CONTENTS

1 OIL TRAJECTORY MODELLING IN THE BARENTS SEA

2 OIL TRAJECTORY MODELING IN THE WHITE SEA

2.1 Approved oil trajectory modelling conditions in the White Sea.

2.1.1 The area and point of modelling

Based on the analysis of provisions of the Mode of Navigation in the Barents and White Seas (Summary Description..., 2007) and the Pilot of the White Sea (Pilot of the White Sea, 1983) the shipping route area with the highest navigation risk has been selected in the White Sea. The area is bounded by lines connecting points with the coordinates as follows:

Area 1. The White Sea:

1)	66°09,50'N,	40°28,80'E;
2)	66 11,80	40 19,50
3)	66 16,00	40 13,20
4)	66 21,70	40 34,80
5)	69 19,40	40 44,40

Resulting from the analysis of the set shipping routes in the selected area of the White Sea, the point of intersection of basic shipping routes by tankers/carbon carriers with the coordinates as follows (Figure 309):

Point 2. The White Sea: 66°16,80'N, *40°30,00'E*

Figure 309 The Modelling point OS-2

2.1.1. Types of oil

Based on the analysis of types of oil shipped across the White Sea the following types have been accepted for modelling: crude oil (Ukhta oil grade), black oil of M-100 grade, stable gas condensate (SGC), naphtha (stable natural gasoline).

Tables 2.1.2.1 – 2.1.2.4. present the basic physical-chemical properties of crude oil types applied for computer-based modelling.

Table 2.1.2.1. Physical-chemical properties of the crude oil (Ukhta oil grade)

No	GOST P 51858-2002 Index Name	Value
1.	Density at 20^0C, kg/m^3	854,7
2.	Water content, %	absence
3.	Mass fraction of solids %	absence
4.	Mass fraction of sulphur, %	0,629
5.	Saturated vapour pressure, kPa, (mm Hg)	7,9 (59,30)
6.	Fractions yield, % at temperature: 200 °C 300 °C	 23,5 46,5
7.	Mass fraction of paraffin, %	-

Table 2.1.2.2. Physical-chemical properties of black oil, grade M-100 type VI

No	GOST 10585–99 Index Name	Value
1.	Viscosity at T not exceeding 80^{0}C: kinematic, m^2/s (cSt) funnel, degrees FV	 66, 9,0
2.	Ash content, mass fraction %	0,037
3.	Mass fraction of solids %	0,034
4.	Mass fraction of water %	0,24
5.	Content of water-soluble acids and alkalis	absence
6.	Flashpoint COC,^{0}C	136
7.	Mass fraction of sulphur %	2,68
8.	Congelation point,^{0}C	21
9.	Combustion heat, kJ/kg	43825
10.	Hydrogen sulfide and volatile mercaptans	absence
11.	Density at 20^{0}C, kg/m^3	975,2

Table 1.1.2.3. Physical-chemical properties of SGC

No	OST 51.65-80 Index Name	Value
1.	Density at 20^{0}C, kg/m^3	739,5
2.	Kinematic viscosity at 20^{0}C, m^2/c (cSt)	1,058
3.	Saturated vapour pressure, kPa, (mm Hg)	56,6 (425,3)
4.	Mass fraction of solids %	absence
5.	Mass fraction of water %	absence
6.	Mass fraction of chloride salts, mg/l	0,7
7.	Mass fraction of the total sulphur, % of mass	Less than 0,01
8.	Fractions yield Start of boiling, °C 10% (vol.) 50% (vol.) 90% (vol.) End of boiling, °C Yield, % (vol.) Residue, % (vol.) Loss, % (vol.)	 39,0 67,0 139,0 295,0 312,0 94,0 2,5 3,5

Table 2.1.2.4. Physical-chemical properties of naphtha(stable natural gasoline, grade BL)

No	STO 11605031-019-2007 Index Name	Value
1.	Fractional composition: Initial boiling point, ^{0}C, not below End of boiling, ^{0}C, not higher	 57 111
2.	Density at 15 ^{0}C, kg/m^3	695
3.	Mass fraction of sulphur, %	0,003
4.	Concentration of actual gum, mg per 100 sm^3 of naphtha	2,0
5.	Mass fraction of paraffin, %	69,6
6.	Mass fraction of aromatic hydrocarbons, %	7,4
7.	Mass fraction of naphthenic hydrocarbons %	13,58
8.	Water and solids	Отсутствие
9.	Saturated vapour pressure, kPa, not exceeding	55,0

2.2 Volume of oil

Based on the cargo characteristics of the tankers shipping oil in the White Sea waters and the legal requirements to determination of maximum volume of oil spill occurred from tankers, i.e. the volume of two adjacent tanks, the following parameters have been accepted for modelling

a) Crude oil spill volume – 14 000 m^3
b) Black oil spill volume – 14 000 m^3
c) SGC spill volume – 14 000 m^3
d) Naphtha spill volume – 10 000 m^3

2.2.1 Hydro-meteorological conditions of modelling

The basic parameters of the hydro-meteorological conditions accepted for oil and oil product spill behaviour modelling in case of oil spill in the White Sea are shown in Table 3.1.3.1.
The image of ice conditions in the White Sea is shown on Figure 310.

Table 3.1.3.1: Hydro-meteorological conditions of OS modelling in the Barents Sea

No	Parameter	Indices	
1.	Season	**Autumn**	**Winter**
2.	Average air T, ^{O}C	+1	-11
3.	Average water T, ^{O}C	+2	-1,9
4.	Density of surface water, kg/m^3	1027	1027
5.	Prevailing wind	S, W	S, W
6.	Average monthly wind speed, m/s	12	12
7.	Heaving, m	2	2
8.	Current velocity, km/h	1	1
9.	Cloud conditions	7	8
10	Ice concentration	-	70%

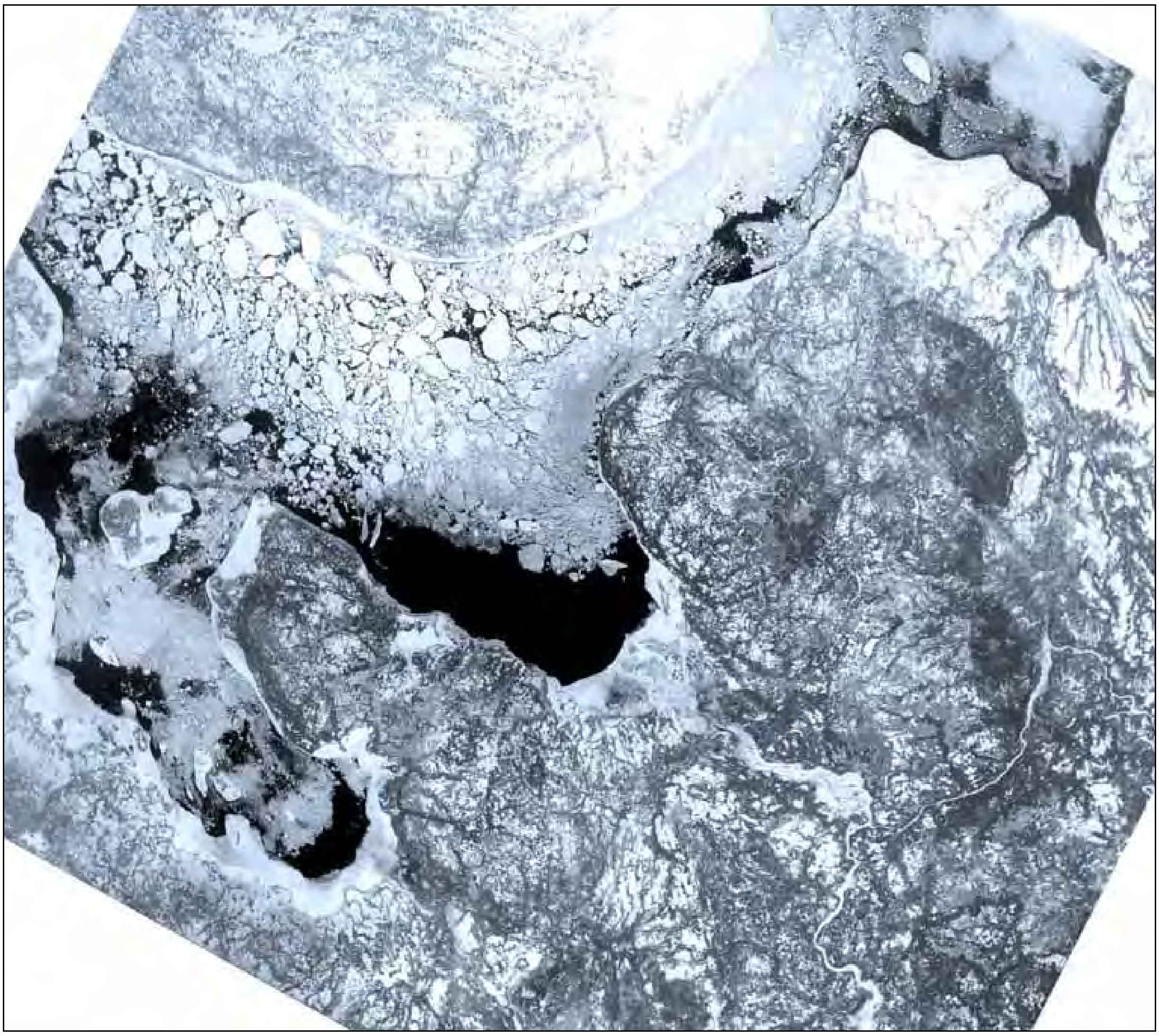


Figure 310. Ice conditions in the White Sea, data by KMSS (the Sattelite Multispectral Imaging System)/Meteor-M No 1, 2010 г. (URL:http://www.ntsomz.ru)

2.2.2 Oil and oil product spill scenarios in the White Sea

16 the scenarios have been determined for the purpose of oil spill behaviour modelling in the OS point for all the four types of oil and oil products. The scenario codes, oil spill volumes and explanation are shown in Table 2.3.4.1.

Table 3.1.5.1.: OS modelling scenarios in the White Sea.

No	The scenario Code	OS Volume, m^3	Explanation
1.	**COU-Aut-S-2**	14 000	COU – crude oil (Ukhta grade); Aut – autumn; S – south wind; 2 – modelling point OS-2
2.	**BO-Aut-S-2**	14 000	BO – black oil; Aut – autumn; S – south wind; 2 – modelling point OS-2
3.	**GC-Aut-S-2**	14 000	GC – gas condensate; Aut – autumn; S – south wind; 2 – modelling point OS-2
4.	**Na-Aut-S-2**	10 000	Na – naphtha; Aut – autumn; S – south wind; 2 – modelling point OS-2
5.	**COU-Aut-W-2**	14 000	COU – crude oil (Ukhta grade); Aut – autumn; W – west wind; 2 – modelling point OS-2

6.	**BO-Aut-W-2**	14 000	BO – black oil; Aut – autumn; W – west wind; 2 – modelling point OS-2
7.	**GC-Aut-W-2**	14 000	GC – gas condensate; Aut – autumn; W – west wind; 2 – modelling point OS-2
8.	**Na-Aut-W-2**	10 000	Na – naphtha; Aut – autumn; W – west wind; 2 – modelling point OS-2
9.	**COU-Win-S-2**	14 000	COU – crude oil (Ukhta grade); Win – winter; S – south wind; 2 – modelling point OS-2
10.	**BO-Win-S-2**	14 000	BO – black oil; Win – winter; S – south wind ; 2 – modelling point OS-2
11.	**GC-Win-S-2**	14 000	GC – gas condensate; Win– winter; S – south wind; 2 – modelling point OS-2
12.	**Na-Win-S-2**	10 000	Na – naphtha; Win– winter; S – south wind; 2 – modelling point OS-2
13.	**COU-Win-W-2**	14 000	COU – crude oil (Ukhta grade»); Win – winter; W – west wind; 2 – modelling point OS-2
14.	**BO-Win-W-2**	14 000	BO – black oil; Win – winter; W – west wind; 2 – modelling point OS-2
15.	**GC-Win-W-2**	14 000	GC – gas condensate; Win – winter; W – west wind; 2 – modelling point OS-2
16.	**Na-Win-W-2**	10 000	Na – naphtha; Win – winter; W – west wind; 2 – modelling point OS-2

2.3 Oil behavior modeling in the White sea under the autumn southward wind (Aut-S-2)

2.3.1 Oil slick behavior modeling as per the scenario COU-Aut-S-2

Table 2.2.1.1: Oil slick spreading parameters as per the scenario COU-Aut-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixturee volume afloat	Average slick thickness	Oil slick area	Viscosity
Unit	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3489	100	3449	98,9	5,60	0,16	34,40	0,99	0	0	5803	18,64	311403	45,3
H+02:00	6991	100	6880	98,4	26,6	0,38	84,9	1,21	0	0	15431	17,32	890765	102
H+03:00	10494	100	10292	98,1	69,3	0,66	132,0	1,26	0	0	26425	15,17	1741382	151
H+04:00	14000	100	13681	97,7	136	0,97	174	1,24	0	0	37667	14,80	2545702	187
H+05:00	14000	100	13600	97,1	210	1,50	190	1,36	0	0	43125	15,70	2747016	285
H+06:00	14000	100	13515	96,5	286	2,04	199	1,42	0	0	44636	15,41	2896977	333
H+08:00	14000	100	13344	95,3	437	3,12	218	1,56	0	0	44500	14,06	3165605	380
H+09:00	14000	100	13258	94,7	514	3,67	229	1,63	0	0	44220	12,48	3542096	401
H+10:00	14000	100	13167	94,0	594	4,24	240	1,71	0	0	43919	11,61	3783720	425
H+11:00	14000	100	13075	93,4	674	4,81	252	1,80	0	0	43612	11,03	3953527	449
H+12:00	14000	100	12983	92,7	752	5,37	264	1,88	0	0	43308	10,15	4267165	475
H+13:00	14000	100	12895	92,1	828	5,92	277	1,98	0	0	43012	9,95	4324213	502
H+13:59 Landfall	14000	100	12805	91,5	904	6,46	290	2,07	0,5	0	42713	9,32	4584944	529
H+18:00	14000	100	12474	89,1	1081	7,72	344	2,46	100	0,73	41610	43,78	950344	600
H+20:00	14000	100	12378	88,4	1099	7,85	373	2,66	150	1,08	41289	117,0	352957	607
H+22:00	14000	100	12313	88,0	1110	7,93	403	2,88	174	1,26	41073	165,7	247841	612

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 2827 m, the volume of the evaporated oil – 0,97%, the volume of the dispersed oil – 1,24%. Further the oil slick drifts northward in the direction of the Terskiy coastline of the White Sea. After 9 hours as of the OS start the oil slick semi-perimeter makes 3335 m, the volume of the evaporated oil – 3,7%, the volume of the dispersed oil – 1,6%. After 12 hours as of the OS start the semi-perimeter makes 3661 m, the volume of the evaporated oil – 5,4%, the volume of the dispersed oil – 1,9%. After 14 hours as of the OS start the oil reaches the coastline in the area of the Glubokaya Bay. After 18 hours as of the OS start aout 7 km of the coastline in the area of the Glubokaya Bay and the western part of the Strait Sosonovskaya Salma have been polluted. The volume of the oil/water mixturee has oincreased compared to the OS volume with 197%, the volume of the evaporated oil – 7,8%, the volume of the dispersed oil – 2,5%. To the moment of the modeling completion (22 hours) all oil has reached the Terskiy coastline of the White Sea. The coastline from the Glubokaya Bay to the Sosnovka river mouth with the total length of more than 12 km has been polluted with oil. The volume of the evaporated oil – 7,9%, the volume of the dispersed oil – 2,9%, the average oil slick thickness by the coastline makes 16,6 sm.

The graphic display of oil slick spearding as per the scenario COU-Aut-S-2 is shown in figures 312 – 328.
The charts of processes typical for oiil behavior on water are shown in figures 329-331.

Figure 312. H+01:00. Oil slick spreading as per the scenario COU-Aut-S-2.

Figure 313. H+02:00. Oil slick spreading as per the scenario COU-Aut-S-2.

Figure 314. H+03:00. Oil slick spreading as per the scenario COU-Aut-S-2.

Figure 315. H+04:00. Oil slick spreading as per the scenario COU-Aut-S-2.

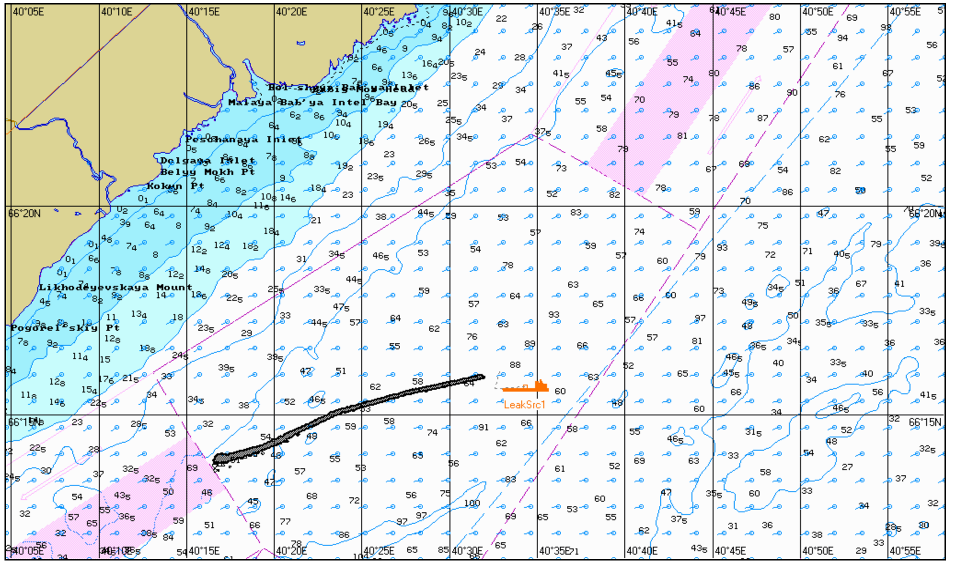


Figure 317. H+05:00. Oil slick spreading as per the scenario COU-Aut-S-2.

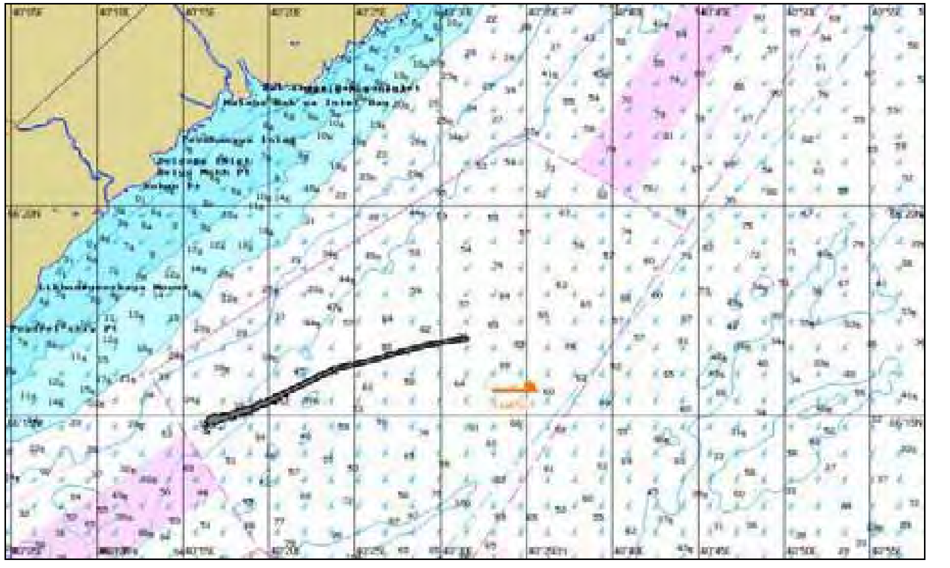


Figure 318. H+06:00. Oil slick spreading as per the scenario COU-Aut-S-2.

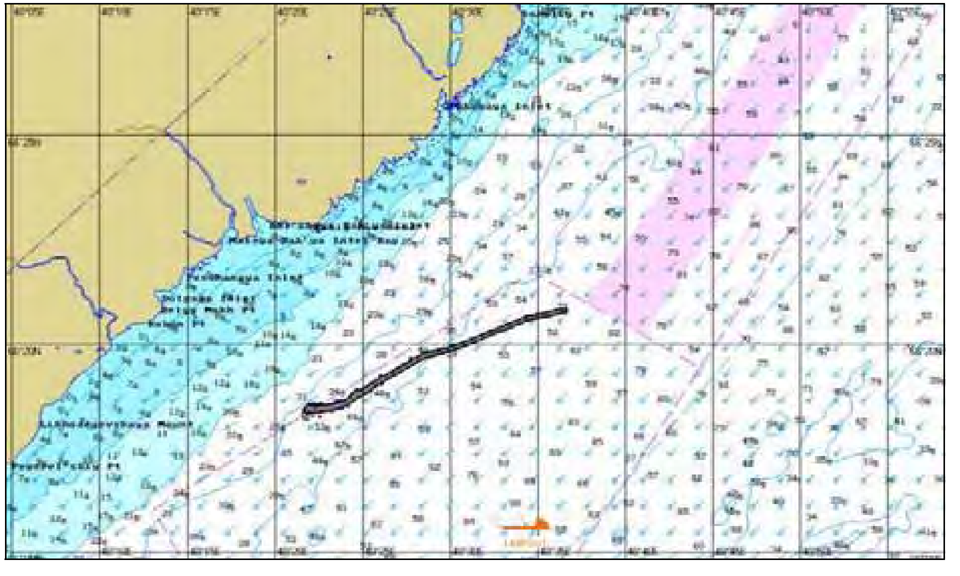


Figure 319. H+08:00. Oil slick spreading as per the scenario COU-Aut-S-2.

Figure 320. H+09:00. Oil slick spreading as per the scenario COU-Aut-S-2.

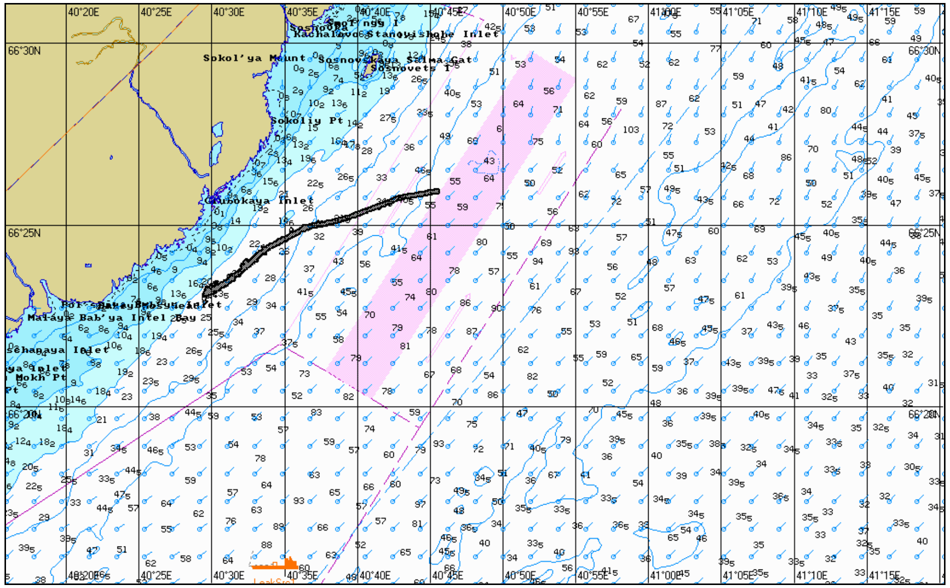


Figure 321. H+10:00. Oil slick spreading as per the scenario COU-Aut-S-2.

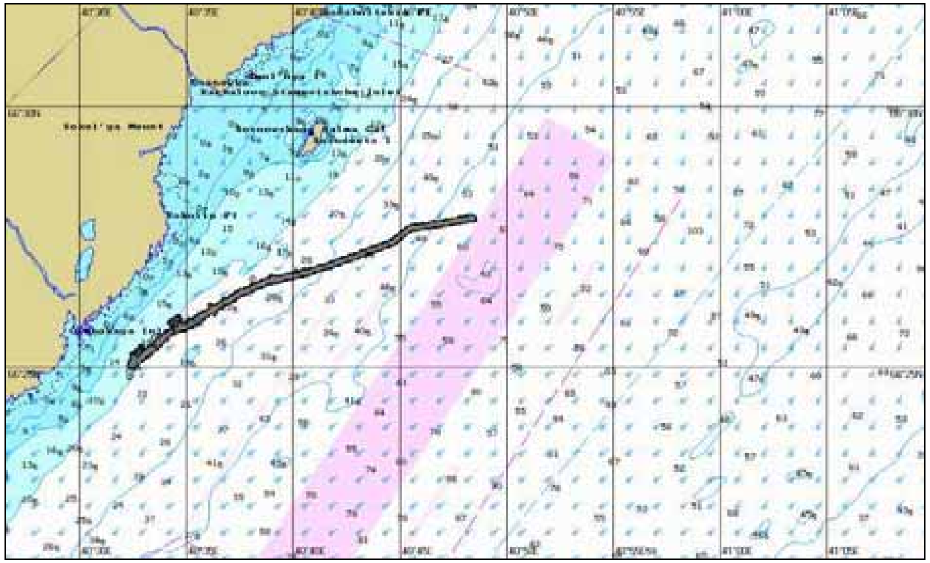


Figure 322. H+11:00. Oil slick spreading as per the scenario COU-Aut-S-2.

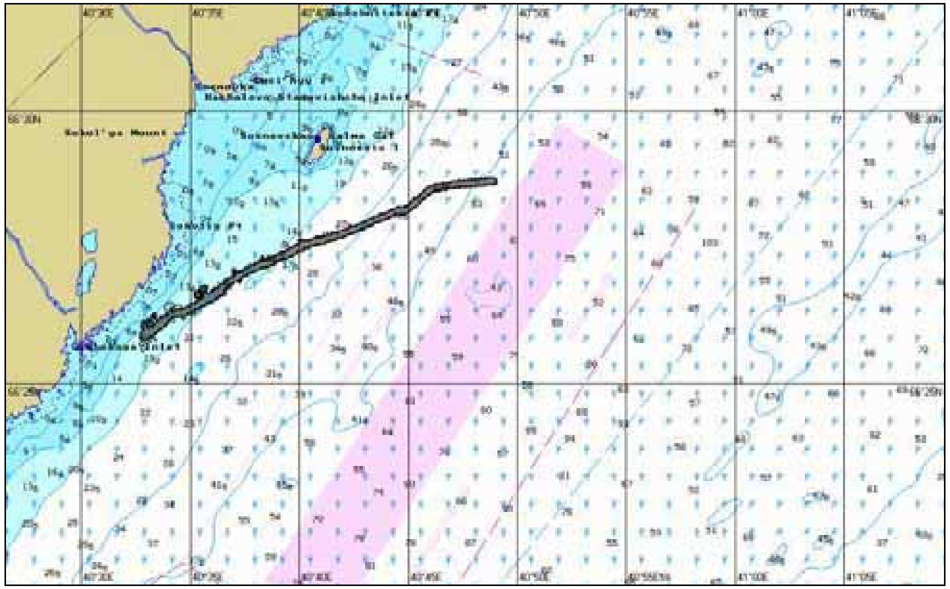


Figure 323. H+12:00. Oil slick spreading as per the scenario COU-Aut-S-2.

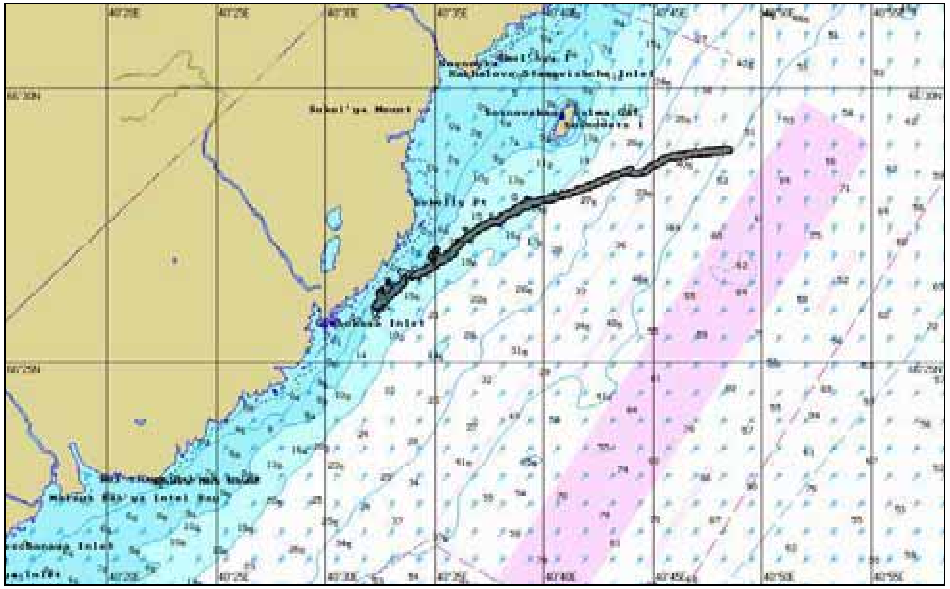


Figure 324. H+13:00. Oil slick spreading as per the scenario COU-Aut-S-2.

Figure 325. **H+13:59.** Oil slick spreading as per the scenario COU-Aut-S-2.

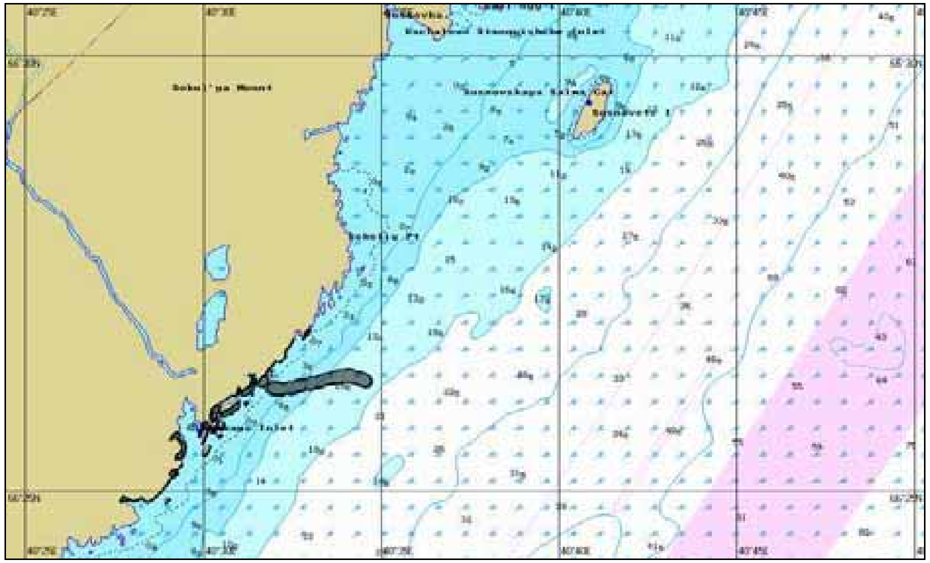


Figure 326. H+18:00. Oil slick spreading as per the scenario COU-Aut-S-2.

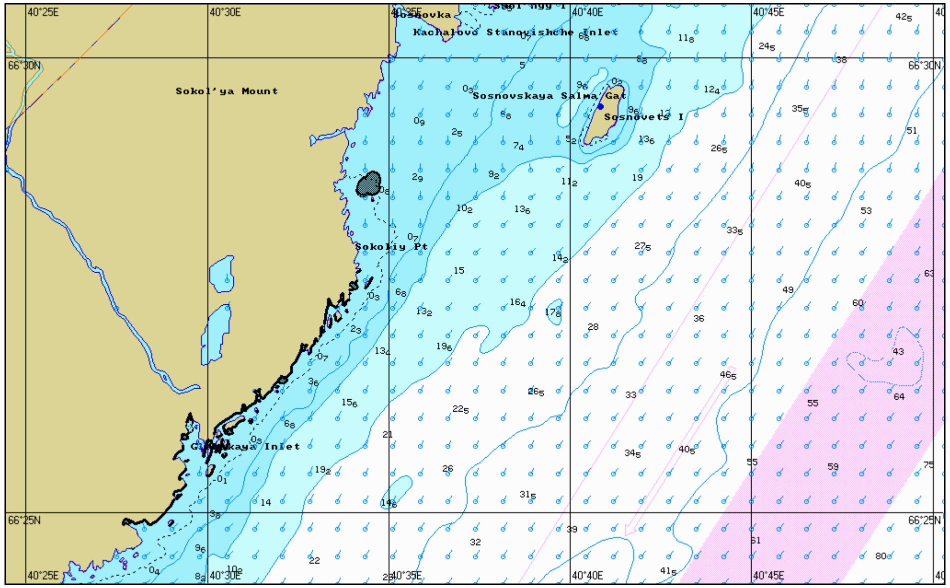


Figure 327. H+20:00. Oil slick spreading as per the scenario COU-Aut-S-2.

