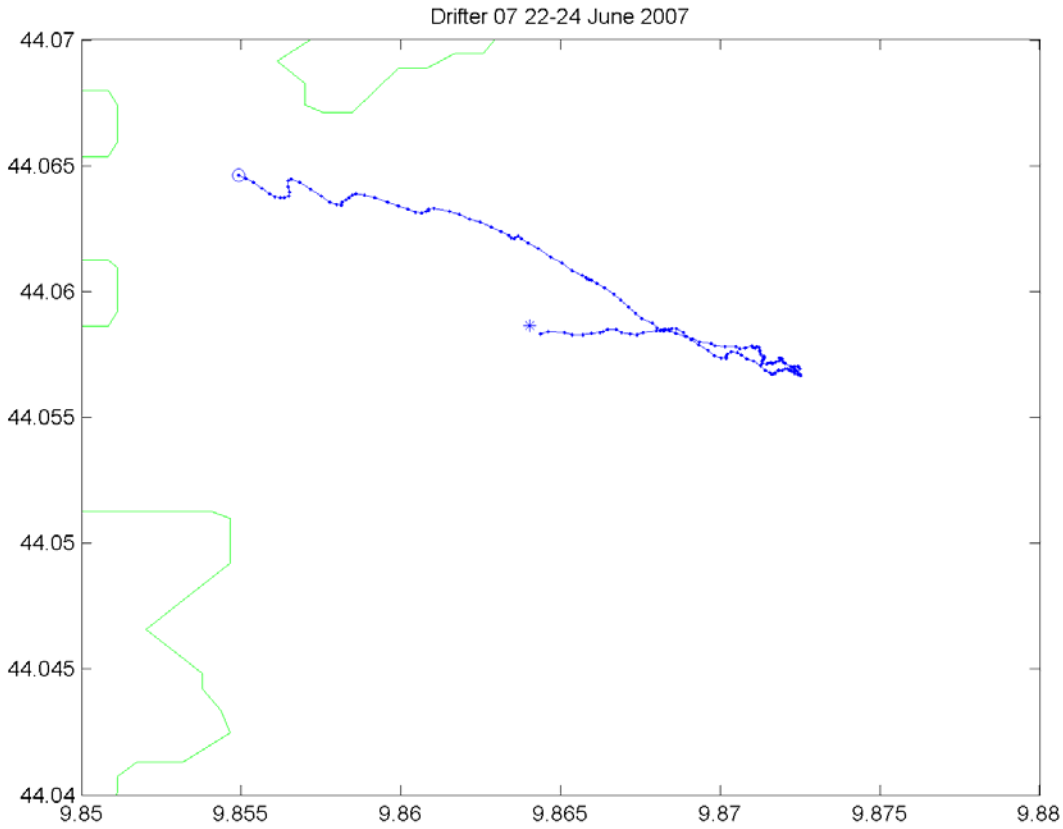

Figure 27. Same as Figure 26 but for drifter 07.

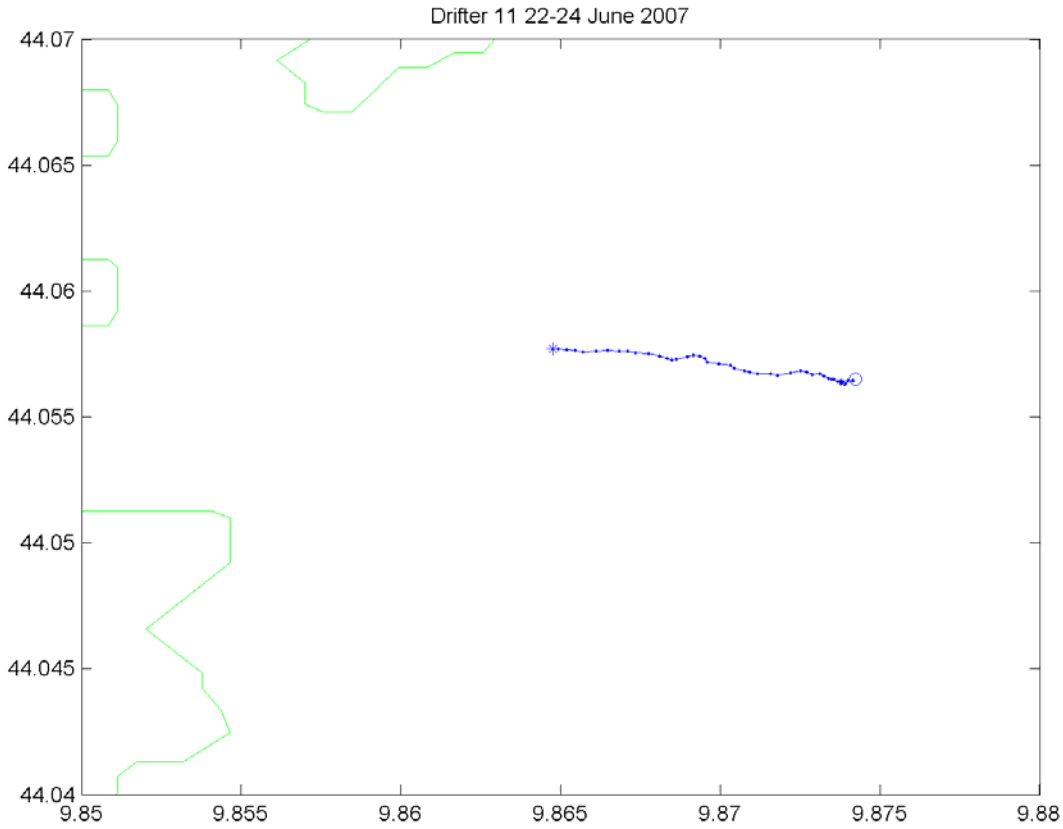

Figure 28. Same as Figure 26 but for drifter 11 (with Aquadopp).

