3.3.3. Drift trajectories of vessels

AIS data

AIS (Automatic Identification System) data provide huge database for historical vessel positions all over the world. Vessel can have several status indicators which changes from time to time:

- Underway using engine
- At Anchor
- Not Under Command
- Restricted Maneuverability
- Constrained by her Draught
- Moored
- Aground
- Engaged in Fishing
- Underway by Sail
- Towing Astern
- Pushing Ahead – Towing
- etc.

From these status indicators, the most useful for drift estimations is "Not Under Command". Usually, it happens when vessel switches off engine and vessel is subjected to move solely by winds, currents and waves. The engine could be switched off for various reasons:

- engine fault,
- crew needs a rest,
- crew needs to do other tasks,
- trying to stay at given location,
- waiting for orders,
- waiting until the destination harbor allows entrance,
- waiting until weather improves (waves, winds, ice, water level, etc.),
- waiting for another vessel,
- save the fuel if wind and currents are oriented in preferred direction,
- during fishing,
- etc.

Fishing vessels may be subjected to other forces due to pulling off fishing nets. Therefore, we will try to exclude most of vessels engaged in fishing. Vessels with status "Not Under Command" are treat for other passing vessels as they are not going to bypass them. Therefore, these vessels are specially marked by two red lights, balls or similar shapes in a vertical line where they can best be seen. In general, vessels from eastern European countries uses this status more frequently and also for prolonged time as vessels from western European countries. Accidents may arise if there are more vessels with the same status "Not Under Command" as they are not going to bypass each other.

Vessel trajectories of the given status in Baltic Sea were collected in September- November, 2019. Usually, there are about 2 useful drifting trajectories in a week, which are longer than 6 hours. It is usually enough to check terrestrial AIS data that has relatively good coverage in the Baltic Sea. Satellite AIS data have to be used for cross ocean voyages but these data are more costly. The parameters that can be extracted from AIS data are date and time (UTC), position (latitude and longitude), source of AIS, vessel speed, course, heading and vessel status.

The largest AIS data set can be obtained from “Marine Traffic” which has the largest user community. Therefore, we will use these data for analysis. As the drift model in “Present the Present” is operational AIS data are nice way to check the drift service operationally.