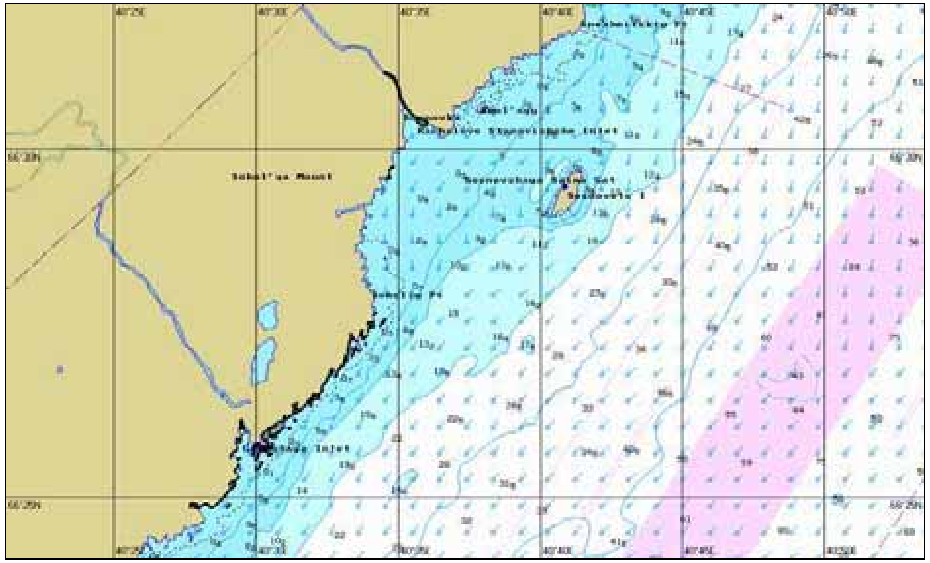


Figure 328. H+22:00. Oil slick spreading as per the scenario COU-Aut-S-2.

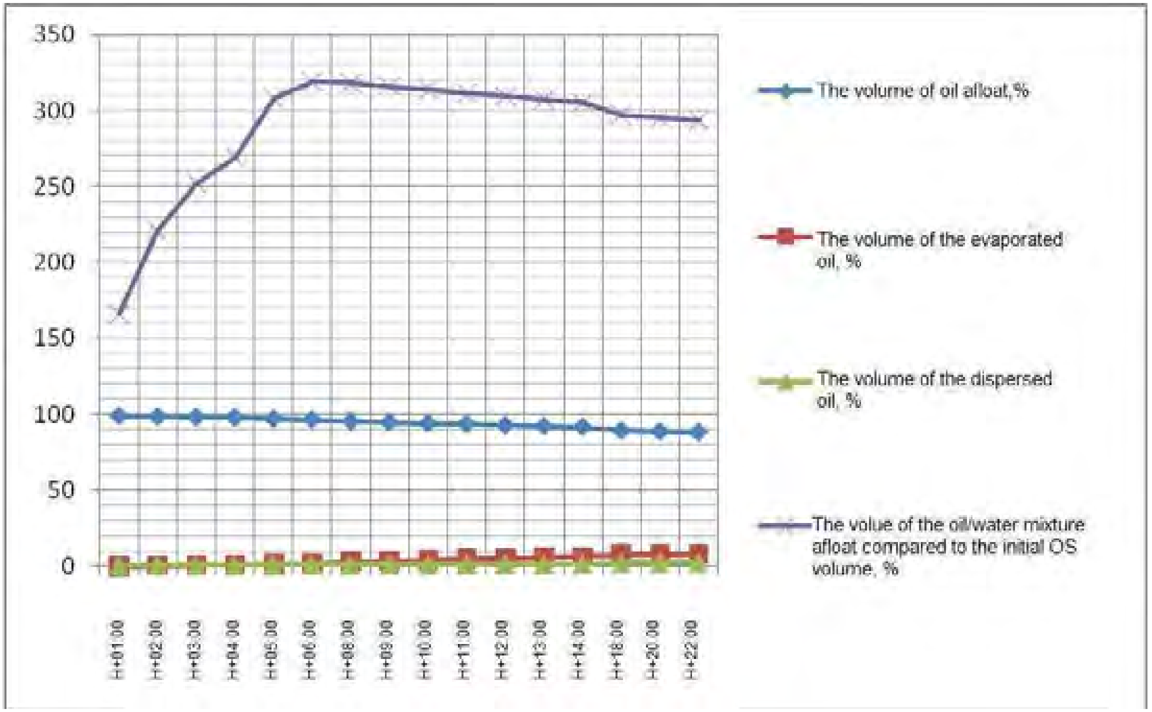


Figure 329. The chart of processes as per the scenario COU-Aut-S-2.

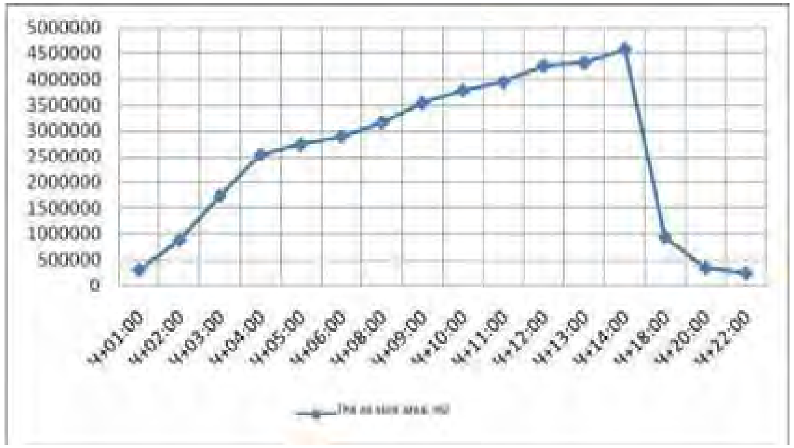


Figure 330. Oil slick area change dynamics as per the scenario COU-Aut-S-2.

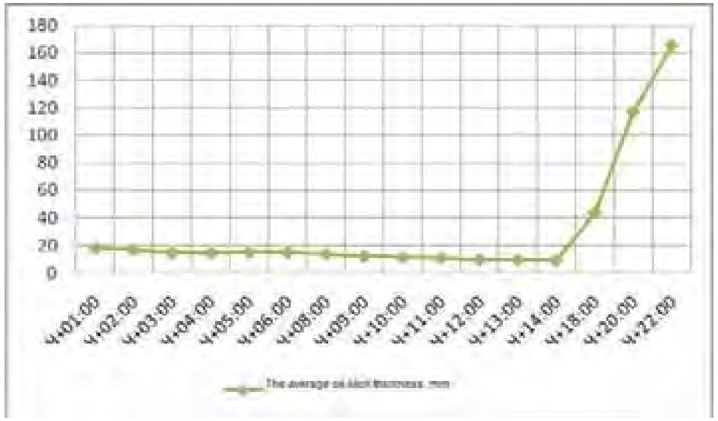


Figure 331. Oil slick thickness change dynamics as per the scenario COU-Aut-S-2.

2.3.2 Oil slick behaviour modelling as per the scenario BO-Aut-S-2

Table 2.2.2.1.: Oil slick spreading parameters as per the scenario BO-Aut-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixturee volume afloat	Average slick thickness	Oil slick area	Viscosity
Unit	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3550	100	3550	100	0	0	0	0	0	0	3550	25,75	137868	16514
H+02:00	7114	100	7114	100	0	0	0	0	0	0	7114	16,41	433595	16514
H+03:00	10679	100	10679	100	0	0	0	0	0	0	10679	12,12	881358	16514
H+04:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,55	1326431	16514
H+05:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,73	1305239	16514
H+06:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,75	1302113	16514
H+08:00	14000	100	14000	100	0	0	0	0	0	0	14000	11,08	1263214	16514
H+09:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,36	1351099	16514
H+10:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,07	1390163	16514
H+11:00	14000	100	14000	100	0	0	0	0	0	0	14000	9,97	1403556	16514
H+12:00	14000	100	14000	100	0	0	0	0	0	0	14000	9,64	1451794	16514
H+13:00	14000	100	14000	100	0	0	0	0	0	0	14000	9,90	1413937	16514
H+14:16 **Landfall**	14000	100	13999	99,99	0	0	0	0	0,7	0,01	13999	9,05	1547540	16514
H+18:00	14000	100	13916	99,40	0	0	0	0	83,9	0,60	13916	61,10	227769	16514
H+20:00	14000	100	13866	99,04	0	0	0	0	134	0,96	13866	249,1	55657	16514
H+22:00	14000	100	13859	98,99	0	0	0	0	141	1,01	13859	482,6	28720	16514

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. ПAfter 4 hours as of the OS start the oil slick semi-perimeter makes 2041 m, the evaporation and dispersion processes are not detected by the programme. Further the oil slick drifts northward in the direction of the Terskiy coastline of the White Sea. After 9 hours as of the OS start the oil slick smi-perimeter makes 2059 m, the evaporation and dispersion processes are not detected by the programme. After 12 hours as of the OS start the oil-slick semi-perimeter makes 2135 m, the evaporation and dispersion processes are not detected by the programme. After 14 hours and 16 minutes as of the OS start the oil reaches the coastline in the area of the Glubokaya Bay. After 18 hours as of the OS start about 8 km of the coastline in the area of the Glubokaya Bay and the western part of the Strait Sosnovskaya Salma have been polluted. The volume of the oil/water mixturee compared to the OS volume has not increased. To the moment of the modeling completion (22 hours) all oil has reached the terskiy coastline of the White Sea. The coastline from the Glubokaya bay to the Sosnovka river mouth with the total length of more than 10 km has been polluted with oil, the average black oil slick thickness in the shore makes 48,2 sm.

The graphic display of oil slick spreading as per the scenario BO-Aut-S-2 is shown in figures 332 – 347.

The charts of processes typical for black oil behavior on water are shown in figures 348-350.

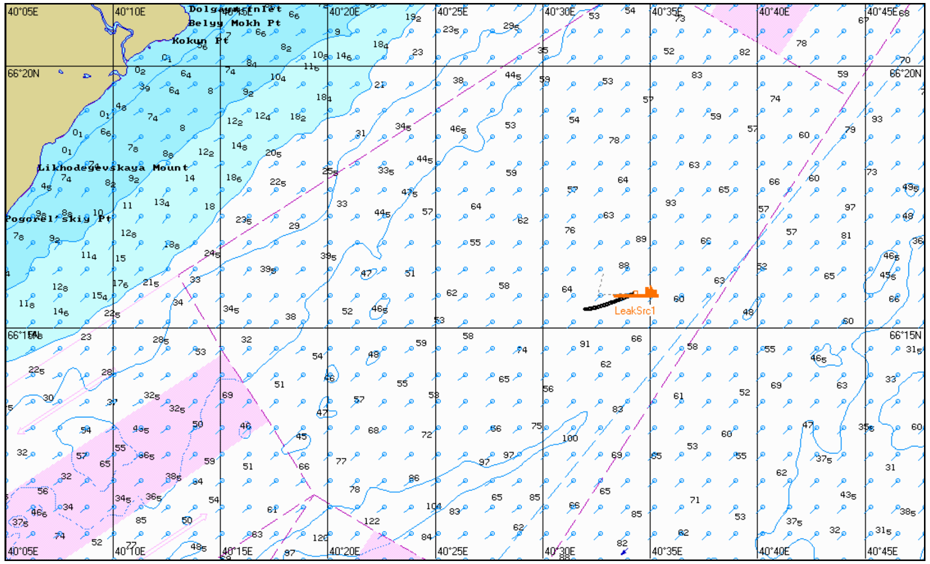


Figure 332. H+01:00. Oil slick spreading as per the scenario BO-Aut-S-2.

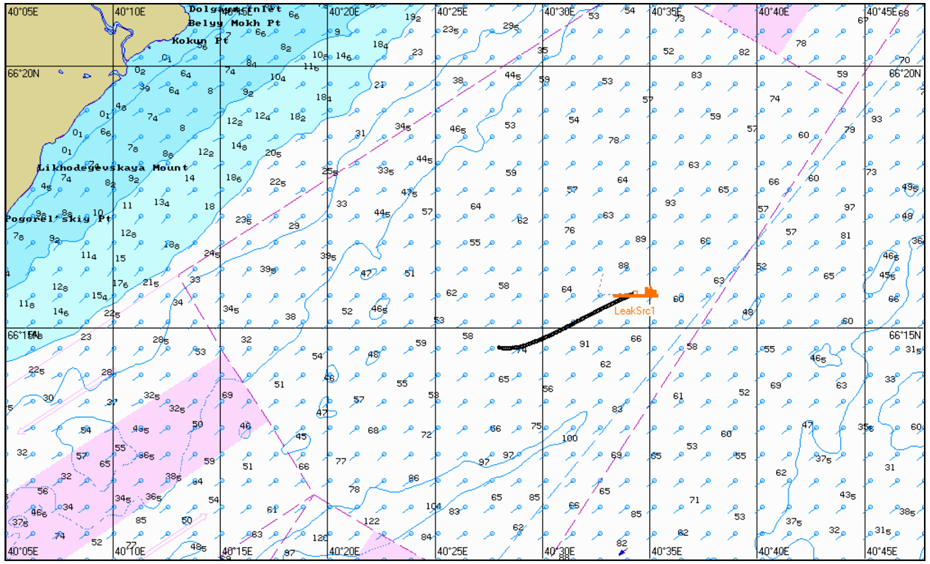


Figure 333. H+02:00. Oil slick spreading as per the scenario BO-Aut-S-2.

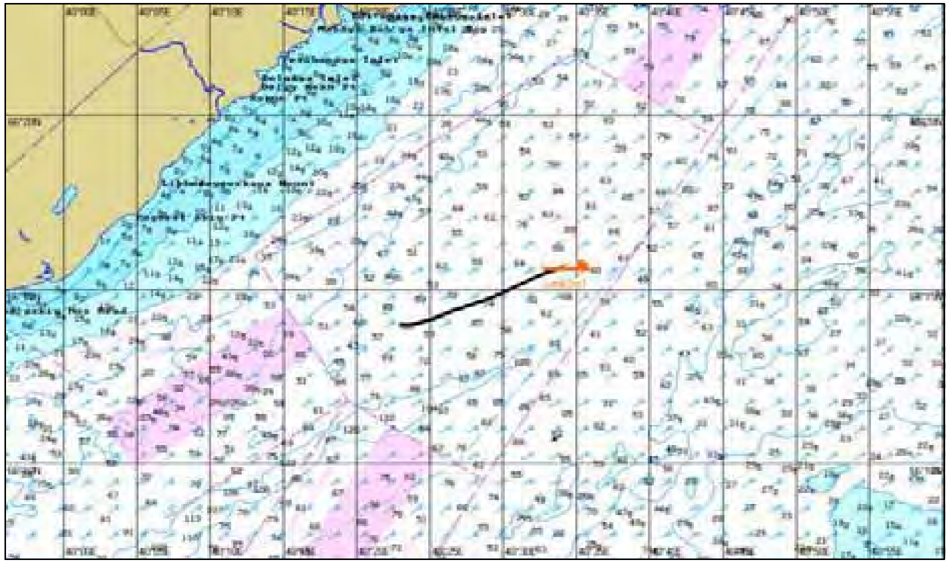


Figure 334. H+03:00. Oil slick spreading as per the scenario BO-Aut-S-2.

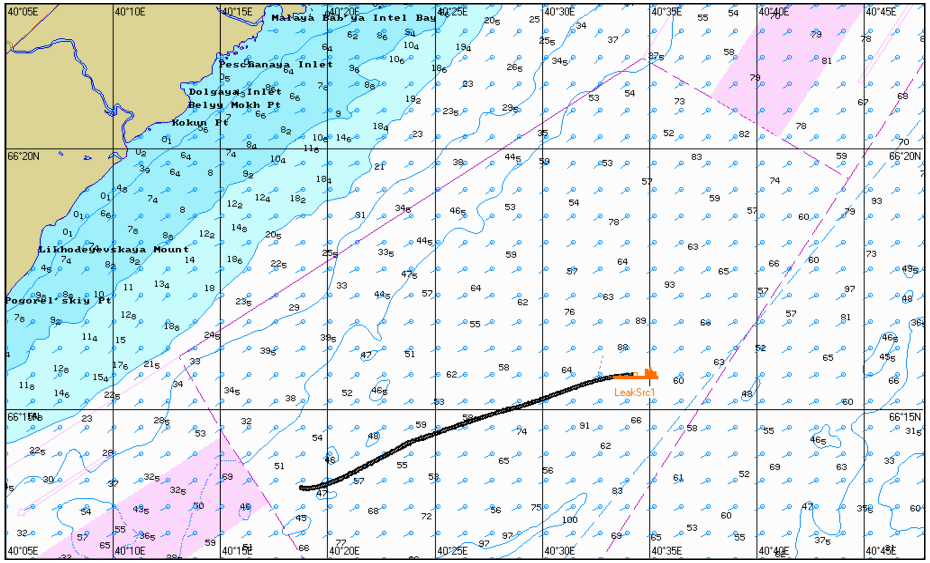


Figure 335. H+04:00. Oil slick spreading as per the scenario BO-Aut-S-2.

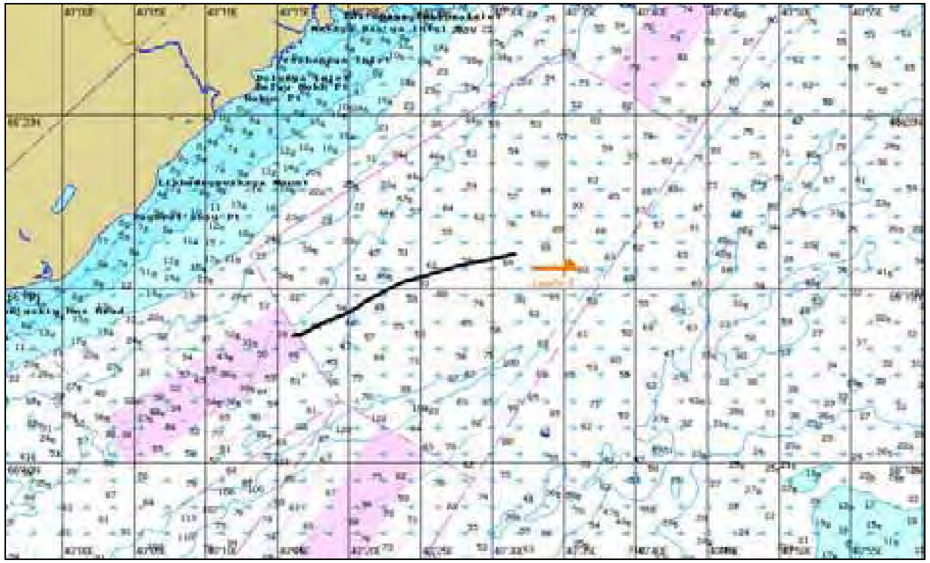


Figure 336. H+05:00. Oil slick spreading as per the scenario BO-Aut-S-2.

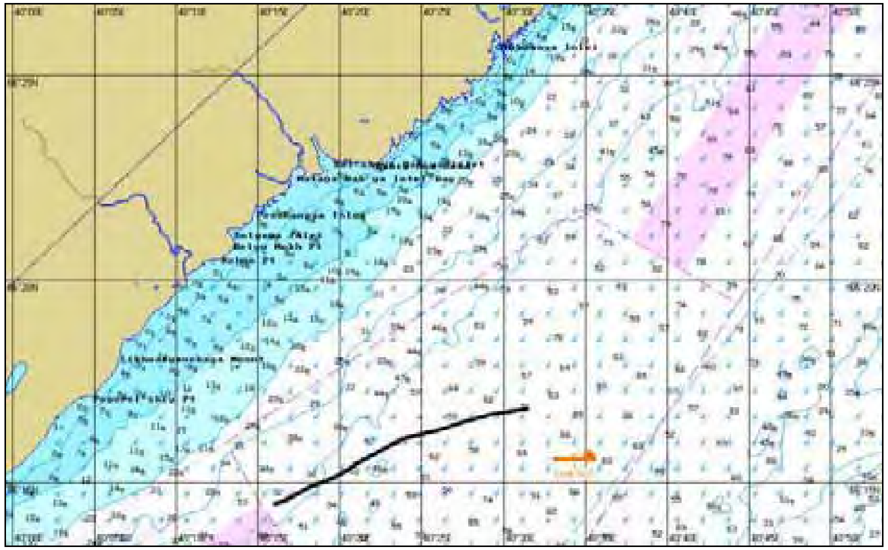


Figure 337. H+06:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 338. H+08:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 339. H+09:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 340. H+10:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 341. H+11:00. Oil slick spreading as per the scenario BO-Aut-S-2.

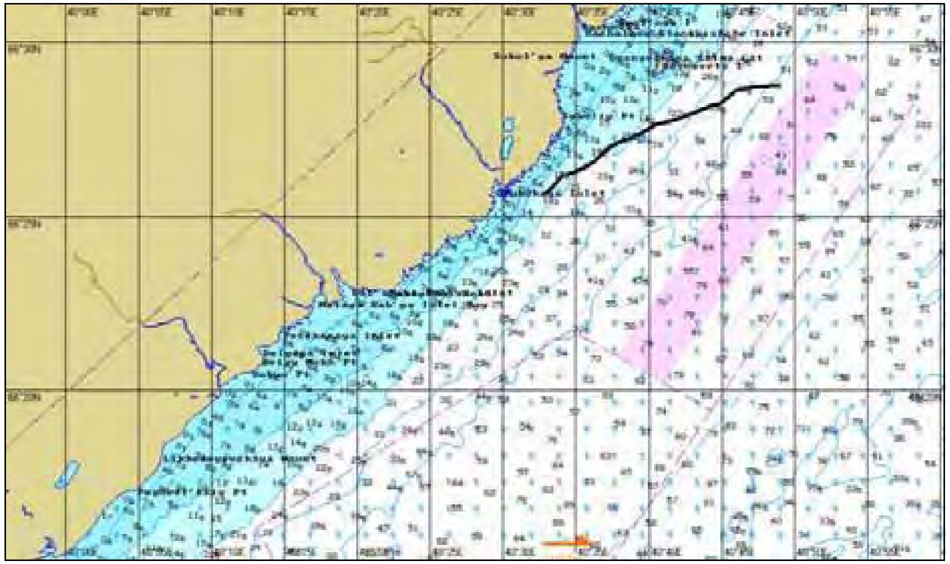


Figure 342. H+12:00. Oil slick spreading as per the scenario BO-Aut-S-2.

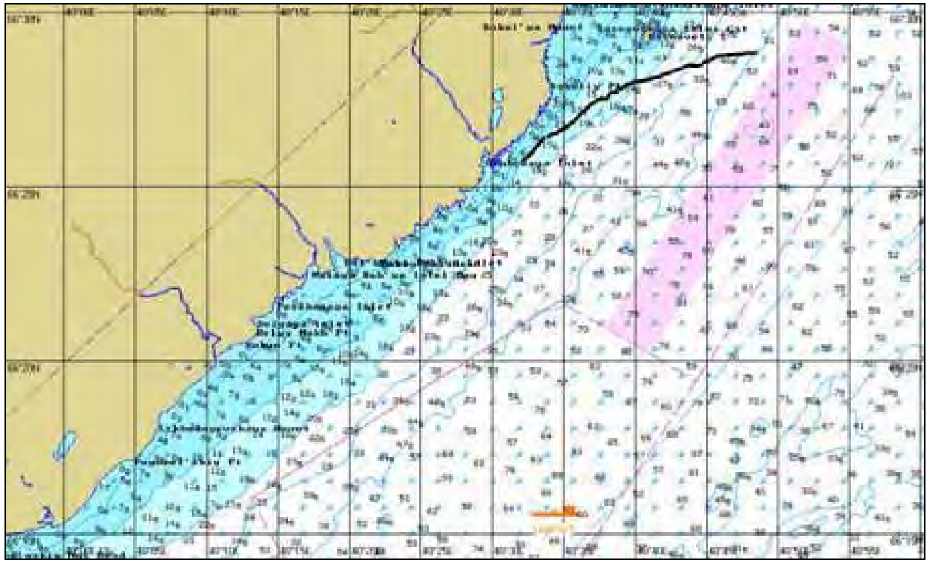


Figure 343. H+13:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 344. **H+14:17.** Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 345. H+18:00. Oil slick spreading as per the scenario BO-Aut-S-2.

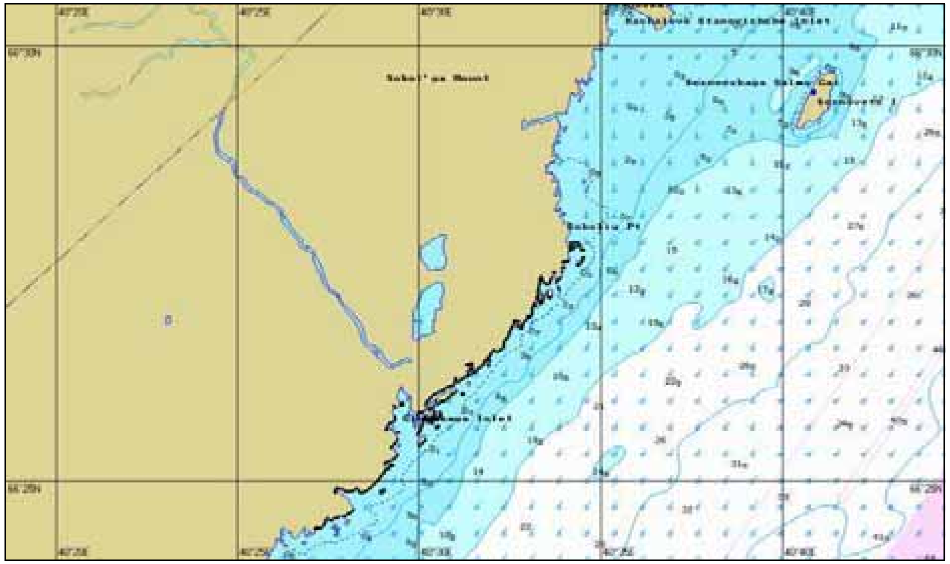


Figure 346. H+20:00. Oil slick spreading as per the scenario BO-Aut-S-2.

Figure 347. H+22:00. Oil slick spreading as per the scenario BO-Aut-S-2.

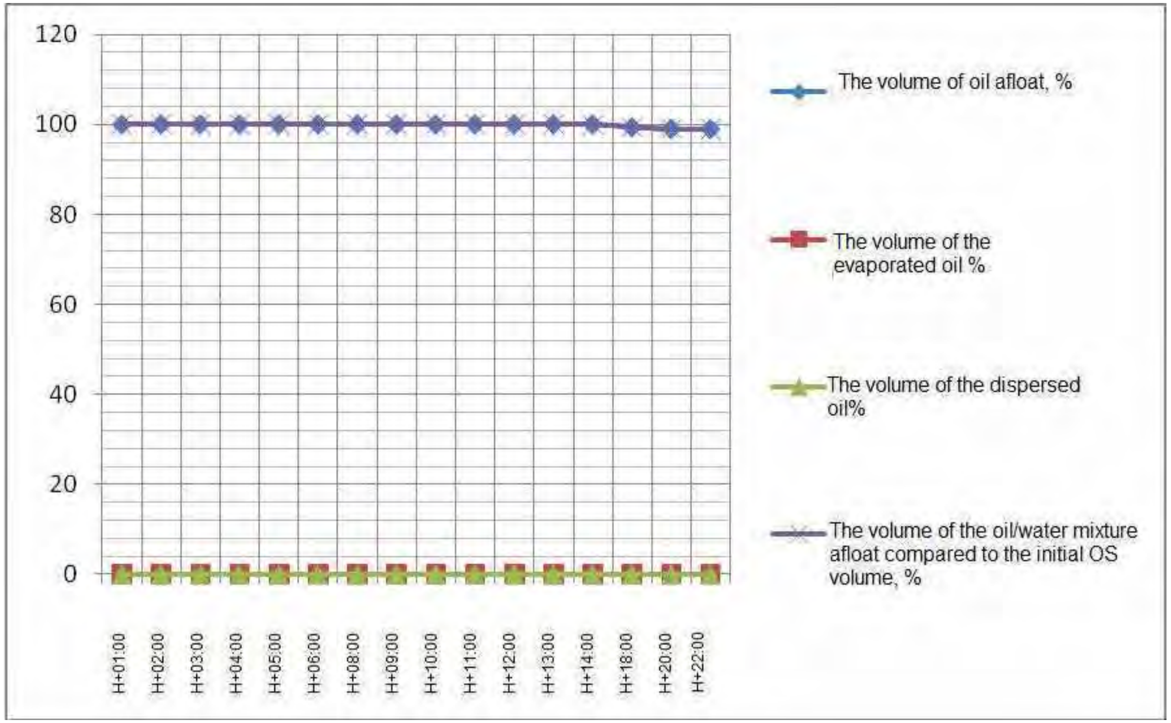


Figure 348. The chart of processes as per the scenario BO-Aut-S-2.

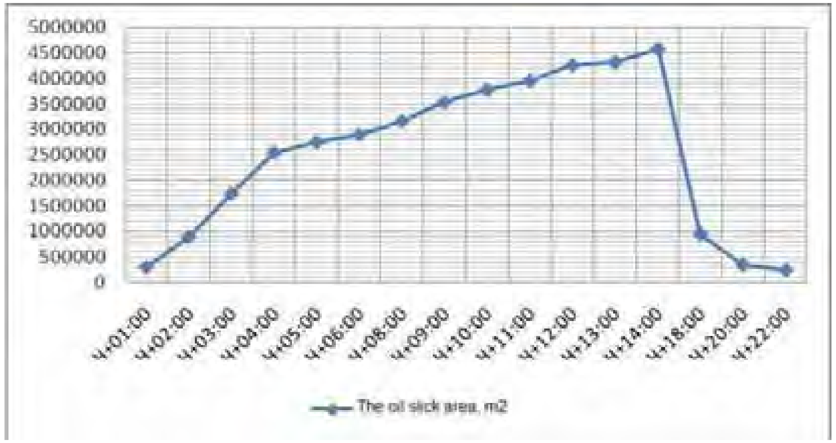


Figure 349. Oil slick area change dynamics as per the scenario BO-Aut-S-2.

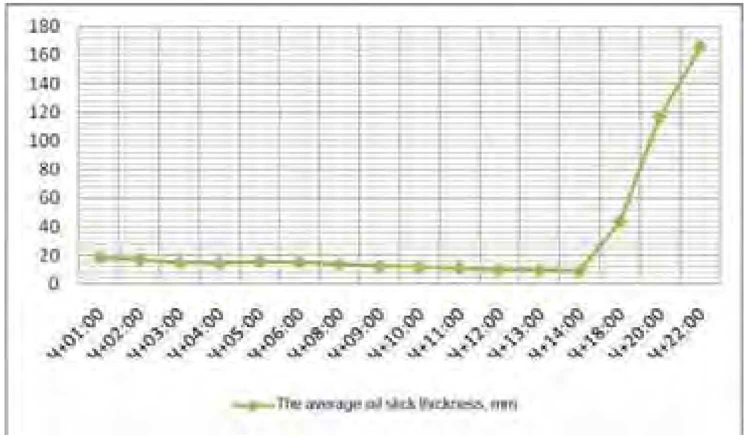


Figure 350. Oil slick thickness change dynamics as per the scenario BO-Aut-S-2.

2.3.3 Oil slick behaviour modelling as per the scenario GC-Aut-S-2

Table 2.2.3.1: Oil slick spreading parameters as per the scenario GC-Aut-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixturee volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3754	100	3442	91,7	34,2	0,91	278	7,41	0	0	5758	15,22	378251	5,1
H+02:00	7506	100	6687	89,1	154	2,05	665	8,86	0	0	14850	13,90	1068389	12,3
H+03:00	10966	100	9537	87,0	398	3,63	1030	9,39	0	0	24520	11,91	2059009	21,5
H+04:00	14000	100	11869	84,8	782	5,59	1356	9,69	0	0	33618	11,29	2977131	33,6
H+05:00	14000	100	11434	81,7	1140	8,14	1433	10,2	0	0	36331	12,02	3023068	58,5
H+06:00	14000	100	10949	78,2	1548	11,1	1511	10,8	0	0	36191	10,31	3510876	86,3
H+08:00	14000	100	10125	72,3	2307	16,5	1576	11,3	0	0	33723	8,05	4186985	151
H+09:00	14000	100	9698	69,3	2691	19,2	1619	11,6	0	0	32308	7,04	4590501	198
H+10:00	14000	100	9285	66,3	3064	21,9	1659	11,9	0	0	30234	6,34	4770960	258
H+11:00	14000	100	8899	63,6	3412	24,4	1696	12,1	0	0	29648	5,76	5142894	330
H+12:00	14000	100	8524	60,9	3753	26,8	1730	12,4	0	0	28398	4,84	5870786	420
H+13:00	14000	100	8175	58,4	4082	29,2	1761	12,6	0	0	27232	4,42	6162694	526
H+13:13 Landfall	14000	100	8122	58,0	4118	29,4	1765	12,6	1,1	0,01	27057	4,34	6237578	544
H+18:00	14000	100	7174	51,2	4833	34,5	1886	13,5	113	0,81	23898	24,2	988635	901
H+20:00	14000	100	7045	50,3	4876	34,8	1931	13,8	155	1,11	23469	136	173117	928
H+22:00	14000	100	6969	49,8	4907	35,1	1976	14,1	155	1,11	23215	96,4	240785	949

Within the first 4 hours as of the OS start the oil slick speards south-westward of the OS point under the action n fo the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 3058 m, the volume of the evaporated oil – 5,6%, the volume of the dispersed oil – 9,7%. Further the oil slick drifts north-eastward in the direction of the Terskiy Coast of the White Sea. After 9 hours ass of the OS start the oil slick semi-perimeter makes 3796 m, the volume of the evaporated oil – 19,2%, the volume of the dispersed oil – 11,6%. After 12 hours as pf the OS start the oil slick semi-perimeter makes 4293 m, the volume of the evaporated oil – 26,8%, the volume of the dispersed oil – 12,4%. After 13 hours and 13 minutes as of the OS start the oil reaches the coastline in the area of the western part of the Strait Sosnovskaya Salma. After 18 hours as of the OS start about 8 km of the coastline in the area of the Glubokaya Bay and the western part of the Strait Sosnovskaya Salma hav been polluted. The volume of the oil/water mixturee as compared to OS volume has increased with 70,7%, the volume of the evaporated oil – 34,5%, the volume of the dispersed oil – 13,5%. To the moment of the modeling completion (22 hours) all oil has reached the Tereskiy Coast of the White Sea. The coastline in the area of the Glubokaya Bay, the western and central parts of the Strait Sosnovskaya Salma with the total length of more than 10 km has been polluted with oil. The volume of the evaporated oil – 35,1%, the volume of the dispersed oil – 41,1%, 49,8% of oil compared to OS volume remains afloat, the average slick thickness in the shore makes 9,7 sm.