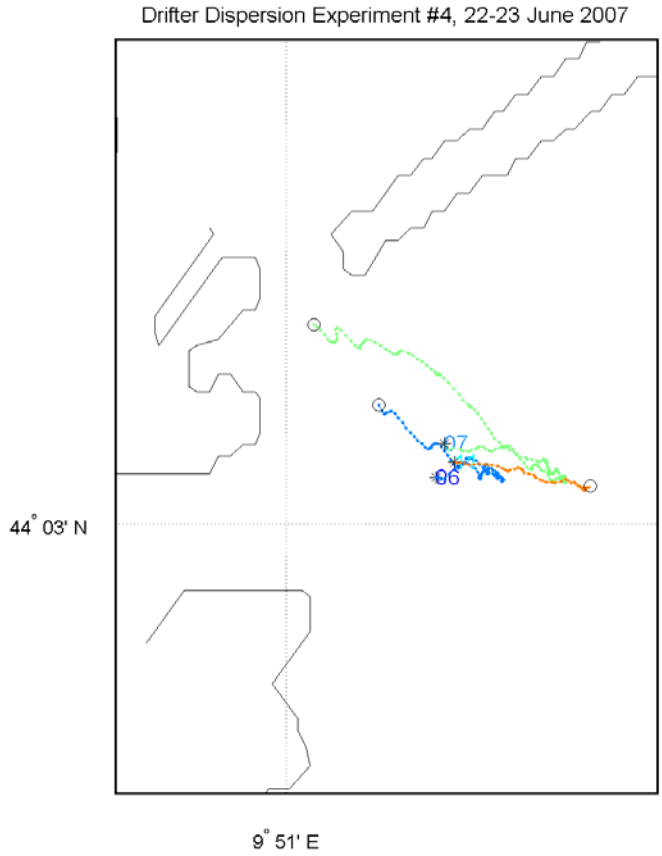

Figure 29. Composite plot with raw trajectories of drifters released during the 4th dispersion experiment (22-23 June 2007).

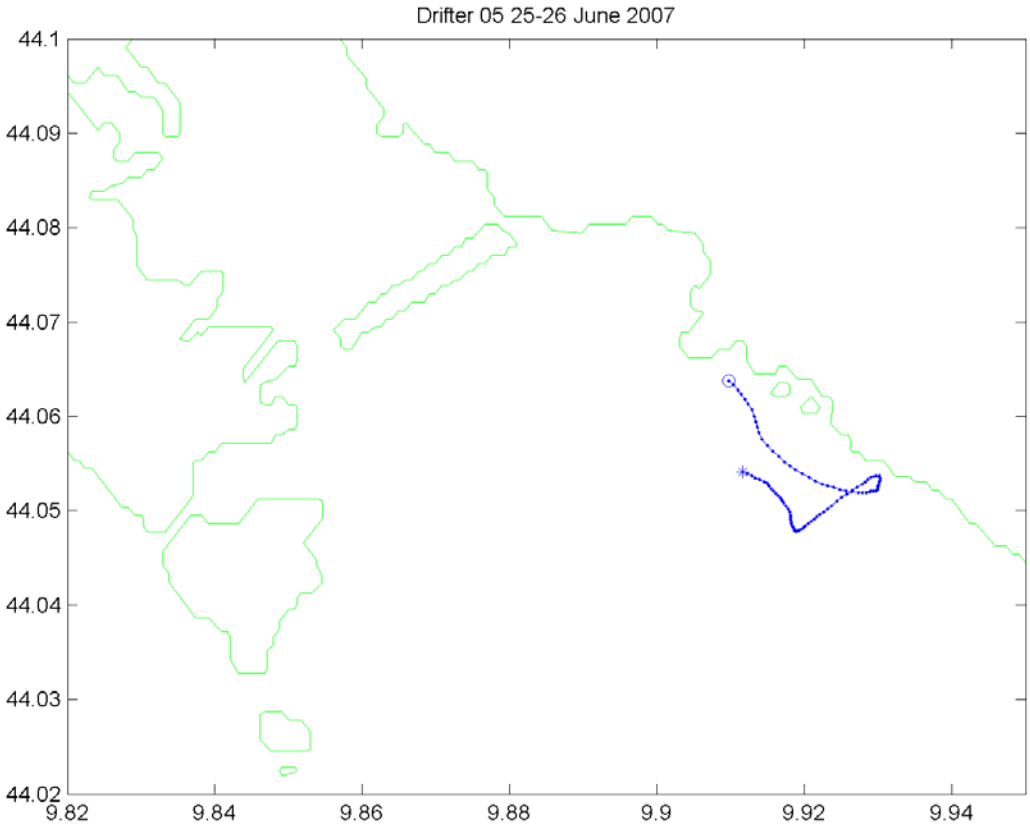

Figure 30. Raw trajectory of drifter 05 during the 5 th dispersion experiment (25-26 June 2007). The star and open circle denote the deployment and recovery locations, respectively. Dots represent the drifter locations every 10 min.