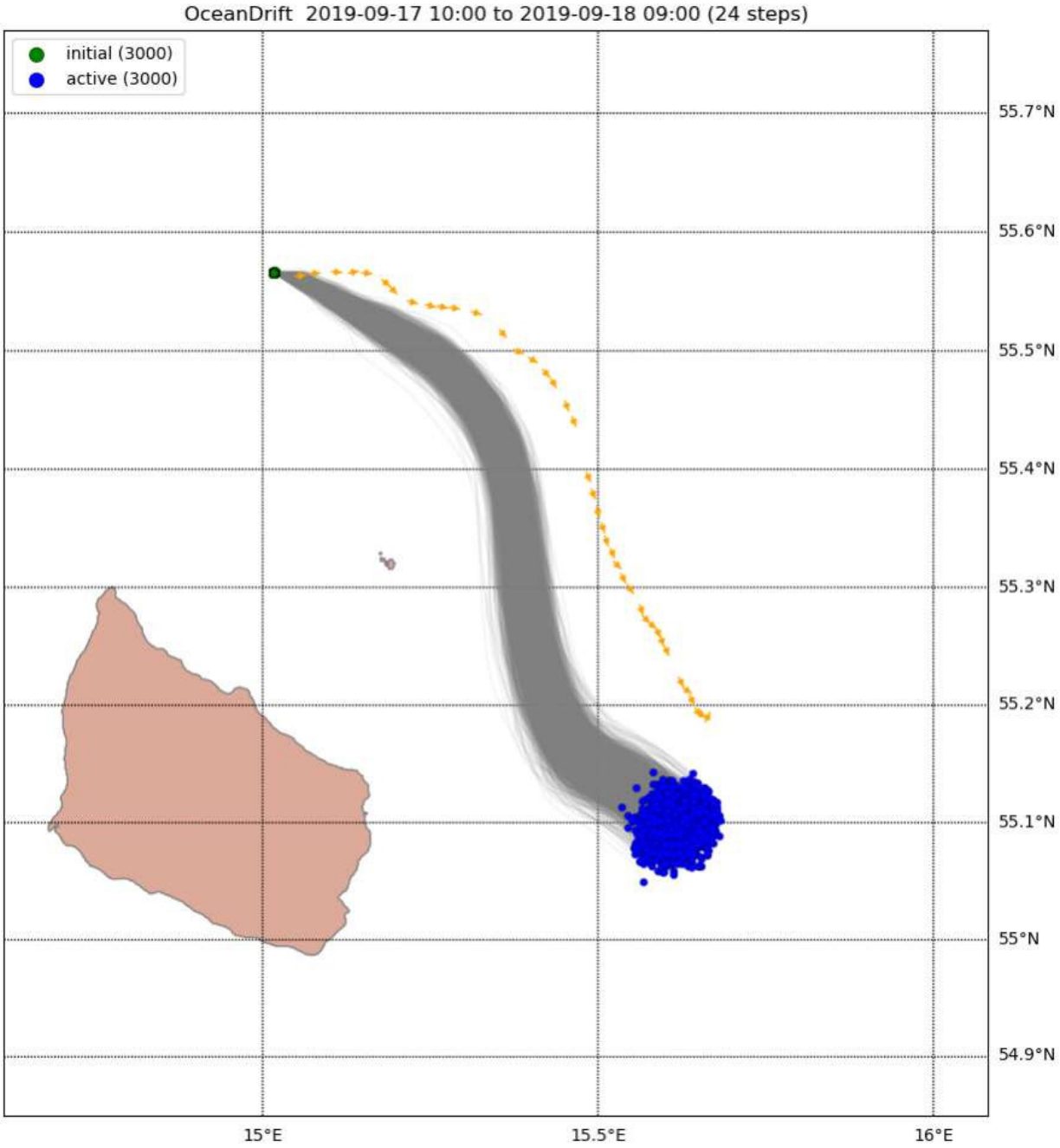

Figure 43: Chemical tanker “Amak Swan” [DK] (113.5 m * 16.9 m). Orange arrow denotes position and the course of the vessel in drift from 2019-09-17 10:00 (UTC) to 2019-09-18 09:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from “Present the Present”.

Drift of large objects

Stokes drift is applicable only to small floating objects whose size is much smaller than the typical wavelength of wind waves. Larger objects influence the wave field, i.e., there is refraction and reflection of waves.

Even more ships have principal part of its body above the water line. Thus, wind factor becomes extremely important for vessels. Usually, it is in range 0.05 to 0.1. Even more, ships are not axially symmetric objects and their orientation to the wind waves is critical for the drift direction. Ship exposed to wind and waves causes leeway, i.e., drift motion to leeward of an object floating in the water caused by the component of the wind vector to the object's forward motion. Usually, heading of vessel becomes oriented 60-120° angle with respect to wind direction. Then, it is critical to which side of the wind the vessel initially rotates. Vessel rarely flips the orientation during a constant wind, i.e., so called jibing. Jibing is more frequent for container like objects. The vessel is designed to to move easier in bow direction than in stern direction. Therefore, the actual drift of the vessel usually shifts towards the bow direction of the vessel from an ideal path of small rounded object.