The graphic display of oil slick spreading as per the scenario GC-Aut-S-2 is shown in figures 351 – 366.

The charts of processes typical for SGC behavior on water are shown in figures 367-369.

Figure 351. H+01:00. Oil slick spreading as per the scenario GC-Aut-S-2.

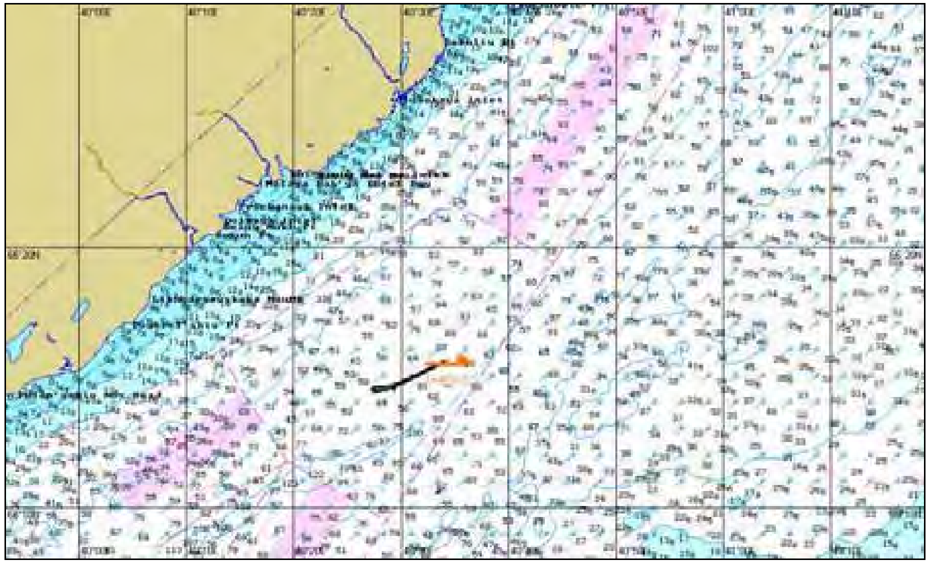


Figure 352. H+02:00. Oil slick spreading as per the scenario GC-Aut-S-2.

Figure 353. H+03:00. Oil slick spreading as per the scenario GC-Aut-S-2.

Figure 354. H+04:00. Oil slick spreading as per the scenario GC-Aut-S-2.

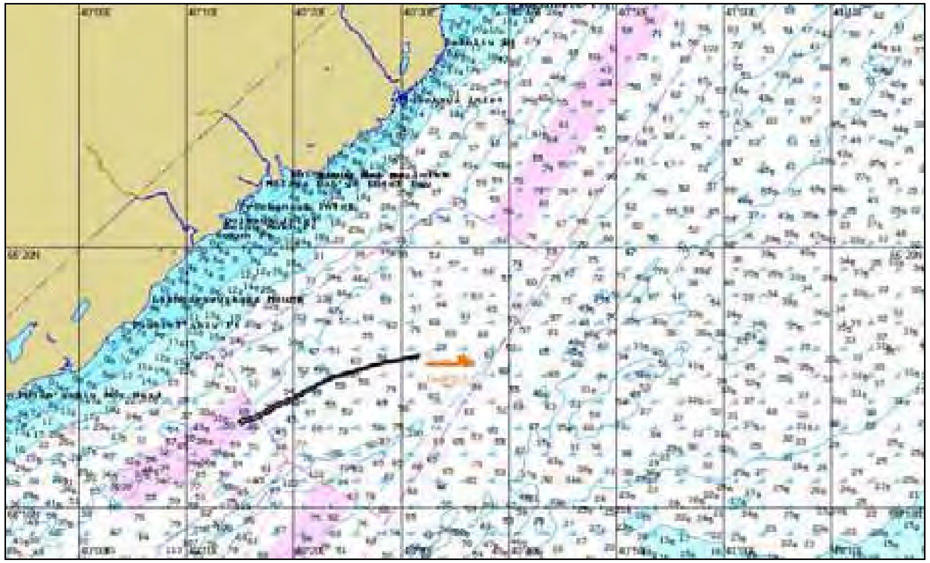


Figure 355. H+05:00. Oil slick spreading as per the scenario BO-Aut-S-2.

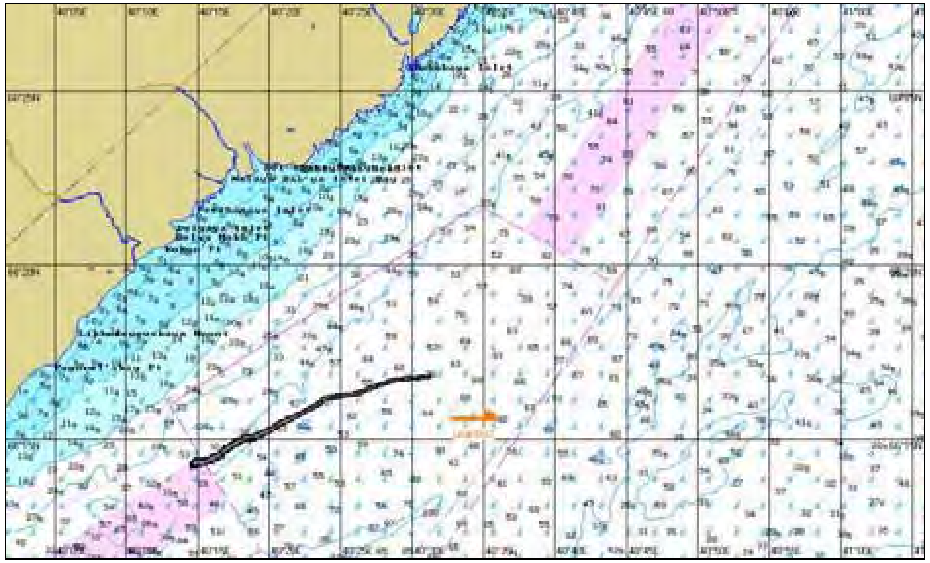


Figure 356. H+06:00. Oil slick spreading as per the scenario GC-Aut-S-2.

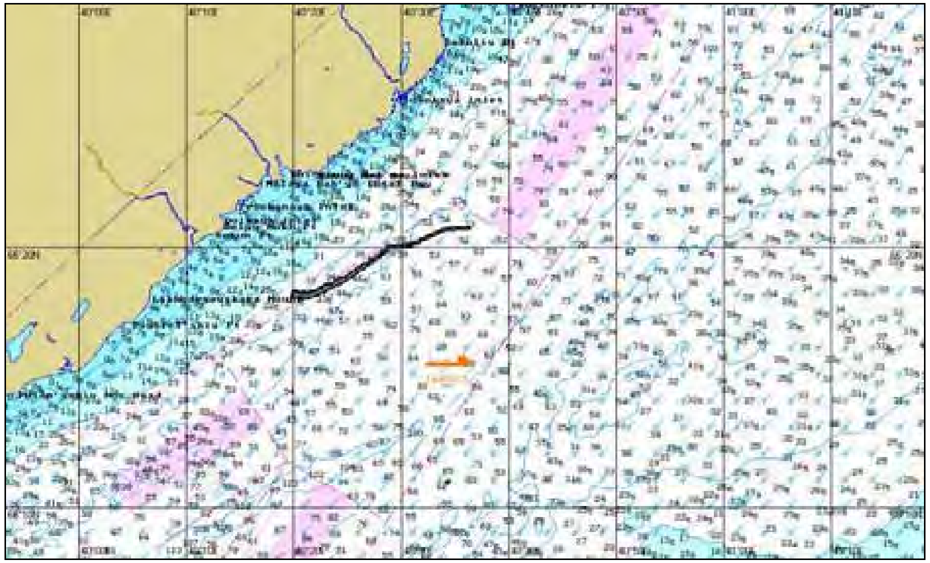


Figure 357. H+08:00. Oil slick spreading as per the scenario GC-Aut-S-2.

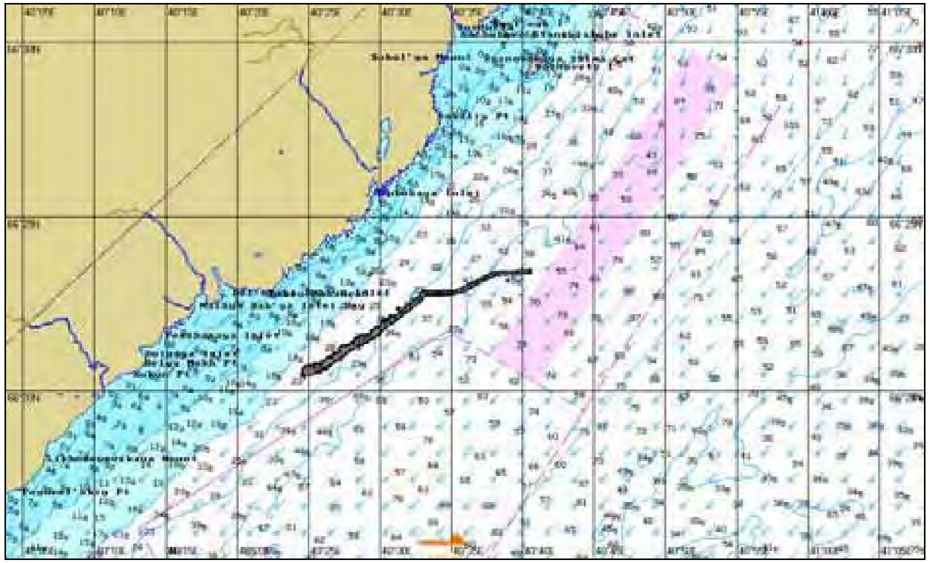


Figure 358. H+09:00. Oil slick spreading as per the scenario GC-Aut-S-2.

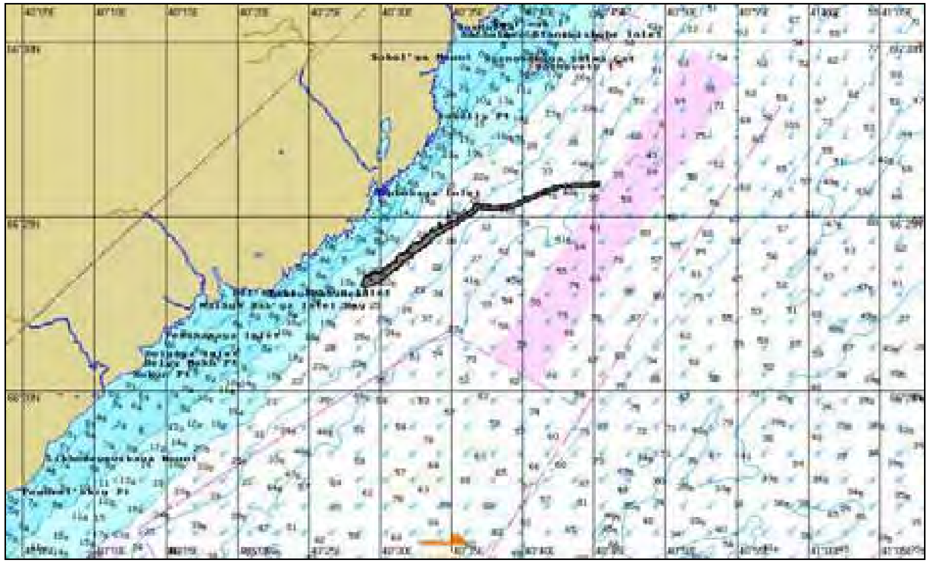


Figure 359. H+10:00. Oil slick spreading as per the scenario GC-Aut-S-2.

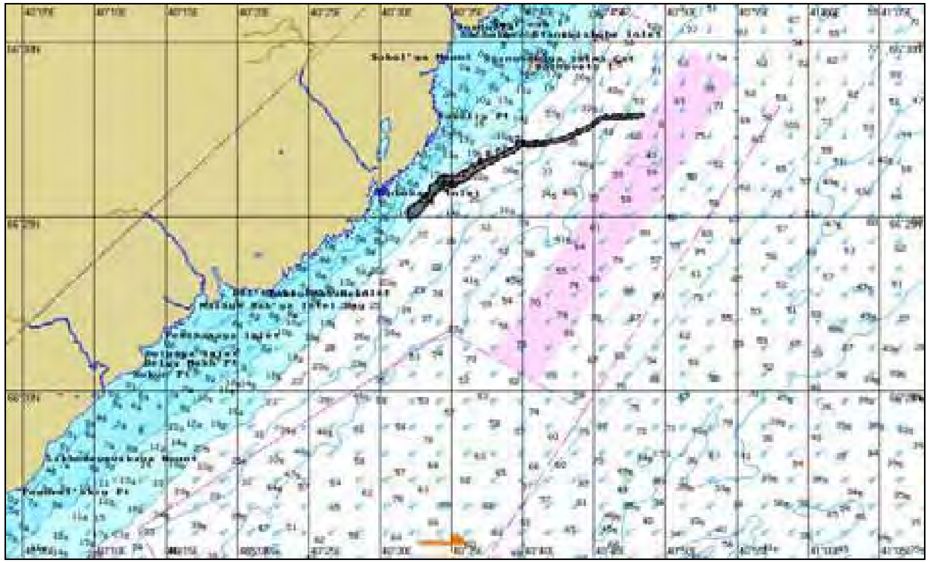


Figure 360. H+11:00. Oil slick spreading as per the scenario GC-Aut-S-2.

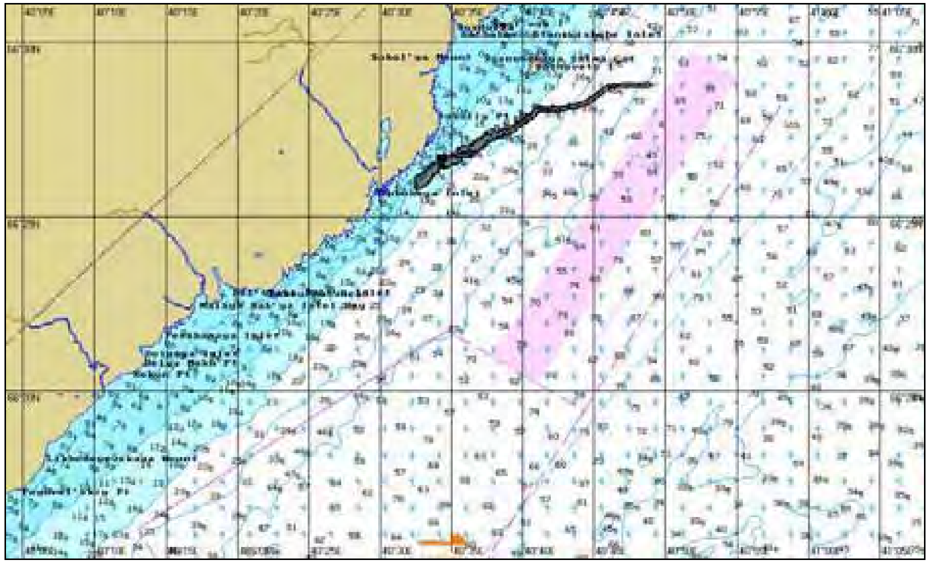


Figure 361. H+12:00. Oil slick spreading as per the scenario GC-Aut-S-2.

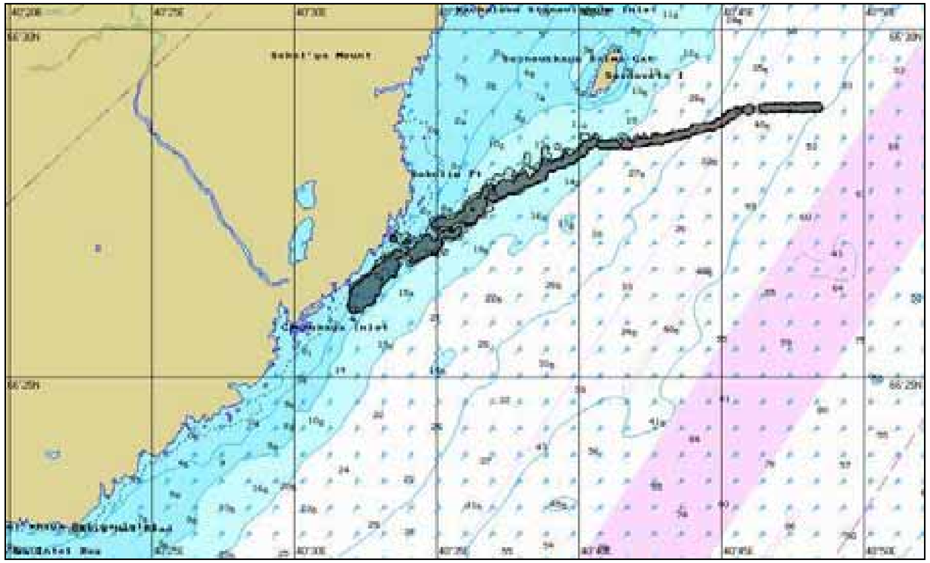
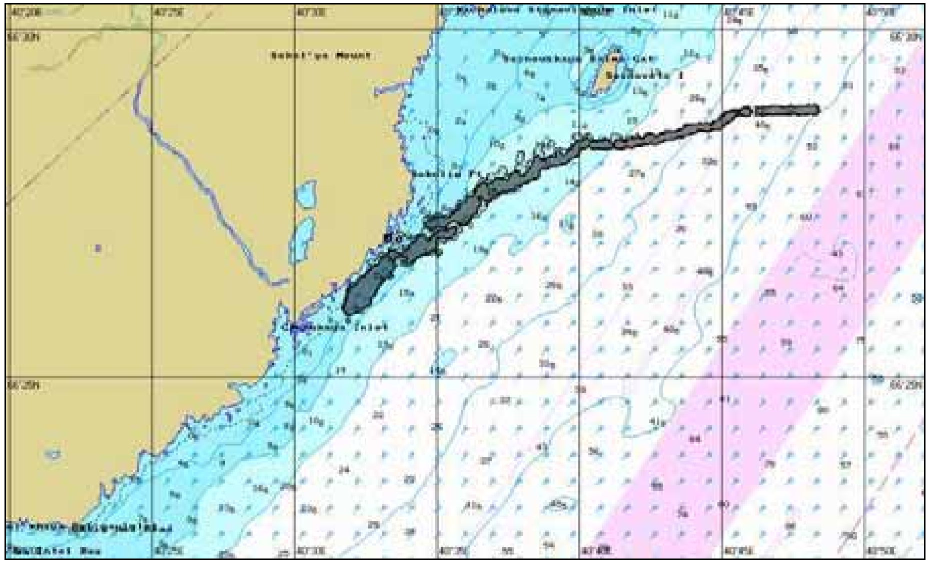


Figure 362. H+13:00. Oil slick spreading as per the scenario GC-Aut-S-2.



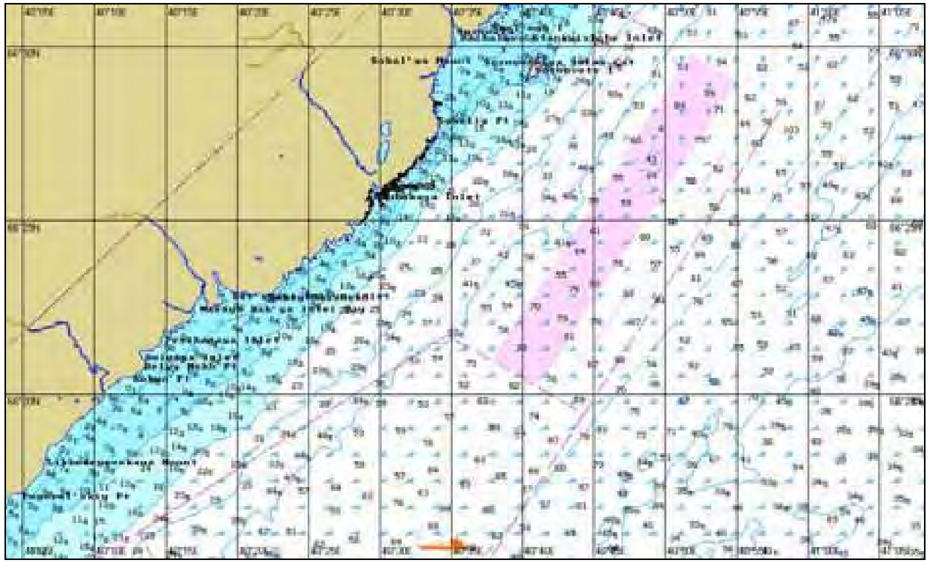
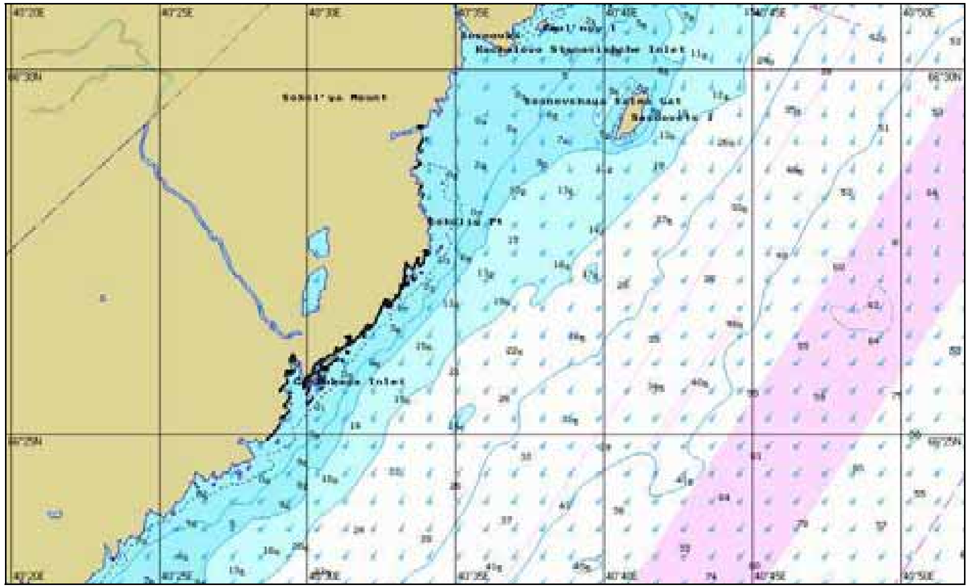


Figure 363. **H+13:13.** Oil slick spreading as per the scenario GC-Aut-S-2.

Figure 364. H+18:00. Oil slick spreading as per the scenario GC-Aut-S-2.



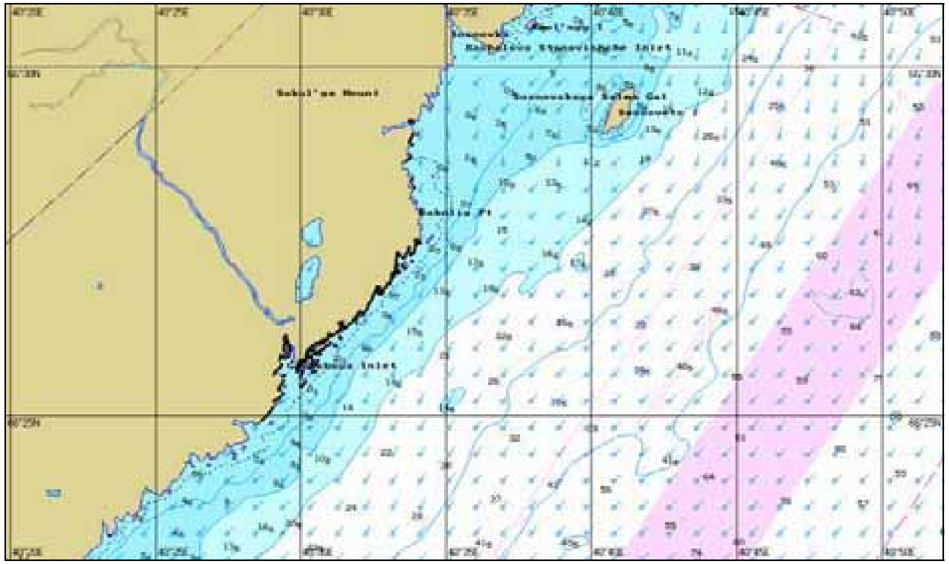


Figure 365. H+20:00. Oil slick spreading as per the scenario GC-Aut-S-2.

Figure 366. H+22:00. Oil slick spreading as per the scenario GC-Aut-S-2.

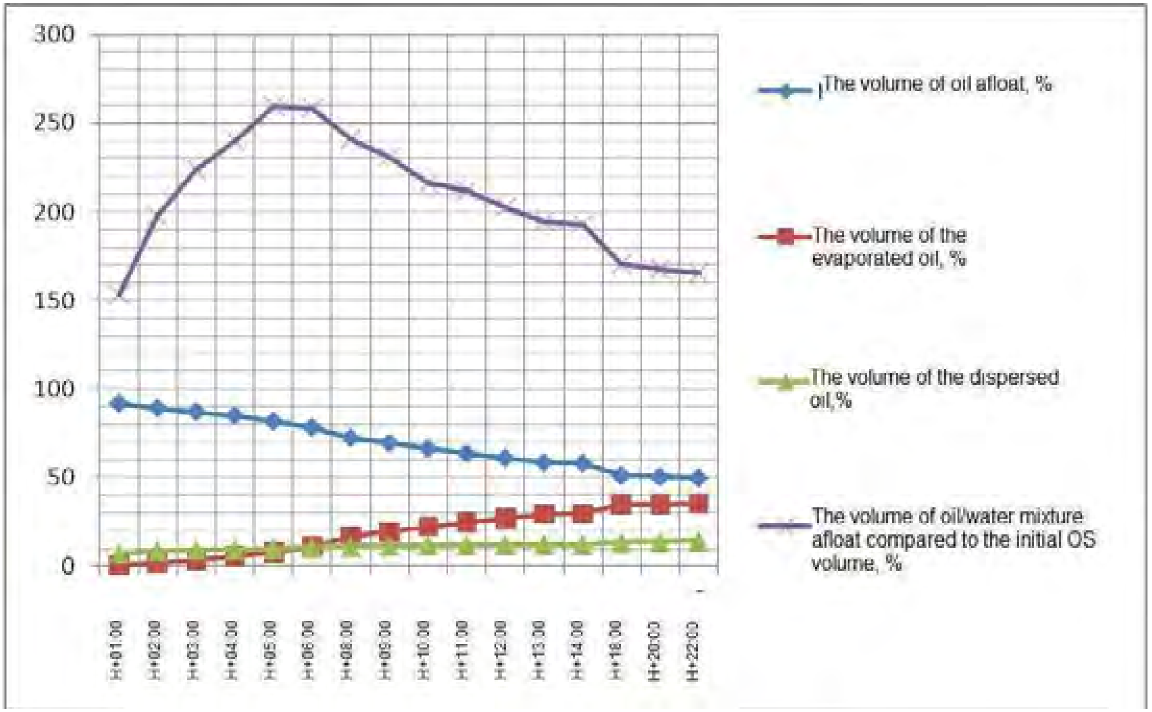


Figure 367. The chart of processes as per the scenario GC-Aut-S-2.

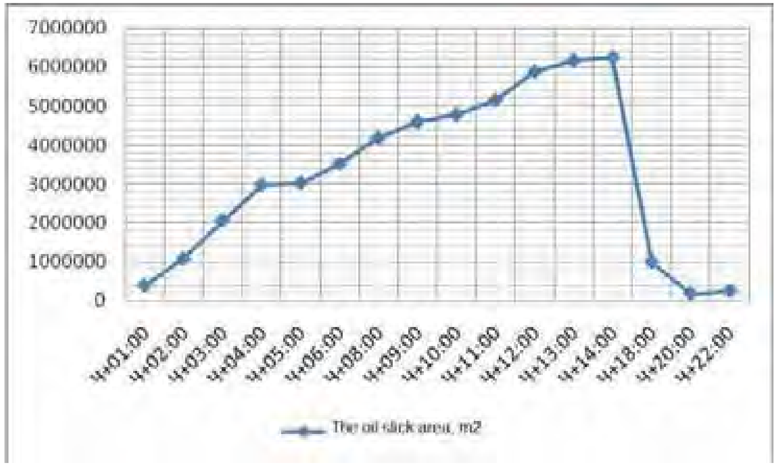


Figure 368. Oil slick area change dynamics as per the scenario GC-Aut-S-2.

Figure 369. Oil slick thickness change dynamics as per the scenario GC-Aut-S-2.

2.3.4 Oil slick behaviour modelling as per the scenario Na-Aut-S-2

Table 2.2.4.1: Oil slick spreading parameters as per the scenario Na-Aut-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil/water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	2326	100	1833	78,8	459	19,7	34,4	1,48	0	0	2362	6,30	374793	11,6
H+02:00	4790	100	3112	65,0	1593	33,3	85,5	1,78	0	0	4178	3,52	1185443	48,7
H+03:00	7407	100	4123	55,7	3147	42,5	137	1,85	0	0	5606	2,24	2504639	125
H+04:00	9981	100	4896	49,1	4896	49,1	190	1,90	0	0	6727	1,83	3677639	146
H+05:00	10000	100	3698	37,0	6088	60,9	214	2,14	0	0	5279	1,24	4247337	836
H+06:00	10000	100	3013	30,1	6763	67,6	224	2,24	0	0	4304	0,92	4690692	1674
H+07:00	10000	100	2519	25,2	7551	75,5	230	2,30	0	0	3599	0,69	5206433	2702
H+08:00	10000	100	2111	21,1	7655	76,6	234	2,34	0	0	3015	0,51	5950279	4021
H+09:00	10000	100	1754	17,5	8008	80,1	237	2,37	0	0	2506	0,39	6497297	5691
H+10:00	10000	100	1402	14,0	8358	83,6	240	2,40	0	0	2002	0,29	6840240	8034
H+12:00	10000	100	907	9,07	8849	88,5	244	2,44	0	0	1296	0,20	6534555	13035
H+12:30 Landfall	10000	100	794	7,94	8960	89,6	245	2,45	0,5	0,01	1135	0,17	6586774	14560
H+14:00	10000	100	358	3,58	9316	93,2	247	2,47	78,1	0,78	512	0,17	2980411	20755
H+18:00	10000	100	180	1,80	9458	94,6	248	2,48	113	1,13	257	0,50	516300	23911
H+20:00	10000	100	140	1,40	9479	94,8	249	2,49	131	1,31	202	1,68	119911	24399

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 3398 m, the volume of the evaporated oil – 49,1%, the volume of the dispersed oil – 1,9%. Further the oil slick drifts northward in the direction of the Terskiy coast of the White Sea. After 9 hours as of the OS start the oil slick semi-perimeter makes 4517 m, the volume of the evaporated oil – 80,1%, the volume of the dispersed oil – 11,6%. After 12 hours as of the OS start the oil slick semi-perimeter makes 4293 m, the volume of the evaporated oil – 26,8%, the volume of the dispersed oil – 2,4%. After 12 hours and 30 minutes as of the OS start the oil reaches the coast in the area of the coastline of the western part of the Strait Sosnovskaya Salma. After 14 hours ass of the OS start about 8 km of the coastline in the area of the Glubokaya Bay and the western part of the Strait Sosnovskaya Salma have been polluted. The volume of the oil/water mixturee compared to the OS volume gass decreased with 94,9%, the volume of the evaporated oil – 93,2%, the volume of the dispersed oil – 2,47%. To the moment of modeling competion (20 hours) the oil slick has reached the Tterskiy Coast of the White Sea. The coastline in the area of the Glubokaya Bay, the western and central parts of the Strait Sosnovskaya Salma, the Sosnovka River mouth with the total length of more than 10 km have been polluted with oil. The volume of the evaporated oil – 94,8%, the volume of the dispersed oil – 2,49%, 1,4% of oil compared to OS volume remains afloat, the average oil slick thickness in the shore makes 1,68 mm.