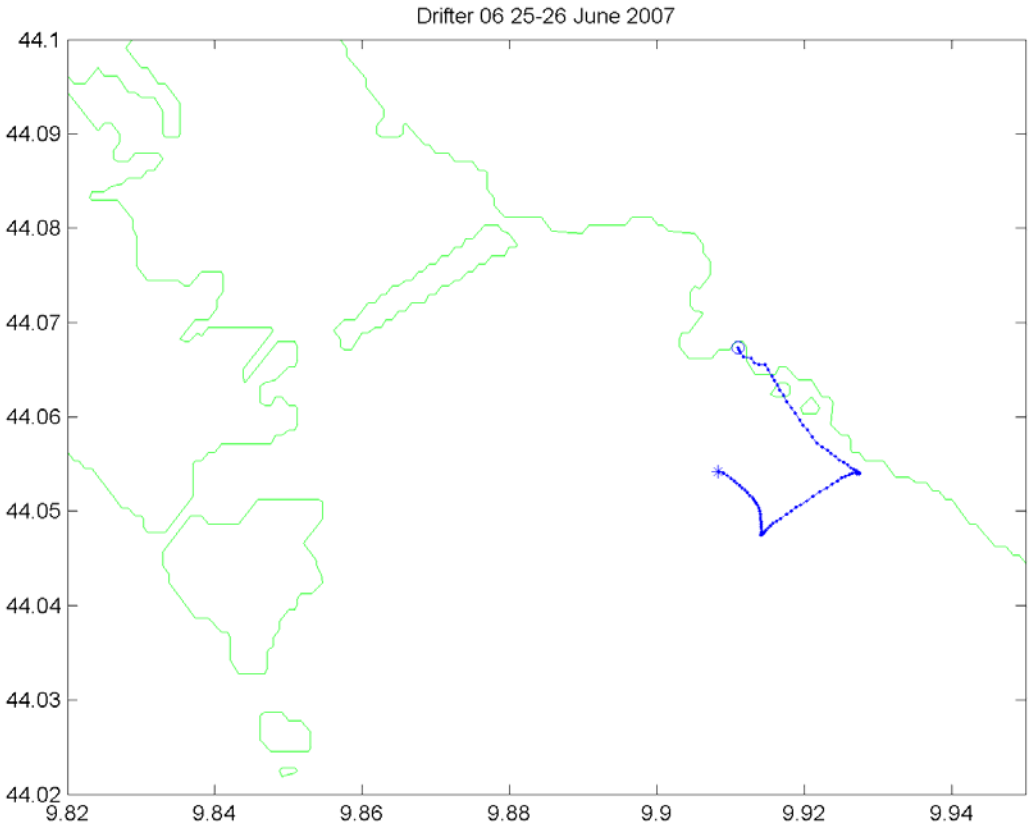

Figure 31. Same as Figure 30 but for drifter 06.

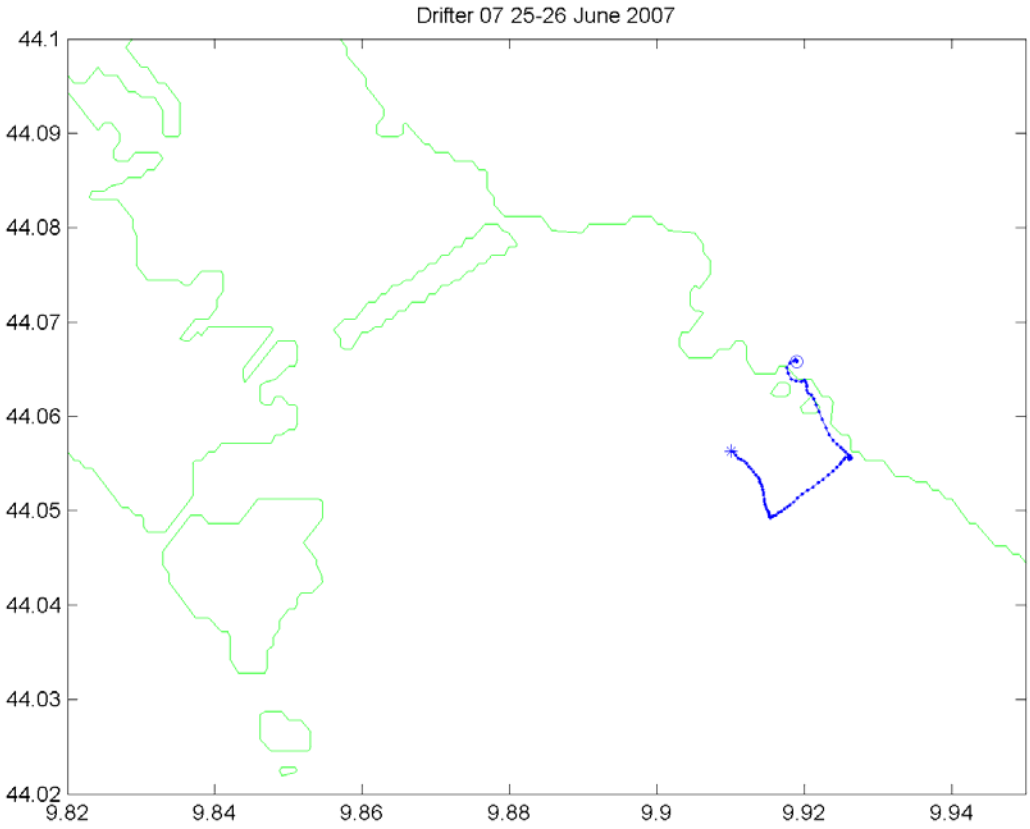

Figure 32. Same as Figure 30 but for drifter 07.