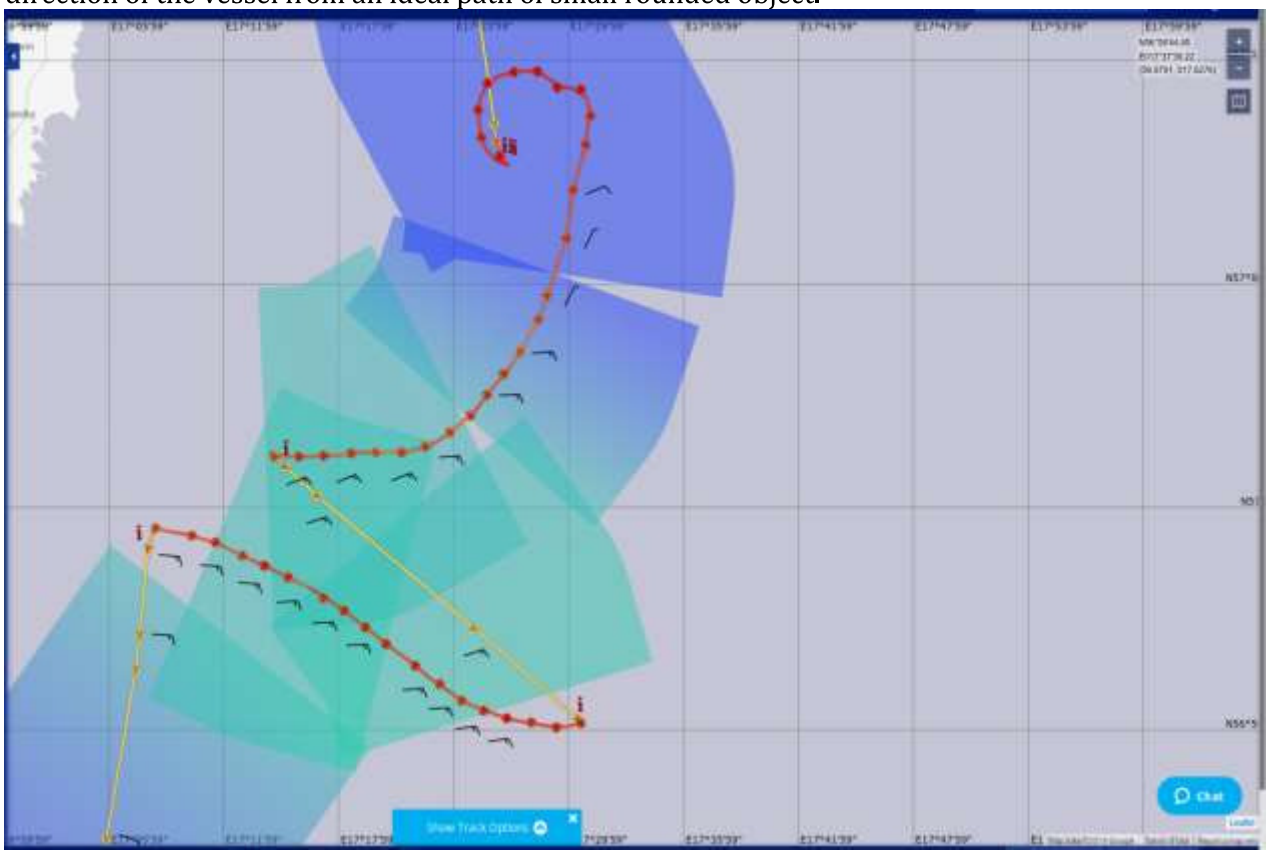

Figure 44: General cargo vessel "Gerda" [LV] (64.33 m * 10.5 m). Vessel trajectories obtained from "Marine Traffic". Color of the trajectory denote speed: red – slow, green -fast. 2 drift cases are red fragments from the vessel's path. The heading of the vessel and winds can also be observed.

Estimation of vessel drift

Let us estimate whether the online drift model of "Present the Present" can be applied for the vessels. First, we will estimate whether drift model is applicable with an open source code[24] for drift modeling supplying it with our data for ocean model and atmosphere.

Afterwards, we will apply the drift model from online drift service "Present the Present".

The vessel trajectories are obtained from "Marine Traffic" as described above. Data for September and beginning of October did not include heading of the vessel. We learned only later, how to include the heading of the vessel in the data as it is excluded by default. The heading of the vessel plays very important role in deviation of trajectory from a idealised drift model for small objects. We have not

[24] https://github.com/OpenDrift/opendrift

observed jibing at constant wind for vessel data in September – November, 2019 in Baltic sea. Vessels usually shift constantly to the direction of heading from an idealised model for small object. As wind factor we will use 0.06 which corresponds to the raft model in online drift service “Present the Present”.

As first example, chemical Tanker “Amak Swan” made a 23 hour drift in September 17-18, 2019 near Bornholm island, see Figure 43. Unfortunately, the data about heading of the vessel are missing and only course is shown. The calculated trajectories quiet well resemble an actual drift trajectory. However, the actual path is slightly more away from Bornholm island.

