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# **ASL Environmental Sciences inc.**

## **Gros Cacouna LNG Terminal**

Final report

**Drifter tracking study**

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Final report  
**Drifter tracking study**


**Prepared by:**



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Jonas Sahlin, biologist

**Verified by:**



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Marc Pelletier, oceanographer

## **PROJECT TEAM**

This document was prepared by Procean Environment Inc., maritime science and technology consultants (a division of SNC-Lavalin). Following is a list of the project team members who collaborated in preparing this report.

Marc Pelletier, M.Sc. Oceanography

Project manager

Paul Blais, B.Sc. Geography

Survey manager

Jonas Sahlin, M.Sc. Biology

Technical assistance and report

Marie-Hélène Michaud, M.Sc. Oceanography

Technical assistance

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## 1.0 INTRODUCTION

This report describes the methodology and results of the drifter tracking study performed at the proposed Gros Cacouna LNG Terminal site by Procean Environment Inc., mandated by ASL Environmental Sciences Inc. The report provides technical information on currents required for the evaluation of the suitability of the LNG terminal.

The surveys were conducted during neap and spring tide cycles from September 29 to October 21, 2004, in order to determine the spatial features of the current field at the site.

## 2.0 METHODOLOGY

In the scope of this study, drifters were released during both flood and ebb at spring and neap tide conditions (table 1). In total, six drifter releases were performed between September 29 and October 21.

**Table 1 Conditions of drifter tests performed in fall, 2004**

| Date              | Tidal conditions |       | High tide |           | Low tide |           | Drifter test |       |
|-------------------|------------------|-------|-----------|-----------|----------|-----------|--------------|-------|
|                   |                  |       | Time      | Amplitude | Time     | Amplitude | Start        | End   |
| Sept 29           | Spring tide      | Flood | 16:16     | 4.7m      | 10:18    | 0.4m      | 11:36        | 16:55 |
| Oct 1, Release 1  | Spring tide      | Ebb   | 5:12      | 4.5m      | 11:24    | 0.7m      | 06:39        | 08:50 |
| Oct 1, Release 2  | Spring tide      | Ebb   | 5:12      | 4.5m      | 11:24    | 0.7m      | 09:08        | 11:37 |
| Oct 20            | Neap tide        | Flood | 20:31     | 3.5m      | 14:05    | 1.5m      | 14:41        | 17:23 |
| Oct 21, Release 1 | Neap tide        | Ebb   | 9:28      | 3.3m      | 15:33    | 1.7m      | 10:18        | 12:49 |
| Oct 21, Release 2 | Neap tide        | Ebb   | 9:28      | 3.3m      | 15:33    | 1.7m      | 11:30        | 12:21 |

The drifters and methodology used were in agreement with the standardized operational method for conducting hydrodynamic surveys developed by the Ministère de l'Environnement du Québec (Thibault, 2000). Each test was made using six drifters with drogues located at a depth of six meters (figure 1). The drifters had a bright and highly visible flag on it's top vertical segment with a unique number marked on it that was visible from a distance up to 500 meters.

Drifter with floater and drogue

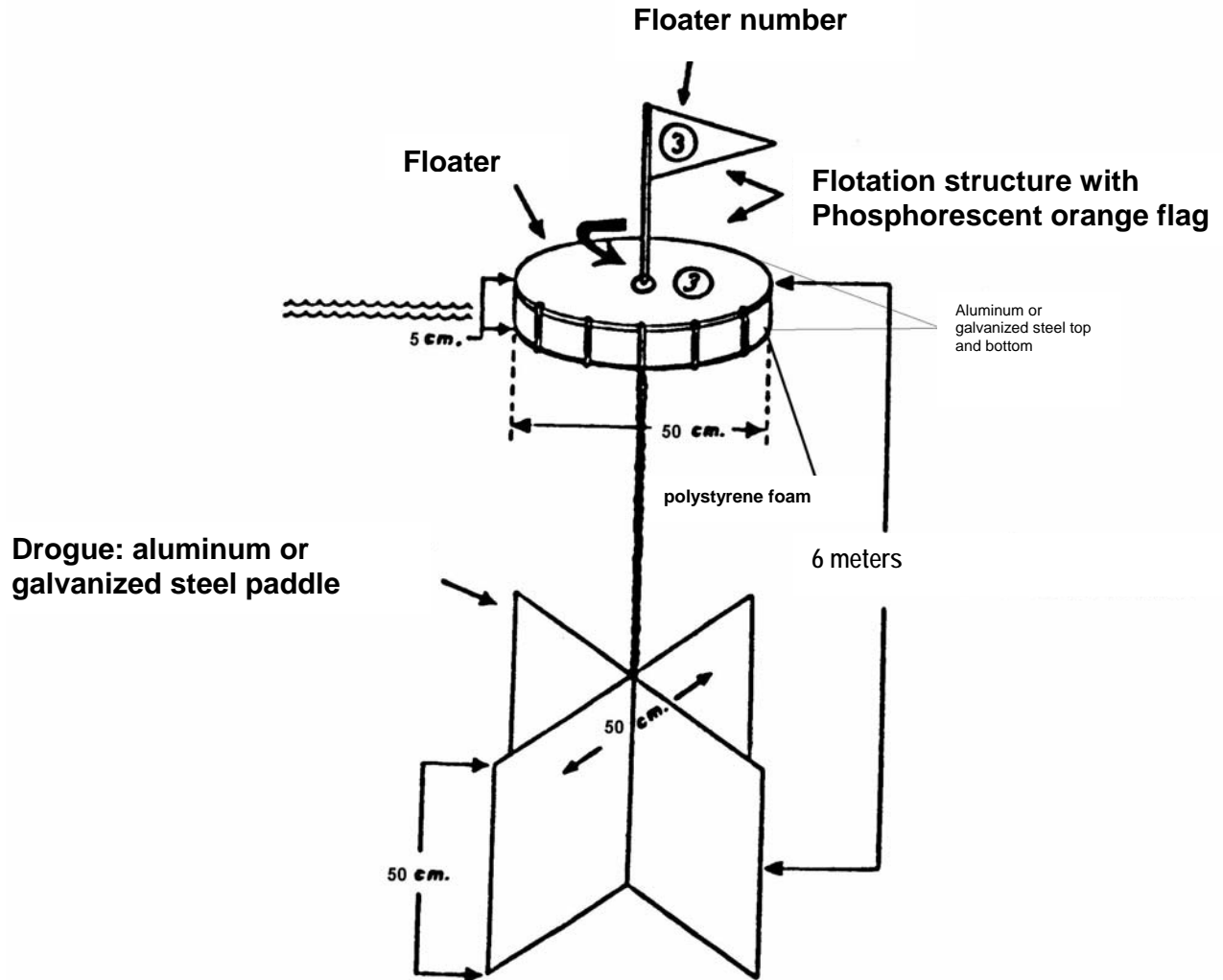


Figure 1 Detail of drifters used in surveys

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The six drifters at 500 meters spacing were released approximately 2000 meters from either side of the center of the proposed berth, upstream during ebb tides and downstream during flood tides (figure 2). Note that throughout this report, downstream refers to flows directed along the direction that the St. Lawrence River flows (northeast) and upstream refers to flows direction opposite to the River flow direction (southwest).

The drifter positions were continuously recorded by technicians who periodically came alongside the drifter with boats (roughly every 15 to 30 minutes depending on conditions). The boats were equipped with a precision GPS unit, a Garmin 76 DGPS (accurate to  $\pm 1.5$  m). Additionally, one of the six drifters in the test on September 29 and two of the six drifters in each of the following tests were equipped with a precision GPS (Garmin ETrex), attached to the base of the drifter stick.

To ensure reliable operation, each GPS used in the study had been co-located and simultaneously operated, with internal track recording, at a known location for a period of 8 hours. Results demonstrated that the accuracy was achieved.

The tests on October 20 and 21 had to be interrupted in order not to lose drifters and associated data, the first day due to nightfall, and the second due to strong winds.



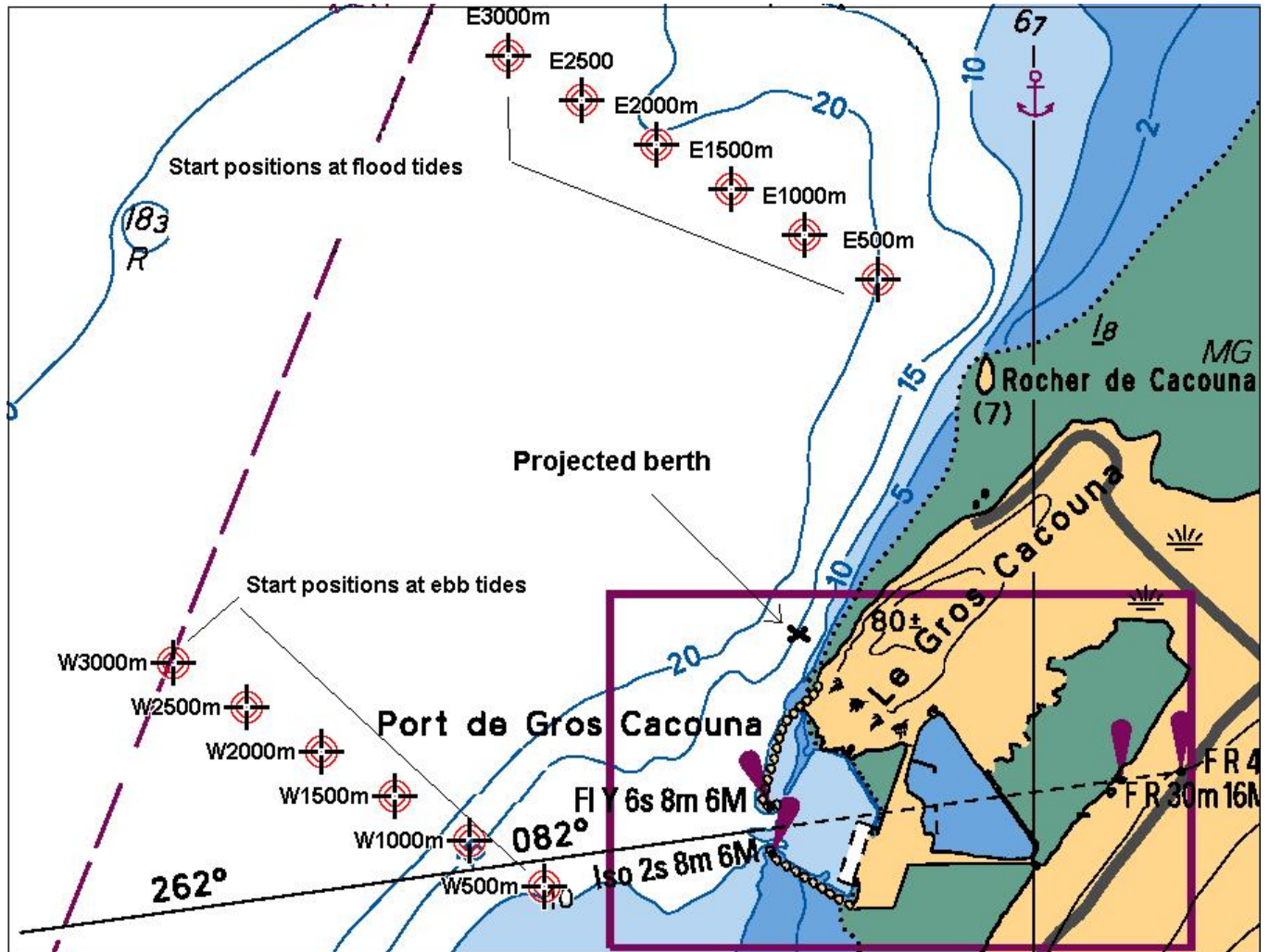


Figure 2 Position of drifters at start of tests

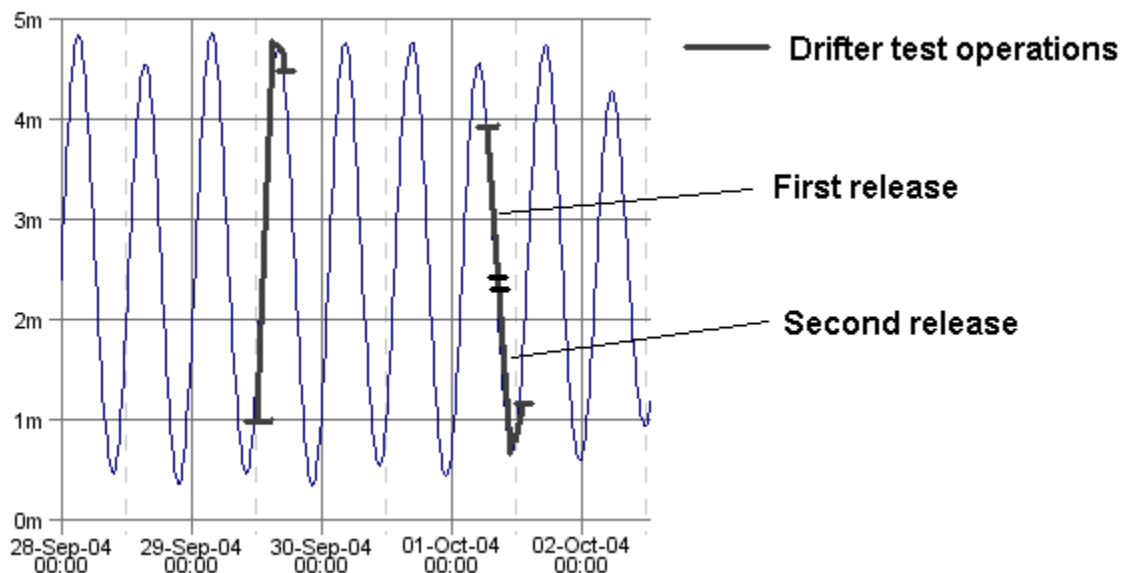
Note : The distance eastward (E) and westward (W) from the projected berth is two kilometers in each direction, while the distance towards open water from the projected berth is indicated in figure in meters for each starting position.

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### 3.0 RESULTS

#### 3.1 SURVEY CONDITIONS

Spring tidal current surveys were conducted under good weather conditions on September 29 between 11:36 and 16:55 (flood tide) as well as on October 1 between 6:39 and 11:37 (ebb tide, figure 3). Southwest winds up to 10 km/h were observed during the first of these two surveys, whereas sea was completely calm (no winds) during the second survey. Due to great drifter movements on October 1, when drifter displacements exceeded 8 kilometers from the start point, a second release was made. The first release was performed between 6:39 and 8:50 (figure 6) and the second release was made between 9:08 and 11:37 (figure 7).

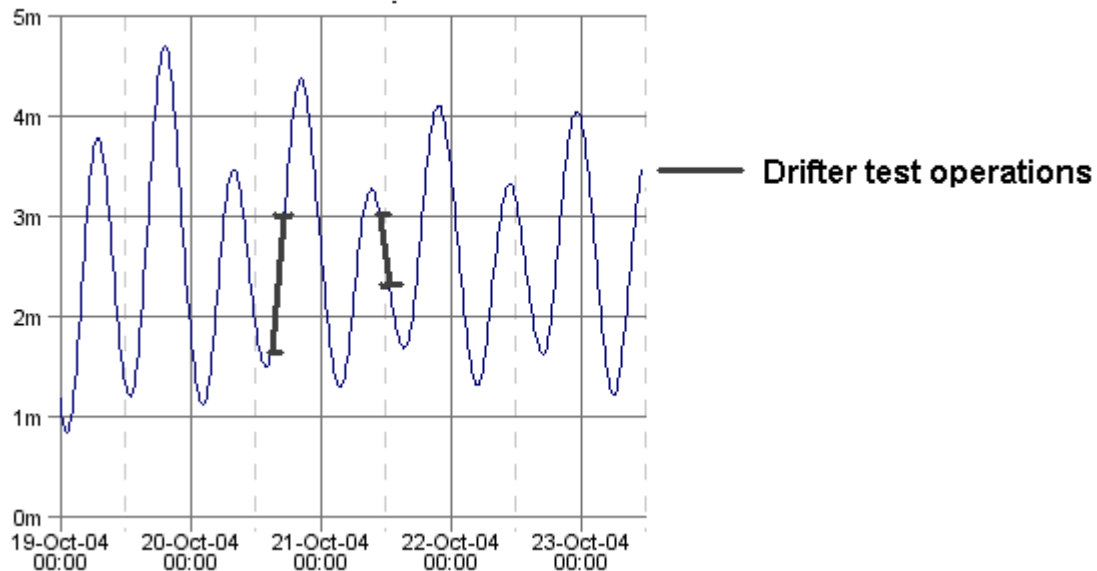


**Figure 3 Survey conditions at spring tides.**

Neap tide current surveys were conducted three weeks later on October 20 and 21, with operations starting at 14:41 through flood the first day and at 10:18 through ebb the following day (figure 4). The survey on October 20 was conducted under good weather conditions, as northeast winds were not exceeding 15 km/h. However, operations had to be interrupted after 2 hours and 40 minutes due to nightfall. On October 21, drifters were collected after 2.5 hours as a result of fairly strong northeast winds reaching 25 km/h. Due to current reversal for offshore drifters the same day, drifter #700 was moving towards the southwest in contrast to others that were moving northeast. Consequently, the great distances created between drifters would have

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made it impossible to continue the test. Therefore, the drifter #700 was picked up at 11:21 and released at its initial position.



**Figure 4 Survey conditions at neap tides.**

Drifter trajectories are presented in figure 5 to 9. Appendix A1 to A5 present in a more comprehensive way these figures with the speed of the drifters added. Additionally, displacement and speed of drifters between positions are presented in table 2 to table 5. Finally, current forecasts produced by the Saint-Lawrence Observatory for the days of interest are presented in Appendix B as a comparison to the results of this study. The forecasts are presented by date and hour starting with September 29.

### **3.2 SPRING TIDE CONDITIONS. FLOOD TIDE**

Drifter movements were in a southwest direction (upstream) for all of the drifters, with the three closest to the coast having a small onshore flow component and those further offshore exhibiting a slight offshore flow component (figure 5). Average speeds varied between 0.45 m/s (drifter # 300) and 0.78 m/s (drifter # 600, table 2). Hence, a greater current velocity was recorded further offshore in open waters.

Maximum speeds (0.67m/s) were reached at around four hours after low tide for drifter # 100 to 300, while five hours was needed for the three outer drifters to reach their maximum speeds (0.97m/s, drifter # 600).

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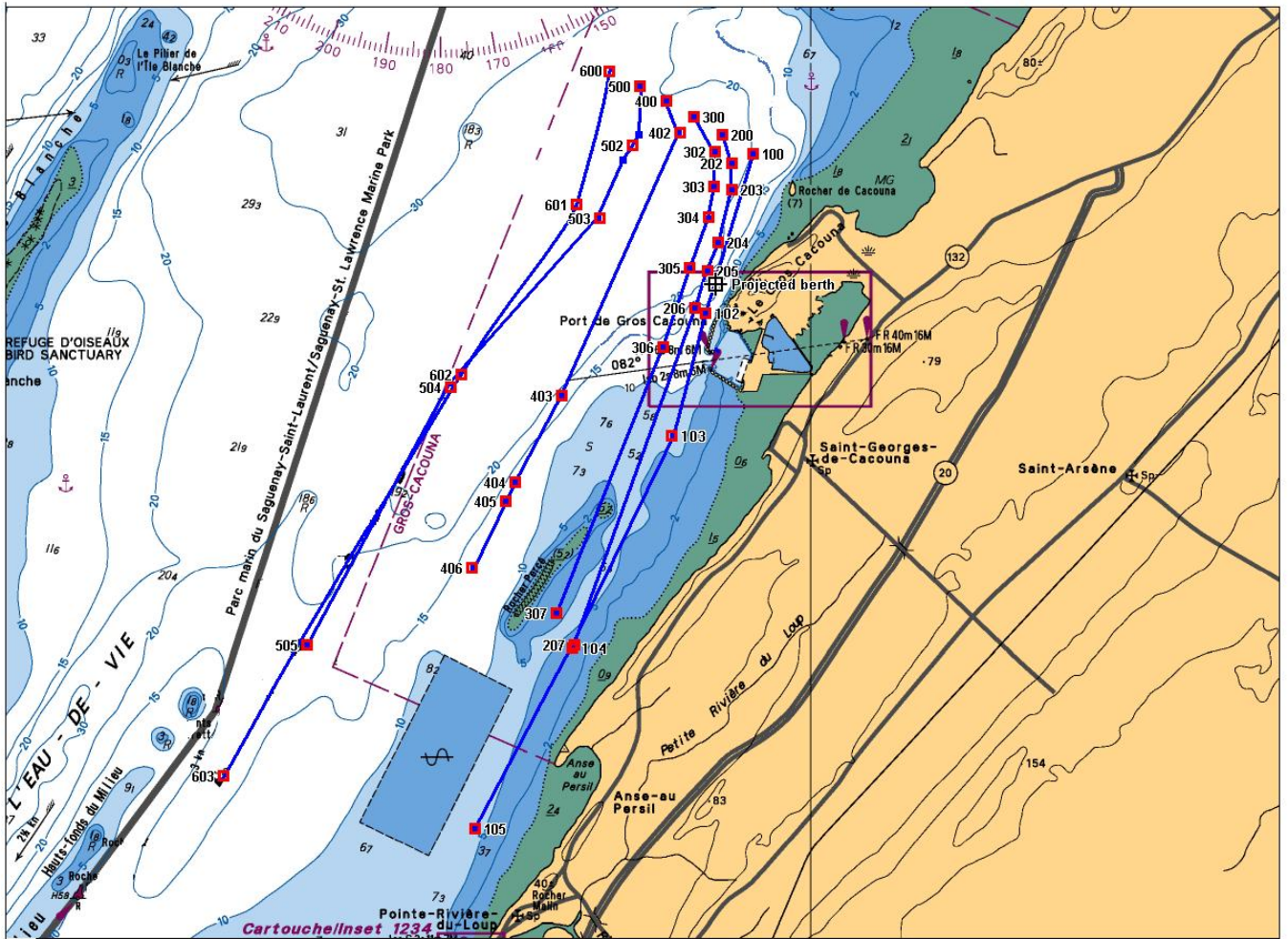


Figure 5 Drifter trajectories. Spring tide conditions, flood.