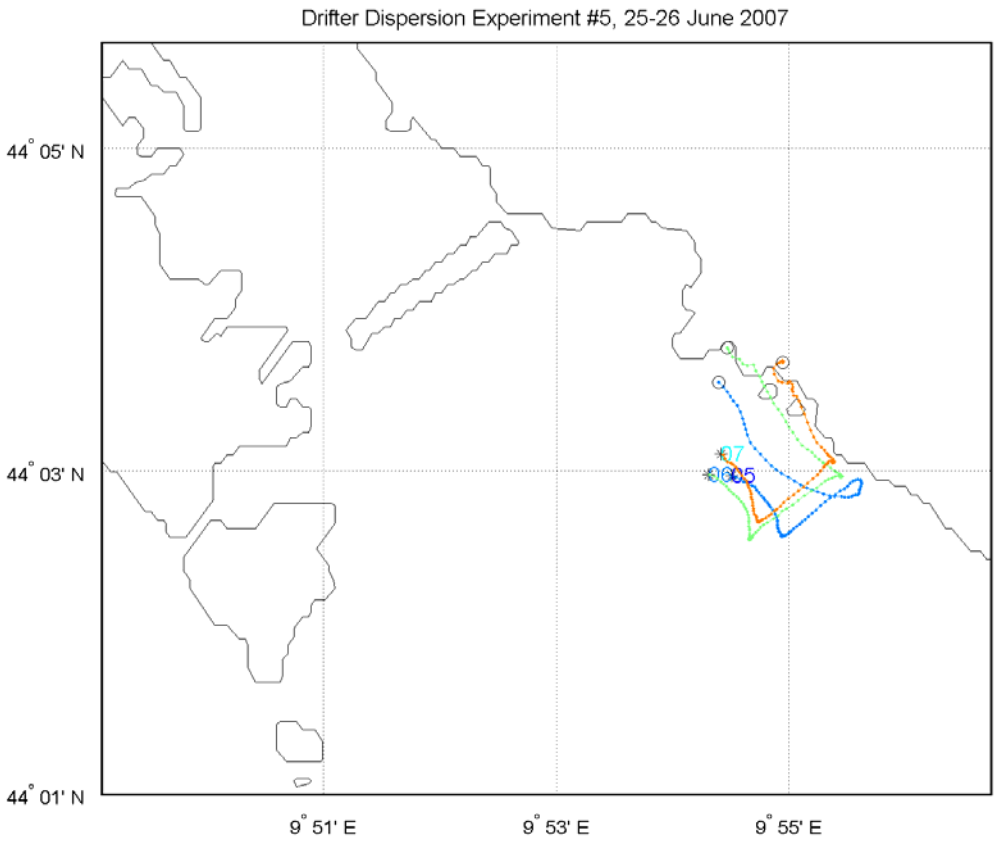

Figure 33. Composite plot with raw trajectories of drifters released during the 5th dispersion experiment (25-26 June 2007).

Figure 34. Composite plot with edited trajectories of drifters released during all the dispersion experiments in the vicinity of the GSP (18-26 June 2007).

4.2 Position data: Interpolation, low-pass filtering, computation of velocities

The drifter data, edited for the spike and offsets mentioned above, were interpolated at common times with uniform intervals of 5 minutes using a cubit spline method. The zonal and meridional components of velocity were estimated by finite differencing the interpolated positions (central differences). The interpolated positions were subsequently low-pass filtered using a Hamming window over an interval of 30 minutes. These filtered time series were used to compute low-pass filtered velocity series. Finally, the filtered time series were sub-sampled at 15 minute intervals. In general, the interpolated filtered sub-sampled tracks are very similar to the original edited trajectories; see for instance the processed data of drifter 08 during the 3rd dispersion experiment in Figure 35. An example of time series of the interpolated low-pass filtered sub-sampled latitude, longitude and the zonal and meridional components of velocity is depicted in Figure 36.

The interpolated, low-pass filtered and sub-sampled data were saved in MATLAB binary files named as d##_n, where ## is the drifter identification number and n is the dispersion experiment number. The list of variables is:

Variable Name	Explanation (units)
timei	MATLAB time with 5 min intervals (days)
lati, loni	Latitude and longitude interpolated very 5 min (degrees)
ui, vi	Zonal and meridional velocities interpolated very 5 min (cm/s)
latim, lonim	Low-pass filtered latitude and longitude (degrees)
uim, vim	Low-pass filtered velocities (degrees)
t	MATLAB time with 15 min intervals (days)
x,y	Low-pass filtered latitude and longitude sub-sampled every 15 min (degrees)
u,v	Low-pass filtered velocities sub-sampled every 15 min (degrees)

Table 6. Variables included in the MATLAB binary files (processed drifter data).

All the processed (edited, interpolated, low-pass filtered and sub-sampled every 15 minutes) drifters tracks are shown in Figure 37.