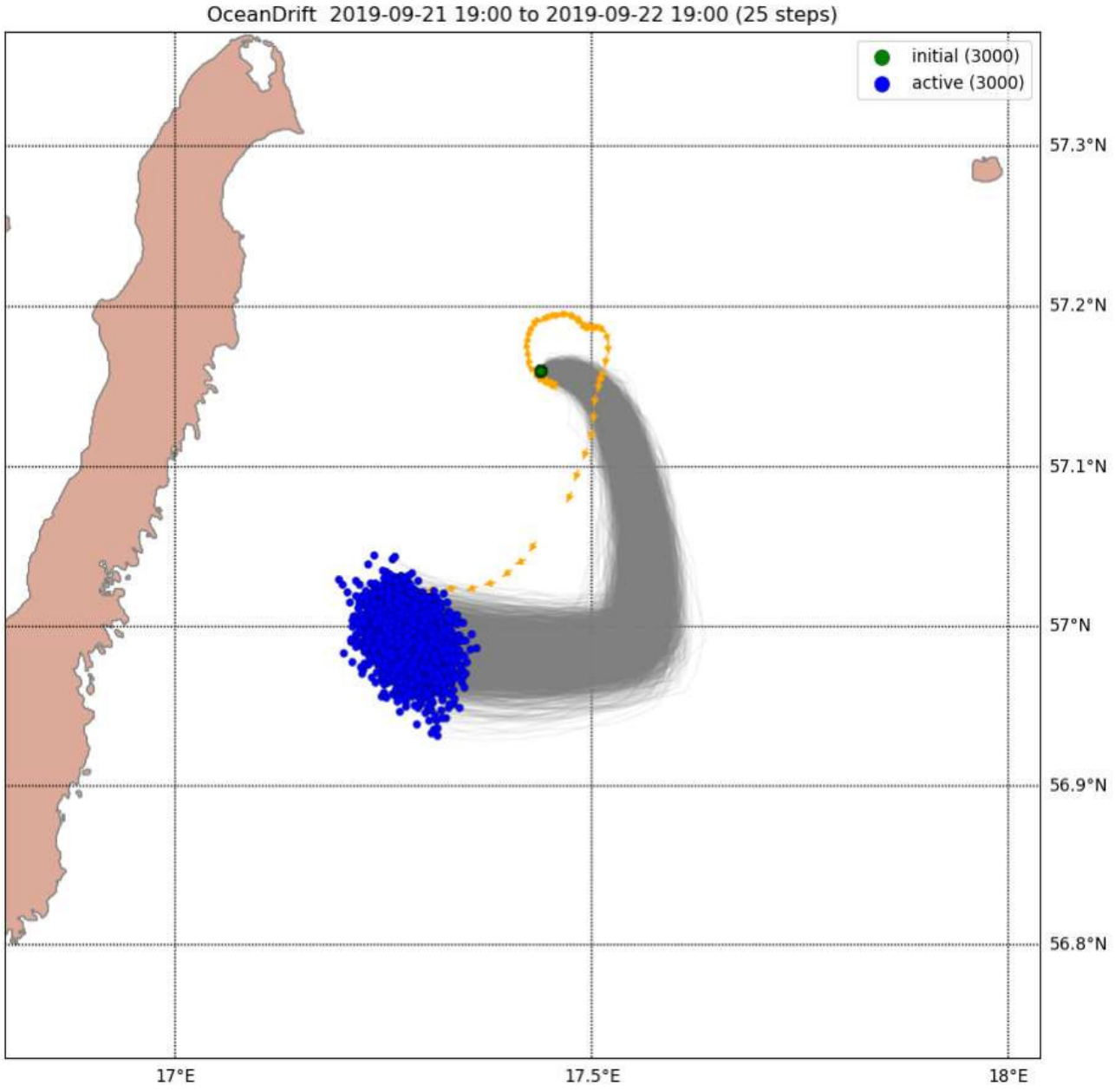

Figure 45: General cargo vessel “Gerda” [LV] (64.33 m * 10.5 m). Orange arrow denotes position and the course of the vessel in drift from 2019-09-21 19:00 (UTC) to 2019-09-22 19:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from “Present the Present”.

General cargo vessel “Gerda” made several drift cases in September, 2019 near Öland island, see Figure 44. Unfortunately, the data about the heading can only be seen in Figure but are not stored as numerical data. In both drift cases vessel is oriented left to the wind.

The first drift case of 24 hours is rather interesting as vessel makes a loop during a drift at low wind situation. That is, we can observe the effects of inertial oscillation of the currents. The basic model, see Figure 45, estimates the final position well, but the loop is not as nice as in reality.

The basic model works well also for the second drift (13 hours) case of "Gerda" at a bit higher winds despite close proximity of Öland island, see Figure 46. The actual path of vessel is slightly shifted southwards which may be result of southward heading of the vessel, see Figure 44.