The graphic display of oil slick spreading as per the scenario Na-Aut-S-2 is shown in figures 370 – 384.

The charts of processes typical for naphtha behavior on water are shown in figures 385-387.

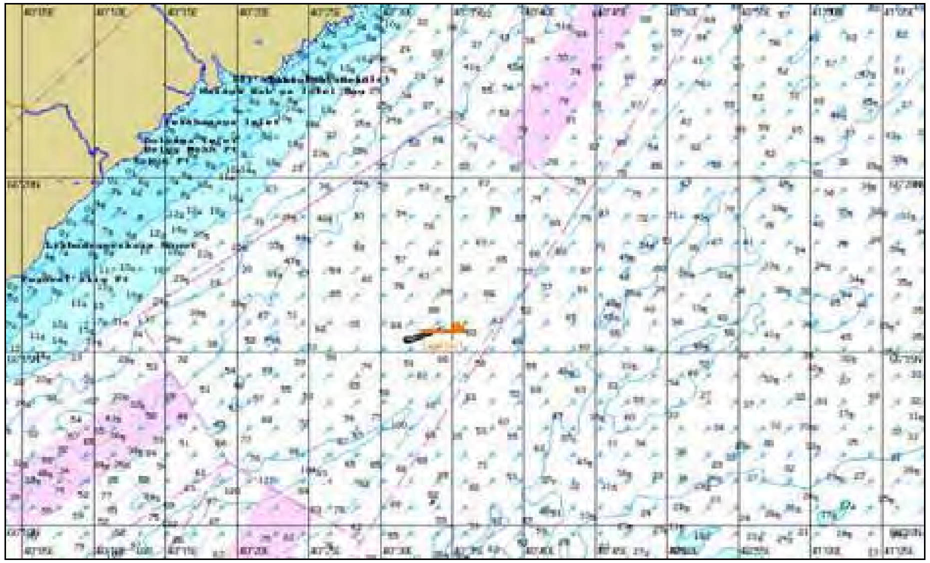


Figure 370. H+01:00. Oil slick spreading as per the scenario Na-Aut-S-2.

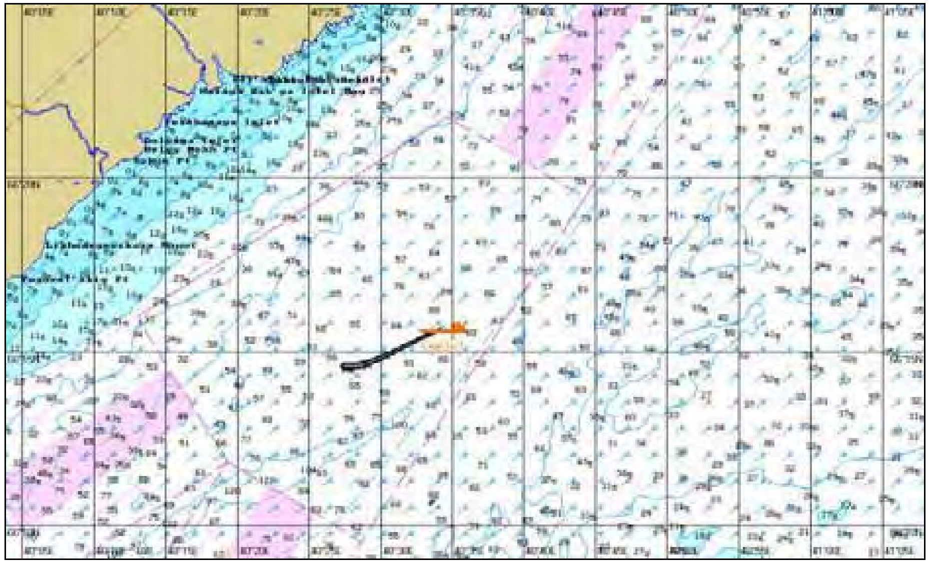


Figure 371. H+02:00. Oil slick spreading as per the scenario Na-Aut-S-2.

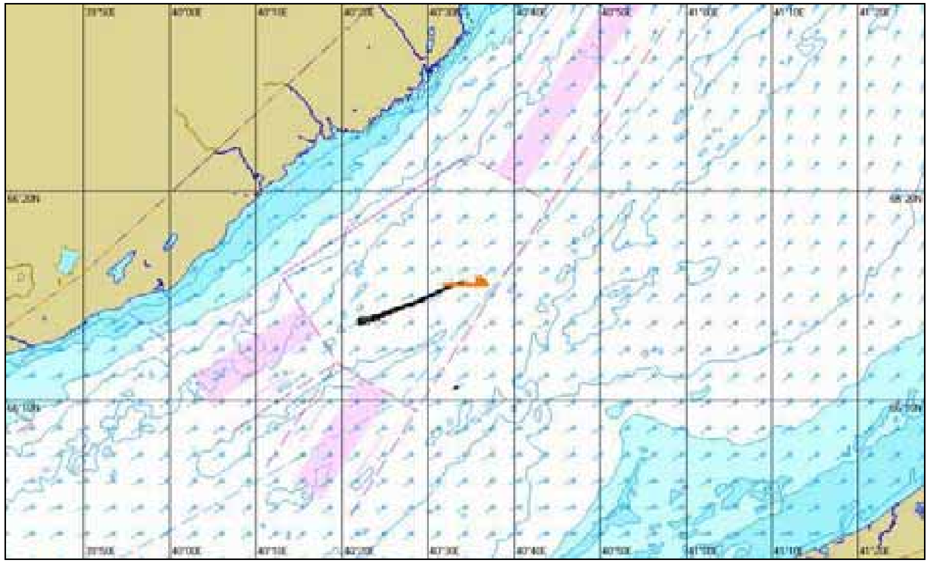


Figure 372. H+03:00. Oil slick spreading as per the scenario Na-Aut-S-2.

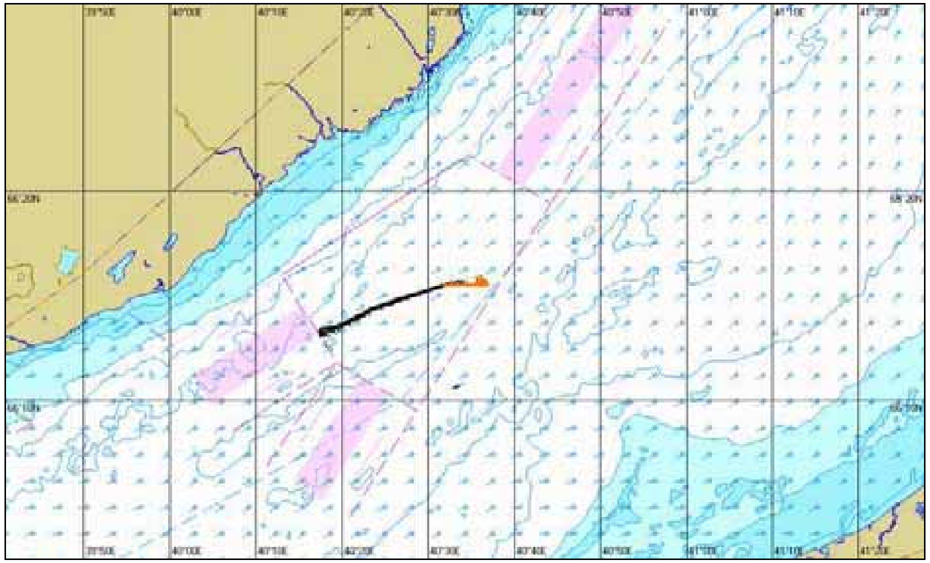


Figure 373. H+04:00. Oil slick spreading as per the scenario Na-Aut-S-2.

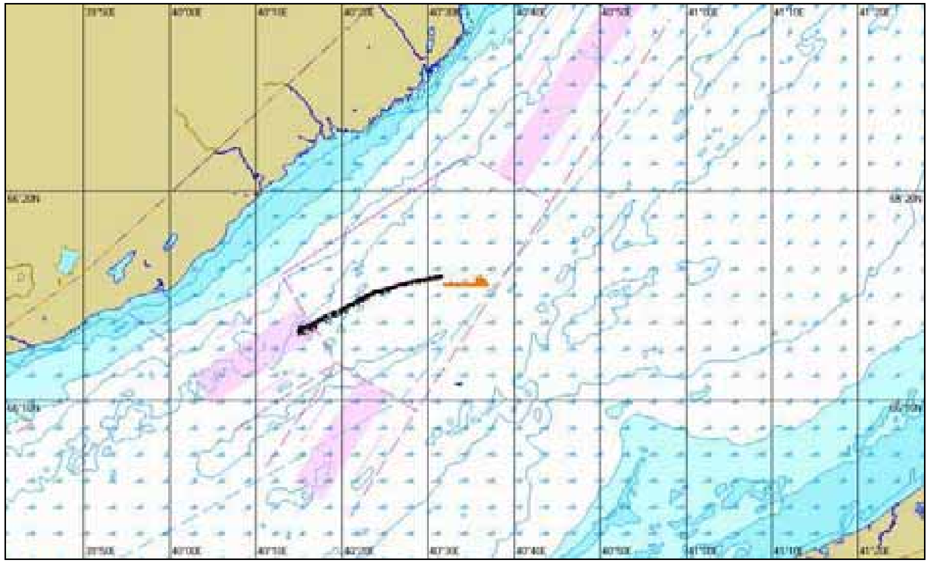


Figure 374. H+05:00. Oil slick spreading as per the scenario Na-Aut-S-2.

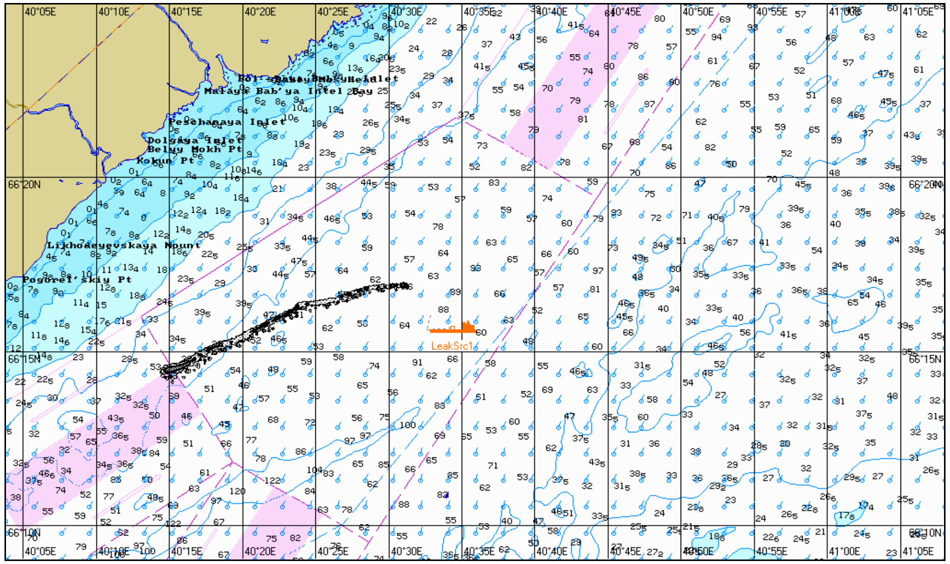


Figure 375. H+06:00. Oil slick spreading as per the scenario Na-Aut-S-2.

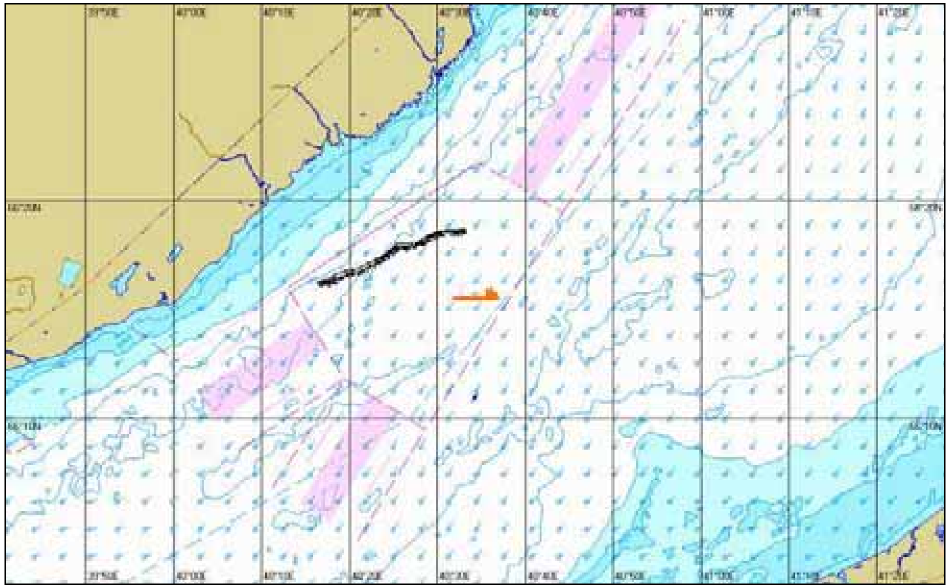


Figure 376. H+07:00. Oil slick spreading as per the scenario Na-Aut-S-2.

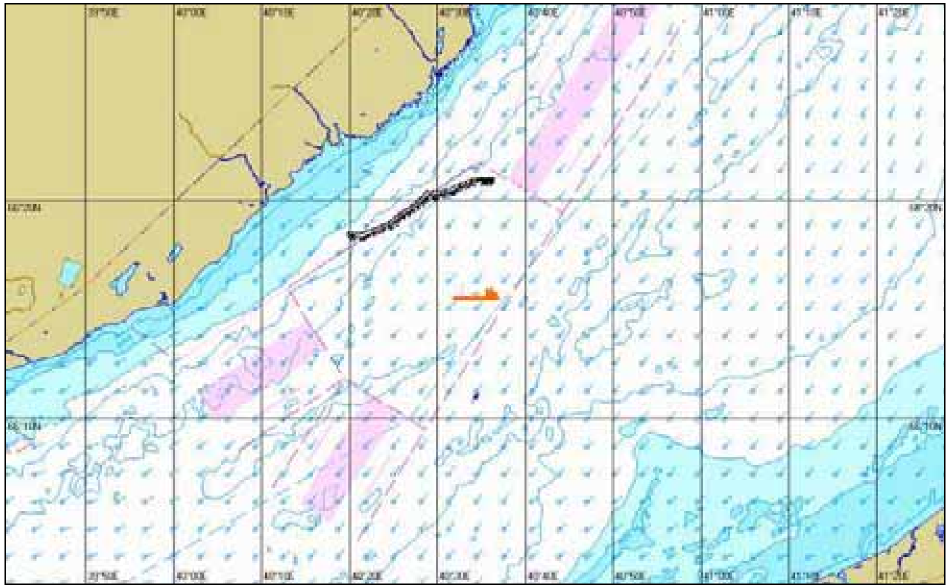


Figure 377. H+08:00. Oil slick spreading as per the scenario Na-Aut-S-2.

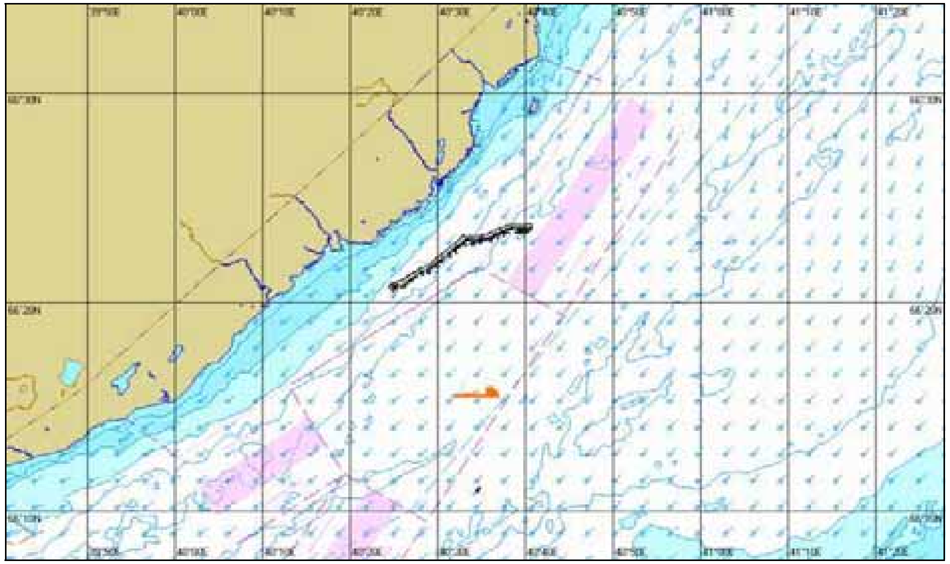


Figure 378. H+09:00. Oil slick spreading as per the scenario Na-Aut-S-2.

Figure 379. H+10:00. Oil slick spreading as per the scenario Na-Aut-S-2.

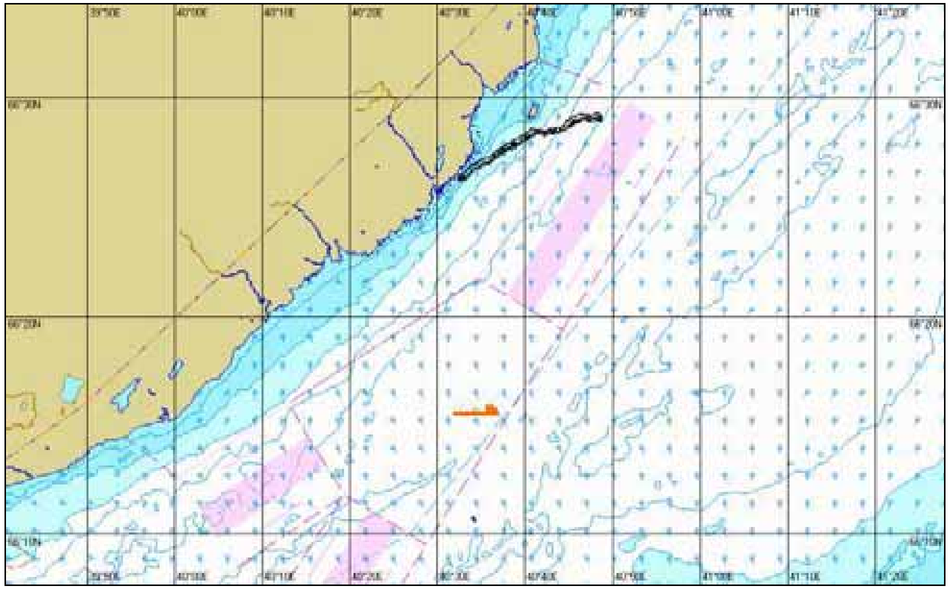


Figure 380. H+12:00. Oil slick spreading as per the scenario Na-Aut-S-2.

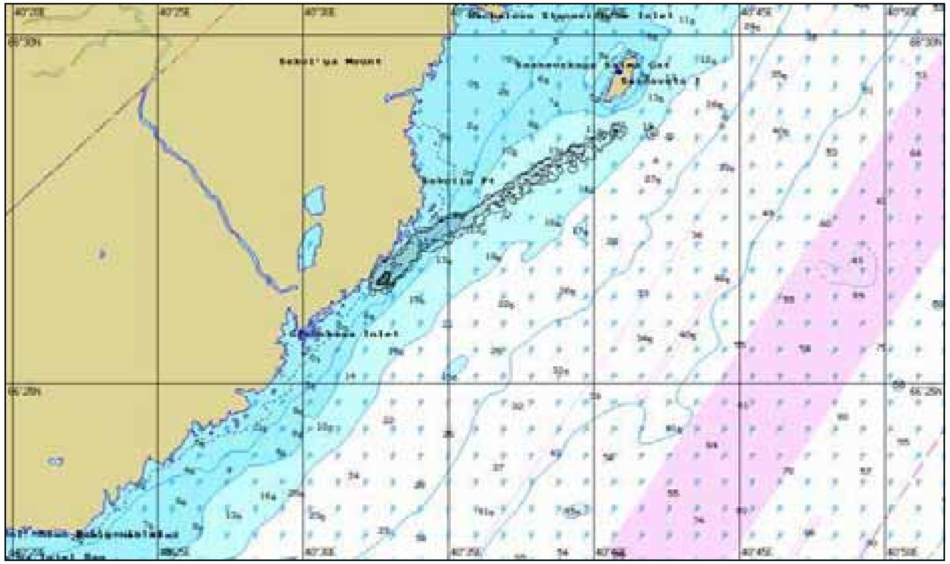


Figure 381. **H+12:21.** Oil slick spreading as per the scenario Na-Aut-S-2.

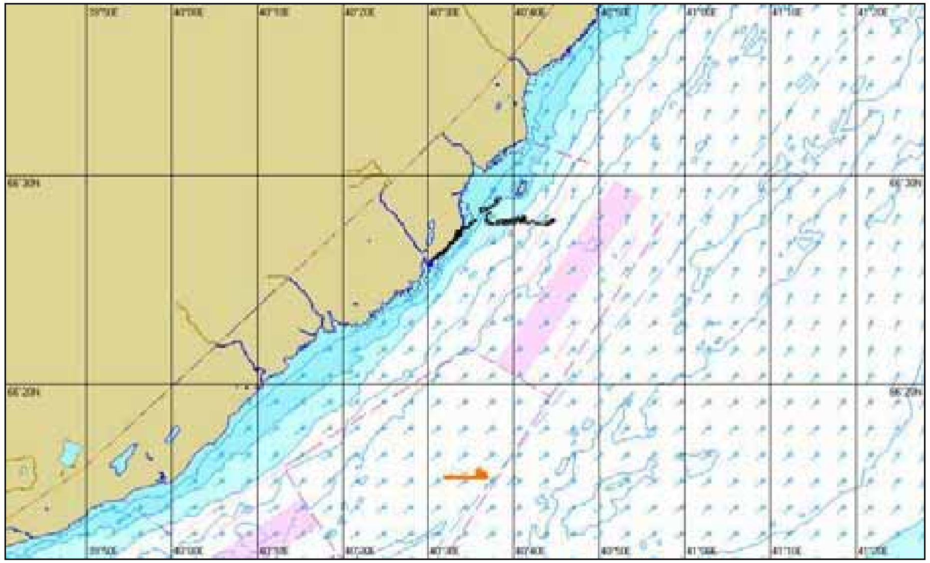


Figure 382. H+14:00. Oil slick spreading as per the scenario Na-Aut-S-2.

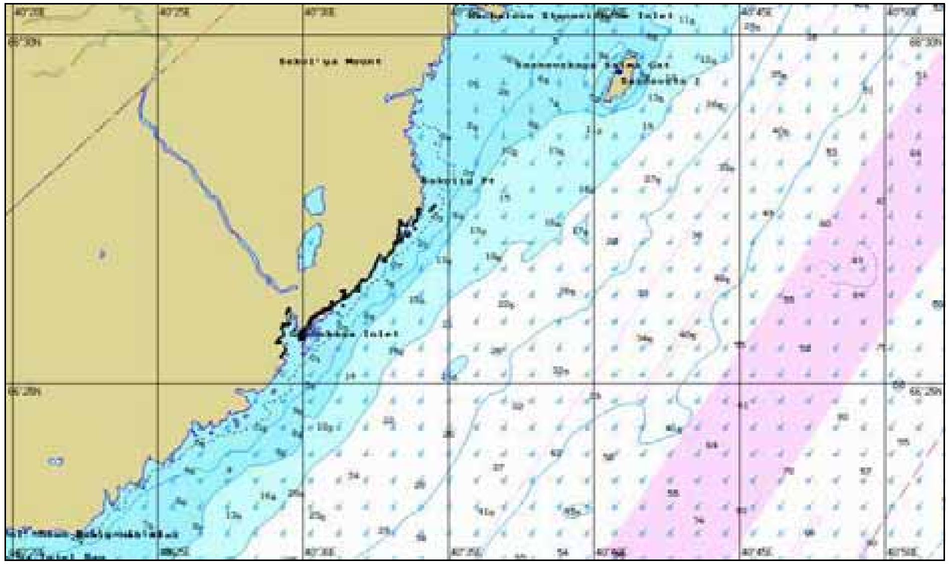


Figure 383. H+18:00. Oil slick spreading as per the scenario Na-Aut-S-2.

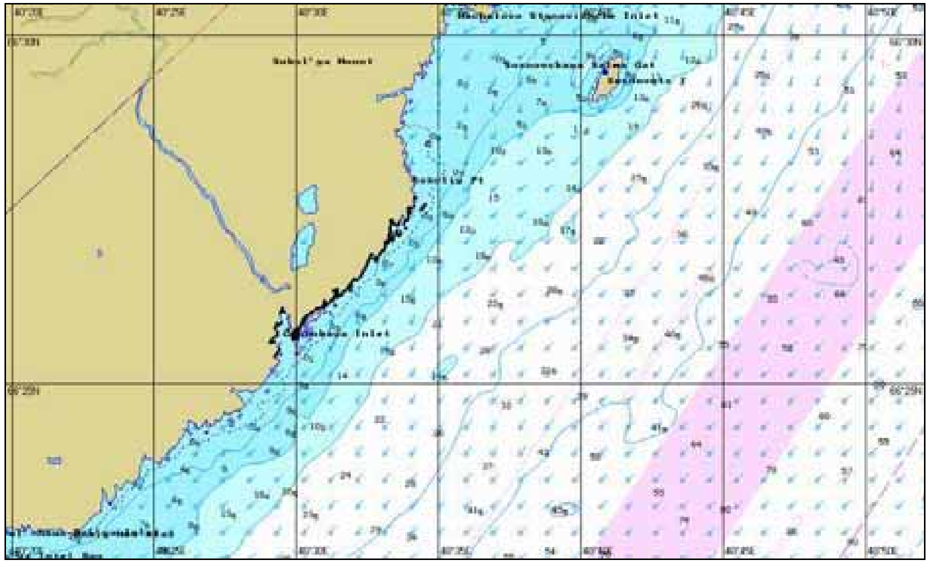


Figure 384. H+20:00. Oil slick spreading as per the scenario Na-Aut-S-2.

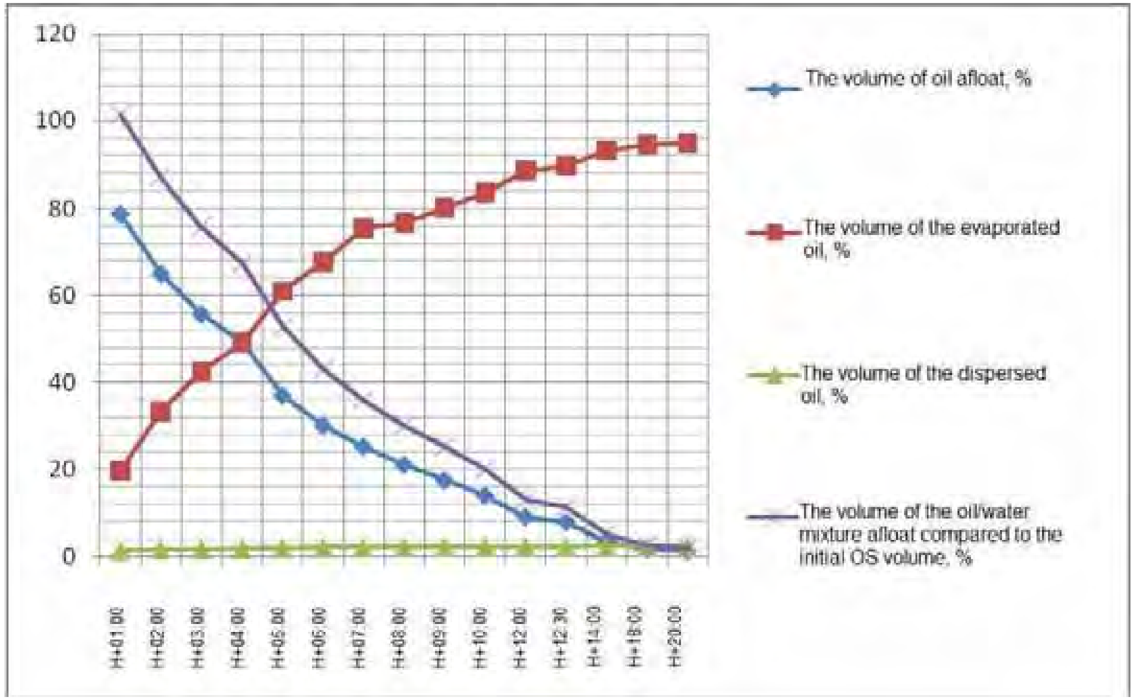


Figure 385. The chart of processes as per the scenario Na-Aut-S-2.

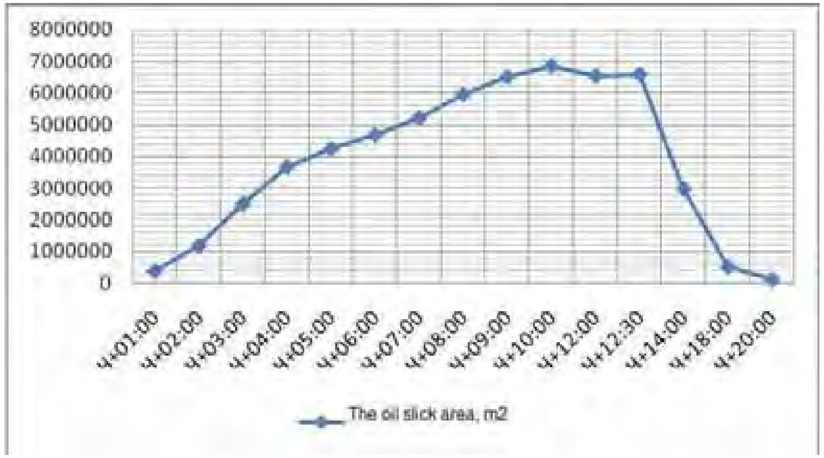


Figure 386. Oil slick area change dynamics as per the scenario Na-Aut-S-2.

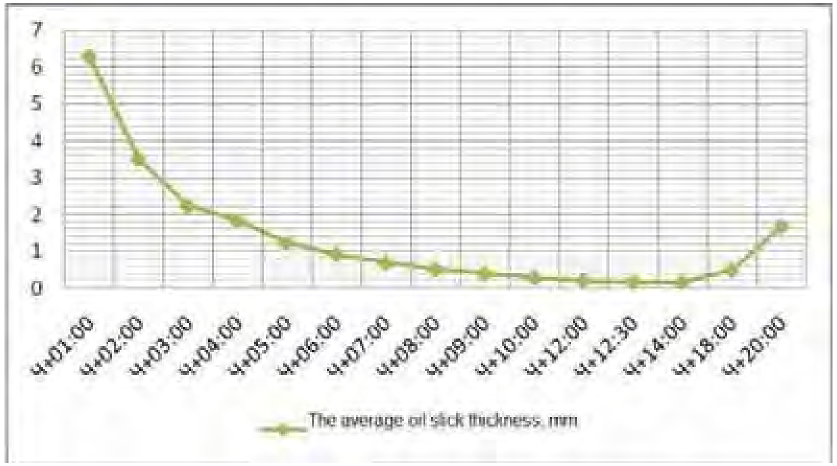


Figure 387. Oil slick thickness change dynamics as per the scenario Na-Aut-S-2.

2.3.5 The process dynamics typical for oil spill behaviour in the White Sea under the autumn southward wind (Aut-S-2)

Figures 388-392 show process dynamics typical for oil behavior in the White Sea as per the scenarios Aut-S-2.

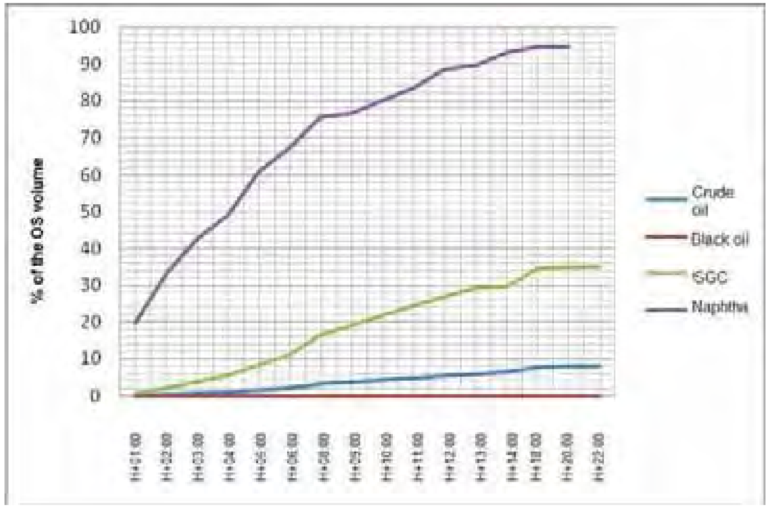


Figure 388. The evaporation process chart as per the scenarios Aut-S-2.