**Table 2. Drifter movements at flood tide during spring tide conditions, September 29.**

| <b>Drifter #<br/>(waypoints)</b>                  | <b>Date<br/>(yyyymmdd)</b> | <b>Time<br/>(hhmmss)</b> | <b>Speed<br/>(m/s)</b> | <b>Direction<br/>(magnetic degrés)</b> | <b>Distance<br/>(m)</b> | <b>Total distance from<br/>releasing point</b> |
|---|----------------------------|--------------------------|------------------------|--|-------------------------|--|
| <b>Low tide at 10:18, High tide at 16:16</b>      |                            |                          |                        |  |                         |  |
| <b>100</b>  | 20040929                   | 113600                   | 0.00                   |  | 0                       | 0  |
| <b>101</b>  | 20040929                   | 114100                   | 0.17                   | 180                                    | 46.7                    | 46.7   |
| <b>102</b>  | 20040929                   | 124400                   | 0.67                   | 197                                    | 2516                    | 2562.7   |
| <b>103</b>  | 20040929                   | 134300                   | 0.53                   | 195                                    | 1914.1                  | 4476.8   |
| <b>104</b>  | 20040929                   | 151300                   | 0.67                   | 205                                    | 3588.3                  | 8065.2   |
| <b>105</b>  | 20040929                   | 163800                   | 0.61                   | 209                                    | 3088.8                  | 11154  |
| <b>200</b>  | 20040929                   | 114100                   | 0.00                   |  | 0                       | 0  |
| <b>202</b>  | 20040929                   | 121700                   | 0.19                   | 164                                    | 446.7                   | 446.7  |
| <b>203</b>  | 20040929                   | 123300                   | 0.42                   | 178                                    | 400.5                   | 847.1  |
| <b>204</b>  | 20040929                   | 130200                   | 0.47                   | 195                                    | 823.6                   | 1670.7   |
| <b>205</b>  | 20040929                   | 131600                   | 0.53                   | 203                                    | 452.2                   | 2122.9   |
| <b>206</b>  | 20040929                   | 133100                   | 0.67                   | 199                                    | 605.4                   | 2728.3   |
| <b>207</b>  | 20040929                   | 163800                   | 0.47                   | 200                                    | 5432.1                  | 8160.4   |
| <b>300</b>  | 20040929                   | 115200                   | 0.00                   |  | 0                       | 0  |
| <b>302</b>  | 20040929                   | 123000                   | 0.28                   | 151                                    | 623.7                   | 623.7  |
| <b>303</b>  | 20040929                   | 125300                   | 0.39                   | 182                                    | 520.5                   | 1144.2   |
| <b>304</b>  | 20040929                   | 131000                   | 0.50                   | 190                                    | 496.4                   | 1640.5   |
| <b>305</b>  | 20040929                   | 133700                   | 0.50                   | 200                                    | 803.3                   | 2443.8   |
| <b>306</b>  | 20040929                   | 141100                   | 0.61                   | 198                                    | 1241.2                  | 3685   |
| <b>307</b>  | 20040929                   | 165500                   | 0.44                   | 202                                    | 4373.6                  | 8058.6   |
| <b>400</b>  | 20040929                   | 115700                   | 0.00                   |  | 0                       | 0  |
| <b>402</b>  | 20040929                   | 123300                   | 0.25                   | 157                                    | 520.4                   | 520.4  |
| <b>403</b>  | 20040929                   | 144700                   | 0.56                   | 204                                    | 4374.3                  | 4894.7   |
| <b>404</b>  | 20040929                   | 151800                   | 0.78                   | 208                                    | 1466.4                  | 6361.1   |
| <b>405</b>  | 20040929                   | 152600                   | 0.67                   | 208                                    | 315.7                   | 6676.8   |
| <b>406</b>  | 20040929                   | 155400                   | 0.67                   | 207                                    | 1136.5                  | 7813.2   |
| <b>500</b>  | 20040929                   | 120500                   | 0.00                   |  | 0                       | 0  |
| <b>501</b>  | 20040929                   | 123600                   | 0.39                   | 186                                    | 745.2                   | 745.2  |
| <b>502</b>  | 20040929                   | 124700                   | 0.69                   | 207                                    | 455.9                   | 1201.1   |
| <b>503</b>  | 20040929                   | 132100                   | 0.47                   | 204                                    | 946.4                   | 2147.5   |
| <b>504</b>  | 20040929                   | 142800                   | 0.83                   | 222                                    | 3363.9                  | 5511.4   |
| <b>505</b>  | 20040929                   | 160800                   | 0.75                   | 209                                    | 4543.9                  | 10055.3  |
| <b>600*: GPS tracked 174 points reduced to 15</b> |                            |                          |                        |  |                         |  |
| <b>600</b>  | 20040929                   | 121009                   | 0.00                   |  | 0                       | 0  |
|   | 20040929                   | 121451                   | 0.72                   | 193                                    | 207.4                   | 207.4  |
|   | 20040929                   | 122354                   | 0.86                   | 193                                    | 473.1                   | 680.5  |
|   | 20040929                   | 125306                   | 0.78                   | 196                                    | 1368.7                  | 2049.2   |
| <b>601</b>  | 20040929                   | 125600                   |                        |  |                         |  |
|   | 20040929                   | 130424                   | 0.47                   | 194                                    | 312.5                   | 2361.7   |
|   | 20040929                   | 133659                   | 0.78                   | 215                                    | 1516.9                  | 3878.6   |
|   | 20040929                   | 134940                   | 0.92                   | 211                                    | 697.9                   | 4576.5   |
| <b>602</b>  | 20040929                   | 140103                   |                        |  |                         |  |
|   | 20040929                   | 140327                   | 0.97                   | 210                                    | 800.1                   | 5376.6   |
|   | 20040929                   | 145550                   | 0.97                   | 212                                    | 3045.4                  | 8421.9   |
|   | 20040929                   | 151632                   | 0.81                   | 210                                    | 1017.5                  | 9439.5   |
|   | 20040929                   | 152558                   | 0.78                   | 212                                    | 436.1                   | 9875.5   |
|   | 20040929                   | 154534                   | 0.83                   | 210                                    | 965.1                   | 10840.7  |
|   | 20040929                   | 155442                   | 0.78                   | 209                                    | 433.4                   | 11274  |
| <b>603</b>  | 20040929                   | 161929                   |                        |  |                         |  |
|   | 20040929                   | 161951                   | 0.72                   | 210                                    | 1089.7                  | 12363.7  |
|   | 20040929                   | 162231                   | 0.50                   | 210                                    | 80.7                    | 12444.3  |

**Table 2. Drifter movements at flood tide during spring tide conditions, September 29.**

***Speed statistics:***

| Drifter # | Speed (m/s) |      |      |
|-----------|-------------|------|------|
|           | min         | max  | mean |
| 100       | 0.17        | 0.67 | 0.53 |
| 200       | 0.19        | 0.67 | 0.46 |
| 300       | 0.28        | 0.61 | 0.45 |
| 400       | 0.25        | 0.78 | 0.58 |
| 500       | 0.39        | 0.83 | 0.63 |
| 600*      | 0.25        | 1.31 | 0.82 |

\* Drifters tracked with GPS attached to the bottom of drifter stick. Speed statistics is calculated with the total numbers of waypoints of these GPS-tracks. Data in table represent a selection of the total numbers of GPS-track waypoints (not numbered), as well as waypoints taken by technician in boat coming alongside drifter (numbered, no speed statistics calculated for these points)

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**3.3 SPRING TIDE CONDITIONS. EBB TIDE**

Drifter speeds recorded during ebb tide and spring tide conditions were the highest observed during the study (table 3a and 3b). Maximum speeds (2.06 m/s, drifter # 500), were recorded about 3.5 hours after high tide when drifters speeded up passing Île Verte island. On approaching the island, drifters closer to the shoreline changed direction towards the north-northeast, ending up close to those further out from the shore (figure 6). The same observations were made for the second release of drifters (figure 7).

Average speeds calculated for the 6 drifters in the first release reveals values shifting from 1.06 m/s (drifter # 600) to 1.27 m/s (drifter # 400). However, the results of the second release of drifters show great variations in average speeds, with offshore drifters moving about twice as fast as those closer to the shoreline (mean values between 1.41 and 1.51 m/s for drifter # 400 to 600 compared to values between 0.58 m/s and 1.13 m/s for drifter # 100 to 200).

**3.4 NEAP TIDE CONDITIONS. FLOOD TIDE**

Measurements started 0.5 hour after low tide (14:05) before current inversion. Figure 8 shows the inversion taking place around 15:15, 1.5 hours after low tide. Drifters were all turning upstream during the inversion and thereafter accelerating. The highest velocity appeared close to the shore (drifter # 100, maximum speed 0.67 m/s, table 4).

Average speeds have been calculated from measurements after 16:15, when the flood tide conditions were well established. Mean velocities were relatively constant. Due to nightfall, drifter measurements had to be interrupted before the drifters had reached maximum speeds. Drifters were still accelerating at the time they were recovered.



**Table 3a. Drifter movements at ebb tide during spring tide conditions, October 1, release 1.**

| Drifter #<br>(waypoints)                                    | Date<br>(yyyymmdd) | Time<br>(hhmmss) | Speed<br>(m/s) | Direction<br>(magnetic degrees) | Distance<br>(m) | Total distance from<br>releasing point |
|---|--------------------|------------------|----------------|---------------------------------|-----------------|--|
| High tide at 05:12, Low tide at 11:24                       |                    |                  |                |                                 |                 |  |
| <i>100* release 1: GPS tracked 153 points reduced to 15</i> |                    |                  |                |                                 |                 |  |
| 100   | 20041001           | 70208            | 0.00           |                                 | 0               | 0                                      |
|   | 20041001           | 71349            | 0.72           | 27                              | 505.9           | 505.9                                  |
| 101   | 20041001           | 71754            |                |                                 |                 |  |
|   | 20041001           | 72104            | 0.81           | 19                              | 350.8           | 856.6                                  |
|   | 20041001           | 72905            | 0.92           | 18                              | 445.5           | 1302.2                                 |
| 103   | 20041001           | 73359            |                |                                 |                 |  |
|   | 20041001           | 73747            | 0.97           | 15                              | 508.2           | 1810.4                                 |
| 104   | 20041001           | 74454            |                |                                 |                 |  |
|   | 20041001           | 75649            | 1.06           | 15                              | 1193.4          | 3003.8                                 |
| 105   | 20041001           | 80035            |                |                                 |                 |  |
|   | 20041001           | 80554            | 1.14           | 16                              | 614.2           | 3617.9                                 |
|   | 20041001           | 82240            | 1.19           | 17                              | 1206            | 4824                                   |
| 106   | 20041001           | 82303            |                |                                 |                 |  |
|   | 20041001           | 82631            | 1.33           | 10                              | 307.2           | 5131.2                                 |
|   | 20041001           | 82846            | 1.42           | 2                               | 190.2           | 5321.4                                 |
|   | 20041001           | 83603            | 1.64           | 2                               | 716.4           | 6037.8                                 |
|   | 20041001           | 83940            | 1.67           | 4                               | 363.9           | 6401.8                                 |
|   | 20041001           | 84159            | 1.69           | 8                               | 236             | 6637.8                                 |
|   | 20041001           | 84444            | 1.81           | 14                              | 300             | 6937.8                                 |
|   | 20041001           | 84740            | 1.83           | 18                              | 321             | 7258.8                                 |
| 107   | 20041001           | 84801            |                |                                 |                 |  |
| 200   | 20041001           | 65500            | 0.00           |                                 | 0               | 0                                      |
| 201   | 20041001           | 70800            | 0.72           | 33                              | 568.9           | 568.9                                  |
| 202   | 20041001           | 72200            | 0.86           | 27                              | 731.3           | 1300.3                                 |
| 203   | 20041001           | 73700            | 0.97           | 23                              | 864.3           | 2164.6                                 |
| 204   | 20041001           | 74800            | 1.08           | 14                              | 722.7           | 2887.3                                 |
| 205   | 20041001           | 80600            | 1.11           | 35                              | 1204.4          | 4091.7                                 |
| 206   | 20041001           | 82800            | 1.50           | 10                              | 1986.1          | 6077.8                                 |
| 207   | 20041001           | 84200            | 1.97           | 18                              | 1652.5          | 7730.2                                 |
| 300   | 20041001           | 65200            | 0.00           |                                 | 0               | 0                                      |
| 301   | 20041001           | 71100            | 0.86           | 30                              | 983.7           | 983.7                                  |
| 302   | 20041001           | 72700            | 0.94           | 29                              | 918             | 1901.6                                 |
| 303   | 20041001           | 74000            | 1.00           | 26                              | 788.1           | 2689.7                                 |
| 304   | 20041001           | 75200            | 1.19           | 16                              | 866             | 3555.8                                 |
| 305   | 20041001           | 81100            | 1.42           | 12                              | 1615.9          | 5171.7                                 |
| 306   | 20041001           | 83500            | 1.92           | 19                              | 2763.7          | 7935.5                                 |
| 400   | 20041001           | 64500            | 0.00           |                                 | 0               | 0                                      |
| 401   | 20041001           | 70000            | 0.78           | 31                              | 691.2           | 691.2                                  |
| 402   | 20041001           | 71500            | 0.94           | 33                              | 860             | 1551.2                                 |
| 403   | 20041001           | 73000            | 1.06           | 32                              | 943.6           | 2494.8                                 |
| 404   | 20041001           | 74500            | 1.14           | 24                              | 1017            | 3511.8                                 |
| 405   | 20041001           | 80000            | 1.42           | 14                              | 1283.5          | 4795.3                                 |
| 406   | 20041001           | 81600            | 1.75           | 16                              | 1691.2          | 6486.5                                 |
| 407   | 20041001           | 83300            | 1.83           | 25                              | 1861.5          | 8348                                   |
| 500   | 20041001           | 64000            | 0.00           |                                 | 0               | 0                                      |
| 501   | 20041001           | 65500            | 0.64           | 39                              | 578.2           | 578.2                                  |
| 502   | 20041001           | 71000            | 0.72           | 38                              | 661.7           | 1239.9                                 |
| 503   | 20041001           | 72500            | 0.97           | 30                              | 865.3           | 2105.2                                 |
| 504   | 20041001           | 74000            | 1.03           | 27                              | 920.4           | 3025.6                                 |
| 505   | 20041001           | 80400            | 1.28           | 18                              | 1838            | 4863.6                                 |
| 506   | 20041001           | 81200            | 2.06           | 17                              | 987.4           | 5851                                   |
| 507   | 20041001           | 83500            | 1.94           | 23                              | 2702.2          | 8553.2                                 |



**Table 3a. Drifter movements at ebb tide during spring tide conditions, October 1, release 1.**

| Drifter #<br>(waypoints)                                   | Date<br>(yyyymmdd) | Time<br>(hhmmss) | Speed<br>(m/s) | Direction<br>(magnetic degrés) | Distance<br>(m) | Total distance from<br>releasing point |
|--|--------------------|------------------|----------------|--------------------------------|-----------------|--|
| High tide at 05:12, Low tide at 11:24                      |                    |                  |                |                                |                 |  |
| <i>600* release 1: GPS tracked 210 points reduced to 9</i> |                    |                  |                |                                |                 |  |
| 600  | 20041001           | 63935            | 0.00           |                                | 0               | 7390                                   |
| 601  | 20041001           | 65200            |                |                                |                 |  |
|  | 20041001           | 65858            | 0.42           | 37                             | 475.7           | 475.7                                  |
| 602  | 20041001           | 70500            |                |                                |                 |  |
| 603  | 20041001           | 71900            |                |                                |                 |  |
|  | 20041001           | 72643            | 0.64           | 33                             | 1048.3          | 1524                                   |
| 604  | 20041001           | 73400            |                |                                |                 |  |
|  | 20041001           | 74035            | 0.81           | 27                             | 671.1           | 2195.1                                 |
| 605  | 20041001           | 75000            |                |                                |                 |  |
|  | 20041001           | 75654            | 0.97           | 24                             | 960.5           | 3155.5                                 |
| 606  | 20041001           | 80700            |                |                                |                 |  |
| 607  | 20041001           | 82200            |                |                                |                 |  |
|  | 20041001           | 81840            | 1.33           | 18                             | 1733.3          | 4888.8                                 |
|  | 20041001           | 82518            | 1.50           | 22                             | 597.7           | 5486.5                                 |
|  | 20041001           | 83710            | 1.56           | 25                             | 1113.2          | 6599.6                                 |
| 608  | 20041001           | 84500            |                |                                |                 |  |
| 609  | 20041001           | 85019            | 1.89           | 27                             | 1487.3          | 8086.9                                 |

**Speed statistics:**

| Drifter # | Speed (m/s) |      |      |
|-----------|-------------|------|------|
|           | min         | max  | mean |
| 100*      | 0.31        | 1.92 | 1.17 |
| 200       | 0.72        | 1.97 | 1.17 |
| 300       | 0.86        | 1.92 | 1.22 |
| 400       | 0.78        | 1.83 | 1.27 |
| 500       | 0.64        | 2.06 | 1.23 |
| 600*      | 0.22        | 2.25 | 1.06 |

\* Drifters tracked with GPS attached to the bottom of drifter stick. Speed statistics is calculated with the total numbers of waypoints of these GPS-tracks. Data in table represent a selection of the total numbers of GPS-track waypoints (not numbered), as well as waypoints taken by technician in boat coming alongside drifter (numbered, no speed statistics calculated for these points)