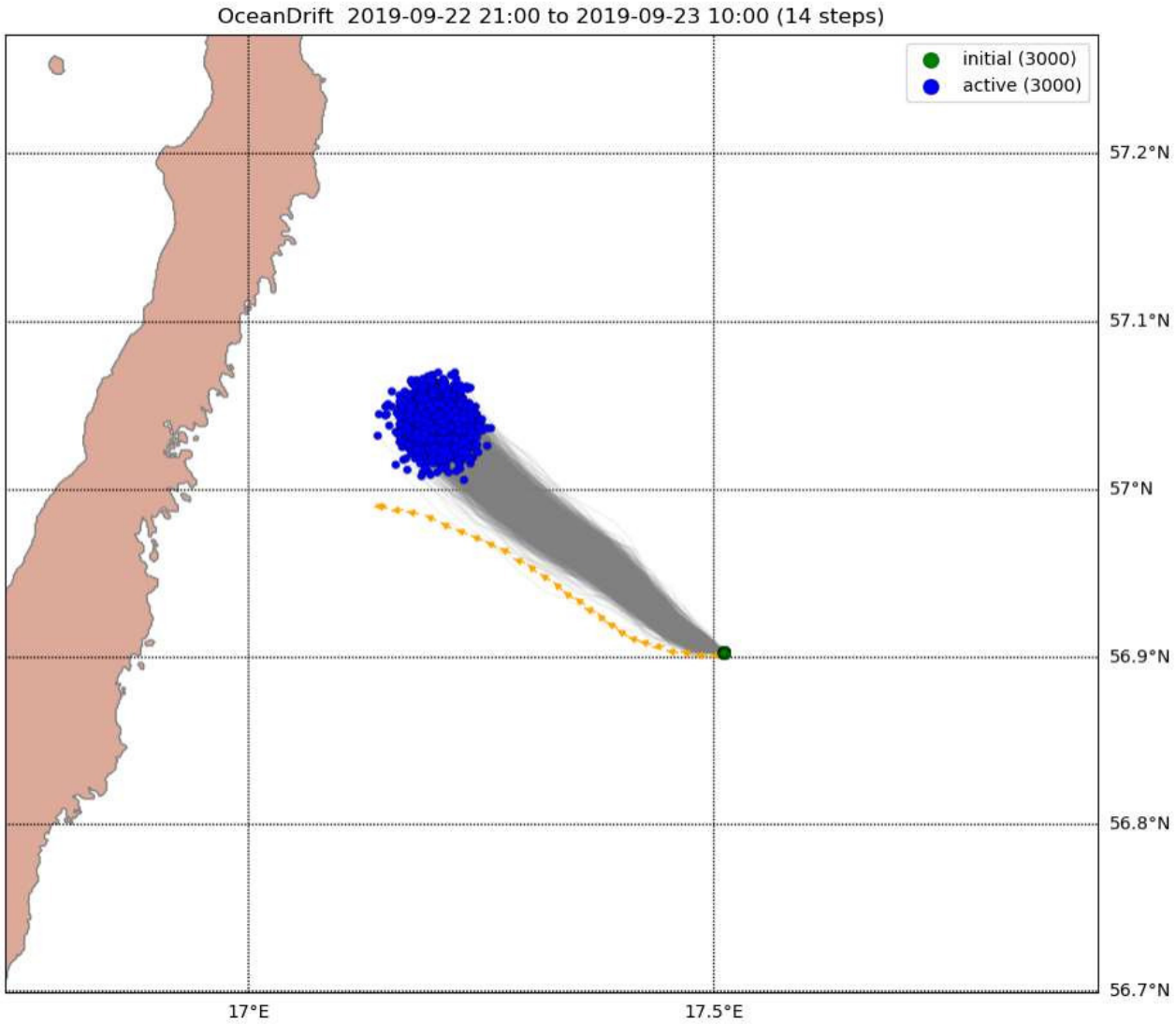

Figure 46. General cargo vessel "Gerda" [LV] (64.33 m * 10.5 m). Orange arrow denotes position and the course of the vessel in drift from 2019-09-22 21:00 (UTC) to 2019-09-23 10:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from "Present the Present".

Very large bulk carrier "Ultra lynx" drifted several times in October between Ventspils and Gotland with duration 7-11 hours. The first drift case is shown in Figure 47. The heading of the vessel was southward in all 3 drift cases of the vessel. Therefore, the actual trajectories are also shifted southwards from an idealised trajectory of small object. Nevertheless, the length of the drift is quiet similar to the idealised drift model.

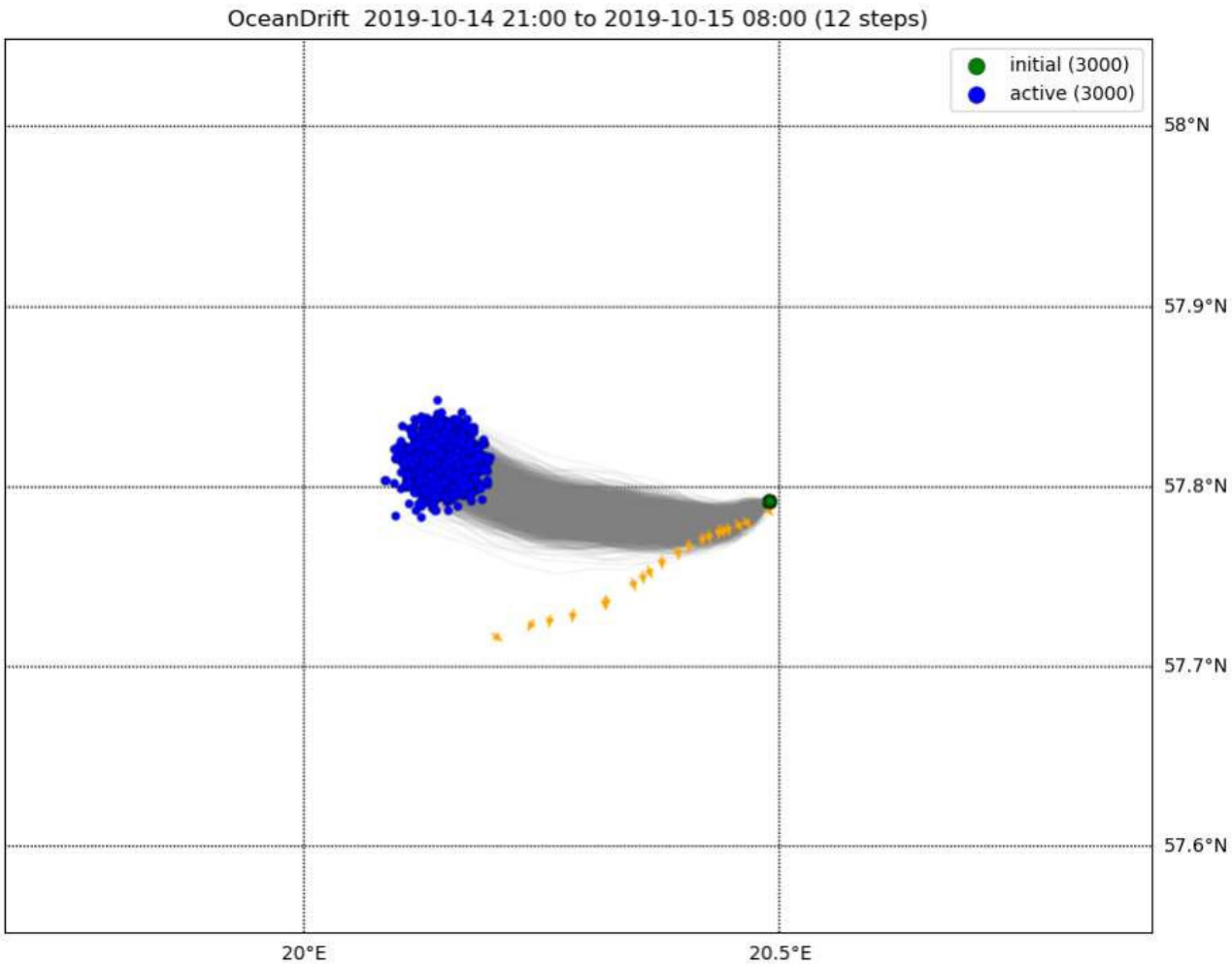

Figure 47. Bulk carrier "Ultra Lynx" [PA] (228.94 m * 32 m). Orange arrow denotes position and heading of the vessel in drift from 2019-10-14 21:00 (UTC) to 2019-10-15 08:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from "Present the Present".