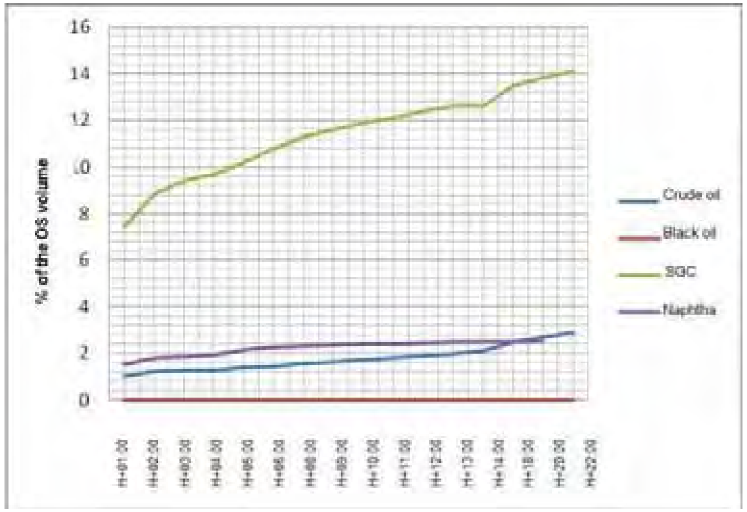


Figure 389. The dispersion process chart as per the scenarios Aut-S-2.

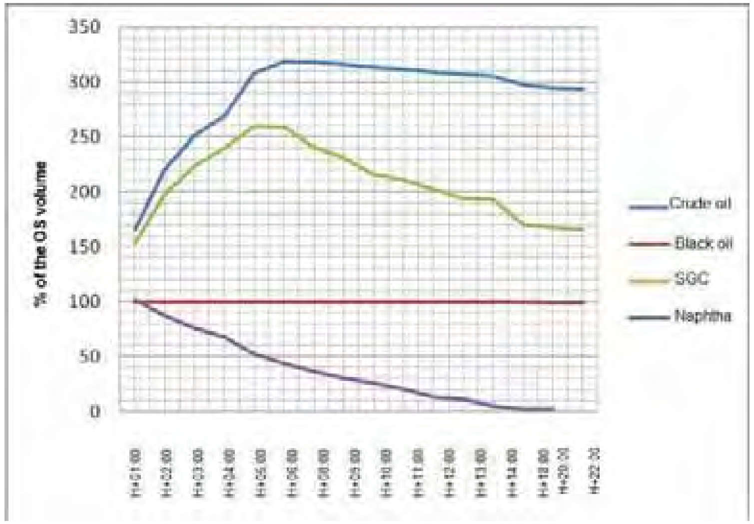


Figure 390. Oil/water mixturee volume change dynamics as per the scenarios Aut-S-2.

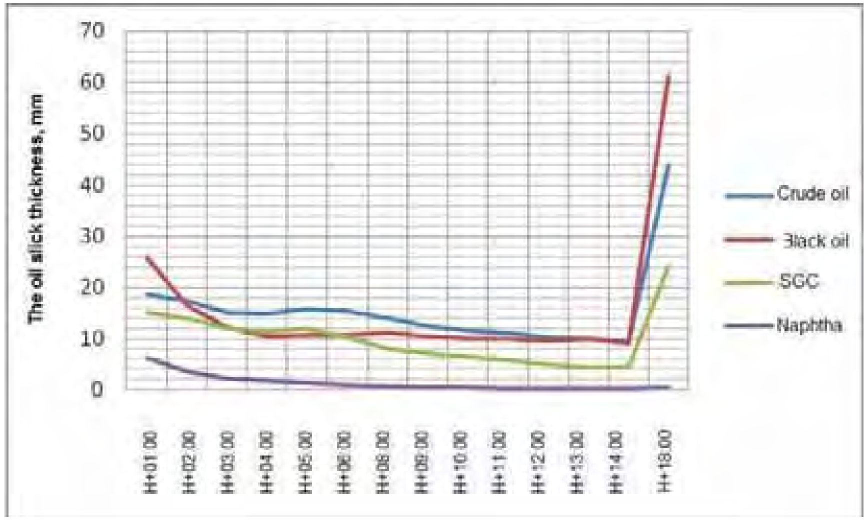


Figure 391. Oil slick thickness change dynamics as per the scenarios Aut-S-2.

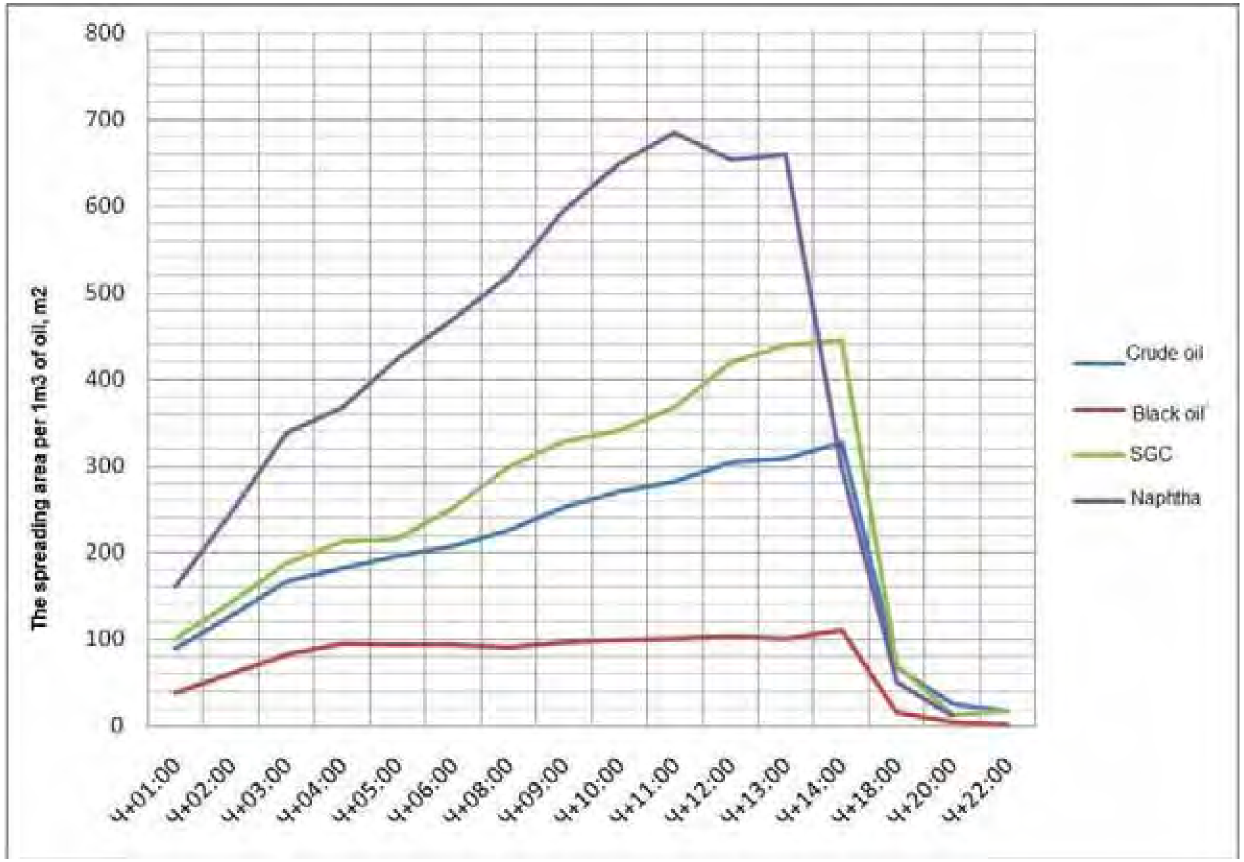


Figure 392. Oil slick spreading area change dynamics per 1 m ^{3} of various oil types as per the scenarios Aut-S-2.

2.4 Oil spill behavior modeling in the White Sea under the autumn westward wind (Aut-W-2)

2.4.1 Oil slick behaviour modelling as per the scenario COU-Aut-W-2

Table 2.3.1.1: Oil slick spreading parameters as per the scenario COU-Aut-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3489	100	3449	98,9	5,6	0,16	34,0	0,97	0	0	5804	20,40	284458	45,3
H+02:00	6991	100	6880	98,4	26,3	0,38	84,6	1,21	0	0	15432	16,71	923283	102
H+03:00	10494	100	10293	98,1	69,0	0,66	132	1,26	0	0	26426	16,30	1621506	151
H+04:00	14000	100	13692	97,8	133	0,95	174	1,24	0	0	37718	16,25	2320782	187
H+06:00	14000	100	13521	96,6	277	1,98	201	1,43	0	0	44651	16,33	2734067	331
H+09:00	14000	100	13258	94,7	511	3,65	232	1,66	0	0	44221	12,81	3451870	400
H+12:00	14000	100	12991	92,8	740	5,28	270	1,93	0	0	43334	11,33	3825977	471
H+15:00	14000	100	12740	91,0	944	6,75	311	2,22	0	0	42511	10,10	4207492	544
H+18:00	14000	100	12511	89,4	1133	8,09	356	2,54	0	0	41734	9,30	4486647	622
H+24:00	14000	100	12104	86,5	1449	10,3	447	3,19	0	0	40377	8,75	4616198	777
H+36:00	14000	100	11452	81,8	1924	13,7	625	4,46	0	0	38200	6,23	6127946	1087
H+47:45 Landfall	14000	100	10962	78,3	2244	16,0	787	5,62	5,89	0,04	36567	5,03	7264825	1365
H+48:00	14000	100	10906	77,9	2251	16,1	79	5,65	53,2	0,38	36372	5,45	6677145	1372
H+52:00	14000	100	13692	75,7	133	16,4	84	6,02	270	1,93	35340	4,01	8821160	1412
H+56:00	14000	100	13521	75,0	277	16,5	909	6,50	284	2,03	35023	49,6	706299	1428

Within the first 6 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 2700 m, the volume of the evaporated oil – 0,95%, the dispersed oil – 1,24%. Further the oil drifts north-eastward. Aftr 9 hours as of the OS start the oil slick semi-perimeter makes 3292 m, the volume of the evaporated oil – 3,7%, the dispersed oil – 1,6%. After 12 hours as of the OS start the oil slick drifting direction changes to south-eastward (in the direction of the Zimniy coastline of the White Sea). The oil slick semi-perimeter makes 3466 m, the volume of the evaporated oil – 5,3%, the dispersed oil – 1,9%. After 24 hours as of the OS start the oil slick semi-perimeter makes 3807 m, the volume of the evaporated oil – 10,3%, the dispersed oil – 3,2%. After 36 hours as of the OS start the oil slick semi-perimeter makes 4386 m, the volume of the evaporated oil – 13,7%, the dispersed oil – 4,5%.After 47 hours and 45 minutes the oil reaches the Zimniy Coast of the White Sea in the area of the Cape Oleniy Nos. After 52 hours as of the OS start about 30 km of the coastline in the area of the Capes Oleniy Nos, Tolstiy Nos and the maid River mouth have been polluted. The volume of the oil/water mixturee compared to the OS volume has increased with 152,4%. To the moment of modelling completion (56 hours) the coastline in the area of the Capes Oleniy Nos, Tolsiy Nos as well as the mouth and the distributary of the Maida River with the total length of more than 35 km have been polluted with oil. The average oil slick thickness in the shore makes 4,5 sm.
The graphic display of oil slick spreading as per the scenario COU-Aut-W-2 is shown in figures 393 – 408.
The charts of processes typical for oil behavior on water are shown in figures 409-411.

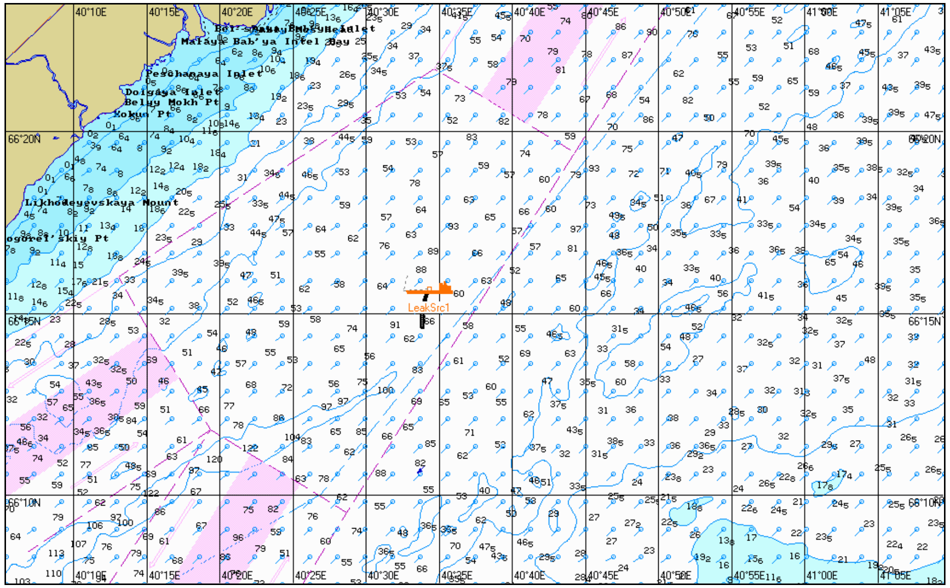


Figure 393. H+01:00. Oil slick spreading as per the scenario COU-Aut-W-2.

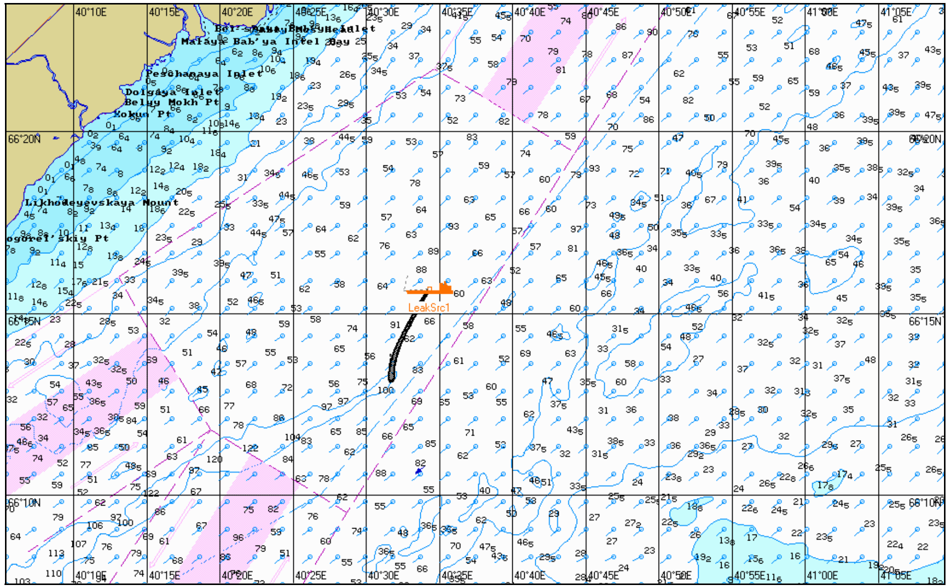


Figure 394. H+02:00. Oil slick spreading as per the scenario COU-Aut-W-2.

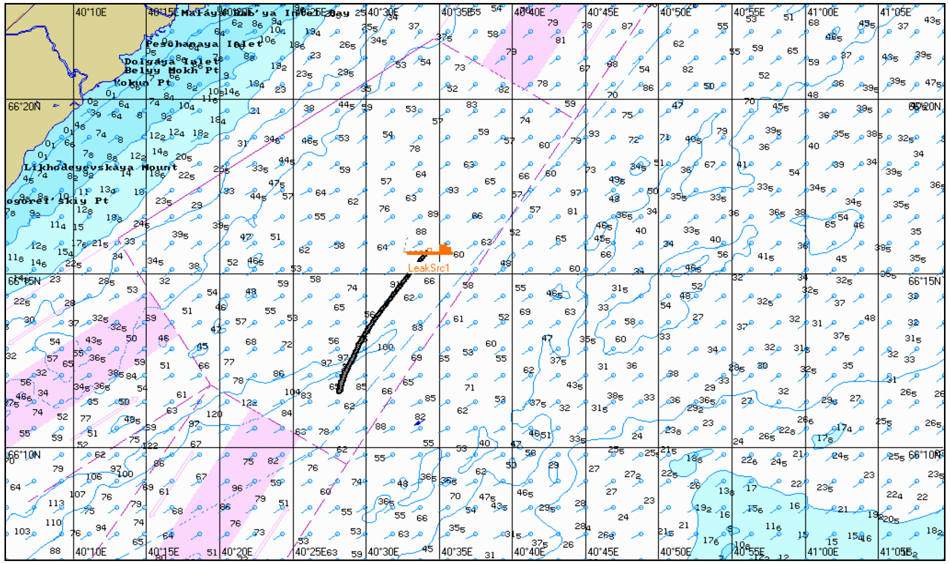


Figure 395. H+03:00. Oil slick spreading as per the scenario COU-Aut-W-2.

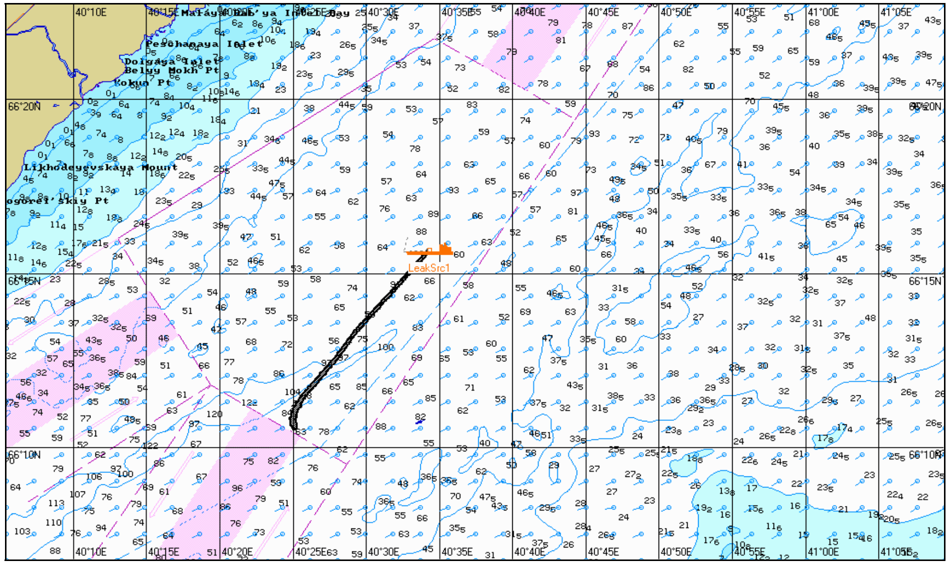


Figure 396. H+04:00. Oil slick spreading as per the scenario COU-Aut-W-2.

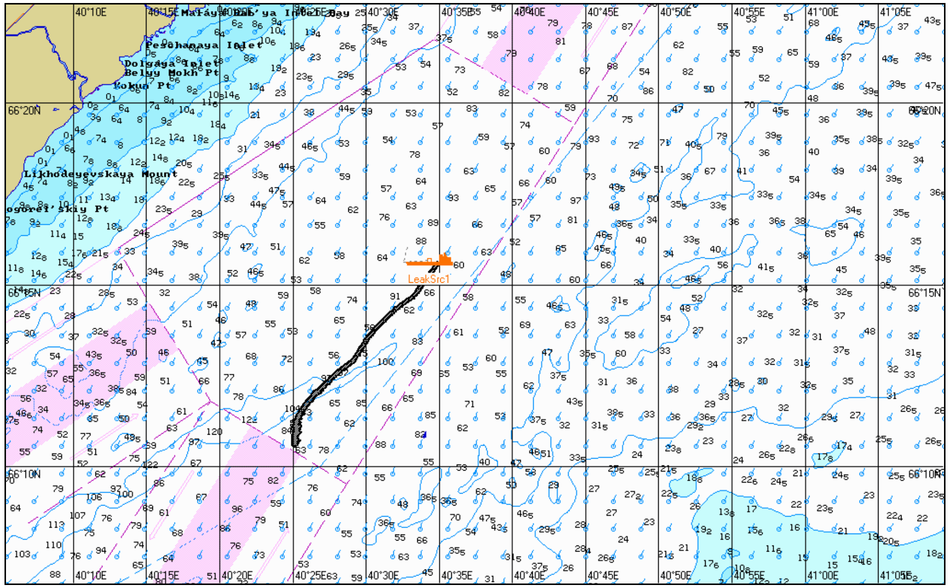


Figure 397. H+06:00. Oil slick spreading as per the scenario COU-Aut-W-2.

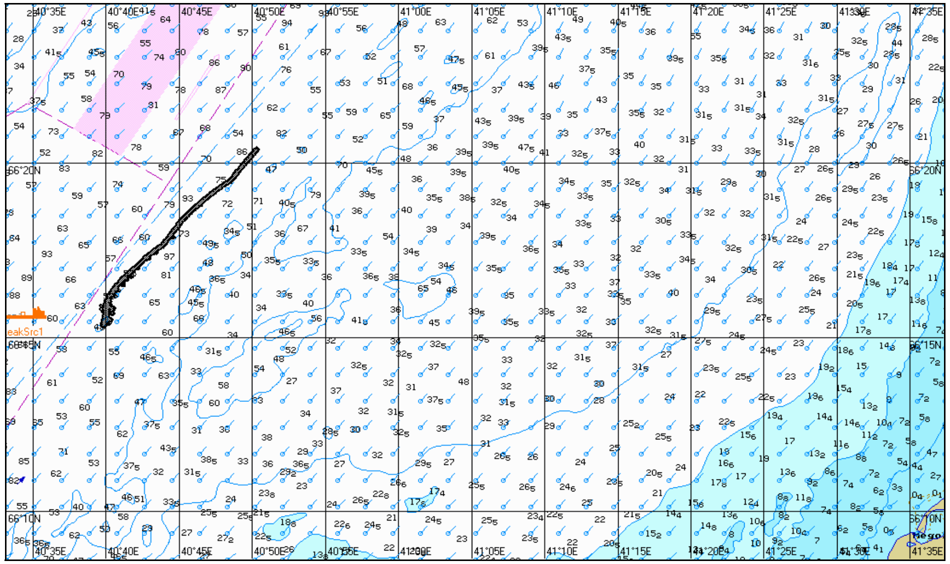


Figure 398. H+09:00. Oil slick spreading as per the scenario COU-Aut-W-2.

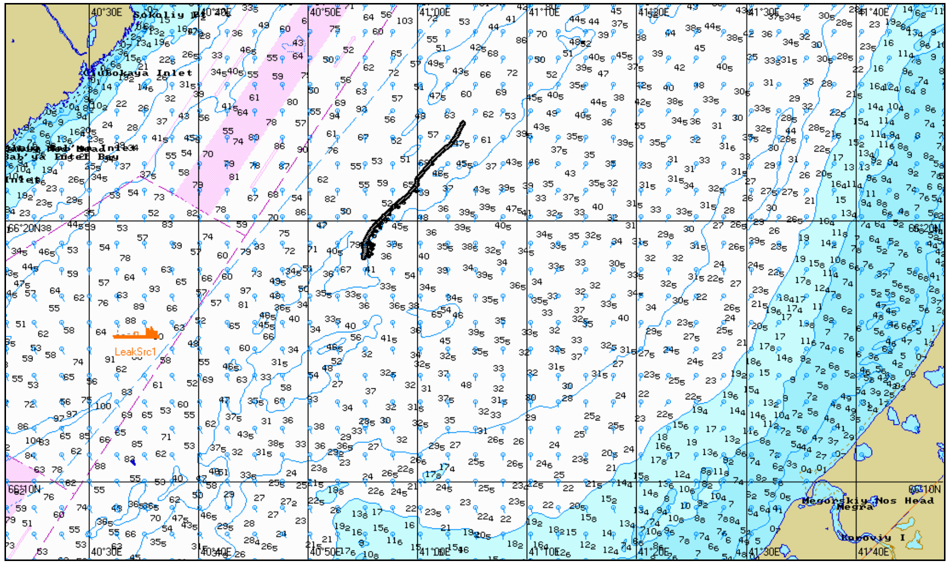


Figure 399. H+12:00. Oil slick spreading as per the scenario COU-Aut-W-2.

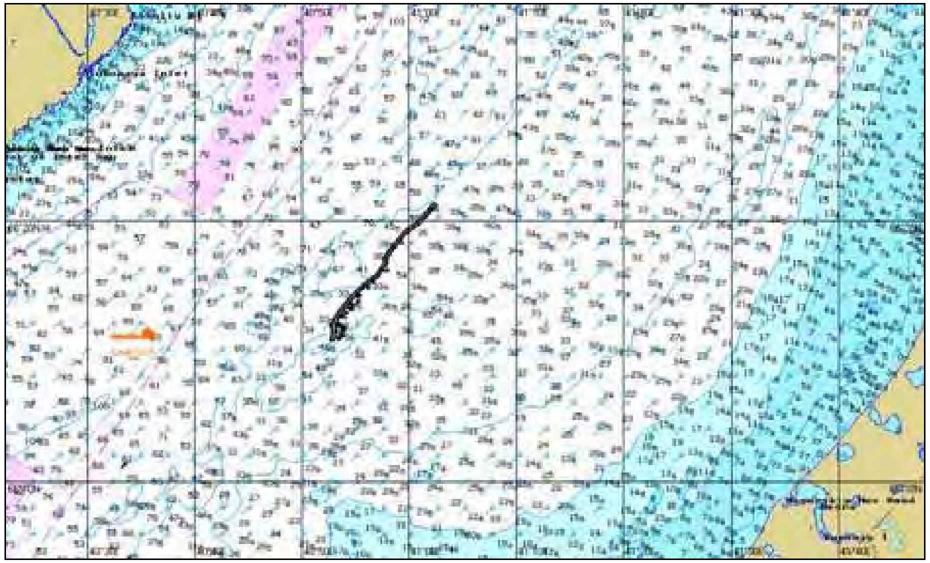


Figure 400. H+15:00. Oil slick spreading as per the scenario COU-Aut-W-2.

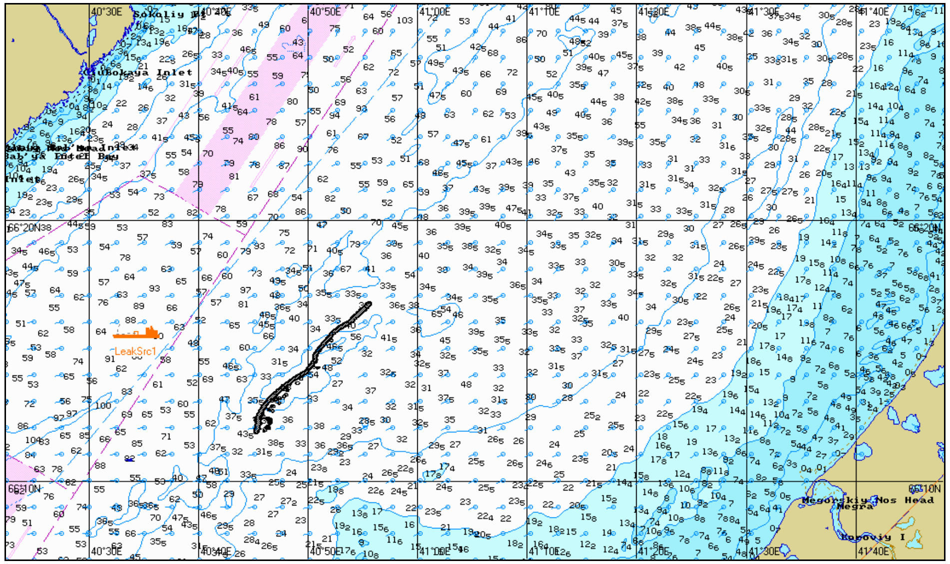


Figure 401. H+18:00. Oil slick spreading as per the scenario COU-Aut-W-2.

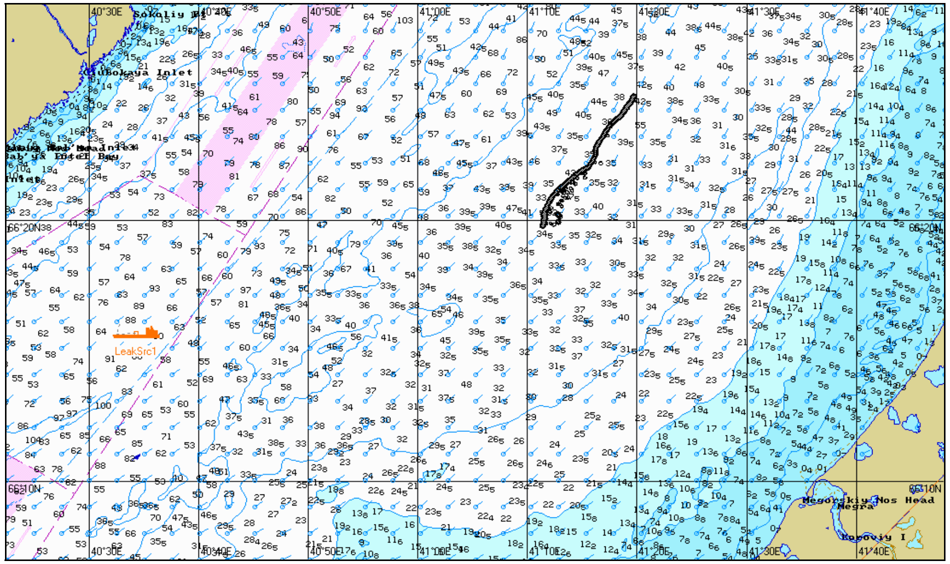


Figure 402. H+24:00. Oil slick spreading as per the scenario COU-Aut-W-2.

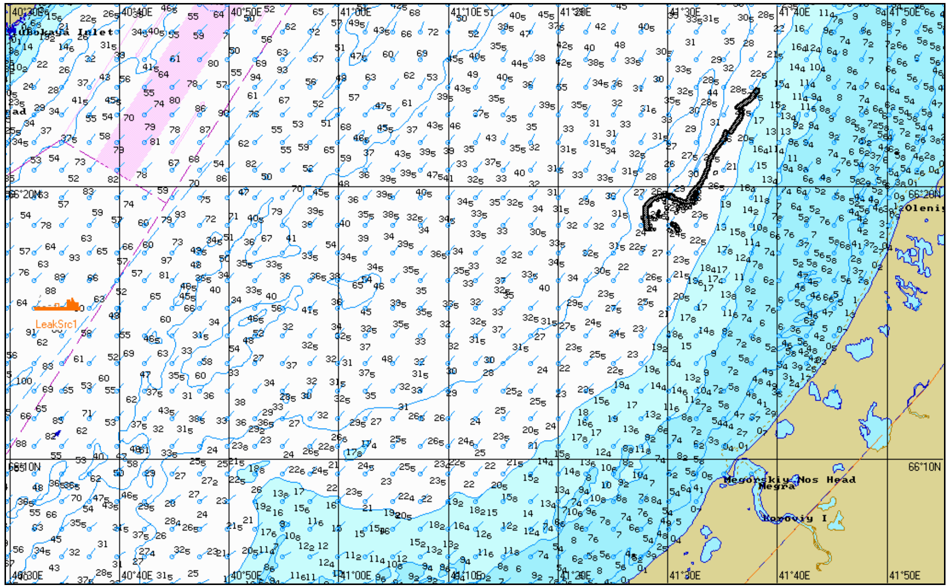


Figure 403. H+36:00. Oil slick spreading as per the scenario COU-Aut-W-2.

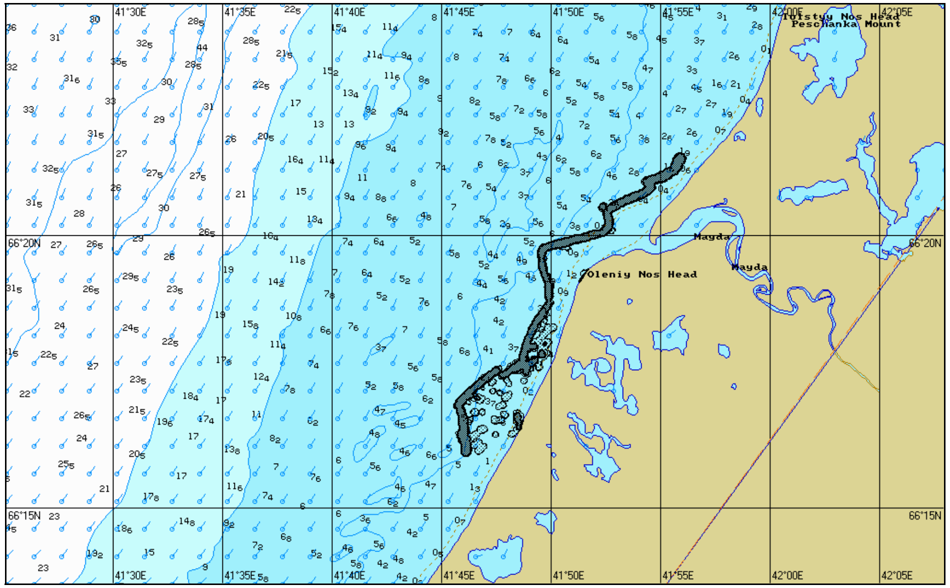


Figure 404. **H+47:45.** Oil slick spreading as per the scenario COU-Aut-W-2.