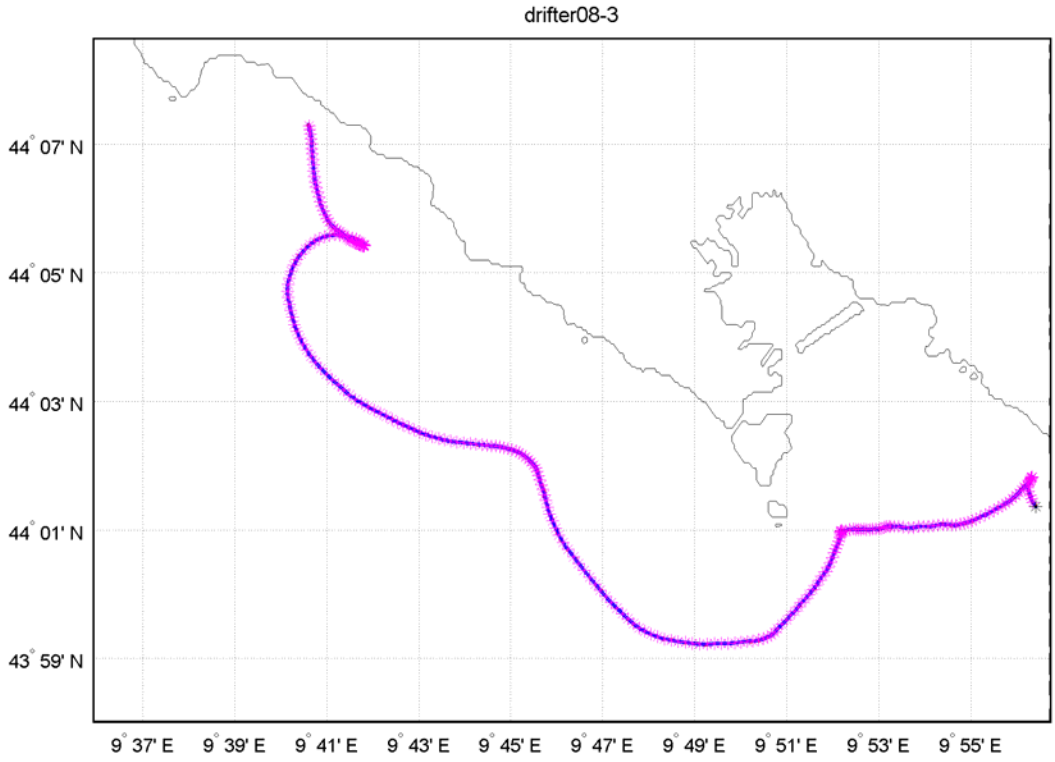

Figure 35. Processed trajectory of drifter 08 released during the 3rd dispersion experiment: raw (blue line), interpolated low-pass filtered (blue dots) and sub-sampled (magenta stars).

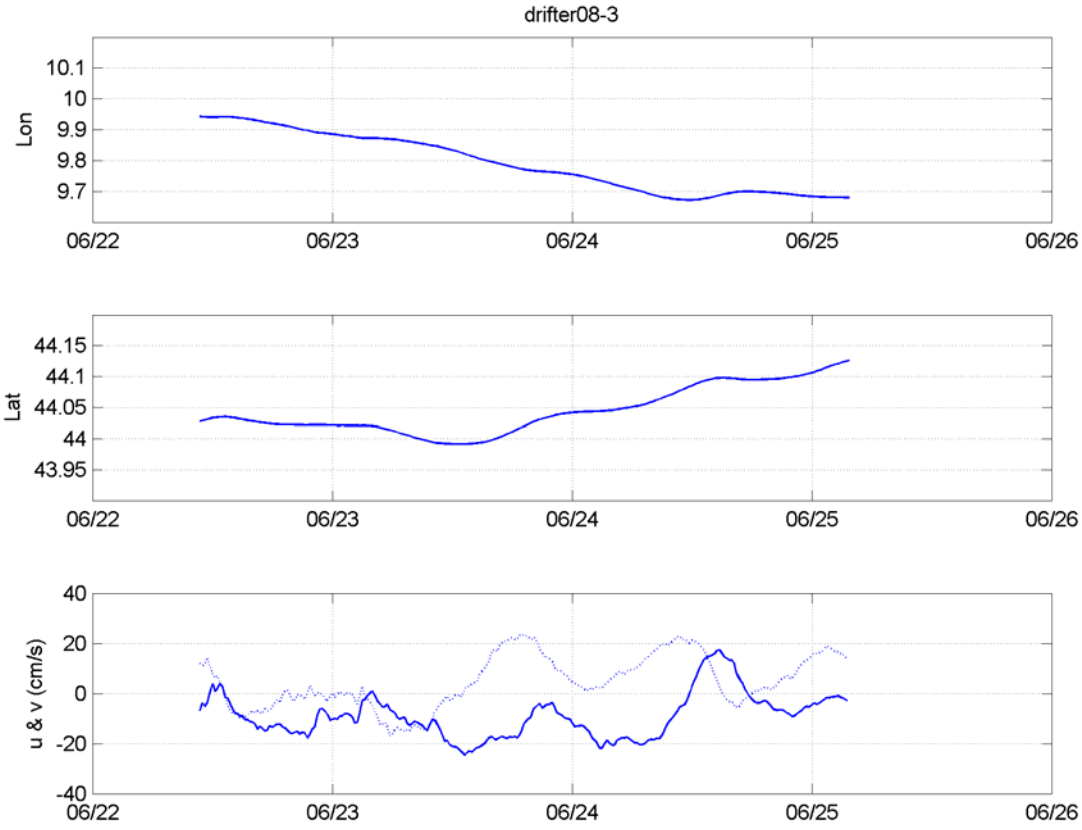

Figure 36. Time series of the interpolated low-pass filtered sub-sampled latitude, longitude and the two components of velocities (solid-zonal and dotted-meridional) for drifter 08 during the 3rd dispersion experiment.