Large bulk carrier "Kamenitza" made a long drift case (49 hours) near Ventspils in October, 2019, see Figure 48. There is some missed part of the trajectory due to limited coverage of terrestrial AIS. It is not known what happened with vessel at missed periods of time, but judging by the trajectory the vessel was freely drifting. The idealised model makes a correct loop towards left and finally to the right. The heading of the vessel is to the left from the wind direction. Therefore, the actual path is more westward as in the model.

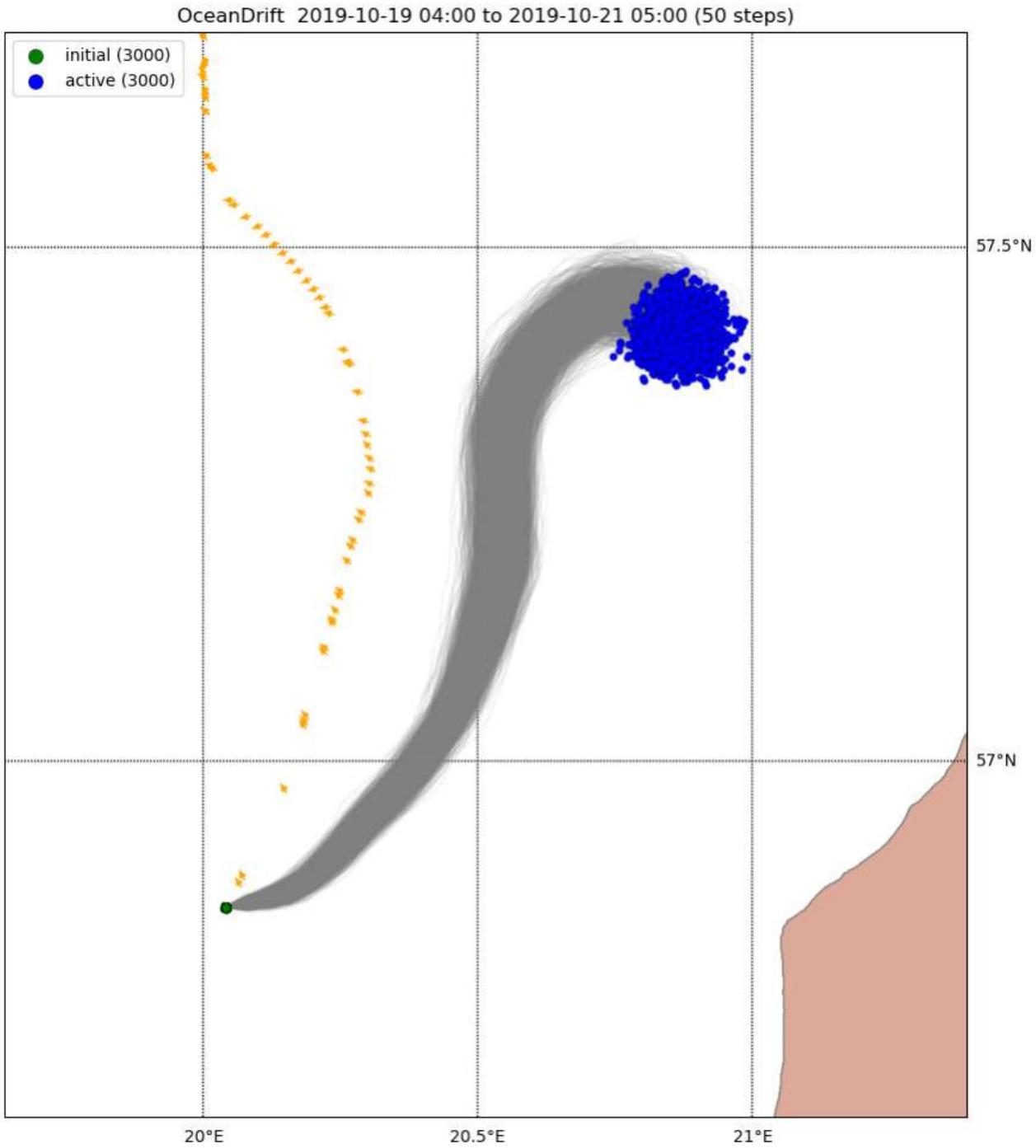

Figure 48. Bulk carrier "Kamenitza" [PA] (179.9 m * 28.4 m). Orange arrow denotes position and heading of the vessel in drift from 2019-10-19 04:00 (UTC) to 2019-10-21 05:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from "Present the Present".