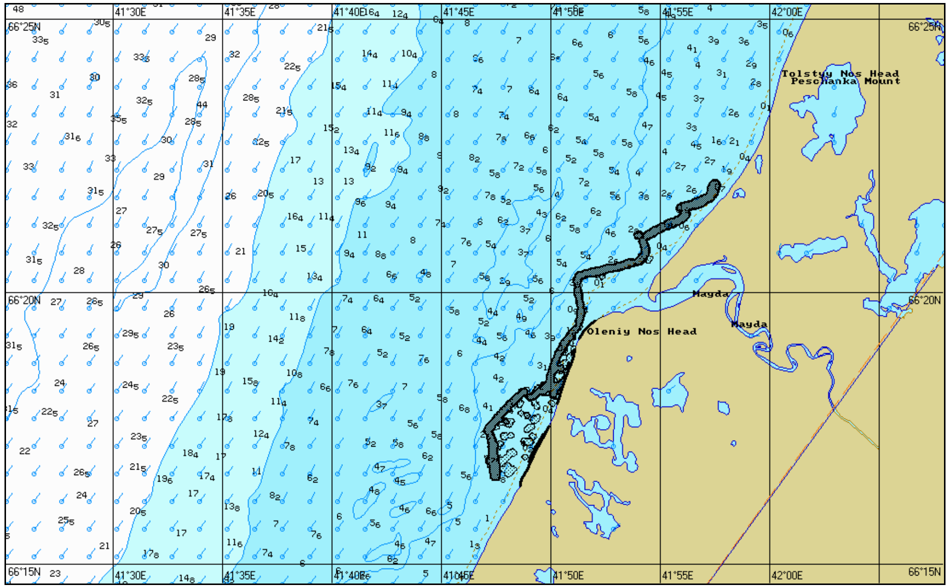


Figure 405. H+48:00. Oil slick spreading as per the scenario COU-Aut-W-2.

Figure 406. H+52:00. Oil slick spreading as per the scenario COU-Aut-W-2.

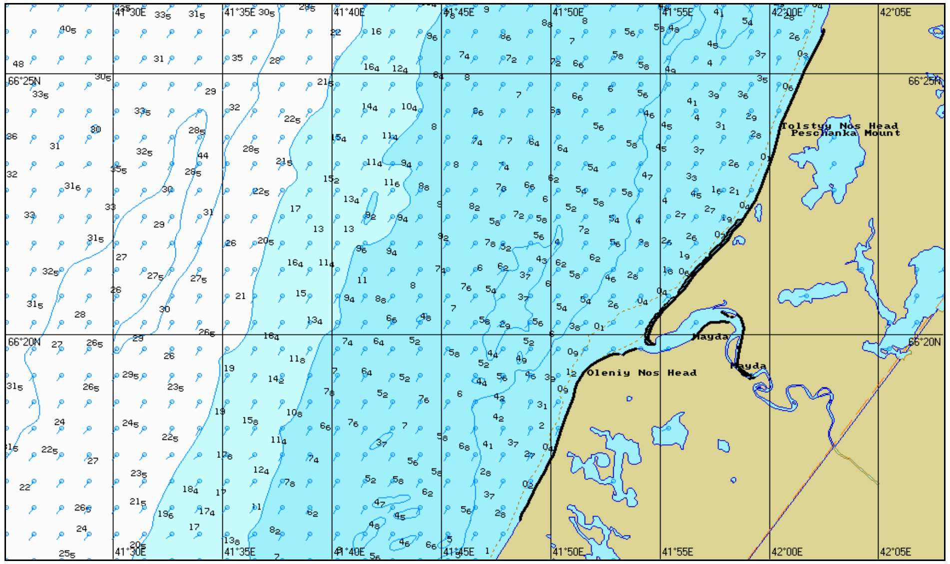


Figure 407. H+56:00. Oil slick spreading as per the scenario COU-Aut-W-2.

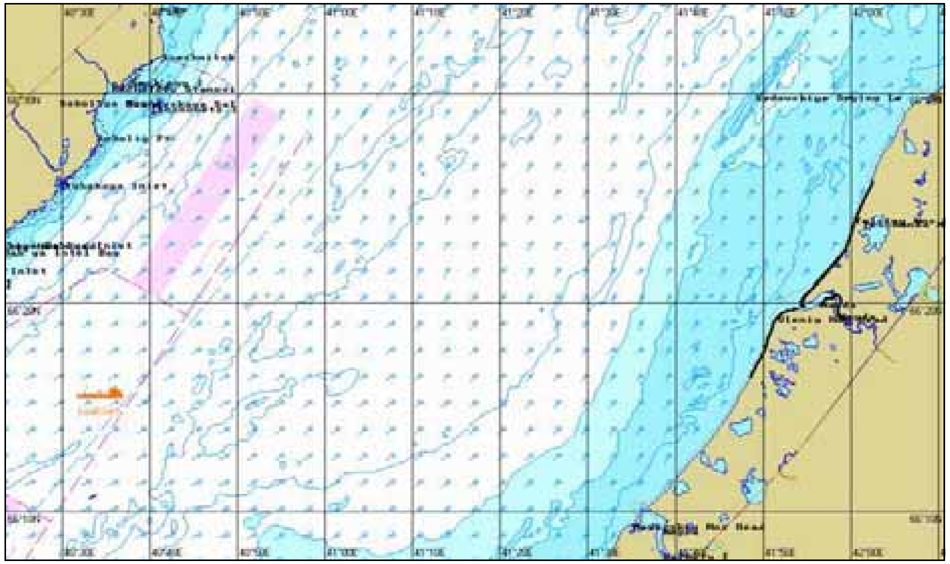


Figure 408. H+56:00. Oil slick spreading as per the scenario COU-Aut-W-2.

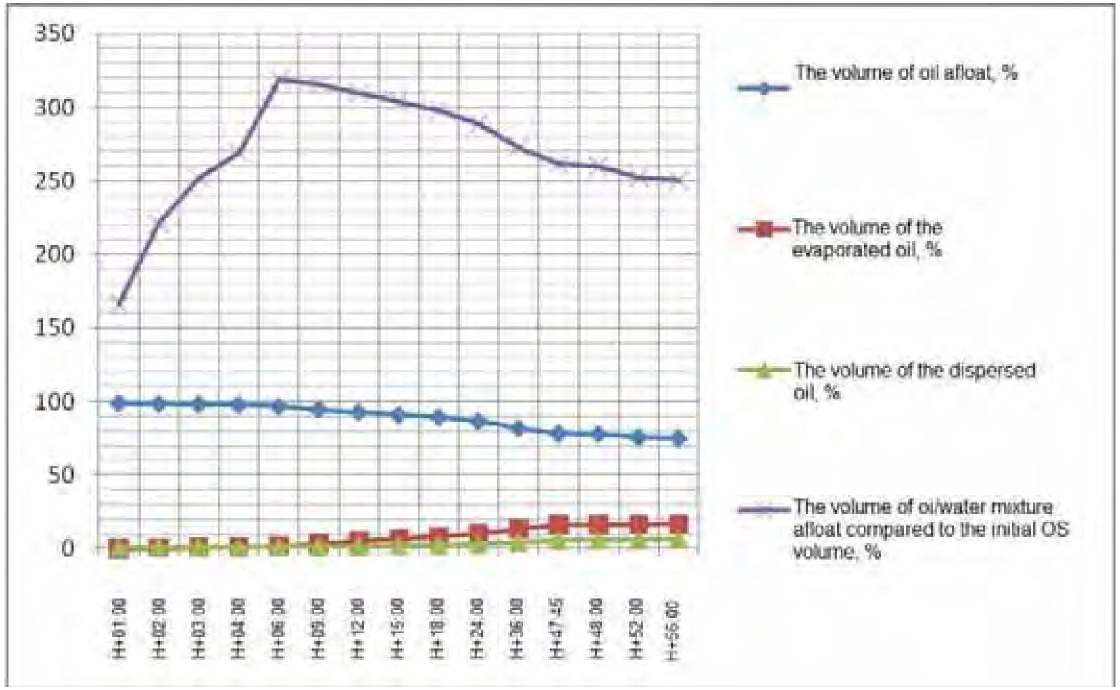


Figure 409. The chart of processes as per the scenario COU-Aut-W-2.

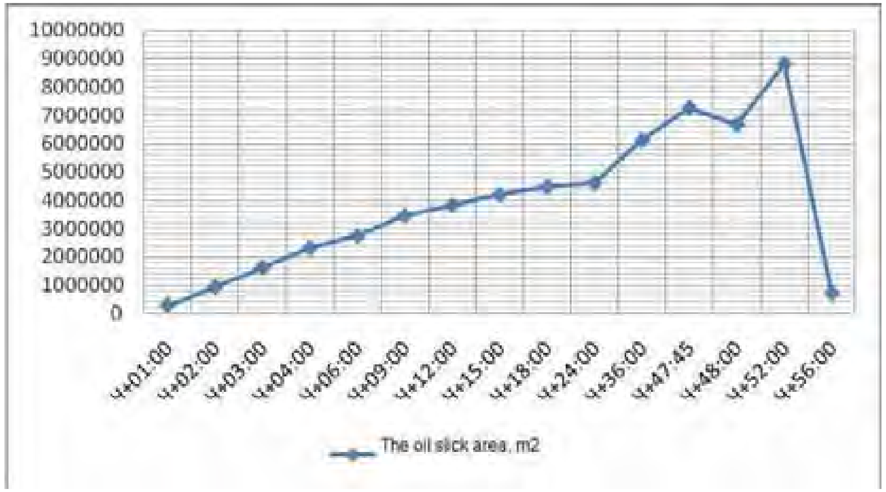


Figure 410. Oil slick area change dynamics as per the scenario COU-Aut-W-2.

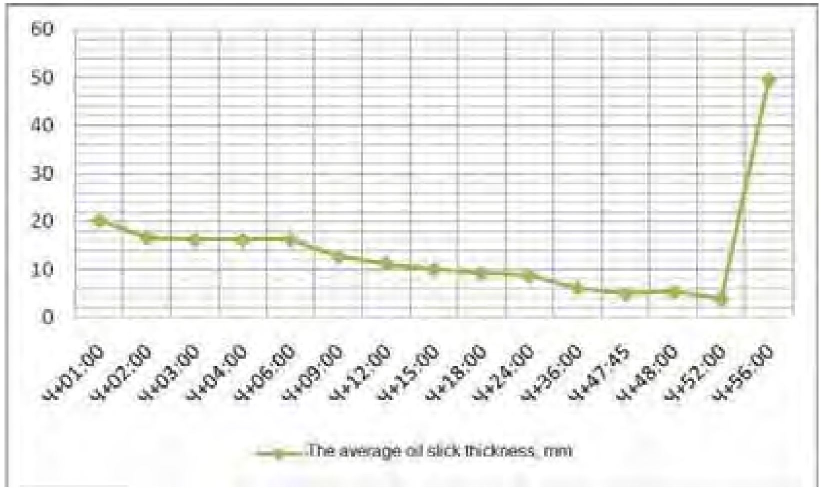


Figure 411. Oil slick thickness change dynamics as per the scenario COU-Aut-W-2.

2.4.2 Oil slick behaviour modelling as per the scenario BO-Aut-W-2

Table 2.3.2.1: Oil slick spreading parameters as per the scenario BO-Aut-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil/water mixturee volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3550	100	3550	100	0	0	0	0	0	0	3550	30,86	115051	16514
H+02:00	7114	100	7114	100	0	0	0	0	0	0	7114	17,87	398061	16514
H+03:00	10679	100	10679	100	0	0	0	0	0	0	10679	13,64	782668	16514
H+04:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,26	1141581	16514
H+06:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,33	1135164	16514
H+09:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,43	1126150	16514
H+12:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,50	1119976	16514
H+15:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,42	1127125	16514
H+18:00	14000	100	14000	100	0	0	0	0	0	0	14000	12,32	1136728	16514
H+24:00	14000	100	14000	100	0	0	0	0	0	0	14000	13,44	1041759	16514
H+36:00	14000	100	14000	100	0	0	0	0	0	0	14000	11,84	1182415	16514
H+46:00	14000	100	14000	100	0	0	0	0	0	0	14000	10,90	1284546	16514
H+48:22 Landfall	14000	100	13994	100	0	0	0	0	6,4	0,05	13994	11,05	1266538	16514
H+50:00	14000	100	13828	98,8	0	0	0	0	172	1,23	13828	26,32	525320	16514

Within the first 6 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1893 m, the evaporation and dispersion processes are not detected by the programme. Further the oil slick drifts north-eastward. After 9 hours as of the OS start the oil slick semi-perimeter makes 1881 m, the evaporation and dispersion processes are not detected by the programme. After 12 hours as of the OS start the drifting direction changes to the south-east (in the direction fo the Zimniy Coast of the White Sea), the oil slick semi-perimeter makes 1875 m. After 24 hours as of the OS start the oil slick semi-perimeter makes 1809 m, the evaporation and dispersion processes are not detected by the programme. After 36 hours as of the OS start the oil slick breaks up in several parts, the oil slick semi-perimeter compared to the total area makes 1927 m. After 48 hours and 22 minutes the oil reaches the Zimniy Coast of the White Sea in the area of the Cape Oleniy Nos. The volume of the oil/water mixturee compared to the OS volume has not increased. To the moment of modelling completion (50 hours) the coastline of the Zimniy Coast of the White Sea in the area of the Capes Oleniy Nos, Tolstiy Nos and the mouth and distributary of the Maida River with the total length of more than 30 km has been polluted with oil. The average oil slick thickness in the shore makes 2,6 sm.

The graphic display of oil slick spreading as per the scenario BO-Aut-W-2 is shown in figures 412 – 425.

The charts of processes typical for oil behavior on water are shown in figures 426-428.

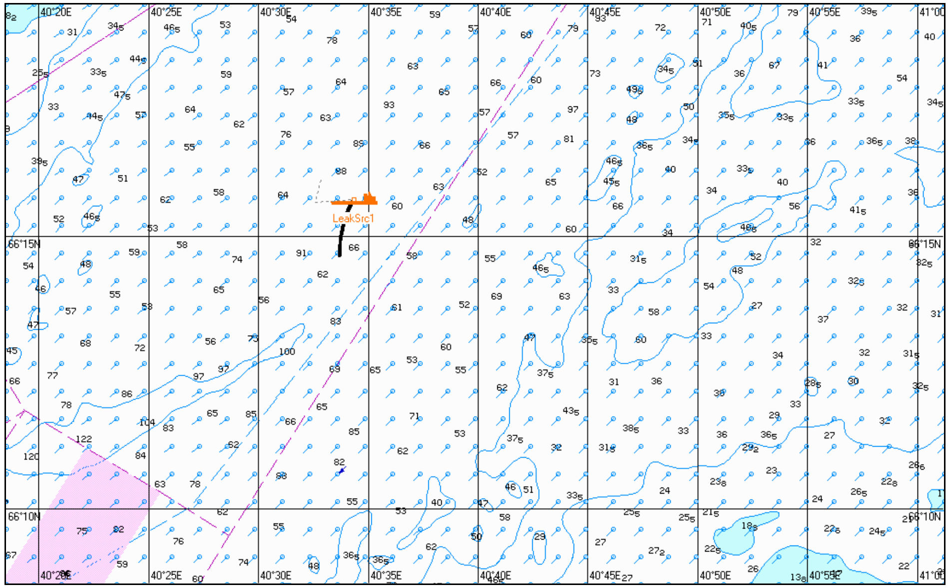


Figure 412. H+01:00. Oil slick spreading as per the scenario BO-Aut-W-2.

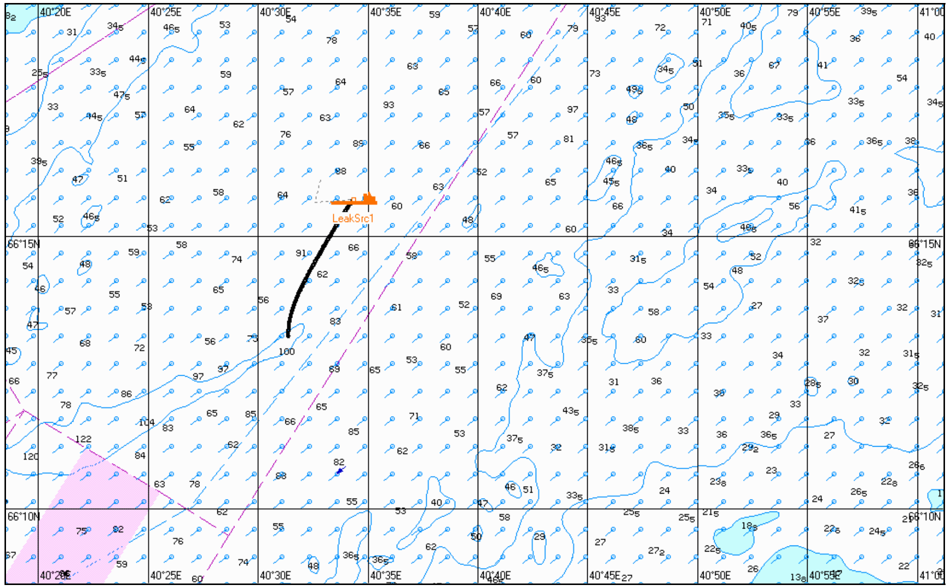


Figure 413. H+02:00. Oil slick spreading as per the scenario BO-Aut-W-2.

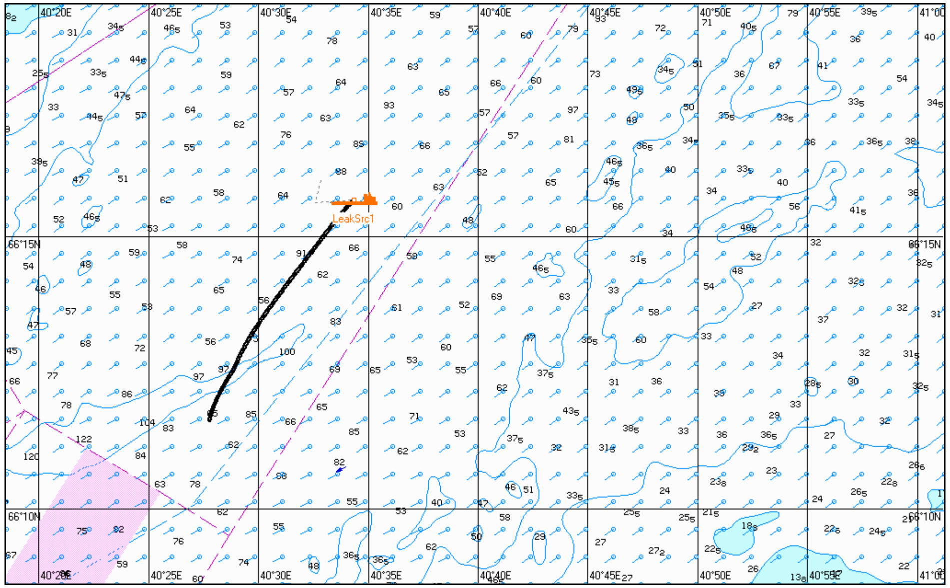


Figure 414. H+03:00. Oil slick spreading as per the scenario BO-Aut-W-2.

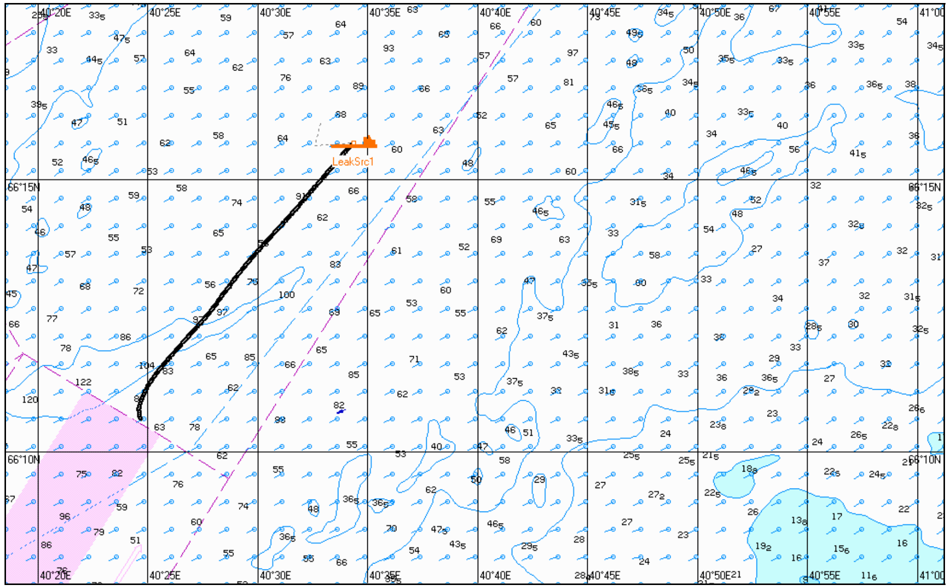


Figure 415. H+04:00. Oil slick spreading as per the scenario BO-Aut-W-2.

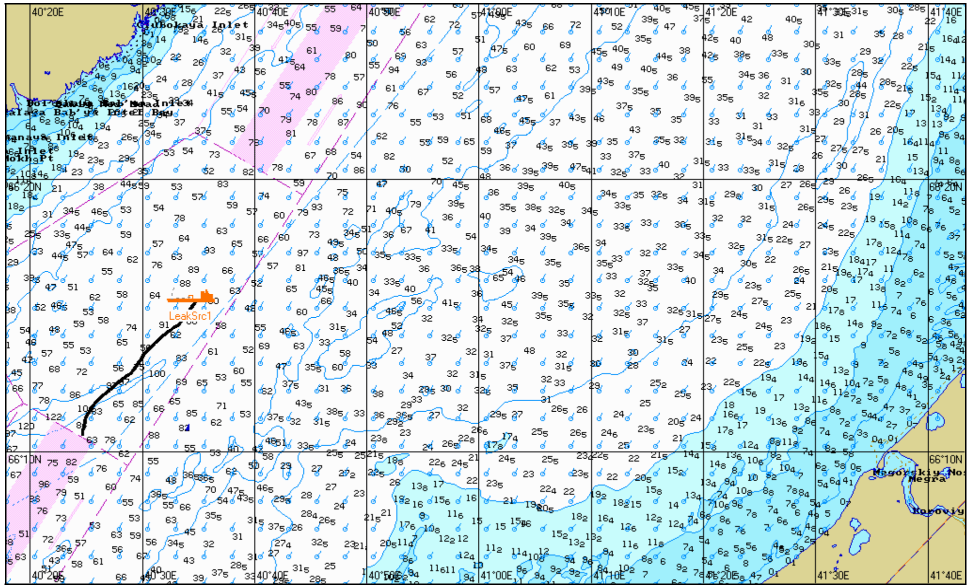


Figure 416. H+06:00. Oil slick spreading as per the scenario BO-Aut-W-2.

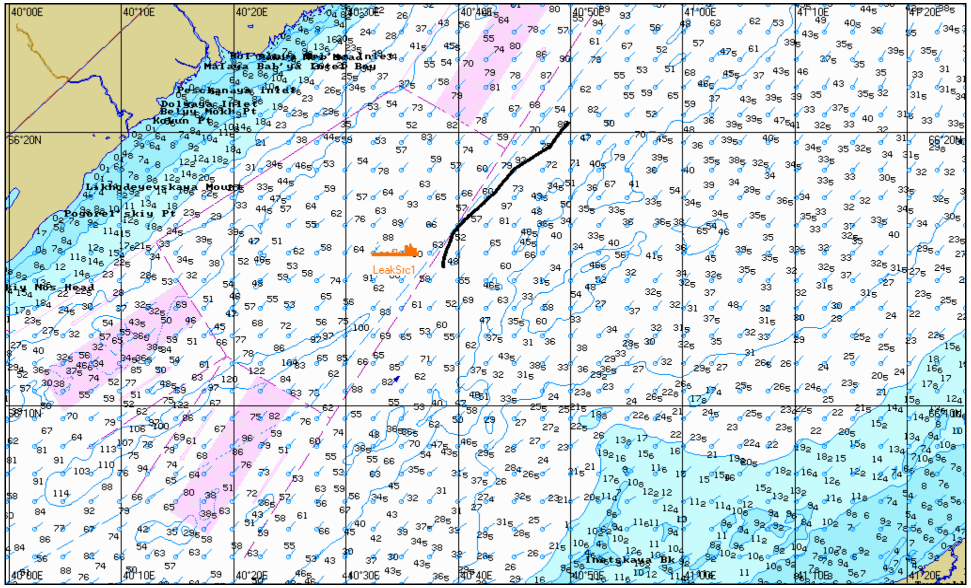


Figure 417. H+09:00. Oil slick spreading as per the scenario BO-Aut-W-2.

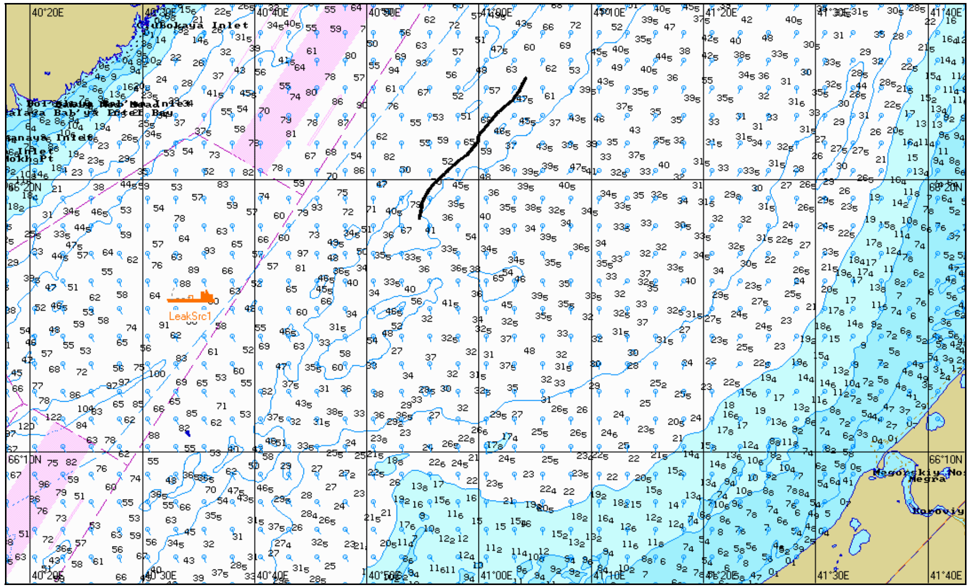


Figure 418. H+12:00. Oil slick spreading as per the scenario BO-Aut-W-2.

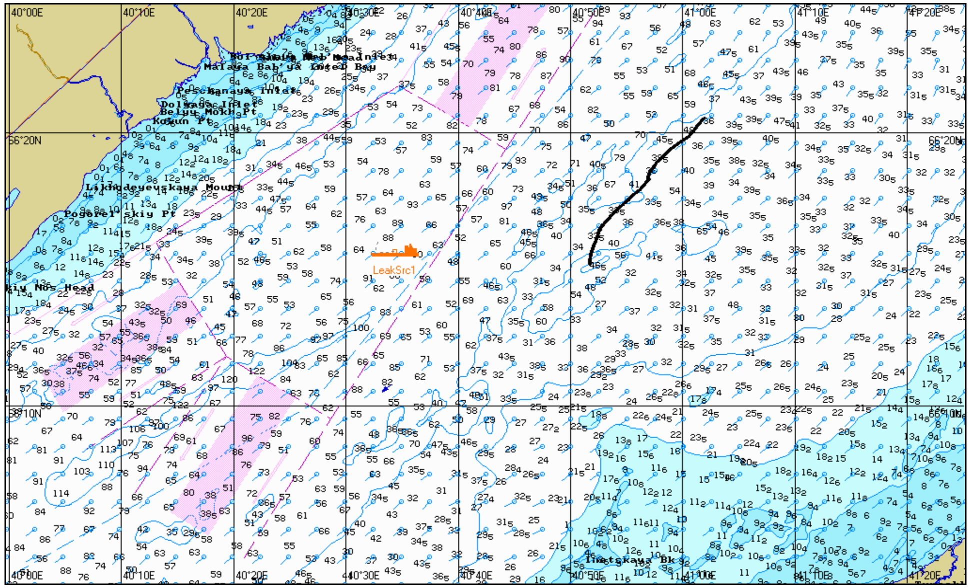


Figure 419. H+15:00. Oil slick spreading as per the scenario BO-Aut-W-2.

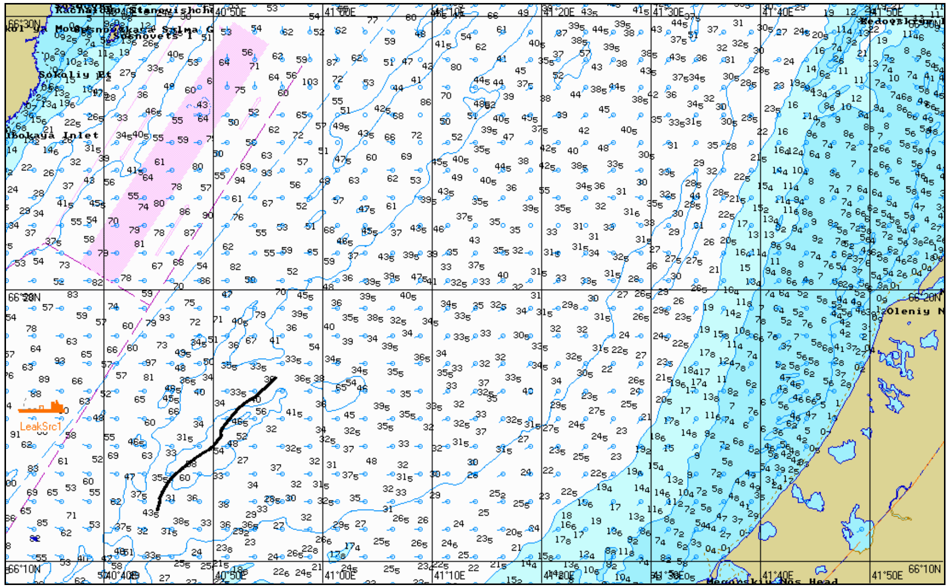


Figure 420. H+18:00. Oil slick spreading as per the scenario BO-Aut-W-2.

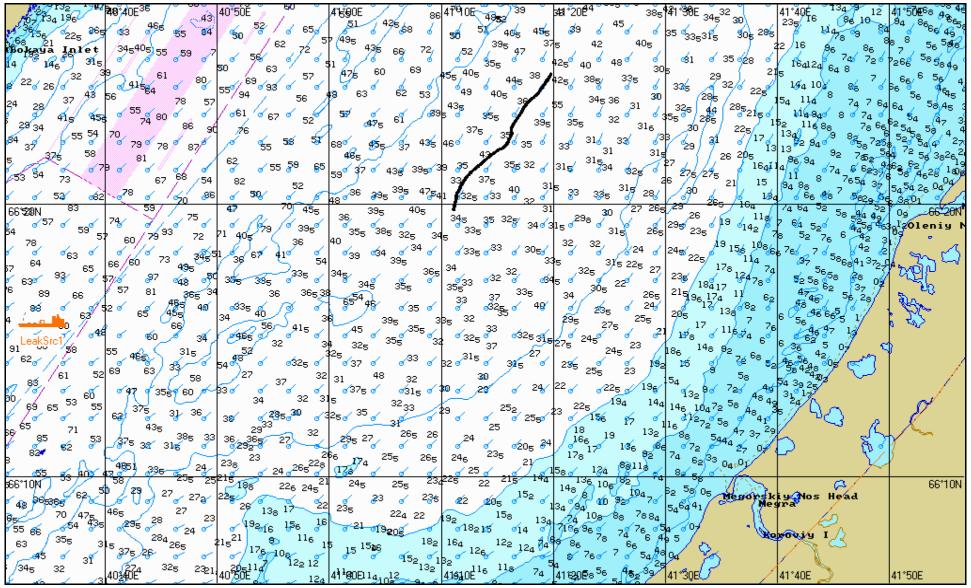


Figure 421. H+24:00. Oil slick spreading as per the scenario BO-Aut-W-2.