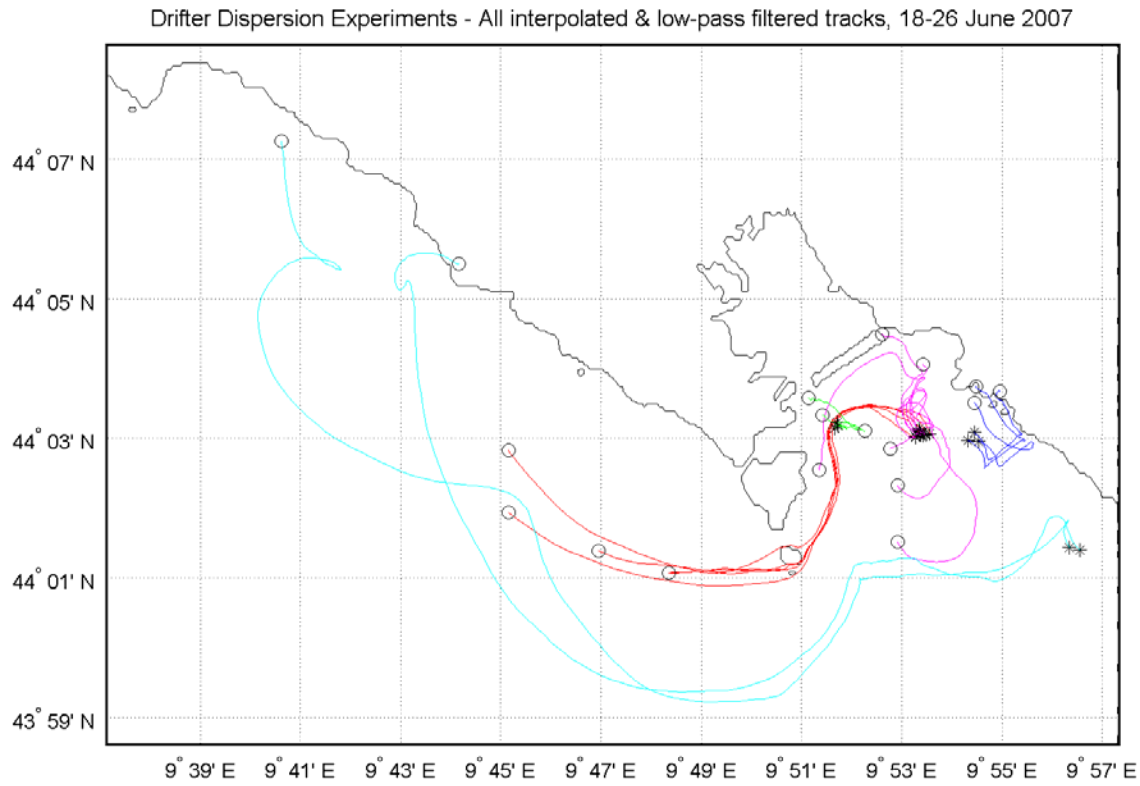

Figure 37. Composite plot with processed (edited, interpolated, low-pass filtered and sub-sampled every 15 minutes) trajectories of drifters released during all the dispersion experiments (18-26 June 2007).

4.3 Relative flow data

As explained in Section 2, drifter 11 was fitted with two Nortek Aquadopp currentmeters to measure the relative flow near the top and bottom of the drifter. Unfortunately, the bottom instrument did not work properly and did not record any useful data. In contrast, the top Aquadopp provide good data. The velocities in the X, Y and Z directions in a coordinate system moving with the drifter (that is, fixed with respect to the three acoustic beams) were not converted into horizontal velocities in the zonal and meridional directions, using the data provided by the compass and the tilt-meter. The quasi-horizontal X and Y components of relative flow are shown in Figure 38 during the 2nd dispersion experiment on 20 June 2007 for about 8 hours. The high-frequency noise or drifter motion is striking, with maximum relative speed reaching 23 cm/s. Over the entire 8 hours of measurements, however, the mean velocity components are bounded by 0.4 cm/s with about 4 cm/s standard deviation.

The above measurements sampled at 1 Hz were averaged over 1 minute intervals, separated by 10 minutes. This averaging reduces drastically the amplitude of the relative flow (Figure 39). Velocity components are now bounded by ±2 cm/s, whereas the speed is essentially less than 4 cm/s.