Small fishing vessel "Tove" made several drift cases at eastern coast of Gotland in end of October. The longest drift case of 24 hours is shown in Figure 49. The model predicted well the loop caused by inertial oscillation of currents at low wind. However, ocean models with resolution of about 1 nm do not work well at coastal locations. As a result eastward drift becomes overestimated. The heading of the vessel seems to be less important for smaller ships. It is unclear, whether vessel "Tove" was engaged in fishing activities during the drift case, but judging from the loop it was moving rather freely.

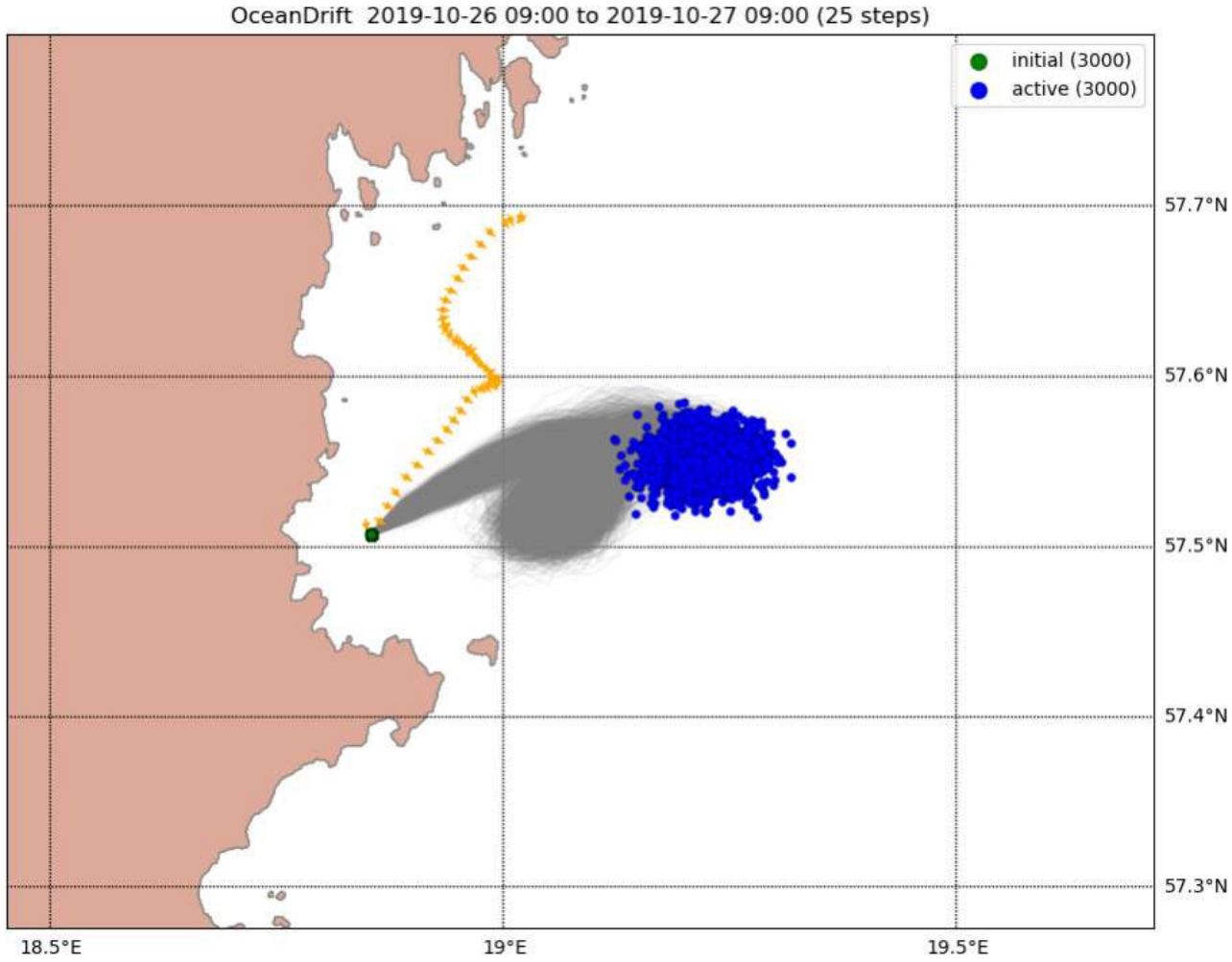

Figure 49. Fishing vessel "Tove" [LT] (34.93 m * 6.71 m). Orange arrow denotes position and heading of the vessel in drift from 2019-10-26 09:00 (UTC) to 2019-10-27 09:00 (UTC). Grey curves and blue points: estimation of drift by OpenDrift basing on currents and winds from "Present the Present".