**Table 3b. Drifter movements at ebb tide during spring tide conditions,  
October 1, release 2.**

| <b>Drifter #<br/>(waypoints)</b>   | <b>Date<br/>(yyyymmdd)</b> | <b>Time<br/>(hhmmss)</b> | <b>Speed<br/>(m/s)</b> | <b>Direction<br/>(magnetic degrés)</b> | <b>Distance<br/>(m)</b> | <b>Total distance from<br/>releasing point</b> |
|--|----------------------------|--------------------------|------------------------|--|-------------------------|--|
| <b>High tide at 05:12, Low tide at 11:24</b>                             |                            |                          |                        |  |                         |  |
| <b><i>100*: release 2    GPS tracked    195 points reduced to 10</i></b> |                            |                          |                        |  |                         |  |
| <b>108</b>   | 20041001                   | 93528                    | 0.00                   |  | 0                       | 0  |
| <b>109</b>   | 20041001                   | 94601                    |                        |  |                         |  |
|  | 20041001                   | 95638                    | 0.69                   | 22                                     | 888                     | 888  |
| <b>110</b>   | 20041001                   | 95642                    |                        |  |                         |  |
|  | 20041001                   | 100702                   | 0.69                   | 20                                     | 428.9                   | 1316.9   |
| <b>111</b>   | 20041001                   | 100738                   |                        |  |                         |  |
|  | 20041001                   | 101342                   | 0.64                   | 15                                     | 252.8                   | 1569.7   |
|  | 20041001                   | 102041                   | 0.67                   | 12                                     | 278.1                   | 1847.8   |
| <b>112</b>   | 20041001                   | 102246                   |                        |  |                         |  |
|  | 20041001                   | 102616                   | 0.67                   | 21                                     | 227.5                   | 2075.4   |
| <b>113</b>   | 20041001                   | 104225                   |                        |  |                         |  |
|  | 20041001                   | 105534                   | 0.61                   | 25                                     | 1062.2                  | 3137.6   |
|  | 20041001                   | 110351                   | 0.58                   | 38                                     | 284.8                   | 3422.4   |
|  | 20041001                   | 112249                   | 0.50                   | 37                                     | 553.2                   | 3975.6   |
| <b>114</b>   | 20041001                   | 113742                   | 0.33                   | 42                                     | 298.9                   | 4274.5   |
| <b>208</b>   | 20041001                   | 93200                    | 0.00                   |  | 0                       | 0  |
| <b>209</b>   | 20041001                   | 94300                    | 0.83                   | 24                                     | 559                     | 559  |
| <b>210</b>   | 20041001                   | 95400                    | 0.78                   | 25                                     | 505.2                   | 1064.2   |
| <b>211</b>   | 20041001                   | 100500                   | 0.72                   | 22                                     | 480.6                   | 1544.8   |
| <b>212</b>   | 20041001                   | 101800                   | 0.75                   | 24                                     | 577.4                   | 2122.2   |
| <b>213</b>   | 20041001                   | 103900                   | 0.72                   | 25                                     | 902.7                   | 3024.9   |
| <b>307</b>   | 20041001                   | 92600                    | 0.00                   |  | 0                       | 0  |
| <b>308</b>   | 20041001                   | 93900                    | 1.17                   | 30                                     | 915.1                   | 915.1  |
| <b>309</b>   | 20041001                   | 95100                    | 1.11                   | 33                                     | 799.8                   | 1714.9   |
| <b>310</b>   | 20041001                   | 100100                   | 1.17                   | 29                                     | 703.3                   | 2418.2   |
| <b>311</b>   | 20041001                   | 101300                   | 1.08                   | 29                                     | 770.8                   | 3189   |
| <b>312</b>   | 20041001                   | 103000                   | 1.17                   | 30                                     | 1202.8                  | 4391.8   |
| <b>313</b>   | 20041001                   | 110900                   | 1.08                   | 31                                     | 2510.9                  | 6902.7   |
| <b>408</b>   | 20041001                   | 92200                    | 0.00                   |  | 0                       | 0  |
| <b>409</b>   | 20041001                   | 93900                    | 1.39                   | 32                                     | 1424.7                  | 1424.7   |
| <b>410</b>   | 20041001                   | 95100                    | 1.42                   | 32                                     | 1026.3                  | 2451   |
| <b>411</b>   | 20041001                   | 95900                    | 1.50                   | 33                                     | 717.4                   | 3168.4   |
| <b>412</b>   | 20041001                   | 101200                   | 1.28                   | 29                                     | 986.1                   | 4154.5   |
| <b>413</b>   | 20041001                   | 102100                   | 1.33                   | 26                                     | 726.8                   | 4881.2   |
| <b>414</b>   | 20041001                   | 105400                   | 1.56                   | 25                                     | 3060                    | 7941.2   |
| <b>508</b>   | 20041001                   | 91700                    | 0.00                   |  | 0                       | 0  |
| <b>509</b>   | 20041001                   | 93600                    | 1.39                   | 32                                     | 1597.2                  | 1597.2   |
| <b>510</b>   | 20041001                   | 94800                    | 1.39                   | 34                                     | 997.2                   | 2594.5   |
| <b>511</b>   | 20041001                   | 95700                    | 1.42                   | 32                                     | 770.7                   | 3365.2   |
| <b>512</b>   | 20041001                   | 100900                   | 1.36                   | 30                                     | 981.8                   | 4347   |
| <b>513</b>   | 20041001                   | 102400                   | 1.58                   | 28                                     | 1417.7                  | 5764.7   |
| <b>514</b>   | 20041001                   | 104200                   | 1.50                   | 32                                     | 1625.3                  | 7390   |

**Table 3b. Drifter movements at ebb tide during spring tide conditions, October 1, release 2.**

| Drifter #<br>(waypoints)                                   | Date<br>(yyyymmdd) | Time<br>(hhmmss) | Speed<br>(m/s) | Direction<br>(magnetic degrés) | Distance<br>(m) | Total distance from<br>releasing point |
|--|--------------------|------------------|----------------|--------------------------------|-----------------|--|
| High tide at 05:12, Low tide at 11:24                      |                    |                  |                |                                |                 |  |
| <i>600* release 2: GPS tracked 161 points reduced to 8</i> |                    |                  |                |                                |                 |  |
| 610  | 20041001           | 90810            | 0.00           |                                | 0               | 0                                      |
|  | 20041001           | 92734            | 1.39           | 30                             | 1616.3          | 1616.3                                 |
| 611  | 20041001           | 93300            |                |                                |                 |  |
| 612  | 20041001           | 94500            |                |                                |                 |  |
|  | 20041001           | 94537            | 1.36           | 34                             | 1485.4          | 3101.7                                 |
| 613  | 20041001           | 95400            |                |                                |                 |  |
| 614  | 20041001           | 100400           |                |                                |                 |  |
|  | 20041001           | 100824           | 1.50           | 32                             | 2064.4          | 5166.1                                 |
| 615  | 20041001           | 101600           |                |                                |                 |  |
|  | 20041001           | 102126           | 1.58           | 35                             | 1234.3          | 6400.4                                 |
| 616  | 20041001           | 102700           |                |                                |                 |  |
|  | 20041001           | 102811           | 1.78           | 43                             | 715.9           | 7116.2                                 |
|  | 20041001           | 103502           | 1.83           | 37                             | 757.7           | 7873.9                                 |
| 617  | 20041001           | 103634           | 1.44           | 53                             | 133.2           | 8007.2                                 |

**Speed statistics:**

| Drifter # | Speed (m/s) |      |      |
|-----------|-------------|------|------|
|           | min         | max  | mean |
| 100*      | 0.08        | 0.83 | 0.58 |
| 200       | 0.72        | 0.83 | 0.76 |
| 300       | 1.08        | 1.17 | 1.13 |
| 400       | 1.28        | 1.56 | 1.41 |
| 500       | 1.36        | 1.58 | 1.44 |
| 600*      | 1.06        | 1.92 | 1.51 |

\* Drifters tracked with GPS attached to the bottom of drifter stick. Speed statistics is calculated with the total numbers of waypoints of these GPS-tracks. Data in table represent a selection of the total numbers of GPS-track waypoints (not numbered), as well as waypoints taken by technician in boat coming alongside drifter (numbered, no speed statistics calculated for these points)

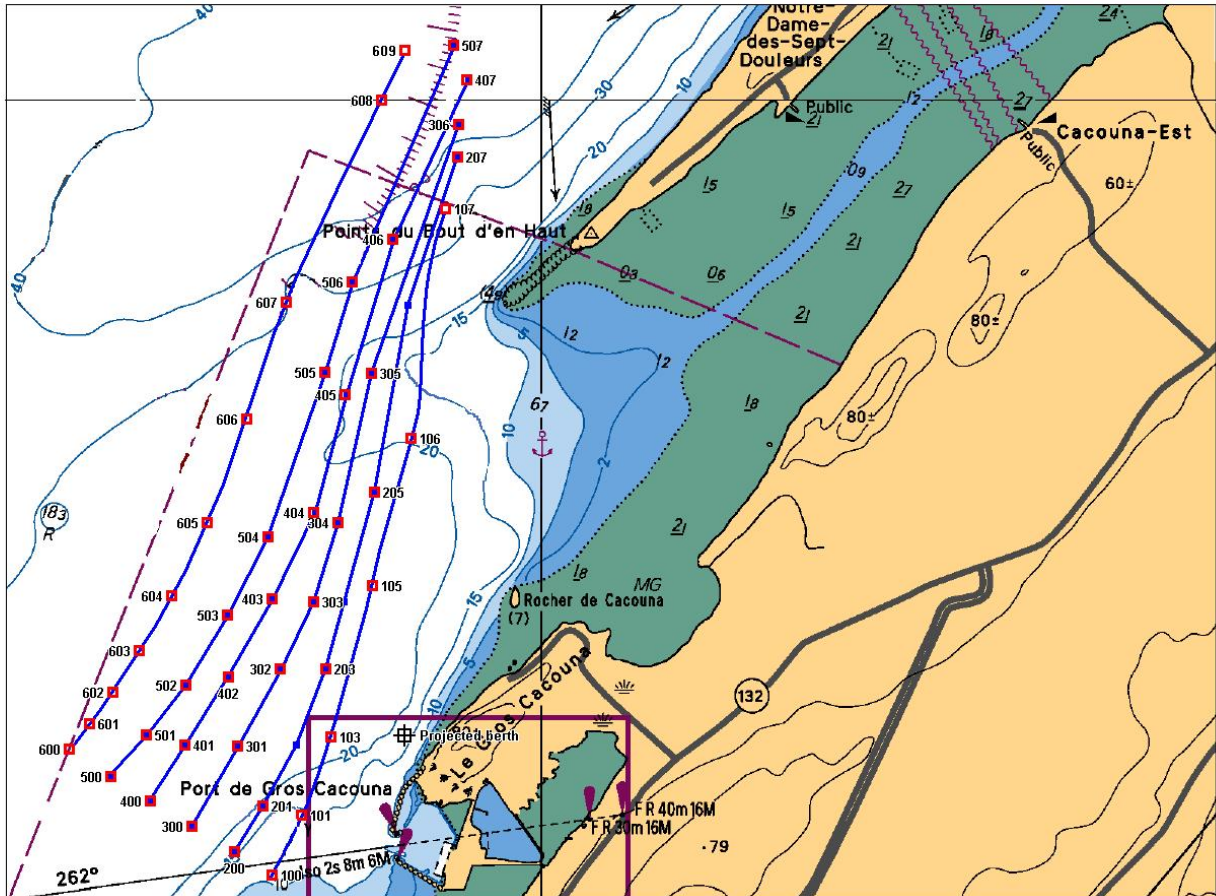


Figure 6 Drifter trajectories. Spring tide conditions. ebb, release 1.

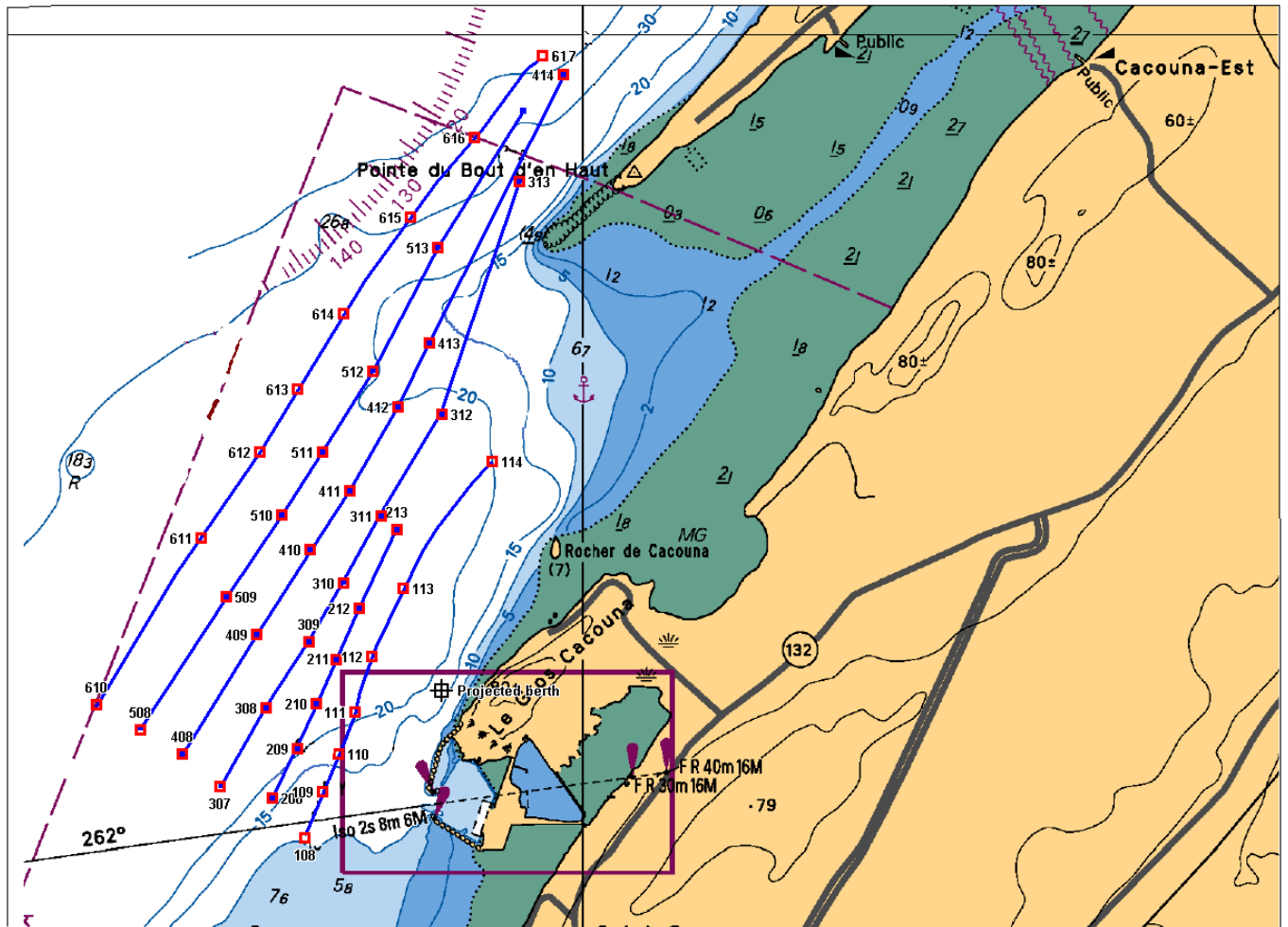


Figure 7 Drifter trajectories. Spring tide conditions, ebb, release 2.

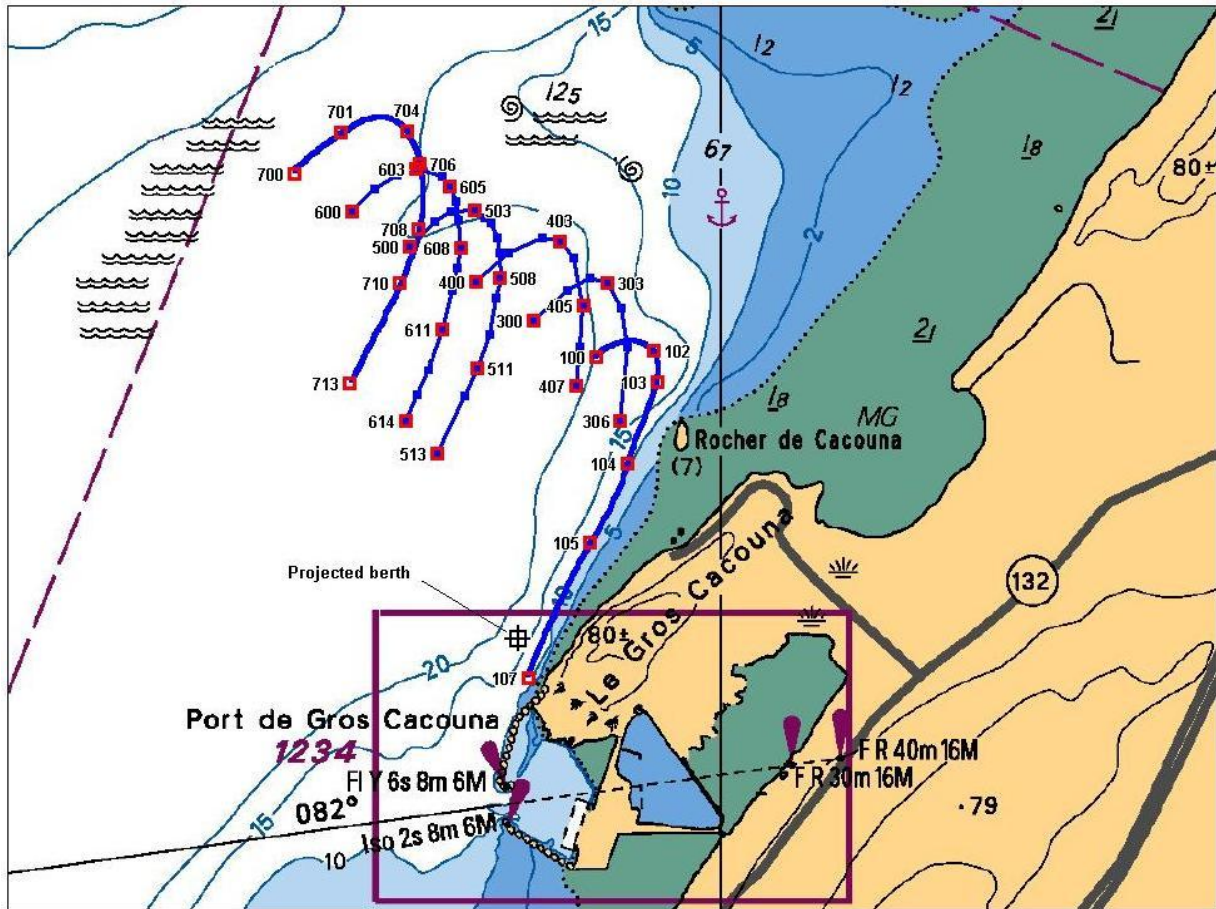


Figure 8 Drifter trajectories. Neap tide conditions, flood.

**Table 4. Drifter movements at flood tide during neap tide conditions, October 20.**

**Drifter test interrupted at 17:23 due to nightfall**

| <b>Drifter #<br/>(waypoints)</b>             | <b>Date<br/>(yyyymmdd)</b> | <b>Time<br/>(hhmmss)</b> | <b>Speed<br/>(m/s)</b>          | <b>Direction<br/>(magnetic degrés)</b> | <b>Distance<br/>(m)</b> | <b>Total distance from<br/>releasing point</b> |
|--|----------------------------|--------------------------|---------------------------------|--|-------------------------|--|
| <b>Low tide at 14:05, High tide at 20:31</b> |                            |                          |                                 |  |                         |  |
|  | <b>100*:</b>               | <b>GPS tracked</b>       | <b>490 points reduced to 17</b> |  |                         |  |
| <b>100</b>                                   | 20041020                   | 150526                   | 0.00                            |  | 0                       | 0  |
|  | 20041020                   | 151358                   | 0.22                            | 55                                     | 119.8                   | 119.8  |
|  | 20041020                   | 151941                   | 0.22                            | 76                                     | 77                      | 196.8  |
|  | 20041020                   | 152525                   | 0.22                            | 79                                     | 78.2                    | 275  |
|  | 20041020                   | 153024                   | 0.22                            | 97                                     | 62.9                    | 337.9  |
|  | 20041020                   | 153528                   | 0.19                            | 113                                    | 58.6                    | 396.5  |
| <b>102</b>                                   | 20041020                   | 153713                   |                                 |  |                         |  |
|  | 20041020                   | 153949                   | 0.22                            | 124                                    | 54.7                    | 451.2  |
|  | 20041020                   | 154445                   | 0.19                            | 146                                    | 56.6                    | 507.8  |
|  | 20041020                   | 154958                   | 0.22                            | 166                                    | 66.8                    | 574.6  |
| <b>103</b>                                   | 20041020                   | 155405                   |                                 |  |                         |  |
|  | 20041020                   | 155452                   | 0.25                            | 174                                    | 71.6                    | 646.2  |
|  | 20041020                   | 160549                   | 0.31                            | 195                                    | 209                     | 855.2  |
|  | 20041020                   | 161640                   | 0.44                            | 200                                    | 293                     | 1148.2   |
| <b>104</b>                                   | 20041020                   | 161800                   |                                 |  |                         |  |
|  | 20041020                   | 162726                   | 0.53                            | 197                                    | 340.8                   | 1489   |
|  | 20041020                   | 163621                   | 0.53                            | 205                                    | 279.3                   | 1768.2   |
| <b>105</b>                                   | 20041020                   | 163741                   |                                 |  |                         |  |
|  | 20041020                   | 164526                   | 0.53                            | 209                                    | 288.6                   | 2056.9   |
|  | 20041020                   | 170221                   | 0.53                            | 207                                    | 541.5                   | 2598.3   |
| <b>107</b>                                   | 20041020                   | 170957                   |                                 |  |                         |  |
|  | 20041020                   | 171332                   | 0.56                            | 201                                    | 377                     | 2975.4   |
| <b>300</b>                                   | 20041020                   | 145600                   | 0.00                            |  | 0                       | 0  |
| <b>301</b>                                   | 20041020                   | 151300                   | 0.31                            | 49                                     | 317.8                   | 317.8  |
| <b>302</b>                                   | 20041020                   | 153200                   | 0.17                            | 58                                     | 186.7                   | 504.6  |
| <b>303</b>                                   | 20041020                   | 154800                   | 0.14                            | 106                                    | 126.6                   | 631.2  |
| <b>304</b>                                   | 20041020                   | 161100                   | 0.14                            | 152                                    | 200.6                   | 831.8  |
| <b>305</b>                                   | 20041020                   | 163200                   | 0.22                            | 186                                    | 276.4                   | 1108.2   |
| <b>306</b>                                   | 20041020                   | 170200                   | 0.31                            | 187                                    | 531.4                   | 1639.7   |
| <b>400</b>                                   | 20041020                   | 145200                   | 0.00                            |  | 0                       | 0  |
| <b>401</b>                                   | 20041020                   | 150800                   | 0.33                            | 49                                     | 311.8                   | 311.8  |
| <b>402</b>                                   | 20041020                   | 152800                   | 0.22                            | 65                                     | 261.7                   | 573.6  |
| <b>403</b>                                   | 20041020                   | 154400                   | 0.14                            | 97                                     | 129.1                   | 702.7  |
| <b>404</b>                                   | 20041020                   | 160300                   | 0.14                            | 143                                    | 160.1                   | 862.8  |
| <b>405</b>                                   | 20041020                   | 162800                   | 0.22                            | 170                                    | 342.3                   | 1205.1   |
| <b>406</b>                                   | 20041020                   | 164700                   | 0.25                            | 185                                    | 296.7                   | 1501.8   |
| <b>407</b>                                   | 20041020                   | 165800                   | 0.42                            | 187                                    | 274.1                   | 1775.9   |
| <b>500</b>                                   | 20041020                   | 144700                   | 0.00                            |  | 0                       | 0  |
| <b>501</b>                                   | 20041020                   | 150400                   | 0.25                            | 42                                     | 249.3                   | 249.3  |
| <b>502</b>                                   | 20041020                   | 151600                   | 0.19                            | 55                                     | 133.2                   | 382.6  |
| <b>503</b>                                   | 20041020                   | 153400                   | 0.17                            | 90                                     | 176.3                   | 558.9  |
| <b>504</b>                                   | 20041020                   | 154200                   | 0.17                            | 124                                    | 85.1                    | 644  |
| <b>505</b>                                   | 20041020                   | 155100                   | 0.11                            | 135                                    | 62.5                    | 706.5  |
| <b>506</b>                                   | 20041020                   | 160100                   | 0.19                            | 159                                    | 111.5                   | 818  |
| <b>507</b>                                   | 20041020                   | 161000                   | 0.19                            | 166                                    | 106.8                   | 924.8  |
| <b>508</b>                                   | 20041020                   | 162500                   | 0.19                            | 180                                    | 184.3                   | 1109.1   |
| <b>509</b>                                   | 20041020                   | 163300                   | 0.31                            | 190                                    | 141.9                   | 1251   |