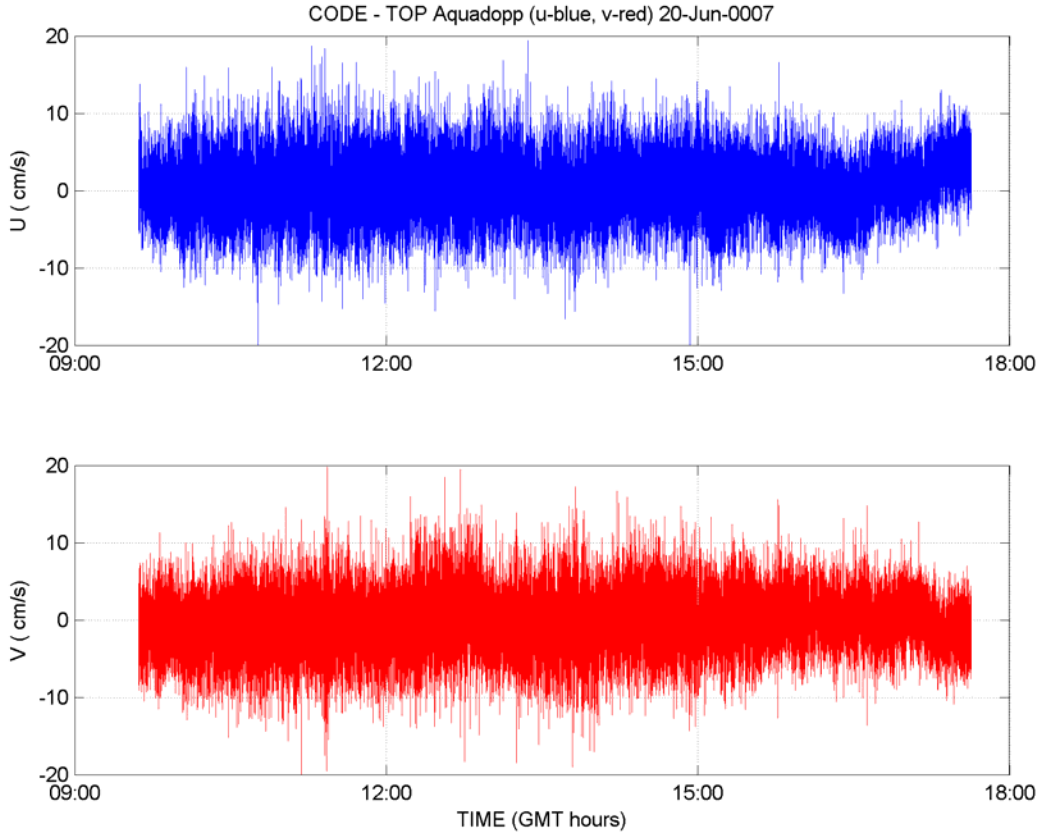

Figure 38. Time series of the raw measurements of relative flow (U and V components) past the top Nortek Aquadopp currentmeter fitted on drifter #11 during the 2nd dispersion experiment on 20 June 2007.

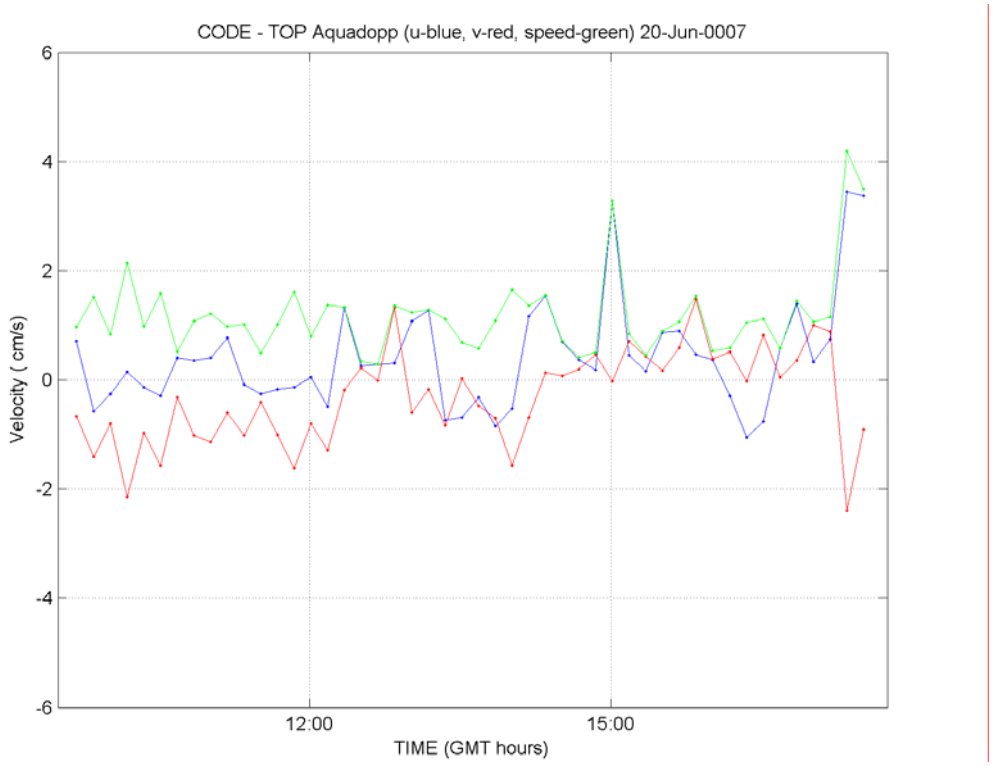

Figure 39. Same as in Figure 38 but with the velocities averaged over 1 minute every 10 minutes.