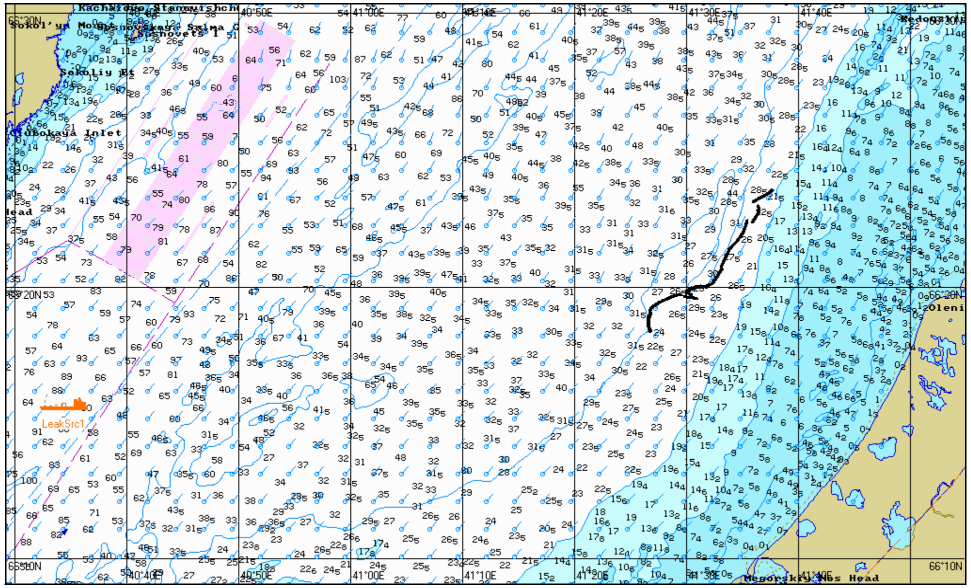


Figure 422. H+36:00. Oil slick spreading as per the scenario BO-Aut-W-2.

Figure 423. H+46:00. Oil slick spreading as per the scenario BO-Aut-W-2.

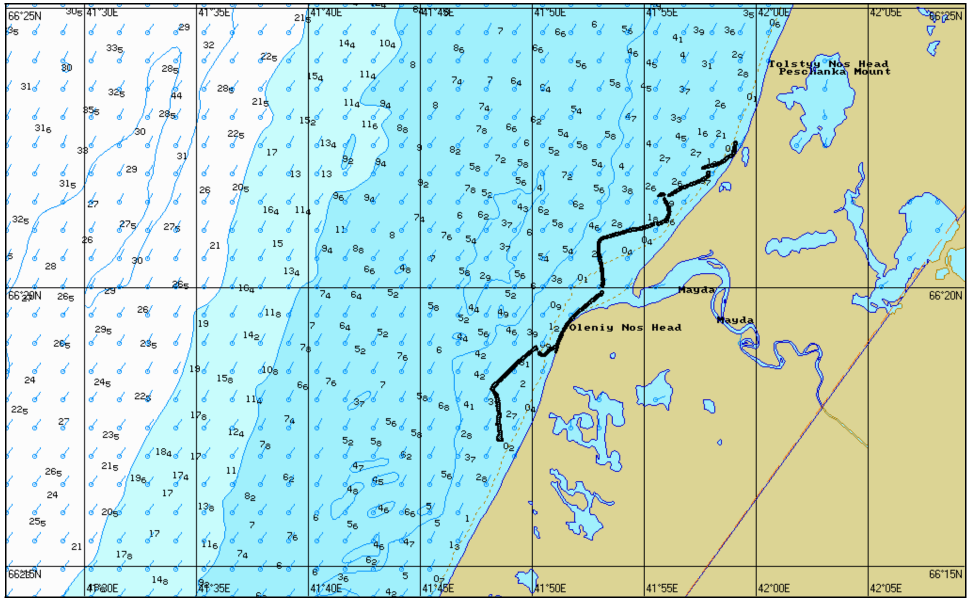


Figure 424. **H+48:22.** Oil slick spreading as per the scenario BO-Aut-W-2.

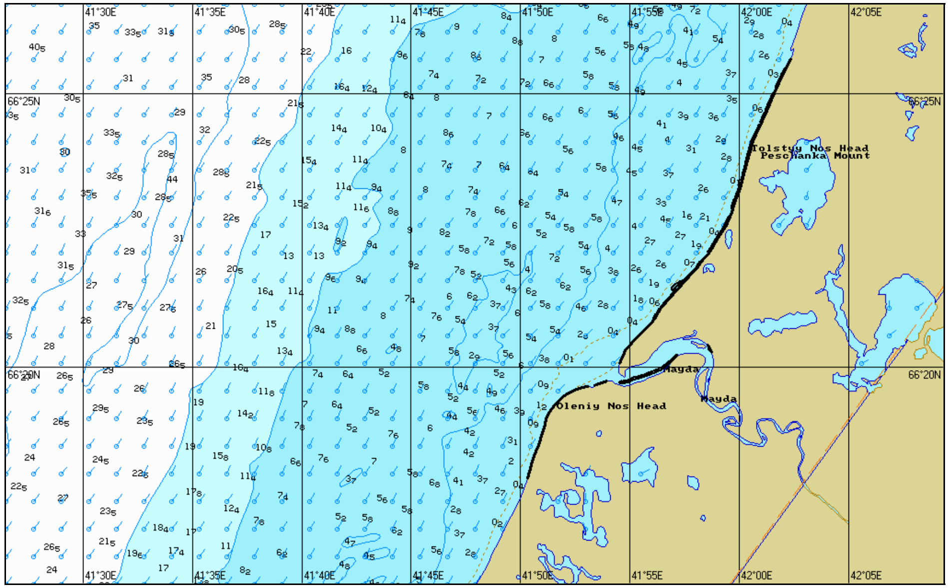


Figure 425. H+50:00. Oil slick spreading as per the scenario BO-Aut-W-2.

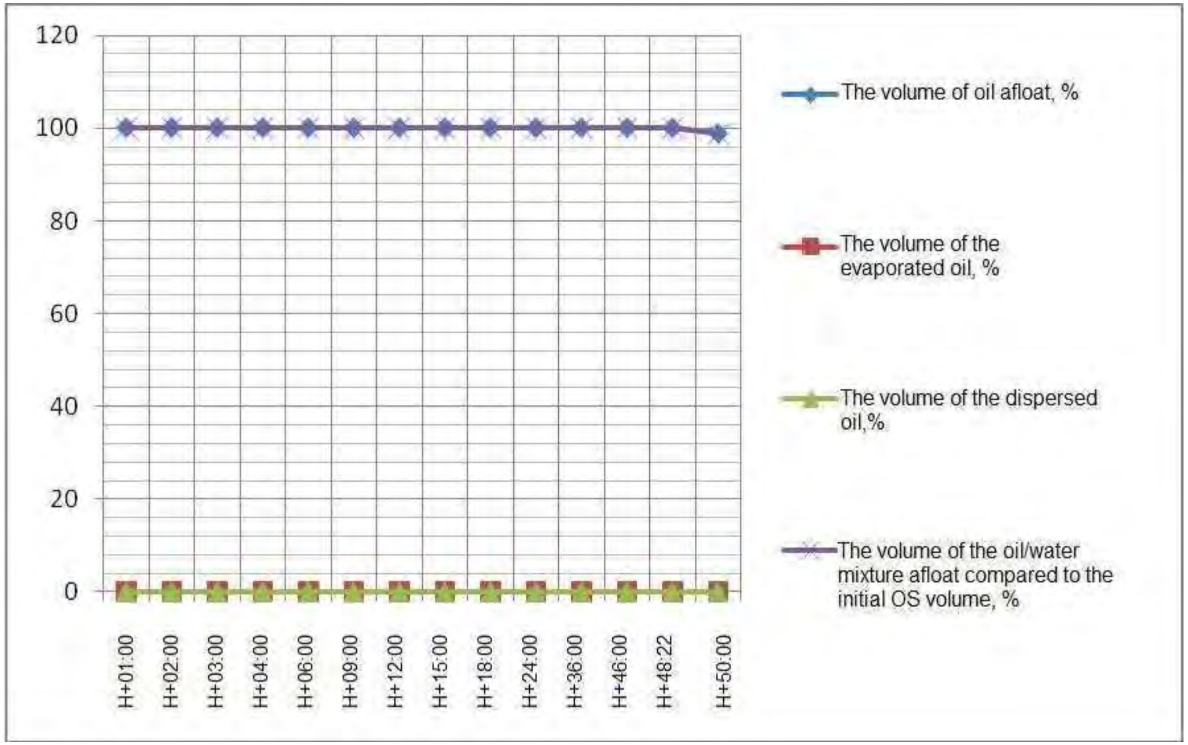


Figure 426. The chart of processes as per the scenario BO-Aut-W-2.

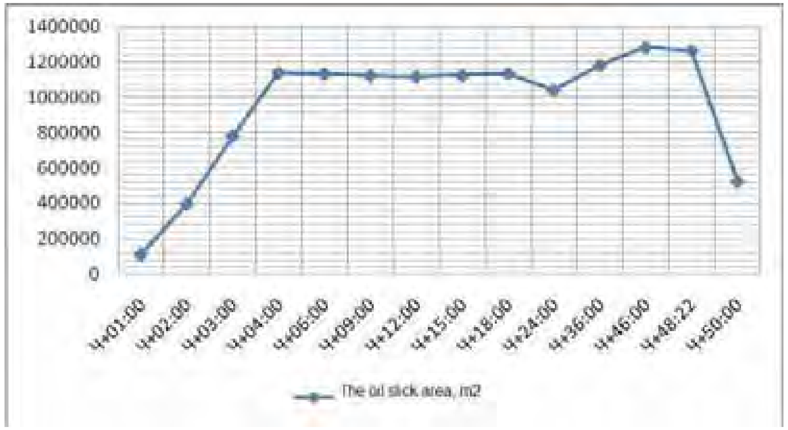


Figure 427. Oil slick area change dynamics as per the scenario BO-Aut-W-2.

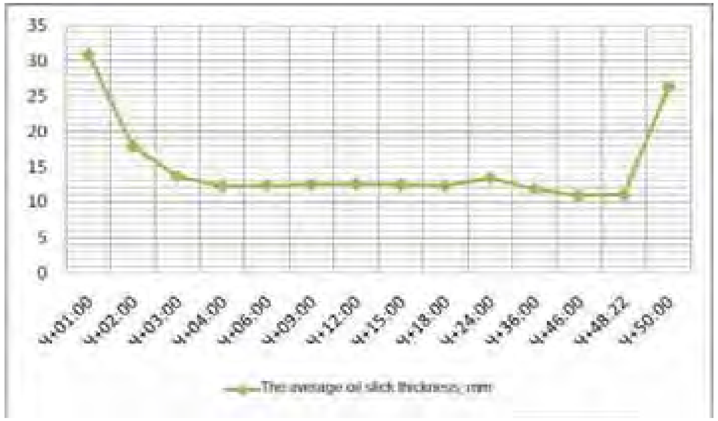


Figure 428. Oil slick thickness change dynamics as per the scenario BO-Aut-W-2.

2.4.3 Oil slick behaviour modelling as per the scenario GC-Aut-W-2

Table 2.3.3.1: Oil slick spreading parameters as per the scenario GC-Aut-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	4445	100	4049	91,1	49,4	1,11	346	7,78	0	0	7256	14,9	485402	6,02
H+02:00	7522	100	6698	89,0	156	2,07	668	8,88	0	0	14883	14,0	1065111	12,4
H+03:00	10966	100	9550	87,1	386	3,52	1029	9,38	0	0	24558	13,4	1831971	21,3
H+04:00	14000	100	11925	85,2	732	5,23	1350	9,64	0	0	33759	13,0	2605531	32,4
H+06:00	14000	100	11069	79,1	1441	10,3	1498	10,7	0	0	36585	11,8	3104690	80,0
H+09:00	14000	100	9826	70,2	2519	18,0	1662	11,9	0	0	32735	7,57	4322649	175
H+12:00	14000	100	8652	61,8	3592	25,7	1763	12,6	0	0	28824	5,24	5502731	374
H+15:00	14000	100	7643	54,6	4443	31,7	1921	13,7	0	0	25461	3,75	6780577	684
H+18:00	14000	100	6860	49,0	5126	36,6	2021	14,4	0	0	22851	2,94	7760514	1107
H+24:00	14000	100	5904	42,2	6038	43,1	2065	14,8	0	0	19663	2,34	8418720	2105
H+36:00	14000	100	4864	34,7	6896	49,3	2247	16,1	0	0	16197	1,50	10814667	3858
H+47:12 **Landfall**	14000	100	4247	30,3	7372	52,0	2385	17,0	3,0	0,02	14139	1,33	10634638	5413
H+48:00	14000	100	3946	28,2	7315	52,3	2600	18,6	146	1,04	13136	1,51	8722776	5198
H+50:00	14000	100	3753	26,8	7345	52,5	2624	18,7	285	2,04	12493	5,31	2354065	5312

Within the first 6 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 2860 m, the volume of the evaporated oil – 5,23%, the volume of the dispersed oil – 9,64%. Further the oil slick drifts north-eastward. After 9 hours as of the OS start the oil slick semi-perimeter makes 3684 m, the volume of the evaporated oil – 18%, the volume of the dispersed oil – 11,9%. After 12 hours asa of the OS start the oil slick drifting direction changes to the south-east (in the direction fo the Zimniy Coast of the White Sea). The oil slick semi-perimeter makes 4157 m, the volume of the evaporated oil – 25,7%, the volume of the dispersed oil – 12,6%. After 24 hours as of the OS start the oil slick semi-perimeter makes 5141 m, the volume of the evaporated oil – 43,1%, the volume of the dispersed oil – 14,8%. After 36 hours as of the OS start the oil slick breaks up in several parts, the oil slick semi-perimeter based on the total area makes 5827 m, the volume of the evaporated oil – 49,3%, the dispersed oil – 16,1%. After 47 hours and 12 minutes the oil reaches the Zimniy Coast of the White Sea in the area of the Cape Oleniy Nos. After 48 hours as of the OS start about 18 km of the coastline in the area of the Capes Oleniy Nos, Tolstiy Nos and the Maida River mouth have been polluted. The volume of the oil/water mixturee has decreased as compared to the OS volume with 6,4%. To the moment of modelling completion (50 hours) more than 30 km of the coastline in the area of the Capes Oleniy Nos, Tolstiy Nos and the mouth and distributary of the Maida River have been polluted with oil. The average oil slick thickness in the shore makes 5,31 mm.

The graphic display of oil slick spreading as per the scenario GC-Aut-W-2 is shown in figures 429 – 442.

The charts of processes typical for SGC behavior on water are shown in figures 443-445.

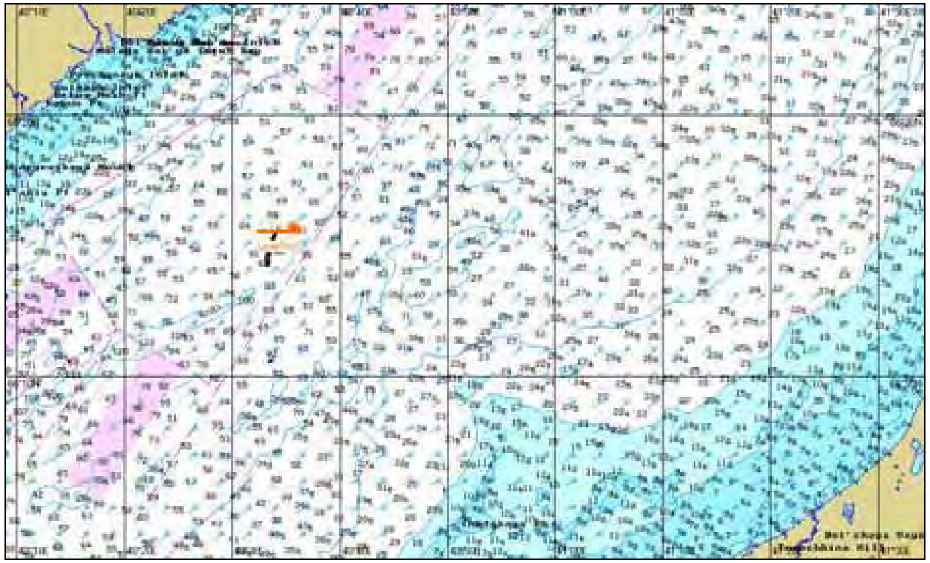


Figure 429. H+01:00. Oil slick spreading as per the scenario GC-Aut-W-2.

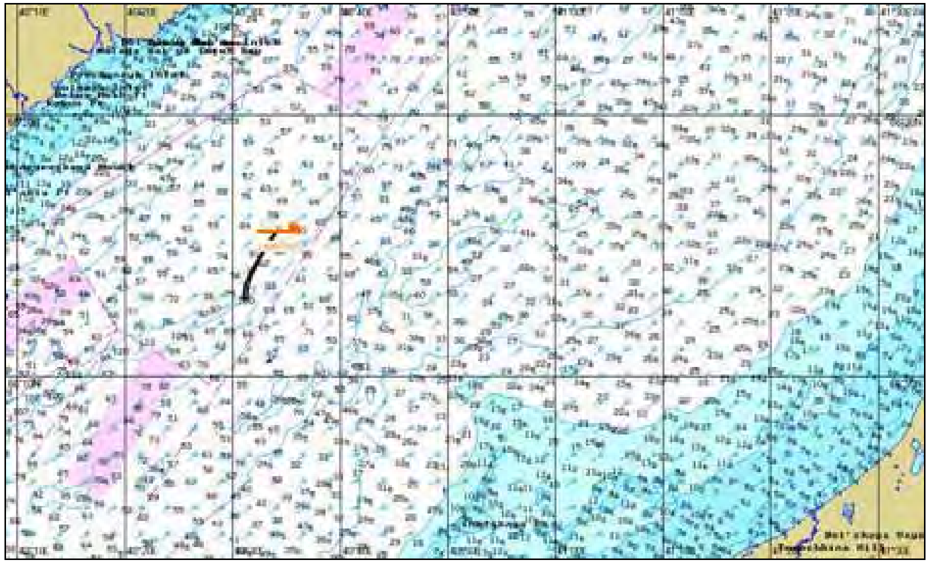


Figure 430. H+02:00. Oil slick spreading as per the scenario GC-Aut-W-2.

Figure 431. H+03:00. Oil slick spreading as per the scenario GC-Aut-W-2.

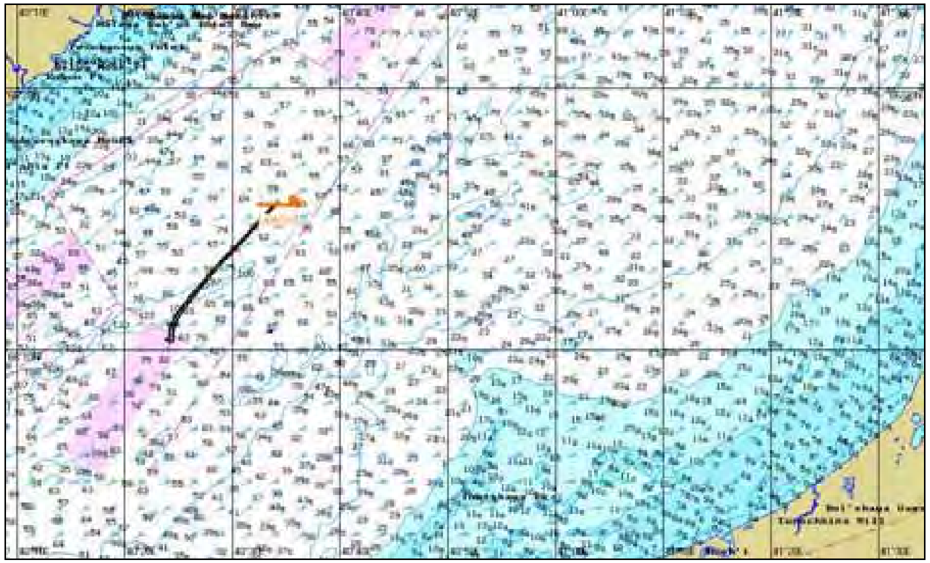


Figure 432. H+04:00. Oil slick spreading as per the scenario GC-Aut-W-2.

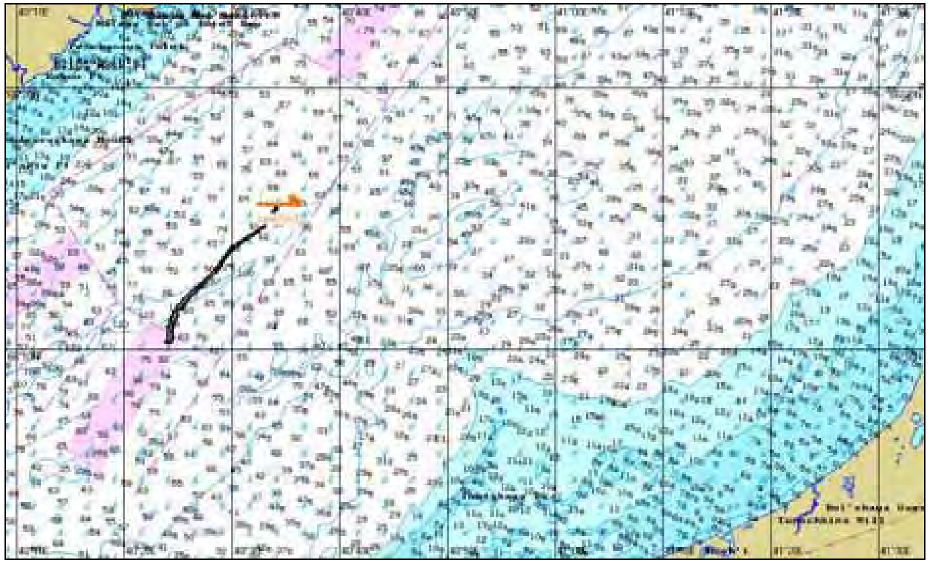


Figure 433. H+06:00. Oil slick spreading as per the scenario GC-Aut-W-2.

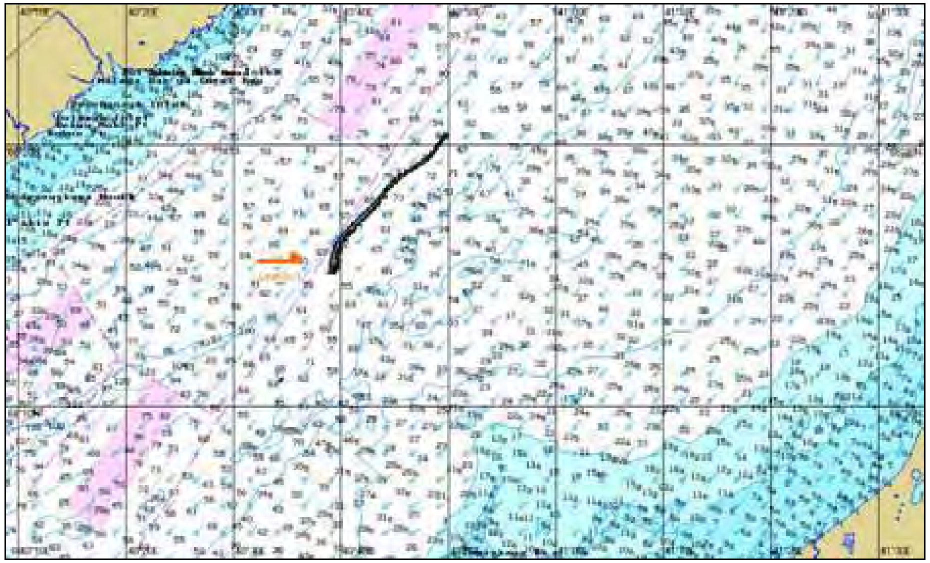


Figure 434. H+09:00. Oil slick spreading as per the scenario GC-Aut-W-2.

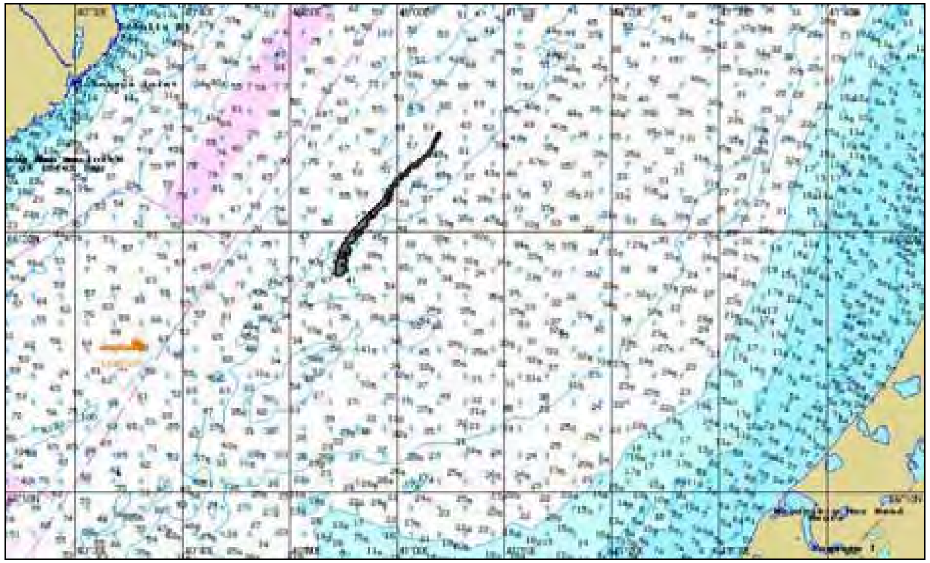


Figure 435. H+12:00. Oil slick spreading as per the scenario GC-Aut-W-2.

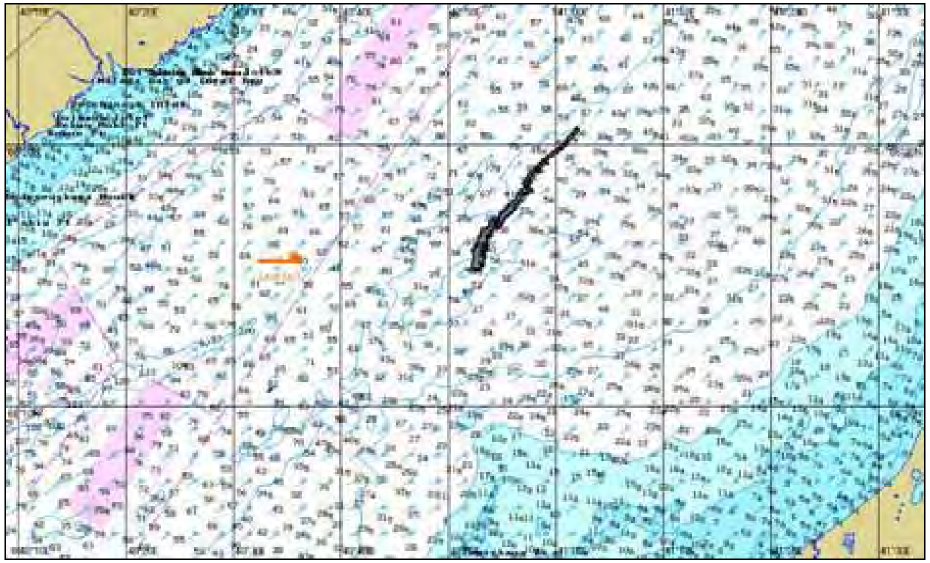


Figure 436. H+15:00. Oil slick spreading as per the scenario GC-Aut-W-2.

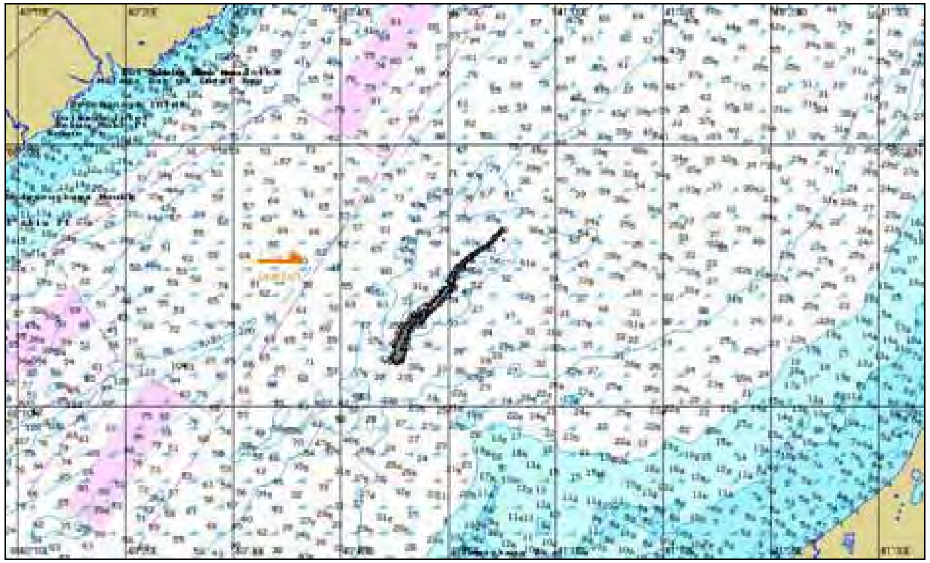


Figure 437. H+18:00. Oil slick spreading as per the scenario GC-Aut-W-2.

Figure 438. H+24:00. Oil slick spreading as per the scenario GC-Aut-W-2.

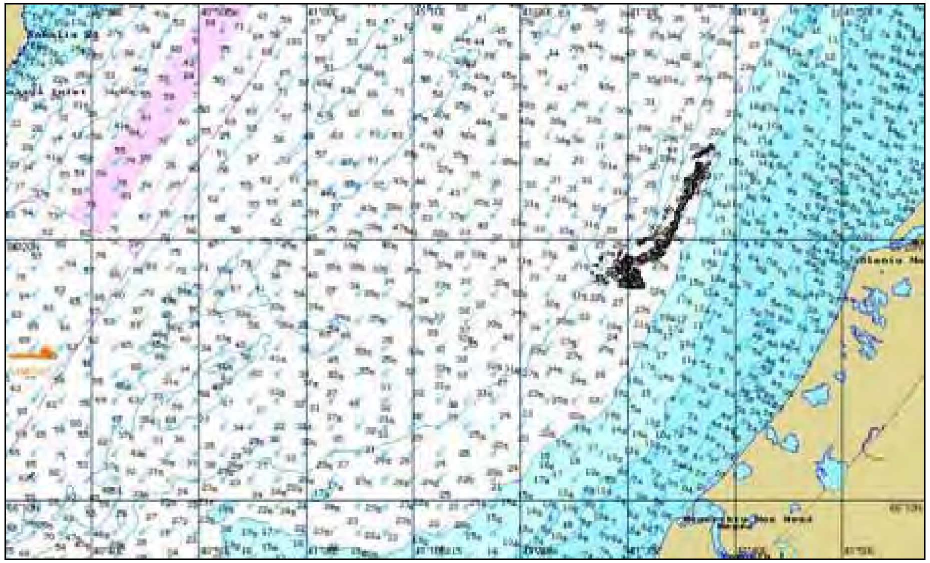


Figure 439. H+36:00. Oil slick spreading as per the scenario GC-Aut-W-2.

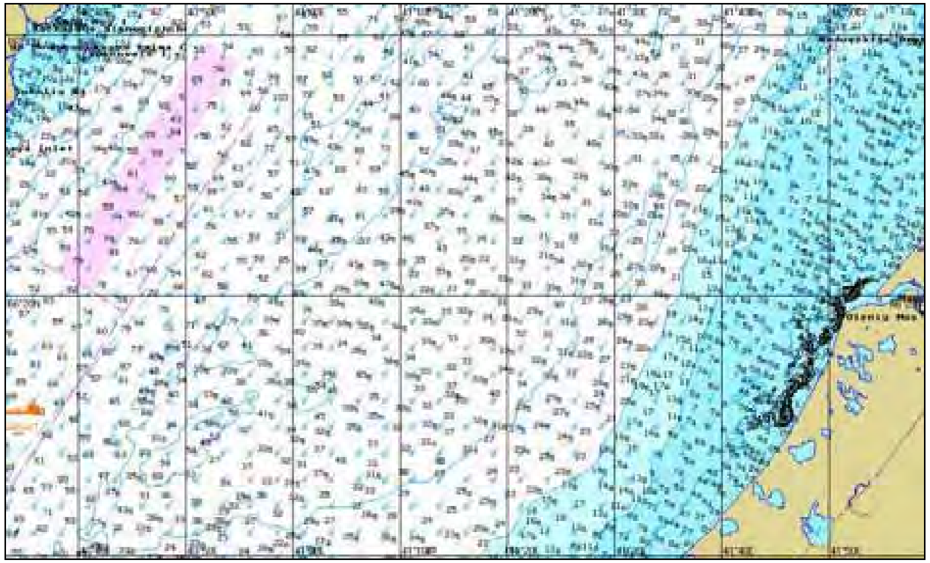


Figure 440. **H+47:12.** Oil slick spreading as per the scenario GC-Aut-W-2.