**Table 4. Drifter movements at flood tide during neap tide conditions, October 20.**

| <b>Drifter #<br/>(waypoints)</b>                  | <b>Date<br/>(yyyymmdd)</b> | <b>Time<br/>(hhmmss)</b> | <b>Speed<br/>(m/s)</b> | <b>Direction</b> | <b>Distance<br/>(m)</b> | <b>Total distance from<br/>releasing point</b> |
|---|----------------------------|--------------------------|------------------------|------------------|-------------------------|--|
| <b>Low tide at 14:05, High tide at 20:31</b>      |                            |                          |                        |                  |                         |  |
| <b>510</b>  | 20041020                   | 164700                   | 0.31                   | 190              | 259.3                   | 1510.3   |
| <b>511</b>  | 20041020                   | 165900                   | 0.36                   | 200              | 263.4                   | 1773.7   |
| <b>512</b>  | 20041020                   | 170700                   | 0.44                   | 205              | 214.9                   | 1988.5   |
| <b>513</b>  | 20041020                   | 172300                   | 0.47                   | 205              | 451.3                   | 2439.9   |
| <b>600</b>  | 20041020                   | 144100                   | 0.00                   |                  | 0                       | 0  |
| <b>601</b>  | 20041020                   | 145700                   | 0.25                   | 46               | 232.2                   | 232.2  |
| <b>602</b>  | 20041020                   | 150700                   | 0.31                   | 56               | 184.3                   | 416.4  |
| <b>603</b>  | 20041020                   | 151900                   | 0.19                   | 74               | 149.5                   | 566  |
| <b>604</b>  | 20041020                   | 153600                   | 0.19                   | 107              | 184.8                   | 750.8  |
| <b>605</b>  | 20041020                   | 154500                   | 0.19                   | 146              | 102.5                   | 853.3  |
| <b>606</b>  | 20041020                   | 155400                   | 0.19                   | 159              | 104.1                   | 957.4  |
| <b>607</b>  | 20041020                   | 160400                   | 0.22                   | 170              | 129.1                   | 1086.5   |
| <b>608</b>  | 20041020                   | 161800                   | 0.25                   | 176              | 200.8                   | 1287.2   |
| <b>609</b>  | 20041020                   | 162700                   | 0.28                   | 190              | 146.1                   | 1433.3   |
| <b>610</b>  | 20041020                   | 163600                   | 0.31                   | 197              | 165.1                   | 1598.4   |
| <b>611</b>  | 20041020                   | 164900                   | 0.36                   | 194              | 289.3                   | 1887.7   |
| <b>612</b>  | 20041020                   | 170100                   | 0.39                   | 198              | 288.7                   | 2176.4   |
| <b>613</b>  | 20041020                   | 170900                   | 0.42                   | 202              | 200.8                   | 2377.2   |
| <b>614</b>  | 20041020                   | 171700                   | 0.42                   | 203              | 200.8                   | 2578.1   |
| <b>700*: GPS tracked 728 points reduced to 16</b> |                            |                          |                        |                  |                         |  |
| <b>700</b>  | 20041020                   | 144113                   | 0.00                   |                  | 0                       | 0  |
|   | 20041020                   | 144937                   | 0.42                   | 48               | 213.3                   | 213.3  |
| <b>701</b>  | 20041020                   | 150000                   |                        |                  |                         |  |
|   | 20041020                   | 150448                   | 0.33                   | 56               | 303.3                   | 516.6  |
|   | 20041020                   | 150947                   | 0.28                   | 54               | 86.9                    | 603.5  |
|   | 20041020                   | 151623                   | 0.25                   | 75               | 95                      | 698.5  |
|   | 20041020                   | 152214                   | 0.19                   | 90               | 67.3                    | 765.8  |
|   | 20041020                   | 152813                   | 0.17                   | 115              | 62.3                    | 828.1  |
|   | 20041020                   | 153515                   | 0.17                   | 122              | 74.5                    | 902.6  |
| <b>704</b>  | 20041020                   | 153900                   |                        |                  |                         |  |
|   | 20041020                   | 154429                   | 0.22                   | 144              | 115.9                   | 1018.4   |
|   | 20041020                   | 155240                   | 0.25                   | 160              | 126.4                   | 1144.8   |
| <b>706</b>  | 20041020                   | 155600                   |                        |                  |                         |  |
|   | 20041020                   | 160002                   | 0.28                   | 169              | 127                     | 1271.9   |
|   | 20041020                   | 161215                   | 0.33                   | 178              | 241.2                   | 1513   |
|   | 20041020                   | 161809                   | 0.31                   | 184              | 110.7                   | 1623.7   |
| <b>708</b>  | 20041020                   | 162100                   |                        |                  |                         |  |
|   | 20041020                   | 162735                   | 0.33                   | 195              | 191.8                   | 1815.5   |
| <b>709</b>  | 20041020                   | 163000                   |                        |                  |                         |  |
| <b>710</b>  | 20041020                   | 163900                   |                        |                  |                         |  |
|   | 20041020                   | 163923                   | 0.36                   | 201              | 261.1                   | 2076.6   |
| <b>713</b>  | 20041020                   | 171044                   | 0.42                   | 207              | 773                     | 2849.6   |



**Table 4. Drifter movements at flood tide during neap tide conditions, October 20.**

***Speed statistics:***

**Speed statistics calculated from drifter movements once flood tide was well established, after 16:15**

| Drifter # | Speed (m/s) |      |      |
|-----------|-------------|------|------|
|           | min         | max  | mean |
| 100*      | 0.39        | 0.67 | 0.54 |
| 300       | 0.22        | 0.31 | 0.26 |
| 400       | 0.22        | 0.42 | 0.30 |
| 500       | 0.19        | 0.47 | 0.35 |
| 600       | 0.28        | 0.42 | 0.36 |
| 700*      | 0.17        | 0.61 | 0.39 |

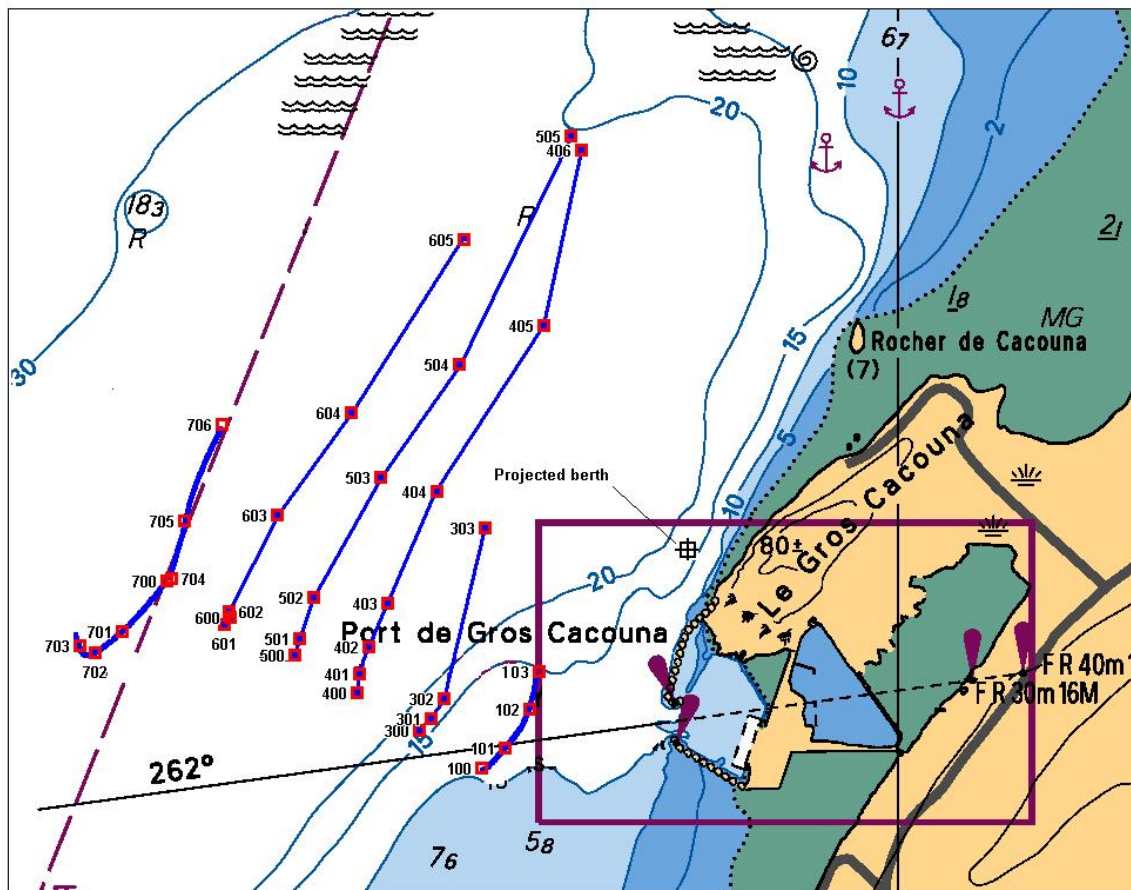
\* Drifters tracked with GPS attached to the bottom of drifter stick. Speed statistics is calculated with the total numbers of waypoints of these GPS-tracks. Data in table represent a selection of the total numbers of GPS-track waypoints (not numbered), as well as waypoints taken by technician in boat coming alongside drifter (numbered, no speed statistics calculated for these points)

## Final Report

**3.5 NEAP TIDE CONDITIONS. EBB TIDE.**

Drifter measurements started 50 minutes after high tide (09:28) and continued for about 2 hours and 20 minutes before interrupted due to strong winds. We notice a current reversal for the 2 drifters furthest out from the shore, as drifter # 700 was moving upstream at start (1 hour after peak high tide) and drifter #600 was immobile, while the four others were moving downstream (# 100, 300-500, figure 9). Hence, it seems that the current reversal occurred later in offshore waters.

Average speeds calculated for drifter # 100 and # 300 to 600, as well as for drifter # 700 during its second release, reveals values that vary between 0.22 m/s (drifter # 300) and 0.47 m/s (drifter # 400, table 5). The highest speed values were reached towards the end of the test, which indicates that peak values were not reached before interruption of test.



**Figure 9 Drifter trajectories. Neap tide conditions, ebb, release 1 and 2**

**Table 5. Drifter movements at ebb tide during neap tide conditions, October 21, release 1 and 2**

**Drifter test interrupted at 12:49 due to bad weather conditions**

**Measurements interrupted at 11:21 for drifter # 100 due to a vessel picking up drifter**

| <b>Drifter #<br/>(waypoints)</b>                                     | <b>Date<br/>(yyyymmdd)</b> | <b>Time<br/>(hhmmss)</b> | <b>Speed<br/>(m/s)</b> | <b>Direction<br/>(magnetic degrés)</b> | <b>Distance<br/>(m)</b> | <b>Total distance from<br/>releasing point</b> |
|--|----------------------------|--------------------------|------------------------|--|-------------------------|--|
| <b>High tide at 09:28, Low Tide at 15:33</b>                         |                            |                          |                        |  |                         |  |
| <b>100*: GPS tracked 194 points reduced to 6</b>                     |                            |                          |                        |  |                         |  |
| <b>Test interrupted due to a vessel picking up drifter at 11 :21</b> |                            |                          |                        |  |                         |  |
| <b>100</b>   | 20041021                   | 103419                   |                        |  |                         |  |
|  | 20041021                   | 103954                   | 0.00                   | 90                                     | 0                       | 0  |
|  | 20041021                   | 103832                   | 0.72                   | 90                                     | 13.7                    | 13.7   |
| <b>101</b>   | 20041021                   | 104910                   |                        |  |                         |  |
|  | 20041021                   | 105310                   | 0.22                   | 44                                     | 205.5                   | 219.2  |
|  | 20041021                   | 110223                   | 0.31                   | 37                                     | 163.7                   | 383  |
|  | 20041021                   | 111017                   | 0.31                   | 25                                     | 150.4                   | 533.3  |
| <b>102</b>   | 20041021                   | 110622                   |                        |  |                         |  |
| <b>103</b>   | 20041021                   | 111940                   | 0.42                   | 11                                     | 241                     | 774.4  |
| <b>300</b>   | 20041021                   | 103039                   | 0.00                   |  | 0                       | 0  |
| <b>301</b>   | 20041021                   | 104600                   | 0.11                   | 48                                     | 113.3                   | 113.3  |
| <b>302</b>   | 20041021                   | 110000                   | 0.19                   | 33                                     | 155.5                   | 268.8  |
| <b>303</b>   | 20041021                   | 115400                   | 0.36                   | 13                                     | 1202.6                  | 1471.5   |
| <b>400</b>   | 20041021                   | 102700                   | 0.00                   |  | 0                       | 0  |
| <b>401</b>   | 20041021                   | 104200                   | 0.14                   | 7                                      | 136.2                   | 136.2  |
| <b>402</b>   | 20041021                   | 105600                   | 0.22                   | 19                                     | 197.8                   | 334  |
| <b>403</b>   | 20041021                   | 111300                   | 0.31                   | 23                                     | 322.9                   | 656.9  |
| <b>404</b>   | 20041021                   | 114400                   | 0.44                   | 23                                     | 828.8                   | 1485.7   |
| <b>405</b>   | 20041021                   | 123300                   | 0.47                   | 33                                     | 1348.3                  | 2834   |
| <b>406</b>   | 20041021                   | 124900                   | 1.25                   | 12                                     | 1212.4                  | 4046.4   |
| <b>500</b>   | 20041021                   | 102400                   | 0.00                   |  | 0                       | 0  |
| <b>501</b>   | 20041021                   | 104500                   | 0.08                   | 16                                     | 116.6                   | 116.6  |
| <b>502</b>   | 20041021                   | 110500                   | 0.25                   | 17                                     | 296.4                   | 413  |
| <b>503</b>   | 20041021                   | 114200                   | 0.42                   | 30                                     | 946.8                   | 1359.8   |
| <b>504</b>   | 20041021                   | 120400                   | 0.69                   | 34                                     | 931                     | 2290.8   |
| <b>505</b>   | 20041021                   | 124600                   | 0.69                   | 26                                     | 1736.8                  | 4027.5   |
| <b>600</b>   | 20041021                   | 102000                   | 0.00                   |  | 0                       | 0  |
| <b>601</b>   | 20041021                   | 104000                   | 0.06                   | 225                                    | 56.6                    | 56.6   |
| <b>602</b>   | 20041021                   | 110000                   | 0.08                   | 20                                     | 86.3                    | 142.9  |
| <b>603</b>   | 20041021                   | 113700                   | 0.33                   | 27                                     | 745.1                   | 888  |
| <b>604</b>   | 20041021                   | 120400                   | 0.53                   | 36                                     | 860.3                   | 1748.3   |
| <b>605</b>   | 20041021                   | 123900                   | 0.67                   | 34                                     | 1415                    | 3163.3   |

**Table 5. Drifter movements at ebb tide during neap tide conditions, October 21, release 1 and 2**

**Drifter test interrupted at 12:49 due to bad weather conditions**

**Measurements interrupted at 11:21 for drifter # 100 due to a vessel picking up drifter**

| Drifter #<br>(waypoints)                                    | Date<br>(yyyymmdd) | Time<br>(hhmmss) | Speed<br>(m/s) | Direction<br>(magnetic degrés) | Distance<br>(m) | Total distance from<br>releasing point |
|---|--------------------|------------------|----------------|--------------------------------|-----------------|--|
| High tide at 09:28, Low Tide at 15:33                       |                    |                  |                |                                |                 |  |
| <b>700*: release 1 GPS tracked 263 points reduced to 12</b> |                    |                  |                |                                |                 |  |
| <b>700</b>  | 20041021           | 101324           |                |                                |                 |  |
|   | 20041021           | 101820           | 0.00           | 217                            | 0               | 0                                      |
|   | 20041021           | 102134           | 0.53           | 216                            | 101.4           | 101.4                                  |
|   | 20041021           | 102611           | 0.44           | 226                            | 124.6           | 226.1                                  |
|   | 20041021           | 103204           | 0.42           | 227                            | 142.4           | 368.5                                  |
| <b>701</b>  | 20041021           | 103500           |                |                                |                 |  |
|   | 20041021           | 103833           | 0.33           | 233                            | 127.8           | 496.2                                  |
|   | 20041021           | 104647           | 0.22           | 243                            | 113.4           | 609.6                                  |
| <b>702</b>  | 20041021           | 105248           | 0.14           | 239                            | 53.2            | 662.8                                  |
|   | 20041021           | 105300           |                |                                |                 |  |
|   | 20041021           | 110005           | 0.11           | 256                            | 47.9            | 710.7                                  |
| <b>702</b>  | 20041021           | 110448           | 0.08           | 315                            | 25.7            | 736.4                                  |
|   | 20041021           | 110748           | 0.11           | 338                            | 20              | 756.4                                  |
|   | 20041021           | 111214           | 0.17           | 340                            | 43.5            | 799.9                                  |
|   | 20041021           | 111300           |                |                                |                 |  |
| <b>703</b>  | 20041021           | 111300           |                |                                |                 |  |
|   | 20041021           | 112109           | 0.17           | 340                            | 91.5            | 891.4                                  |
| <b>700*: release 2 GPS tracked 227 points reduced to 6</b>  |                    |                  |                |                                |                 |  |
| <b>704</b>  | 20041021           | 113025           | 0.00           |                                | 0               | 0                                      |
|   | 20041021           | 114722           | 0.31           | 17                             | 305.1           | 305                                    |
| <b>705</b>  | 20041021           | 115200           |                |                                |                 |  |
|   | 20041021           | 115709           | 0.36           | 12                             | 205.4           | 510.4                                  |
|   | 20041021           | 120435           | 0.36           | 20                             | 155.5           | 666                                    |
|   | 20041021           | 121056           | 0.39           | 18                             | 147.1           | 813.1                                  |
| <b>706</b>  | 20041021           | 122131           | 0.42           | 25                             | 261.5           | 1074.6                                 |

**Speed statistics:**

| Drifter #      | Speed (m/s) |      |      |
|----------------|-------------|------|------|
|                | min         | max  | mean |
| 100*           | 0.22        | 0.72 | 0.39 |
| 300            | 0.11        | 0.36 | 0.22 |
| 400            | 0.14        | 1.25 | 0.47 |
| 500            | 0.08        | 0.69 | 0.43 |
| 600            | 0.06        | 0.67 | 0.33 |
| 700 release 1* | 0.00        | 0.67 | 0.24 |
| 700 release 2* | 0.17        | 0.56 | 0.36 |

\* Drifters tracked with GPS attached to the bottom of drifter stick. Speed statistics is calculated with the total numbers of waypoints of these GPS-tracks. Data in table represent a selection of the total numbers of GPS-track waypoints (not numbered), as well as waypoints taken by technician in boat coming alongside drifter (numbered, no speed statistics calculated for these points)

## 4.0 SUMMARY

The results of the drifter tracking study show a relatively simple circulation pattern. The current circulation is bi-directional as drifter direction is northeast (downstream) during ebb tides and southwest (upstream) during flood tides.

The direction of the currents is generally parallel to the shoreline but undergoes variations when approaching Île Verte island situated downstream of the projected berth and when approaching Rocher Percé rock situated upstream of the projected berth.

Maximum current speeds in Gros Cacouna were observed at spring tide conditions during ebb tide. Values above 2.0 m/s (4 knots) were noted. During flood tide, maximum speeds observed were around 1.0 m/s. The maximum speeds were generally reached 3.5 to 4.5 hours after predicted low tide or high tide for flood and ebb tide.