During the 4th dispersion experiment on 22 June 2007, the Aquadopp currentmeters were operational for about 3.8 hours. Their programming was set to automatically average the 1 Hz measurements over 1 minute intervals separated by 10 minutes. The results are presented in Figure 40 for the top currentmeter. Again, the 1-min averaged relative currents have components essentially bounded by ±2 cm/s, except during a short event just after 15:00 GMT.

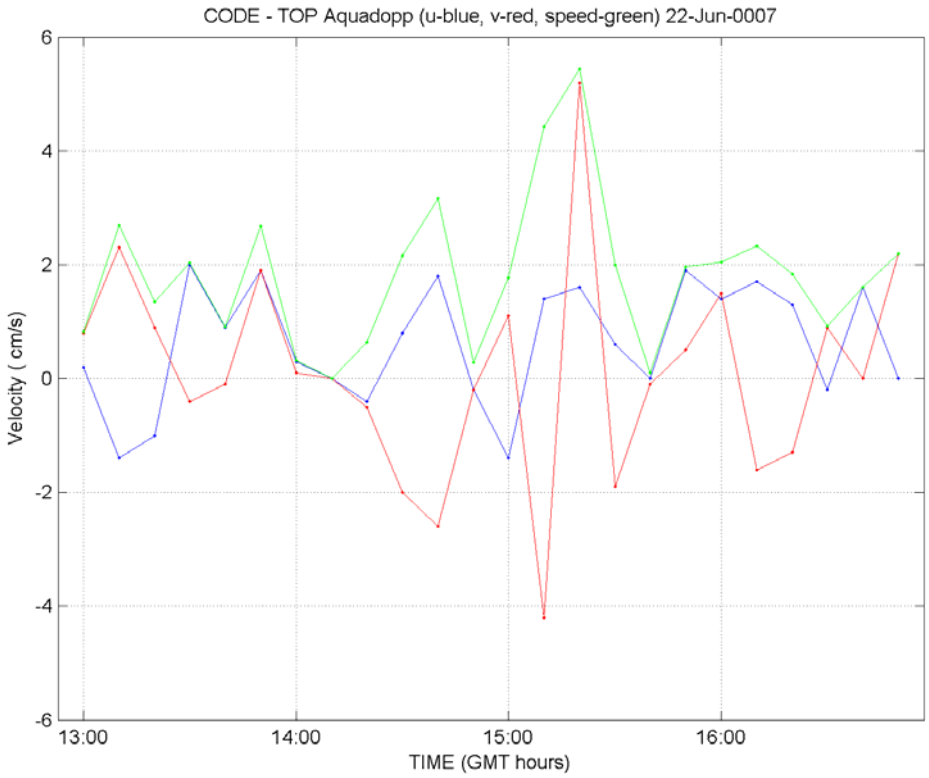

Figure 40. Time series of the averaged measurements of relative flow (U and V components) past the top Nortek Aquadopp currentmeter fitted on drifter #11 during the 4th dispersion experiment on 22 June 2007.

5. Conclusions

Prototype surface drifters with GPS positioning and GSM/GRPS telemetry were successfully operated in the vicinity of the GSP in June 2007 to study the dispersion properties of the surface waters and provide ground truth for VHF radars. These observations were performed simultaneously with other *in situ* (moorings, hydrographic surveys, glider, etc) and remote sensing (coastal radars and satellites) programs of OGS and collaborators as part of the MREA07 and LASIE07 experiments.

In total, five drifter experiments were performed with 2-6 units for periods ranging between 4 and 65 hours. The drifter data show a significant variability of the dispersion properties in the GSP. For instance, during the 1st experiment, the drifters remained together until they eventually escaped in the open sea after about 15 hours of drift. In contrast, the drifters deployed at approximately the same positions two days after experienced significant dispersion within the GSP only after about 5 hours. These remarkable results will have to be interpreted in conjunction with VHF radar and meteorological data obtained contemporaneously.

The acoustic currentmeter equipped on one drifter confirmed that the CODE-type drifters used in the dispersion experiments followed the surface currents (at a depth of ~30 cm) to within 2 cm/s, in the relatively calm conditions encountered in the GSP between 19 and 26 June 2007.

6. Acknowledgments

We thank all the individuals who helped with the drifter preparation at OGS in May-June 2007 and with the drifter logistics in the GSP in June 2007. The hard work of Alessandro Bubbi, Paolo Mansutti and Rajesh Nair for the drifter hardware modification, Stefano Kuechler for the integration of the Nortek Aquadopp currentmeters and Piero Zuppelli for the software development, is particularly acknowledged. Nevio Medeot, Riccardo Gerin, Bartolomè Garau Pujol, Pietro Zanasca, Michel Rixen, Joao Teixeira, Domenico Galletti, Marco Colombo, Annalisa Griffa, Anne Molcard, Nicoletta Fabbroni and Gianpietro Gasparini helped with the drifter deployments and recoveries. Thanks to the NURC Carabinieri, the “Riserva Marine delle Cinque Terre”, Signora Annamaria (Ferry ticket booth in Riomaggiore) and Elena and Nicola Cimati (“Locanda Il Senatore” in Fiascherino) for their kind help.

7. References

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Poulain, P.-M. (1999), Drifter observations of surface circulation in the Adriatic Sea between December 1994 and March 1996, J. Mar. Syst. 20, 231-253.