Oil products tanker "SCF Anadyr" made several drift cases in Gulf of Finland in beginning of November, 2019, see Figure 50. At that time, there were high eastern winds in Gulf of Finland. Presumably, the vessel passively waited for improvement of weather. Drift trajectories were estimated by online drift service for small objects in "Present the Present" with wind factor 0.06. The heading of the vessel in both cases is in right direction to the wind. It seems that due to northward heading actual drift trajectories are also shifted more northward than in the idealised model. The drift length matches well with the observed one.

Oil/chemical tanker "Sea Dolphin" made 3 drift cases near Ventspils coast in November, 2019, see Figure 51. The drift speed was much lower as compared to the drift of "SCF Anadyr" in Figure 8. The actual trajectories in all 3 cases are shifted towards the heading of the vessel.

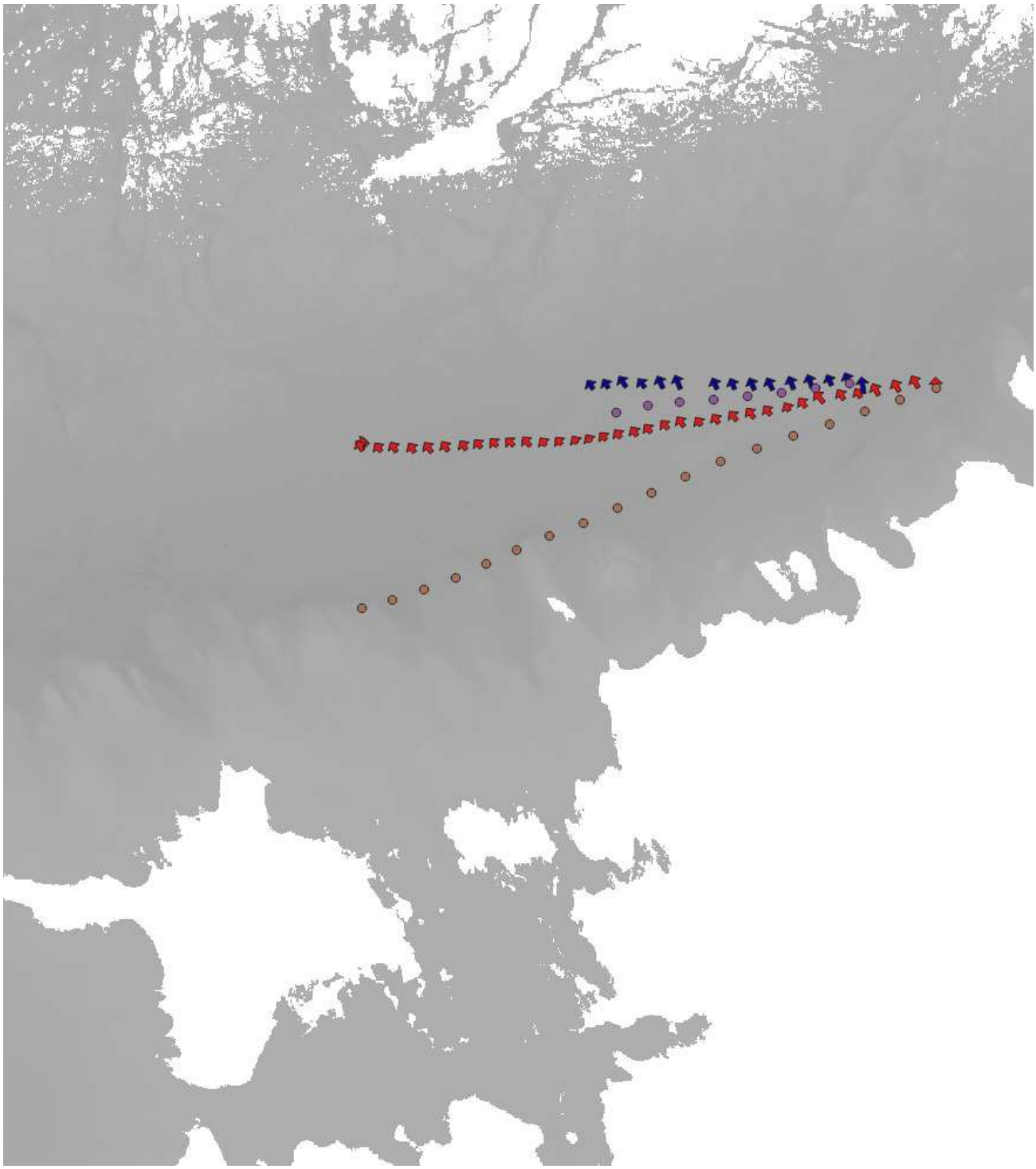

Figure 50. Oil products tanker “SCF Anadyr” [LR] (183 m * 32.23 m). Arrow denotes position and heading of the vessel in westward drifts by different colour: 2019-11-04 16:00 (UTC) (blue and light blue) to 2019-11-04 23:00 (UTC) (red and green) and 2019-11-05 04:00 (UTC) to 2019-11-05 21:00 (UTC). Circles denote drift trajectory according to “Present the Present” at wind factor of 0.06 (“Raft”). The vector size of the vessel denotes actual speed.