Currents measured at neap tide conditions reveal similar circulation patterns and in addition the characteristics of the current reversal. The reversal took place between 1.5 and 2.0 hours after low tide and 1.0 to 1.5 hours after high tide. Maximum speeds observed were equal to 1.25 m/s at ebb tide and 0.67 m/s at flood tide. However, these two drifter tests had to be interrupted before maximum speeds were reached.

The results of this survey are generally in accordance with the Atlas of tidal currents published by the Fisheries and Oceans Canada (1997). The drifter results also exhibit good agreement with OSL numerical model forecasts (Appendix B) in terms of current directions and the drifter speeds range from good agreement to somewhat lower than the model speeds.

## REFERENCES

Pêches et Océans Canada, 1997. *Atlas des courants de marée – Estuaire du Saint-Laurent, du Cap de Bon-Désir à Trois-Rivières*. Ministère des Pêches et Océans, p. 108.

Thibault, A., 2001. *Devis standardisé pour effectuer des relevés courantométriques (Mesures lagrangienne de courant)*. Ministère de l'Environnement, Direction du suivi de l'état de l'environnement, Québec, 8 pages.

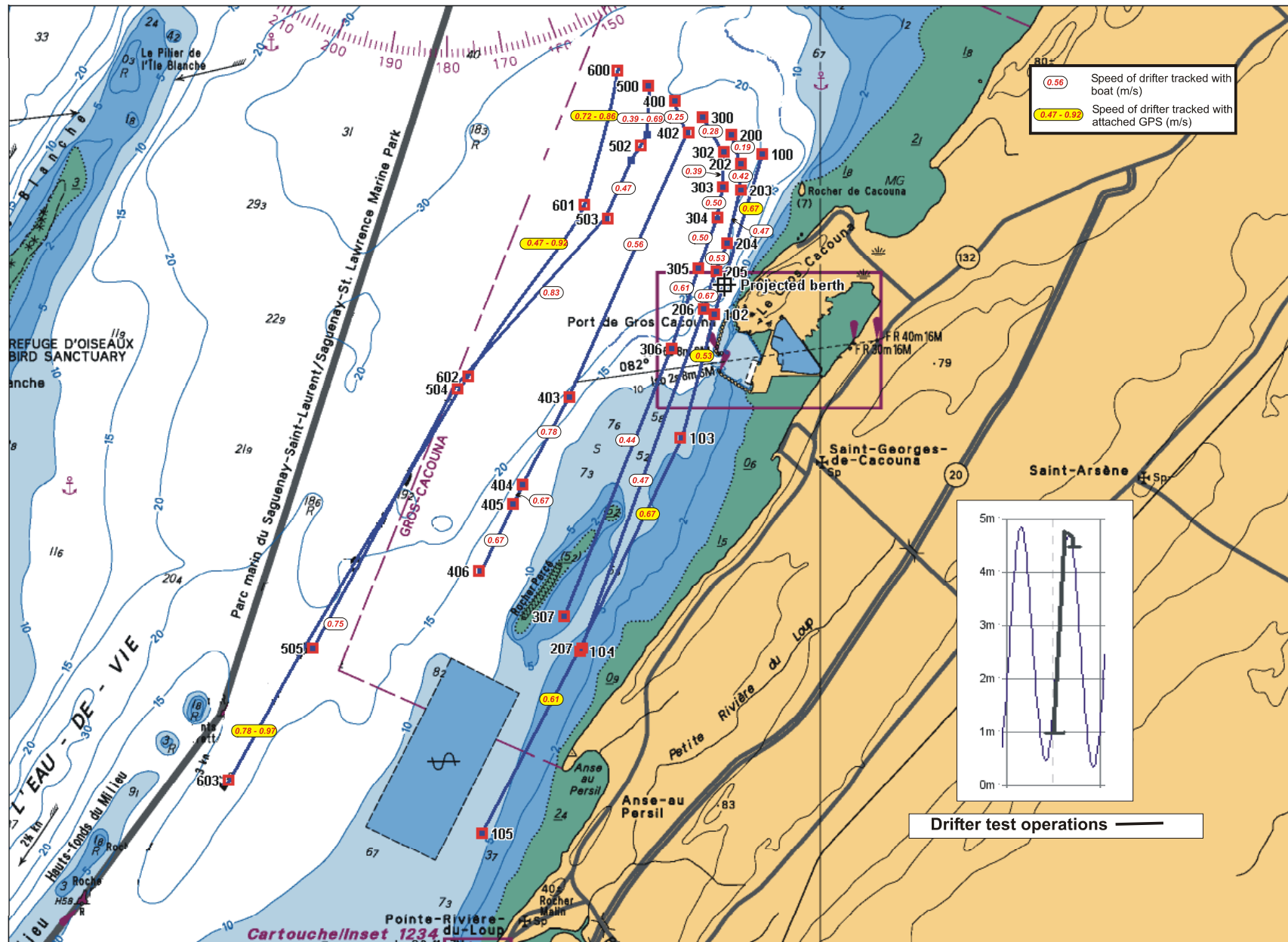
## **APPENDIX A1**

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### **Drifter speeds and trajectories.**

Spring tide conditions, flood, September 29, 11:36 – 16:55. Tabulated values in Table 2.

**Appendix A1** Drifter speeds and trajectories. Spring tide conditions, flood. September 29, 11:36 – 16:55. Tabulated values in Table 2.





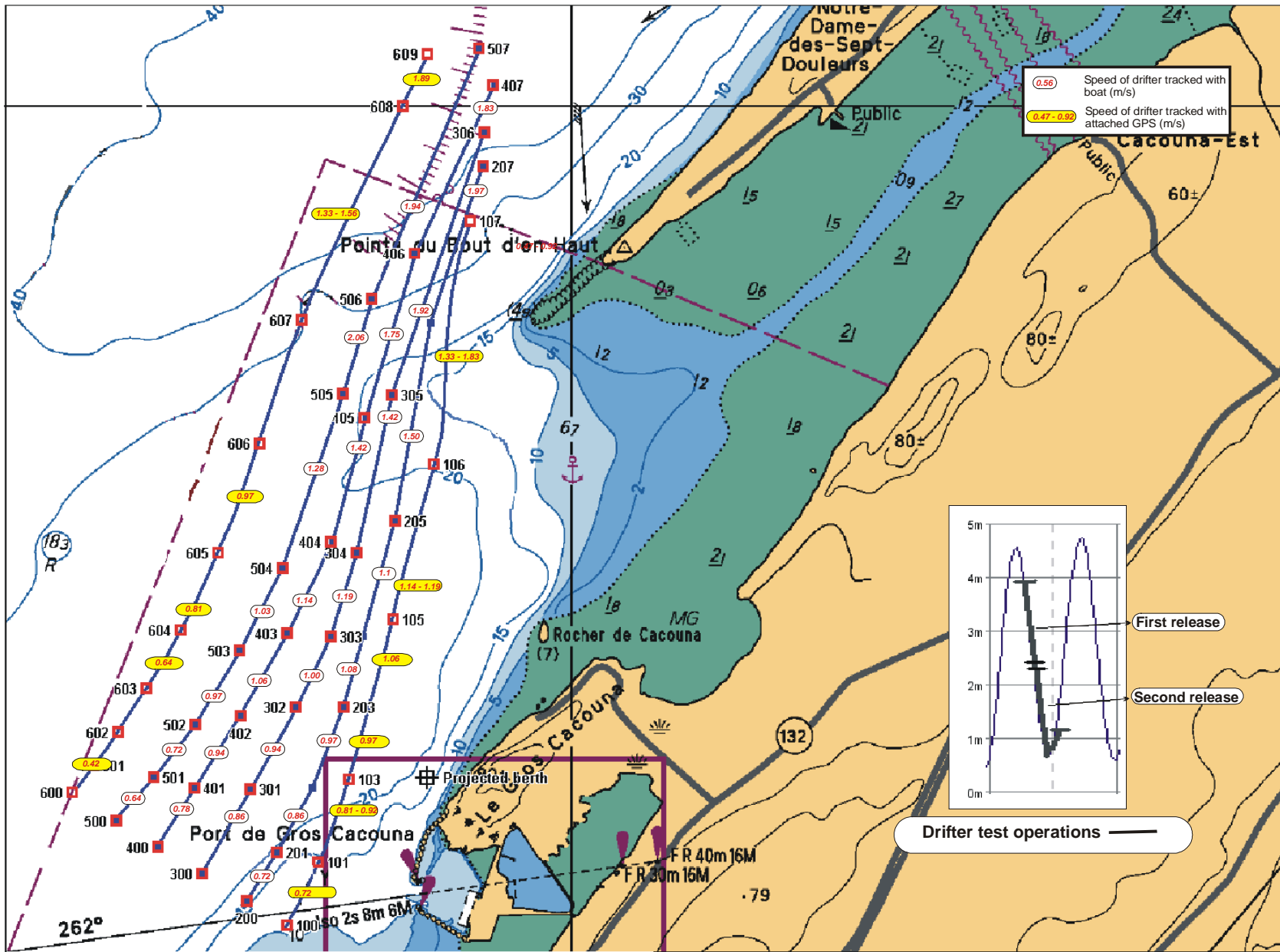
## **APPENDIX A2**

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### **Drifter speeds and trajectories.**

Spring tide conditions, ebb, release 1, October 1, 06:39 – 08:50. Tabulated values in Table 3a.

**Appendix A.2** Drifter speeds and trajectories. Spring tide conditions, ebb, release 1, October 1, 06:39 – 08:50. Tabulated values in Table 3a.



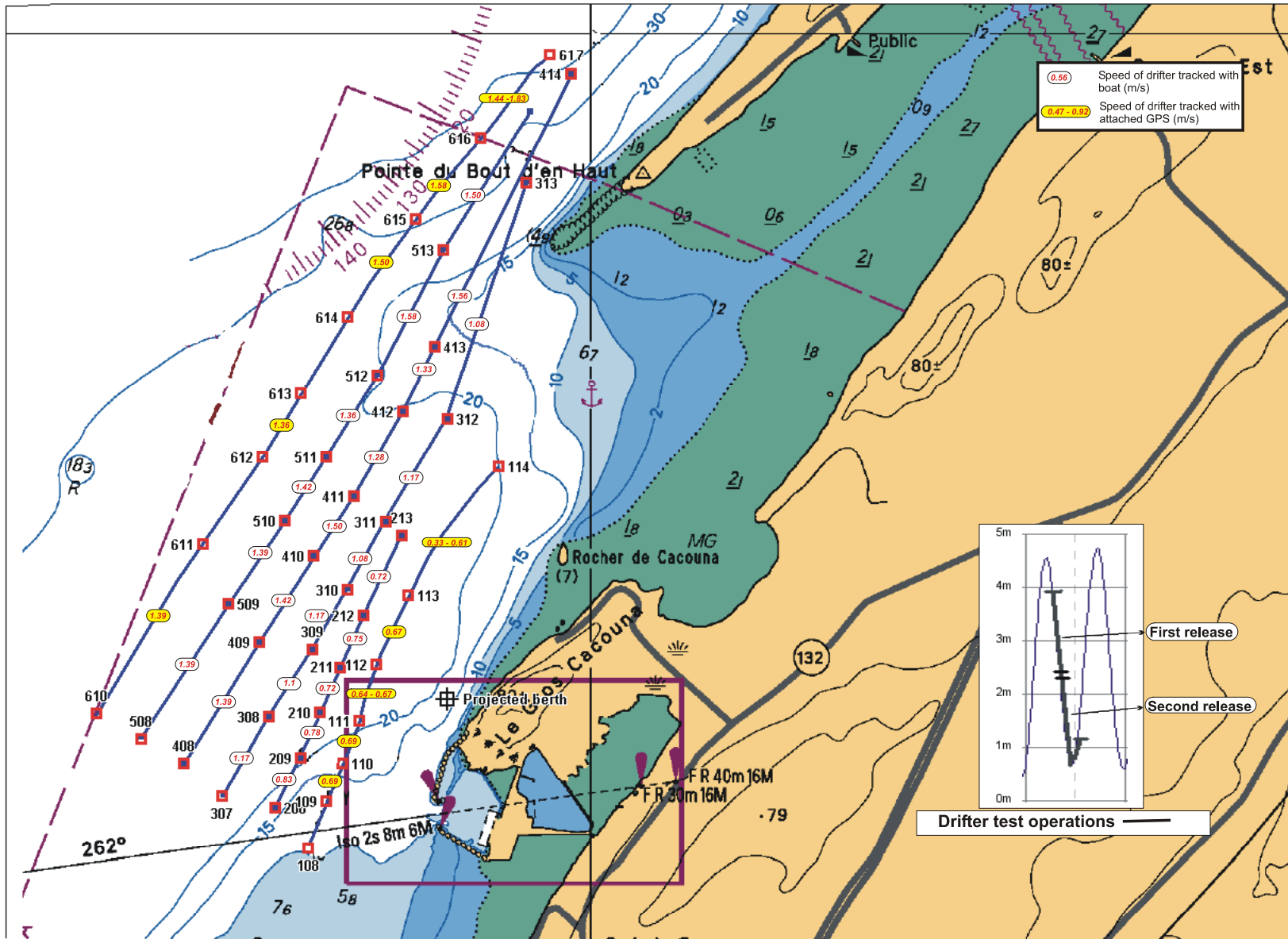
## **APPENDIX A3**

### **Drifter speeds and trajectories**

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Spring tide conditions, ebb, release 2, October 1, 09:08 – 11:37. Tabulated values in Table 3b.

**Appendix A.3** Drifter speeds and trajectories. Spring tide conditions, ebb, release 2, October 1, 09:08 – 11:37. Tabulated values in Table 3b.

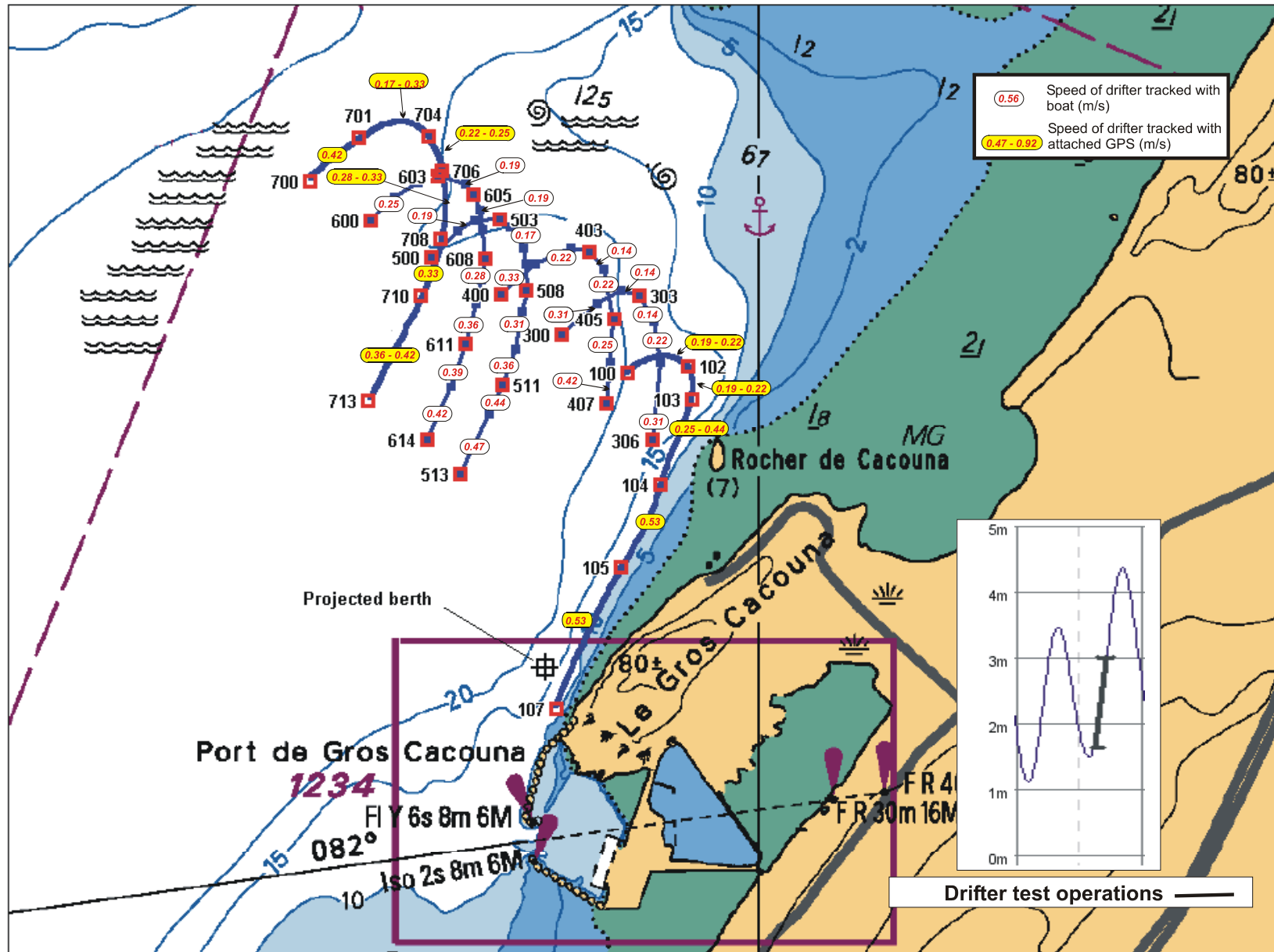


## **APPENDIX A4**

### **Drifter speeds and trajectories.**

Neap tide conditions, flood, October 20, 14:41 – 17:23. Tabulated values in Table 4.

Appendix A.4 Drifter speeds and trajectories. Neap tide conditions, flood, October 20, 14:41 – 17:23. Tabulated values in Table 4.



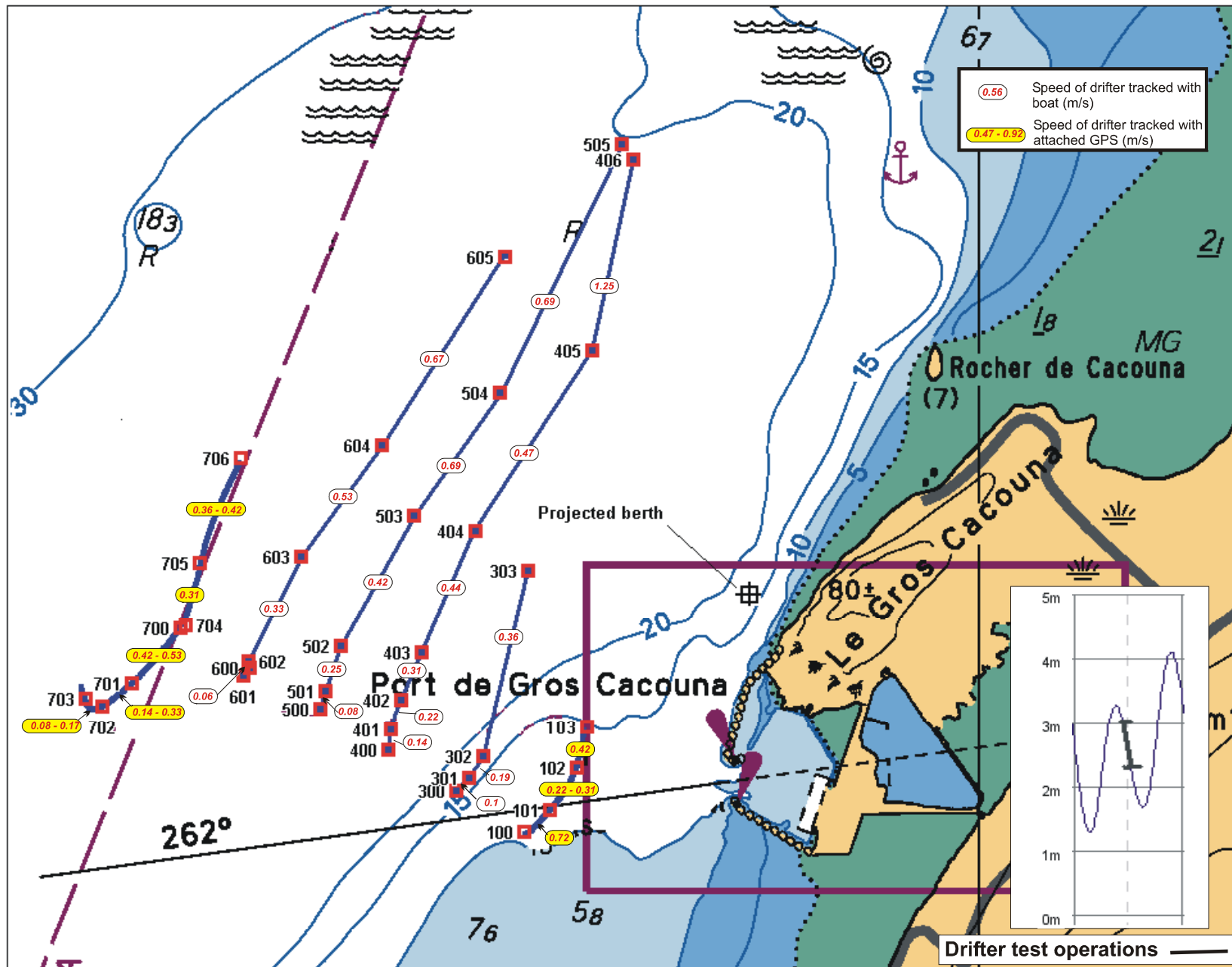
## **APPENDIX A.5**

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### **Drifter speeds and trajectories.**

Neap tide conditions, ebb, release 1 and 2, October 21, 10:18 – 12:49. Tabulated values in Table 5.

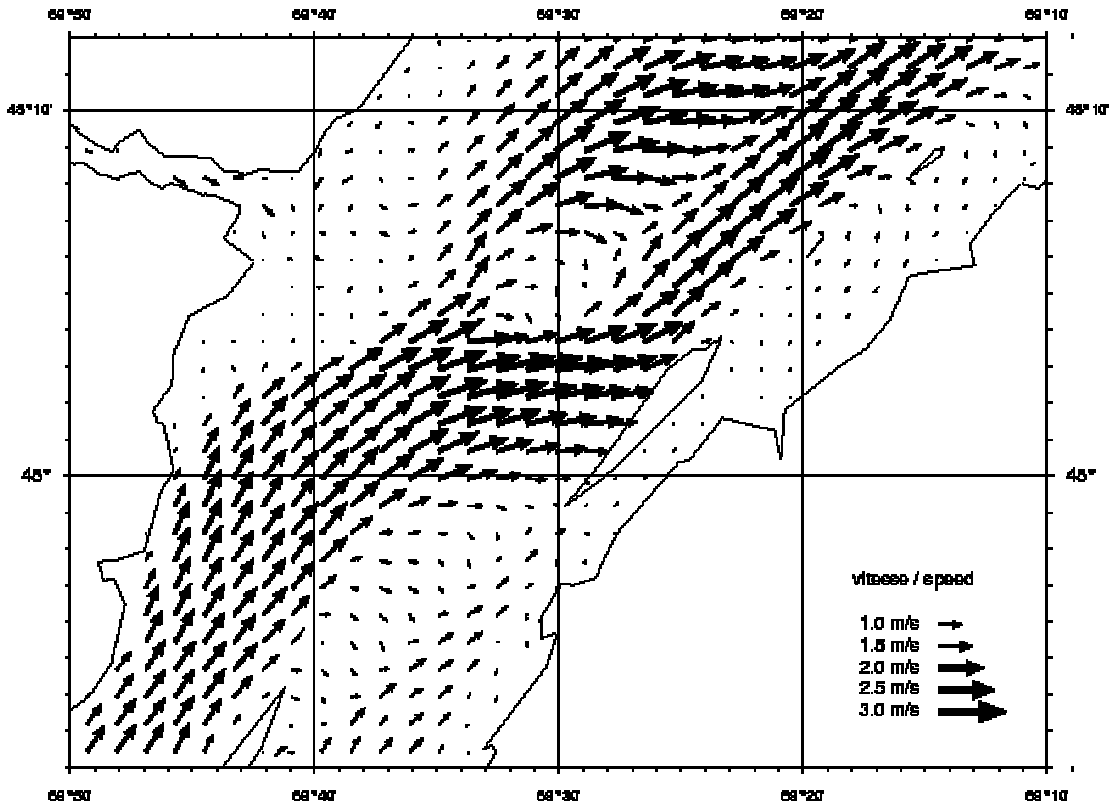
**Appendix A.5** Drifter speeds and trajectories. Neap tide conditions, ebb, release 1 and 2, October 21, 10:18 – 12:49. Tabulated values in Table 5.



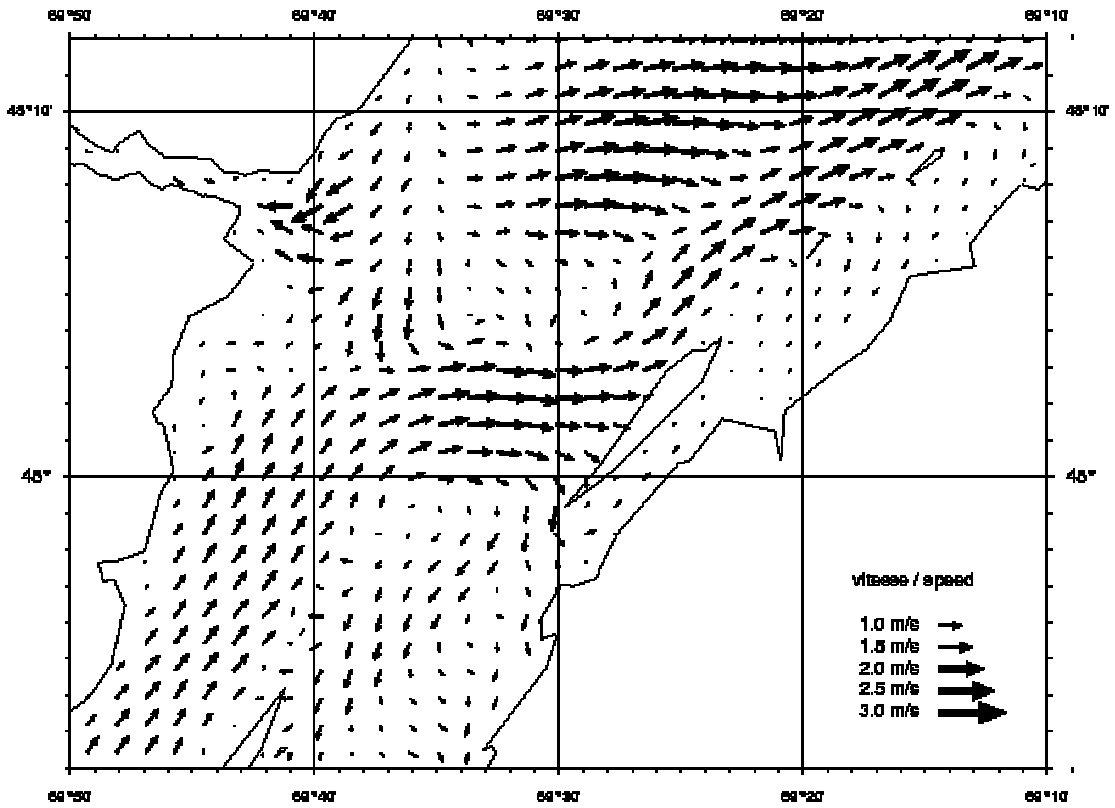




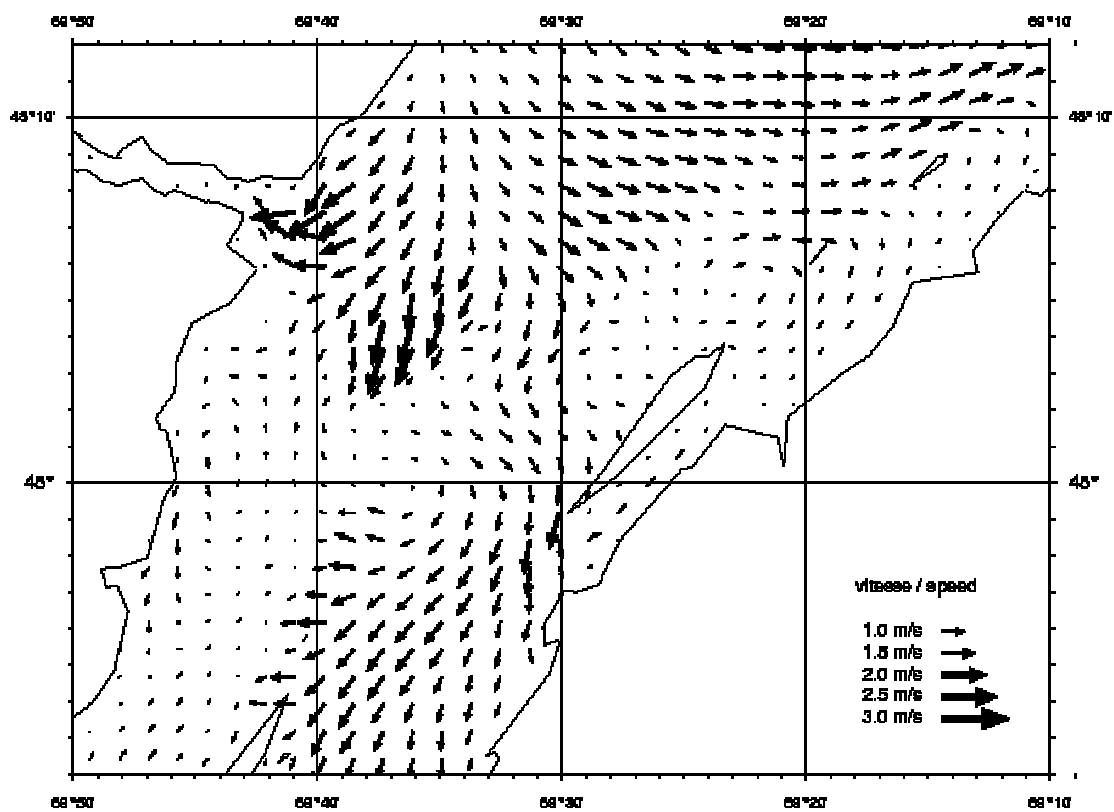
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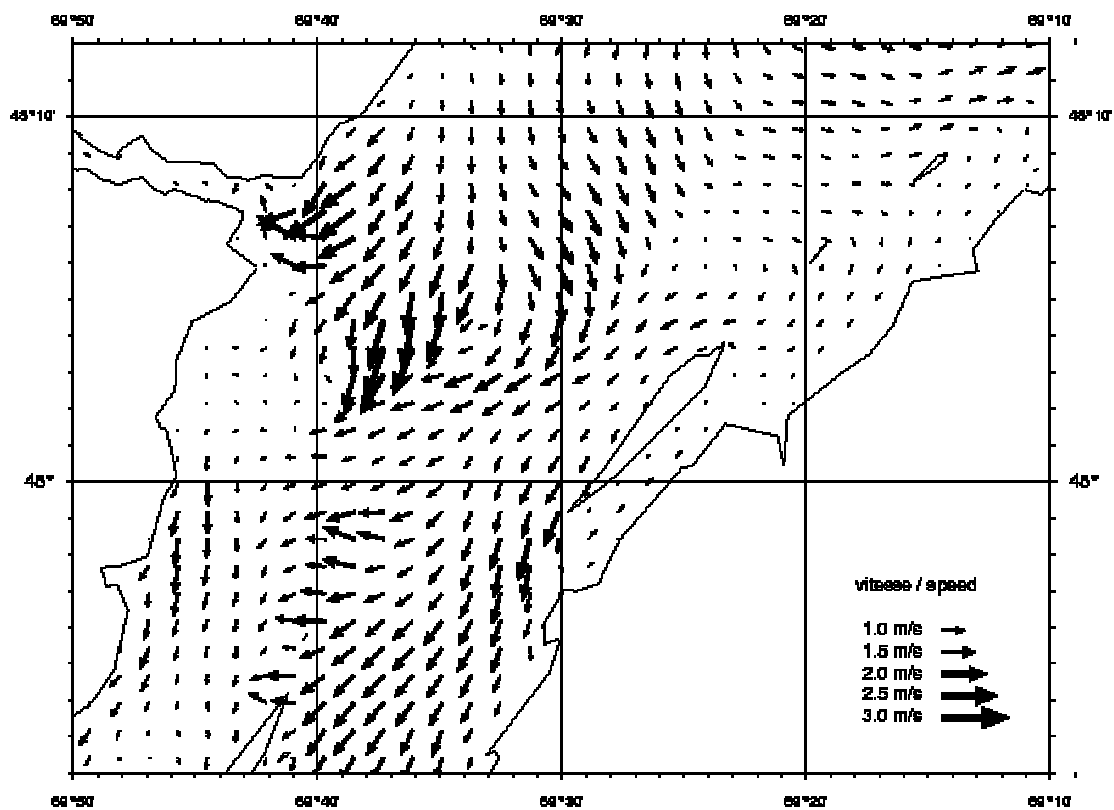
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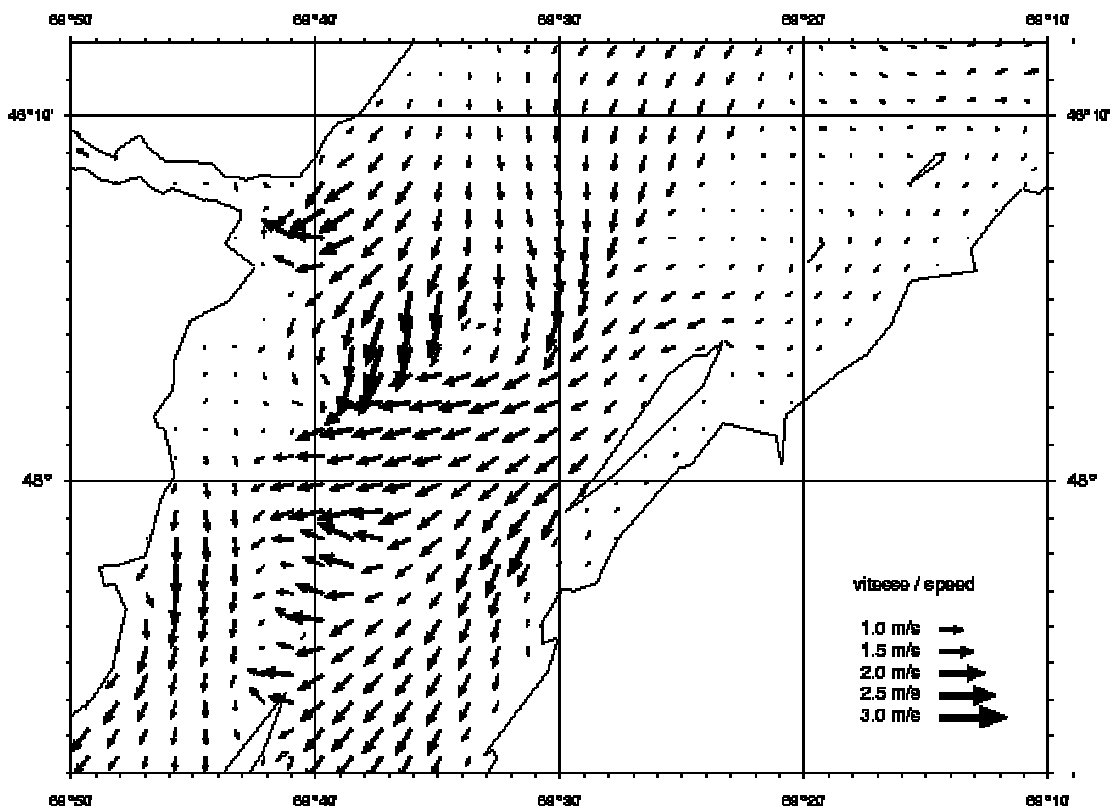
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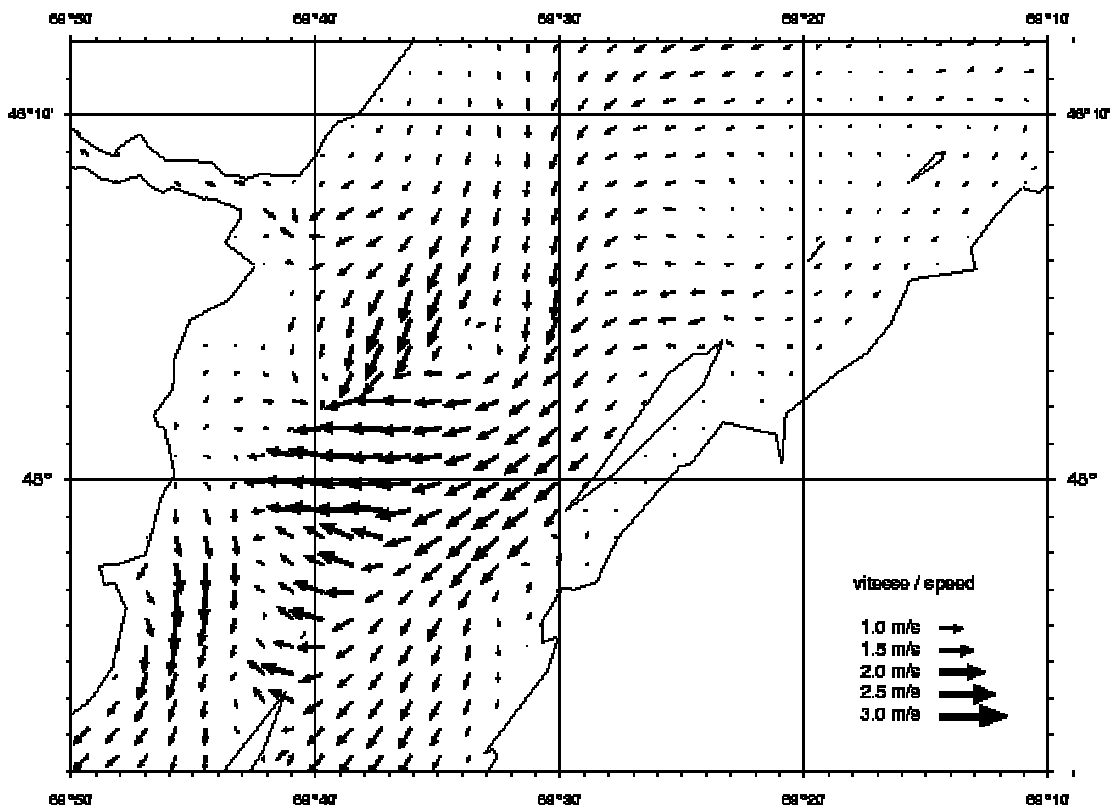
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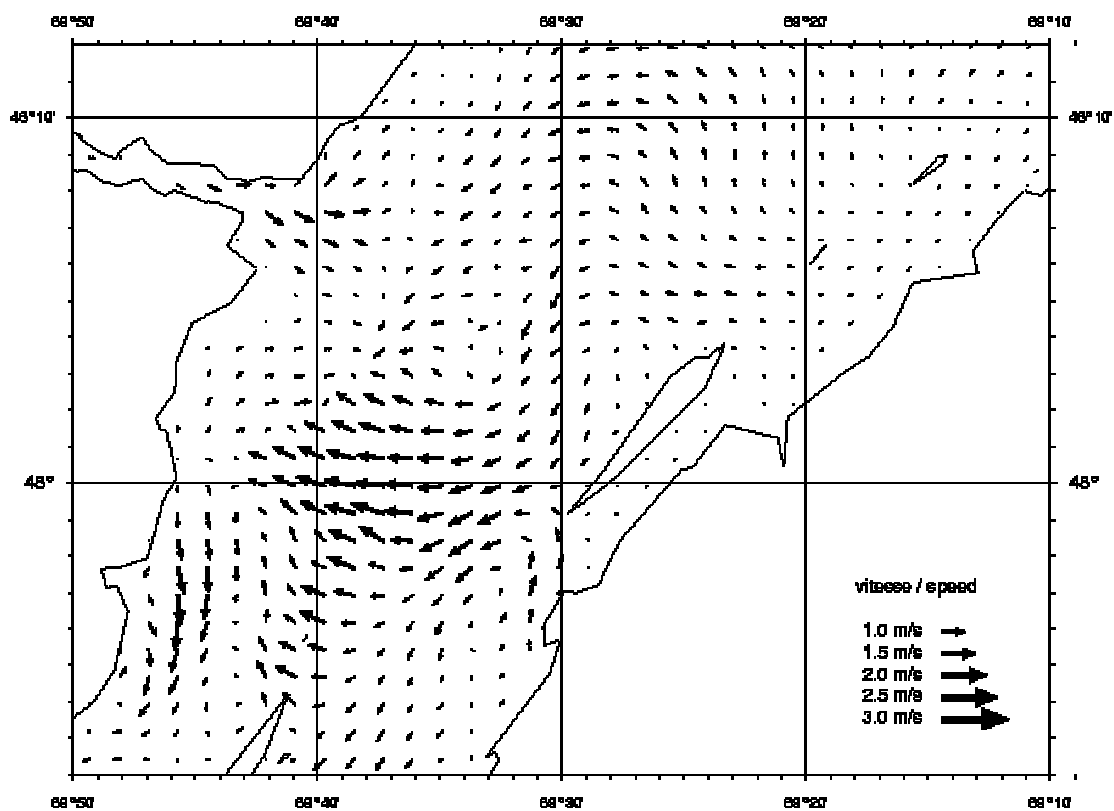
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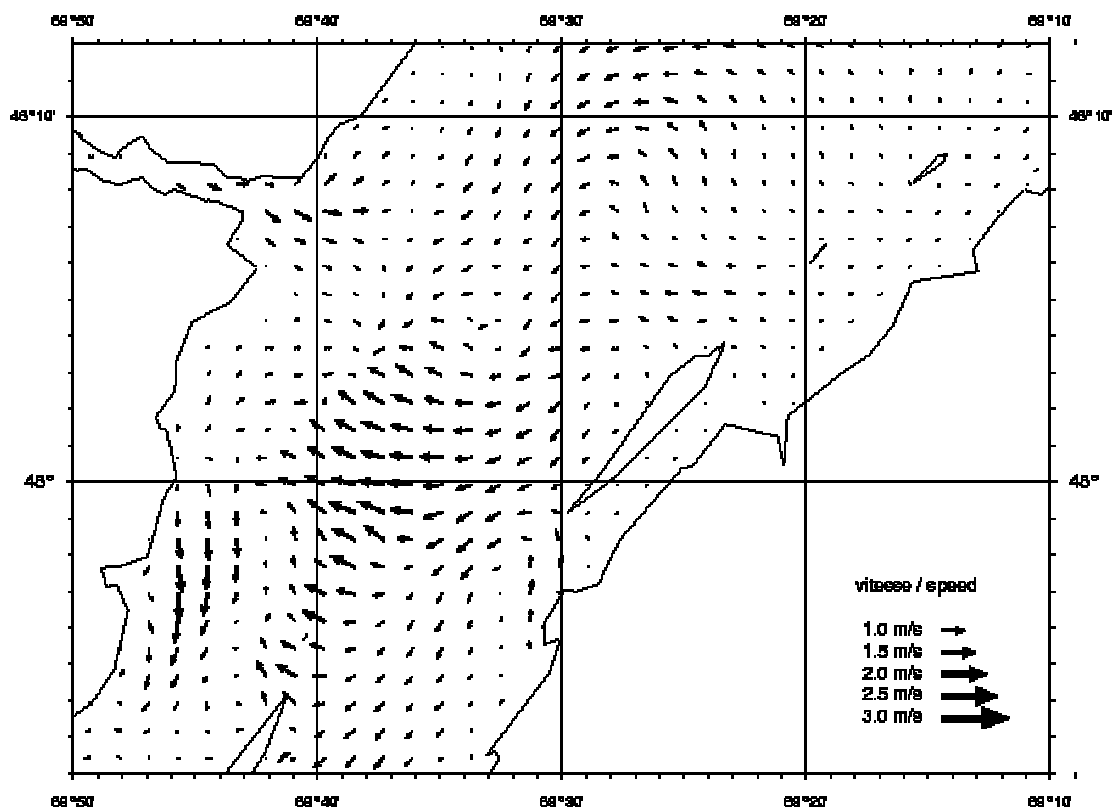
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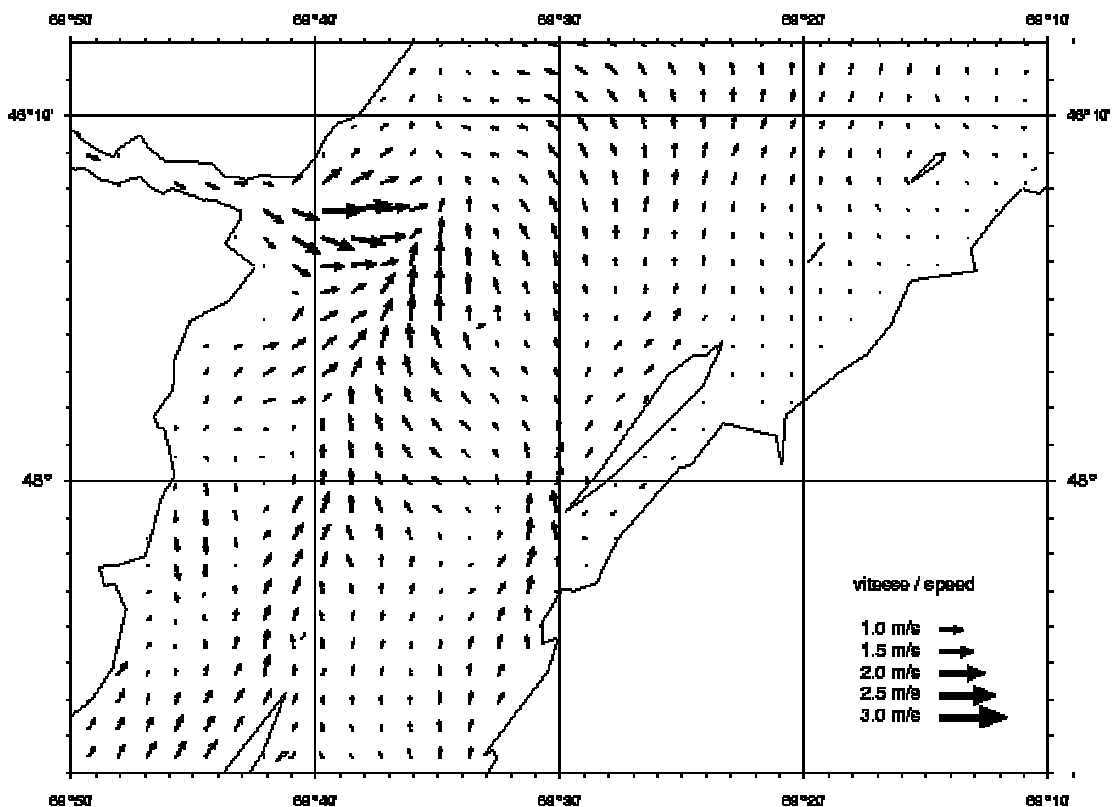
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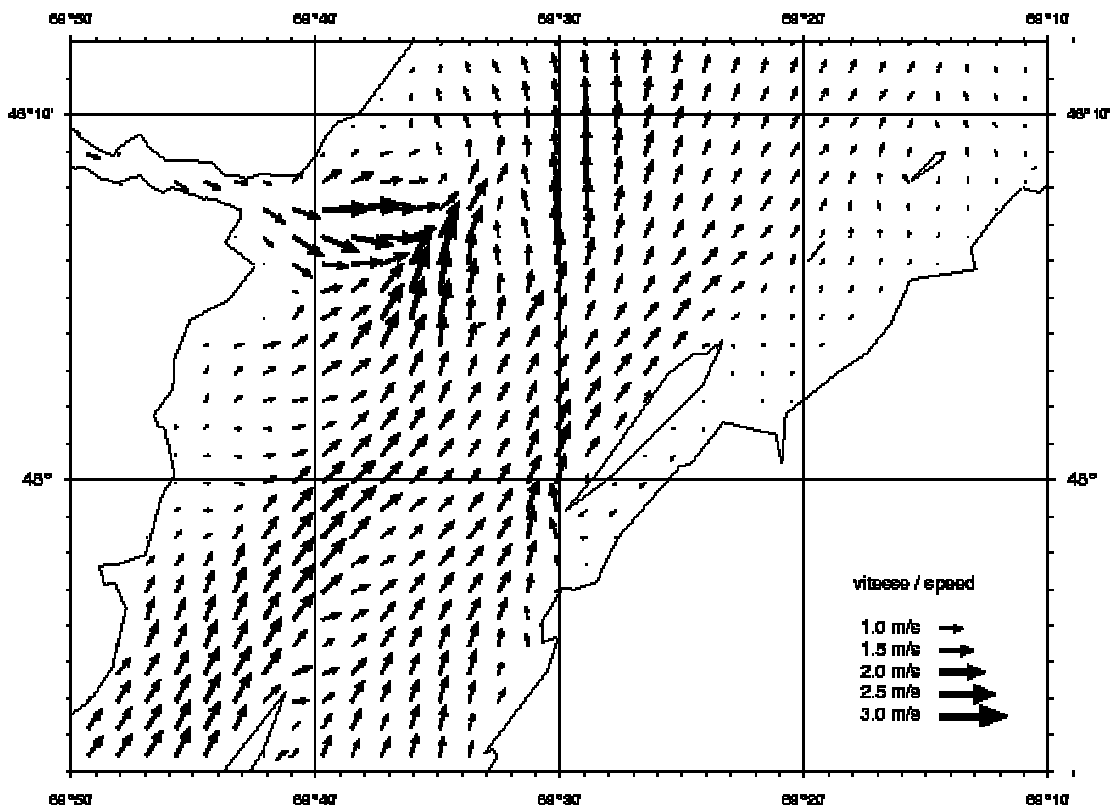
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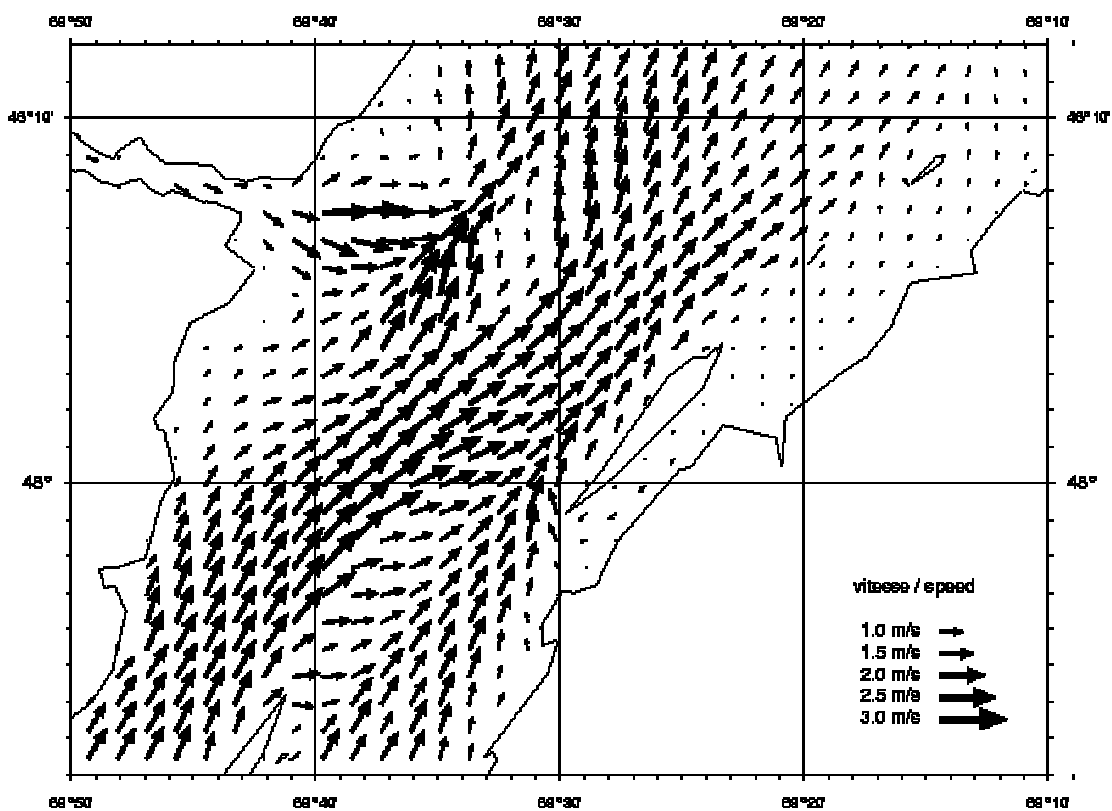
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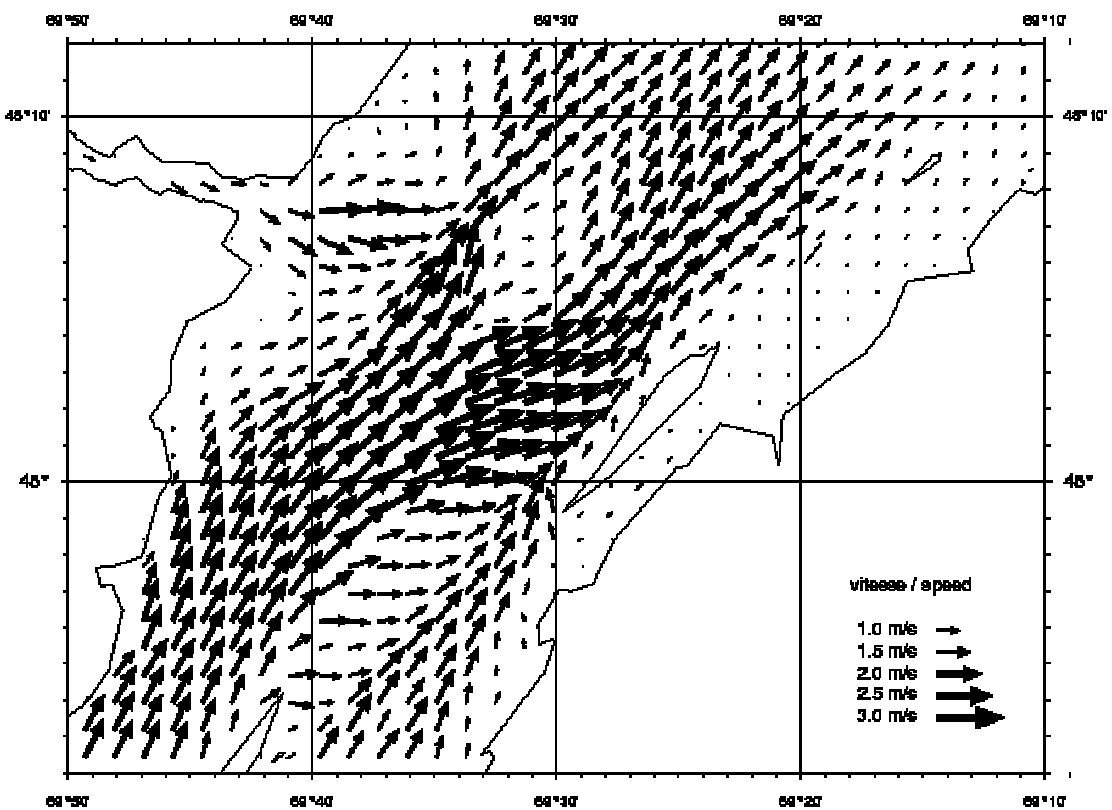
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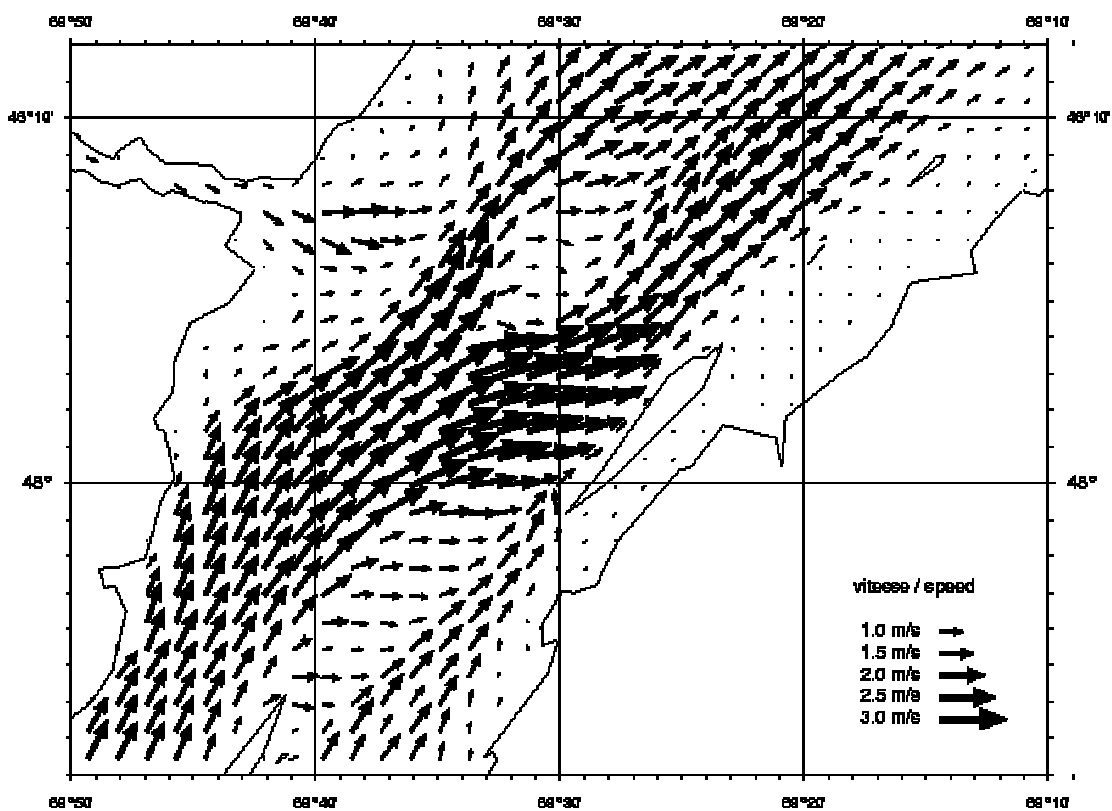
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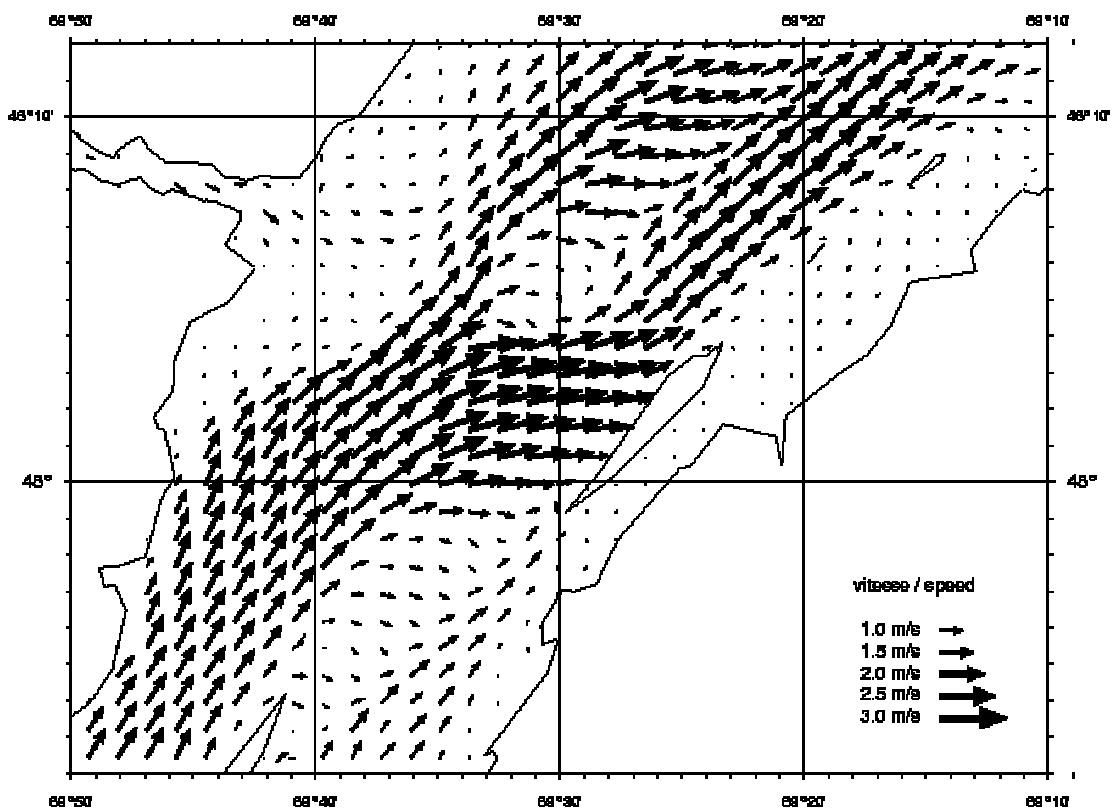
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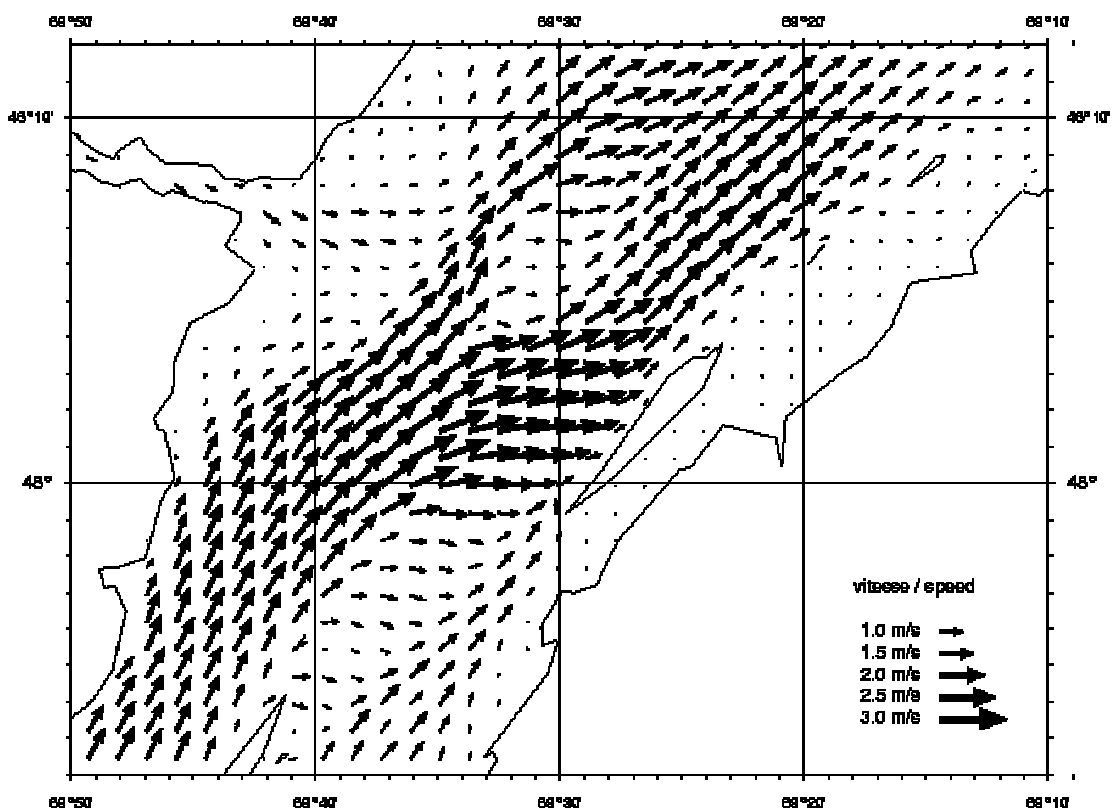


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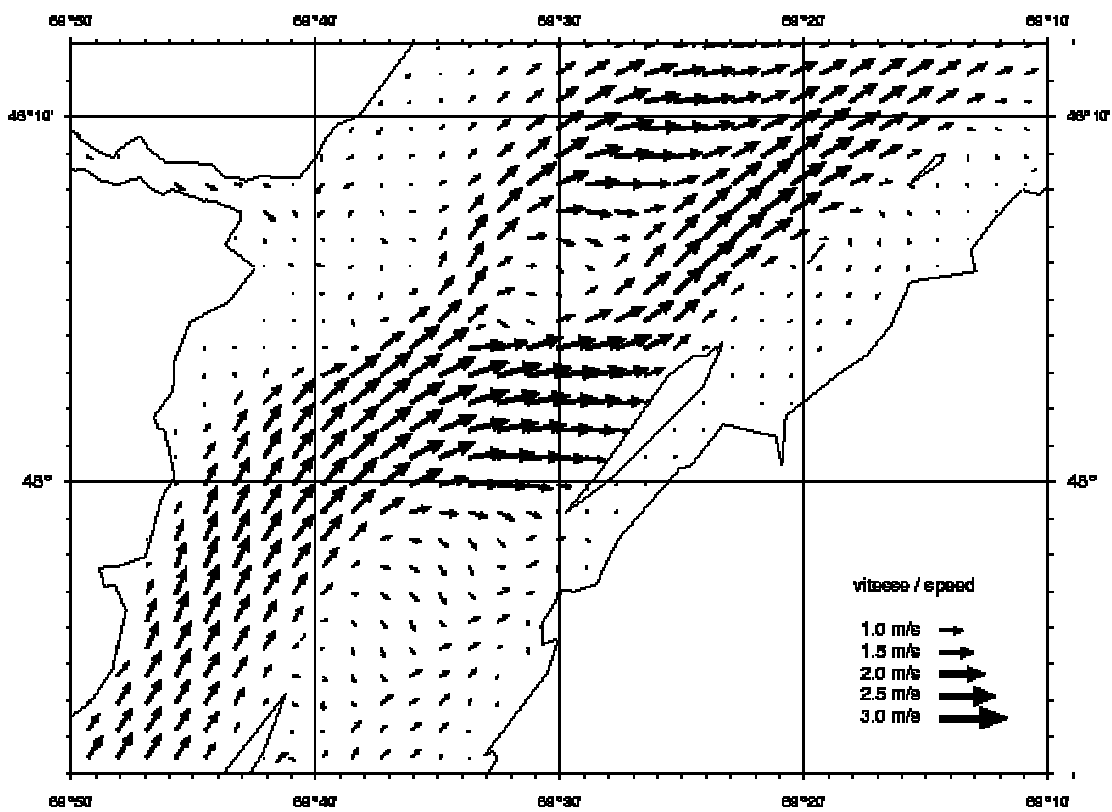




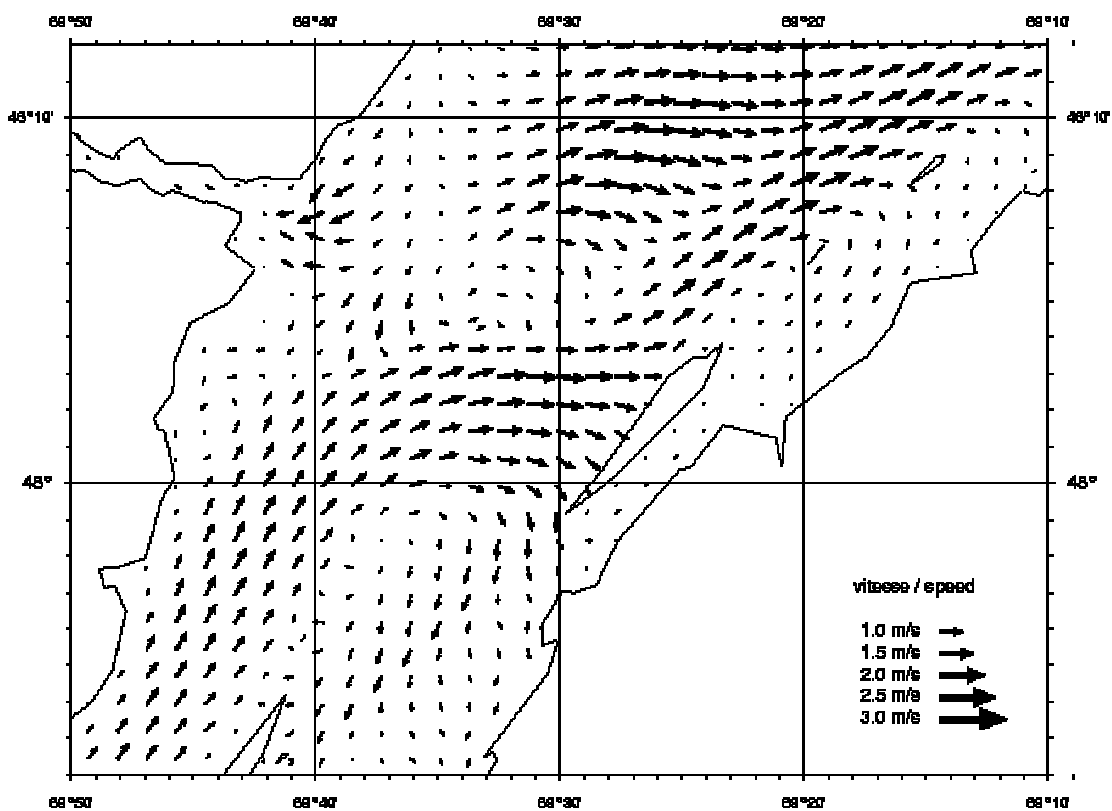
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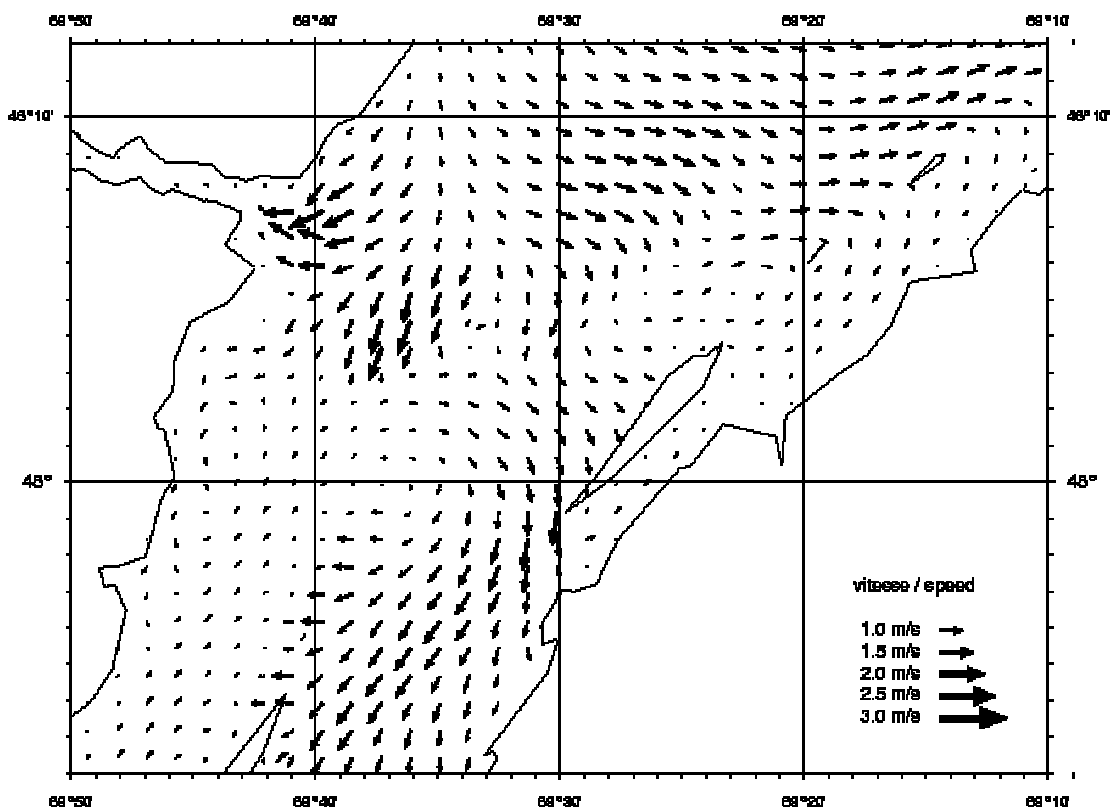
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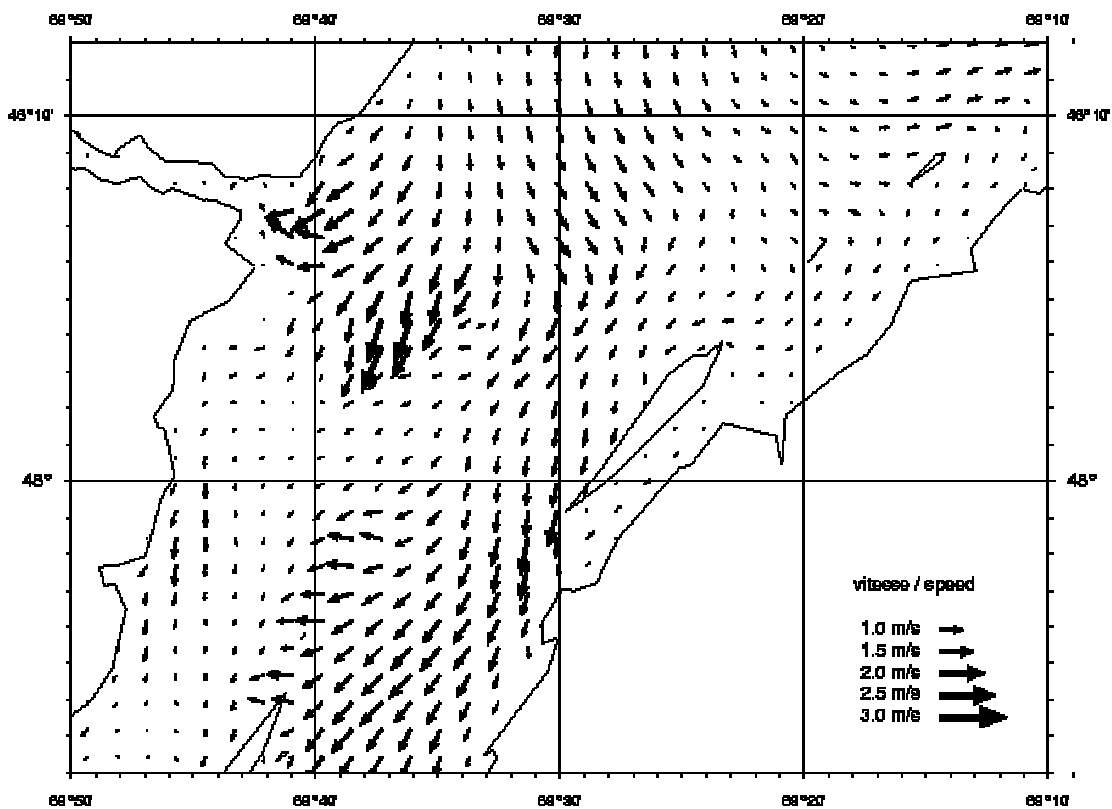
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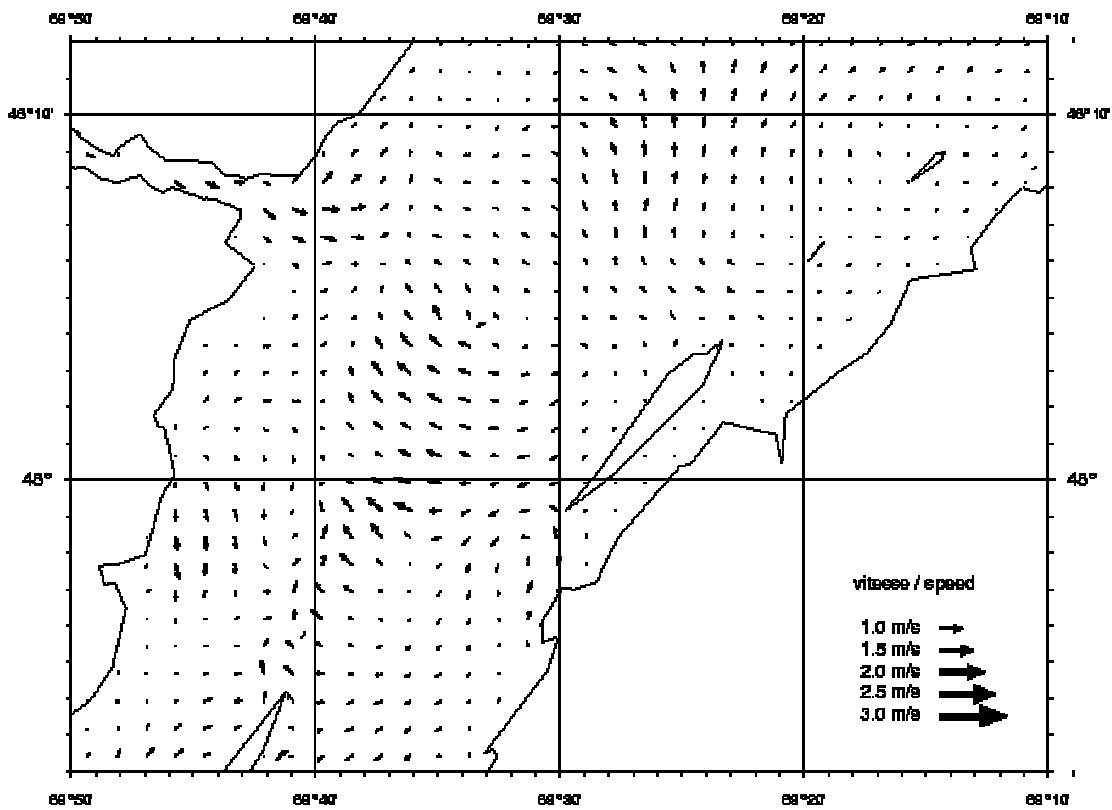
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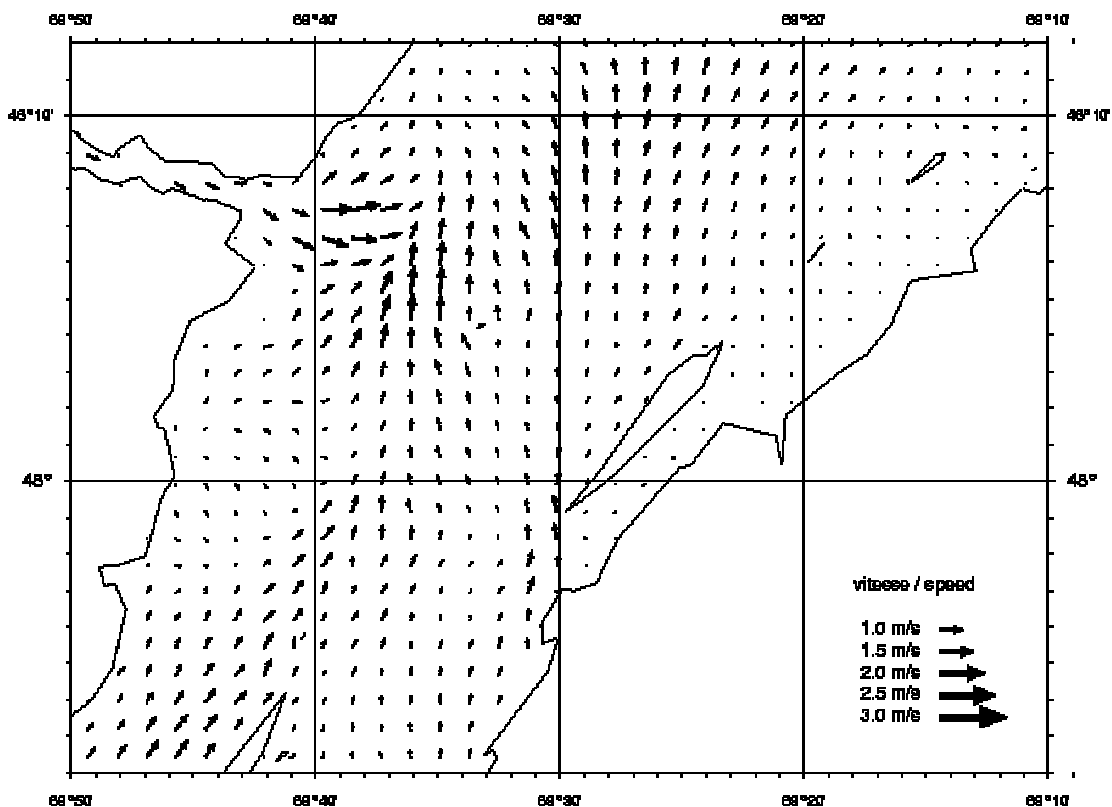
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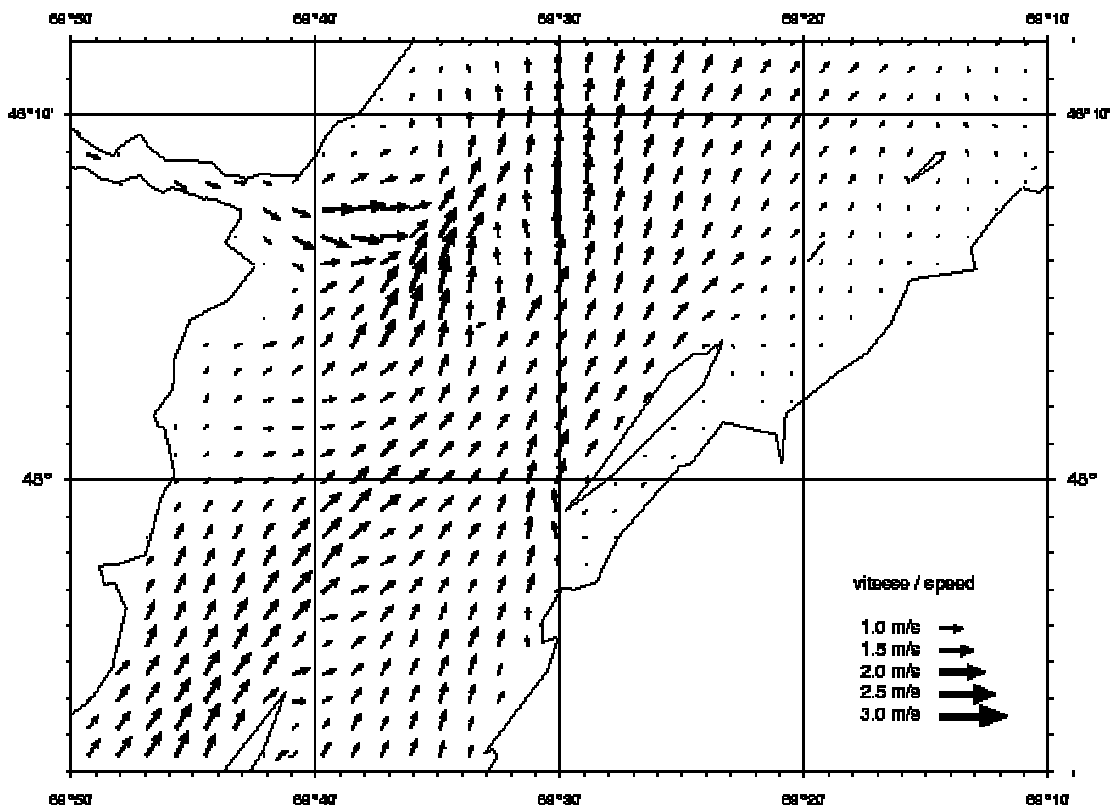
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2004-10-21, 11 : 00



2004-10-21, 12 : 00



2004-10-21, 13:00