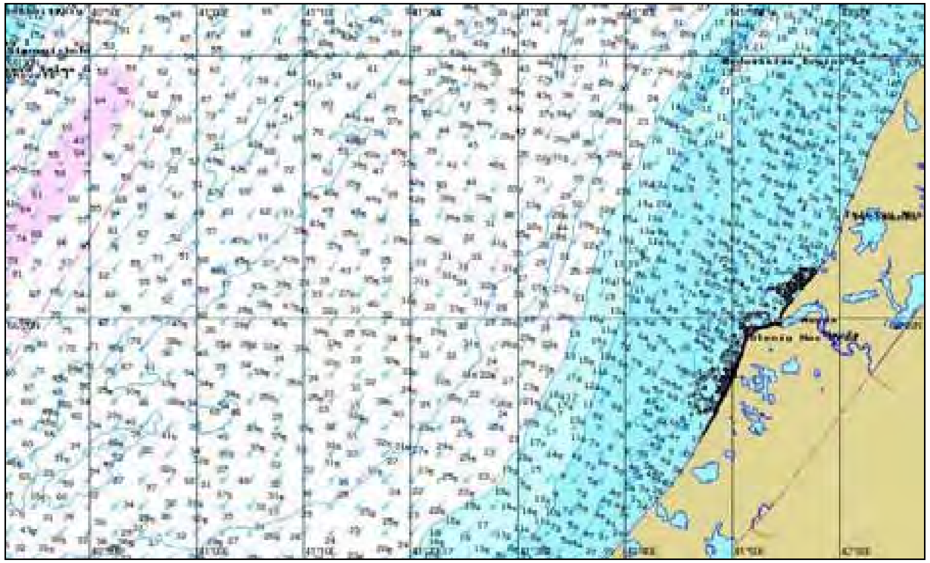


Figure 441. H+48:00. Oil slick spreading as per the scenario GC-Aut-W-2.

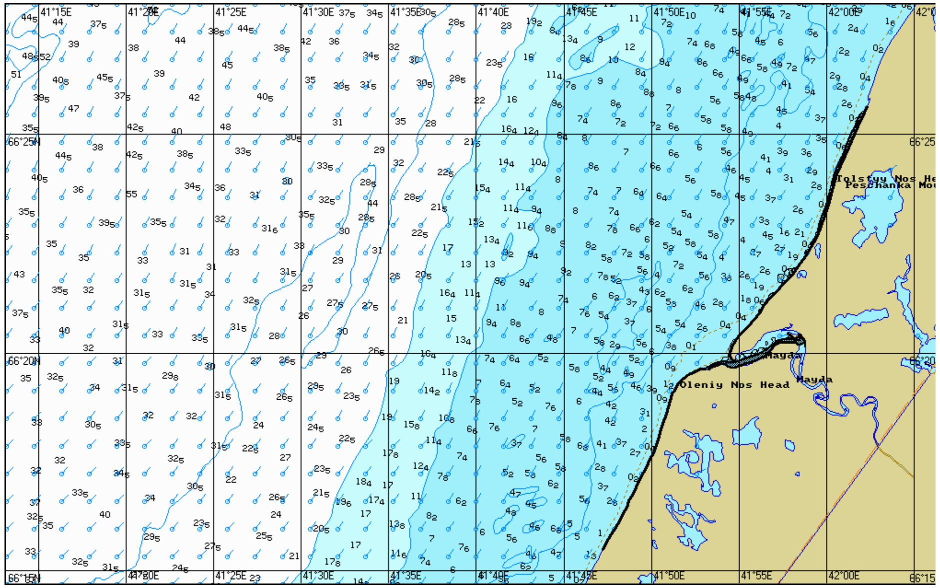


Figure 442. H+50:00. Oil slick spreading as per the scenario GC-Aut-W-2.

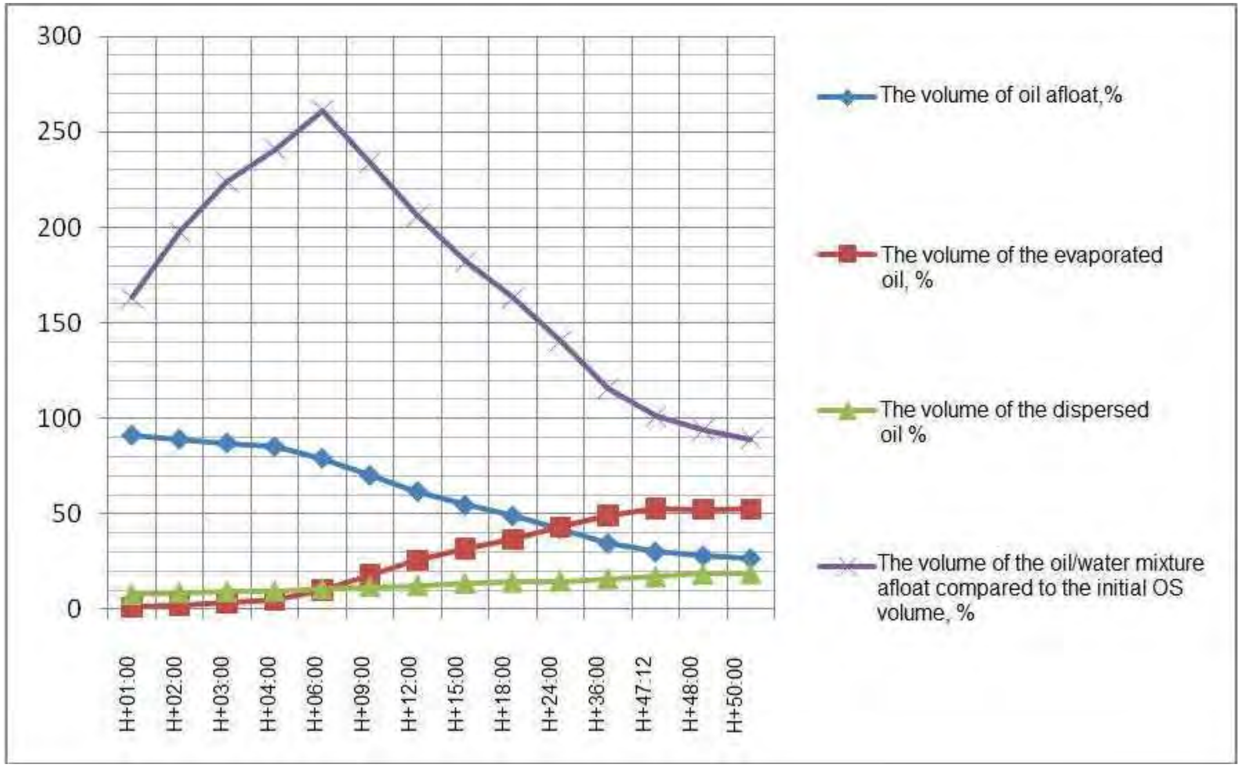


Figure 443. The chart of processes as per the scenario GC-Aut-W-2.

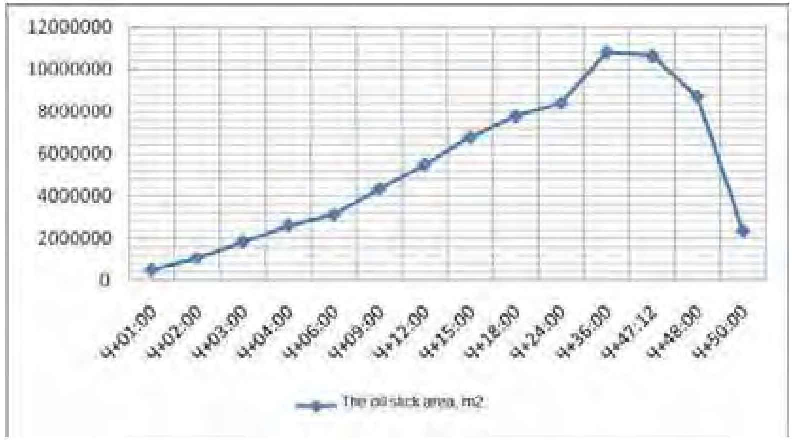


Figure 444. Oil slick area change dynamics as per the scenario GC-Aut-W-2.

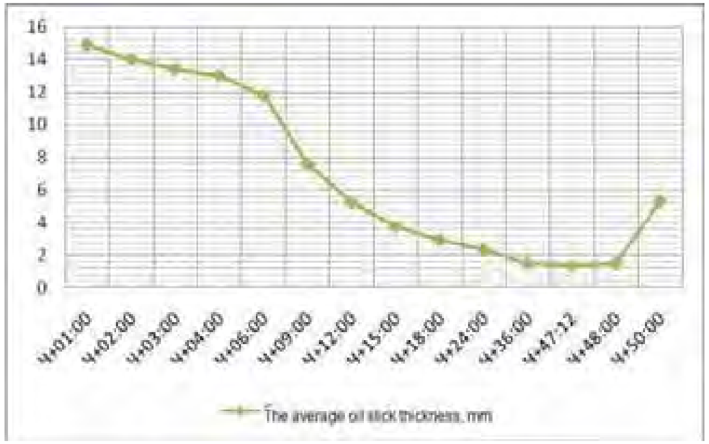


Figure 445. Oil slick thickness change dynamics as per the scenario GC-Aut-W-2.

2.4.4 Oil slick behaviour modelling as per the scenario Na-Aut-W-2

Table 2.3.4.1: Oil slick spreading parameters as per the scenario Na-Aut-W-2.

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Oil volume ashore		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	2326	100	1830	78,7	462	19,9	33,9	1,46	0	0	2359	6,43	366800	11,7
H+02:00	4790	100	3115	65,0	1589	33,2	86,1	1,80	0	0	4182	3,57	1172763	48,3
H+03:00	7407	100	4168	56,3	3100	41,9	139	1,88	0	0	5668	2,50	2271615	117
H+04:00	9981	100	5002	50,1	4785	47,9	194	1,94	0	0	6875	1,97	3483689	221
H+05:00	10000	100	3801	38,0	5977	59,8	221	2,21	0	0	5426	1,34	4034307	774
H+06:00	10000	100	3099	31,0	6668	66,7	232	2,32	0	0	4428	0,98	4522856	1525
H+09:00	10000	100	1825	18,3	7927	79,3	248	2,48	0	0	2607	0,42	6245912	5256
H+12:00	10000	100	985	9,85	8759	87,6	256	2,56	0	0	1407	0,22	6392309	11935
H+15:00	10000	100	372	3,72	9367	93,7	261	2,61	0	0	531	0,10	5288531	21814
H+18:00	10000	100	77,3	0,77	9660	96,6	263	2,63	0	0	110	0,08	1452243	29181
H+20:00	10000	100	17,3	0,17	9720	97,2	263	2,63	0	0	24,8	0,04	568721	30968
H+22:00	10000	100	0	0	9737	97,4	263	2,63	0	0	0	0	-	-

Within the first 6 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 3307 m, the volume of the evaporated oil – 47,9%, the volume of the dispersed oil – 1,94%. Further the oil slick drifts north-eastward. After 9 hours as of the OS start the oil slick semi-perimeter makes 4429 m, the volume of the evaporated oil – 79,3%, the volume of the dispersed oil – 2,48%. After 12 hours as of the OS start the drifting direction changes to the south-east (in the direction of the Zimniy Coast of the White Sea). The oil slick semi-perimeter makes 4480 m, the volume of the evaporated oil – 87,6%, the volume of the dispersed oil – 2,56%. 9,85% of the initial OS volume remains afloat. After 18 hours as of the OS start the oil slick thickness makes 0,08 mm, the oil slick semi-perimeter makes 2135 m, the volume of the evaporated oil – 96,6%, the volume of the dispersed oil – 2,63%. To the moment of modelling completion (22 hours) 0% of oil remain afloat.

The graphic display of oil slick spreading as per the scenario Na-Aut-W-2 is shown in figures 446 – 457.

The charts of processes typical for naphtha behavior on water are shown in figures 458-460.

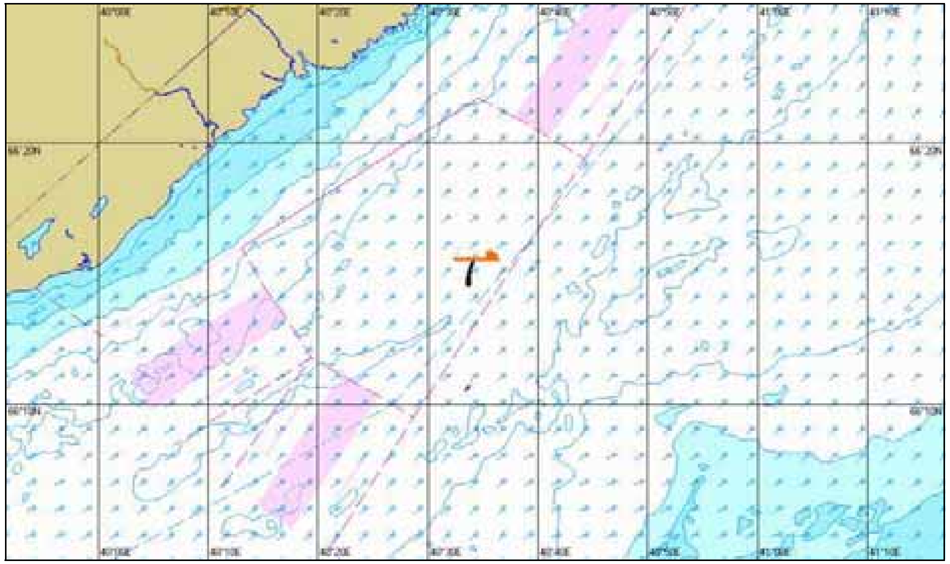


Figure 446. H+01:00. Oil slick spreading as per the scenario Na-Aut-W-2.

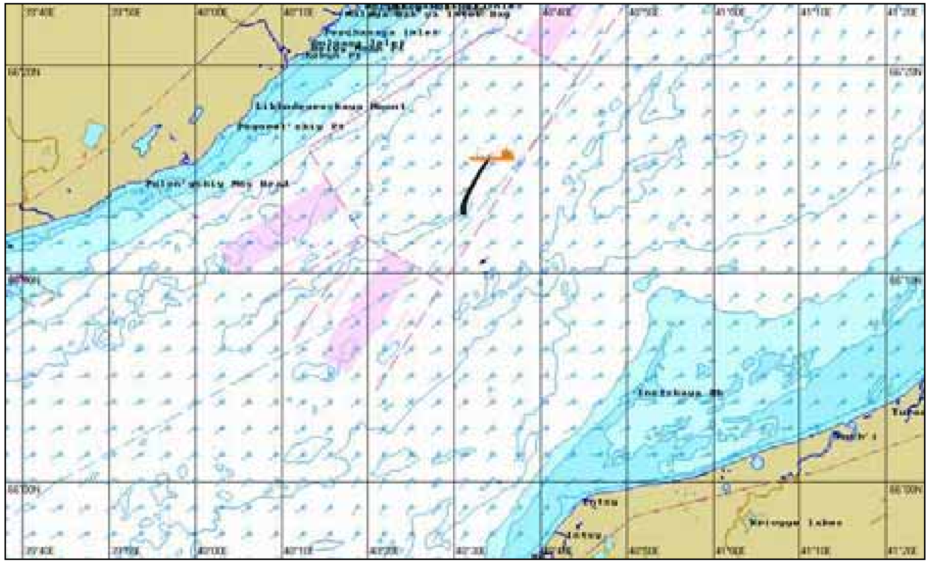


Figure 447. H+02:00. Oil slick spreading as per the scenario Na-Aut-W-2.

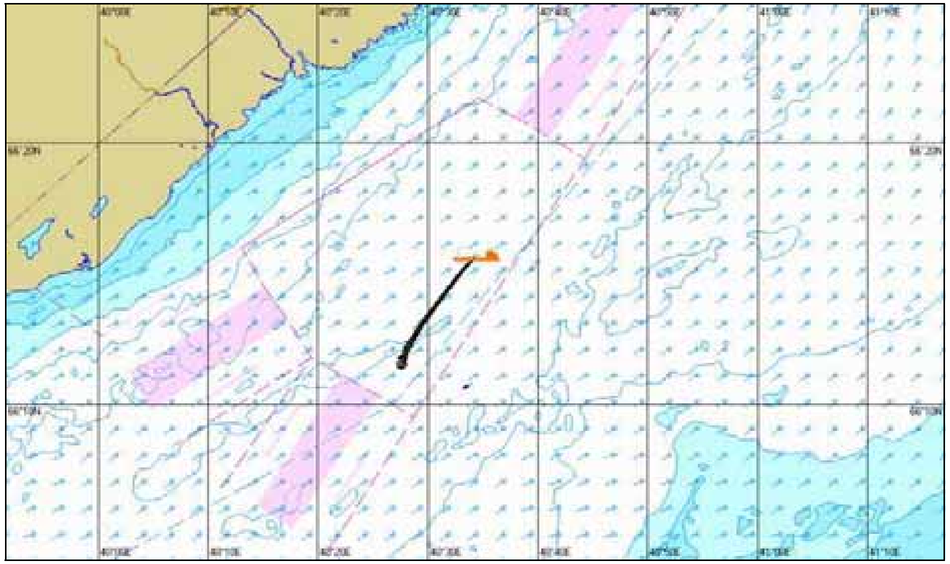


Figure 448. H+03:00. Oil slick spreading as per the scenario Na-Aut-W-2.

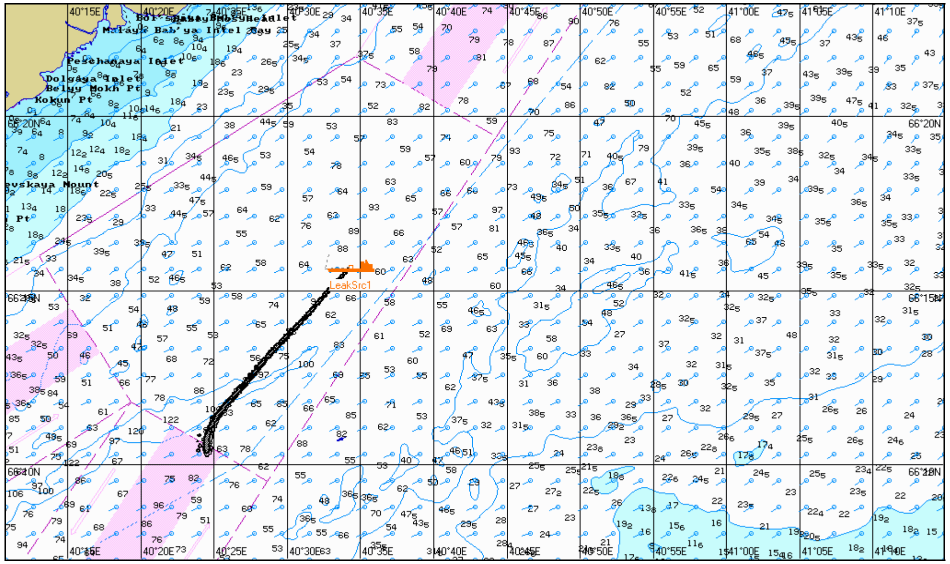


Figure 449. H+04:00. Oil slick spreading as per the scenario Na-Aut-W-2.

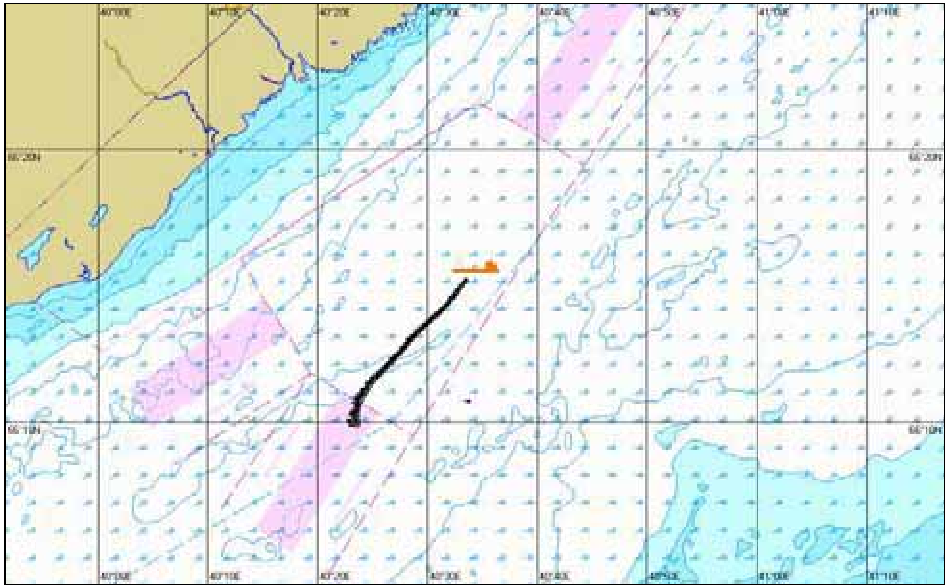


Figure 450. H+05:00. Oil slick spreading as per the scenario Na-Aut-W-2.

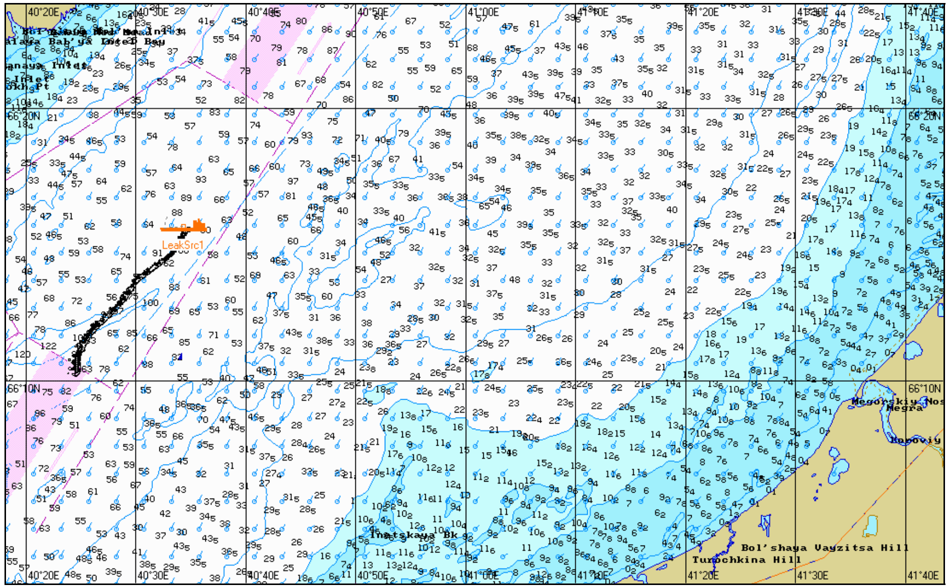


Figure 451. H+06:00. Oil slick spreading as per the scenario Na-Aut-W-2.

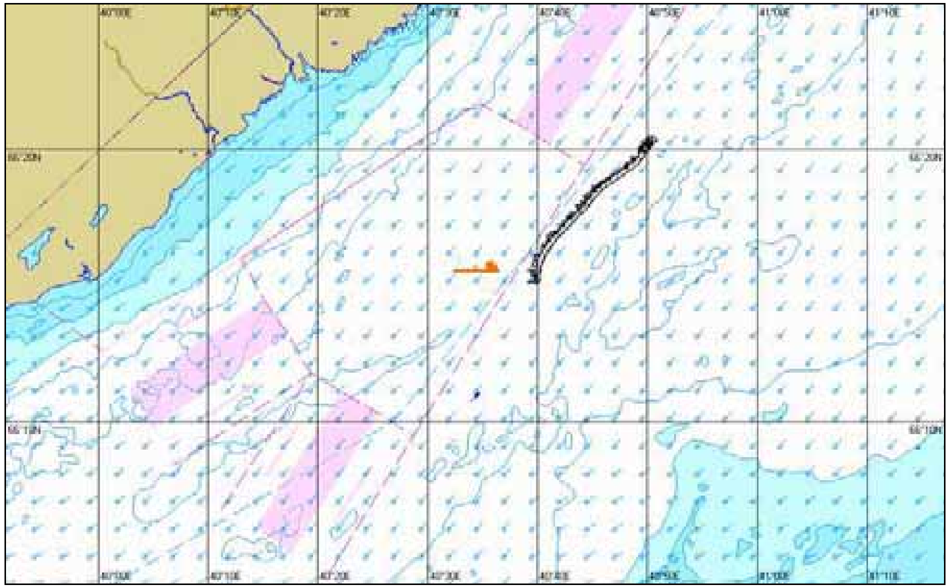


Figure 452. H+09:00. Oil slick spreading as per the scenario Na-Aut-W-2.

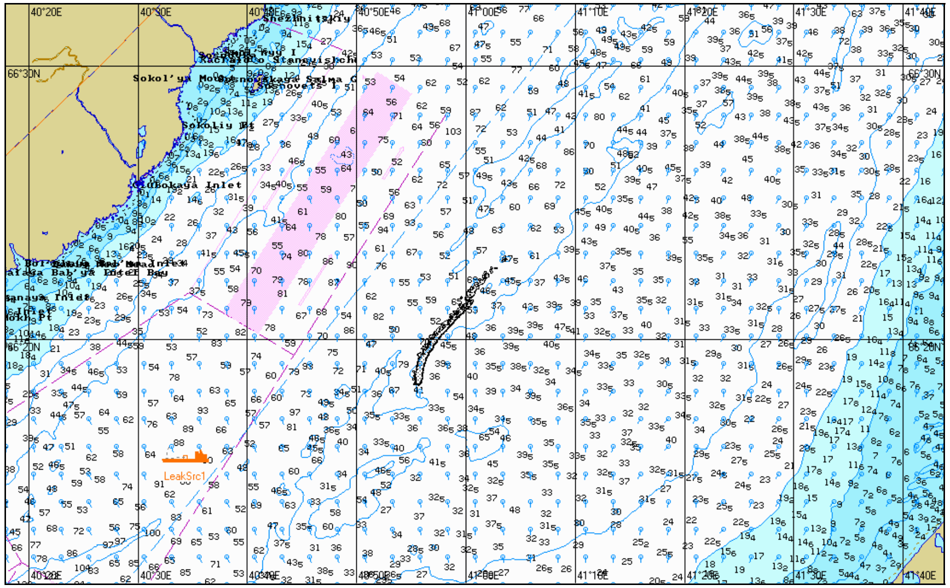


Figure 453. H+12:00. Oil slick spreading as per the scenario Na-Aut-W-2.

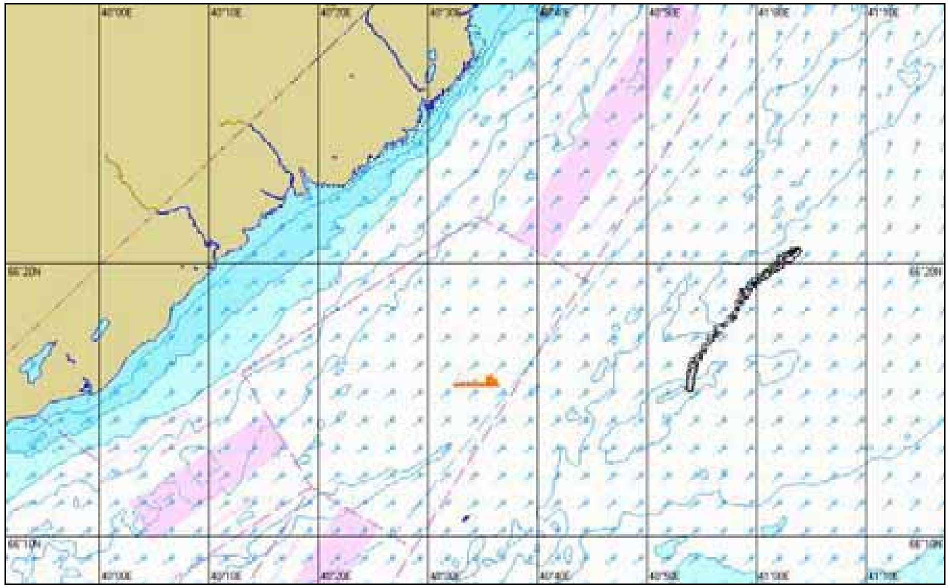


Figure 454. H+15:00. Oil slick spreading as per the scenario Na-Aut-W-2.

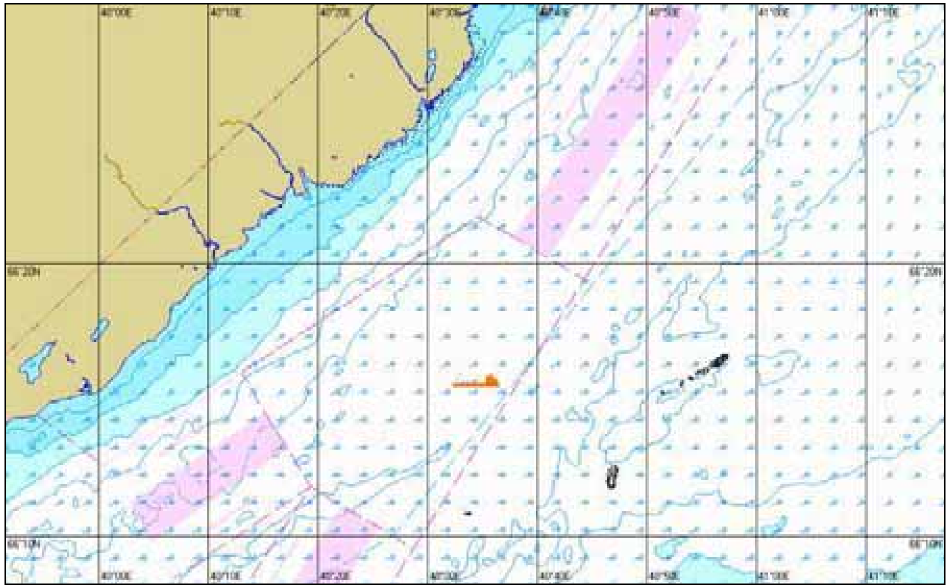


Figure 455. H+18:00. Oil slick spreading as per the scenario Na-Aut-W-2.

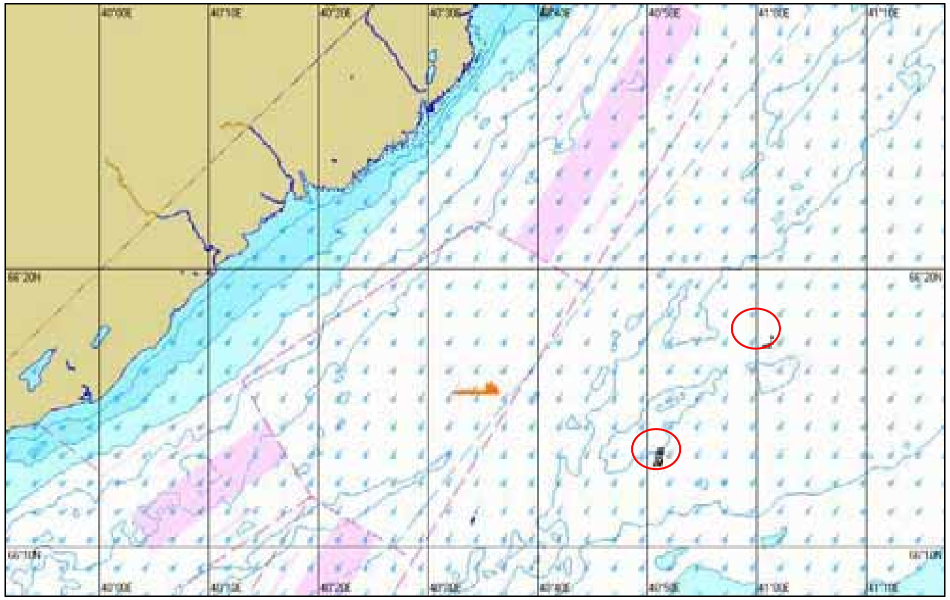


Figure 456. H+20:00. Oil slick spreading as per the scenario Na-Aut-W-2.

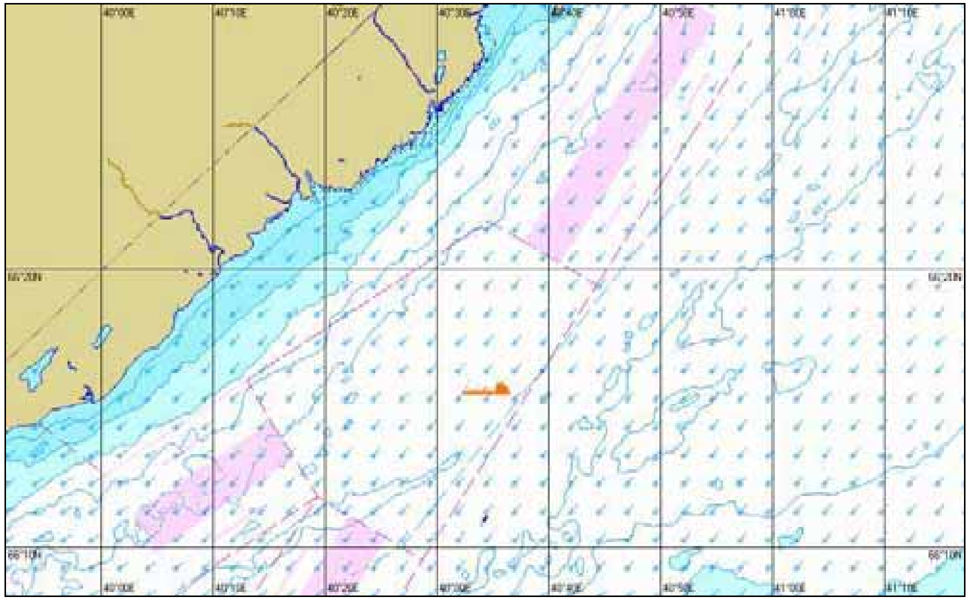


Figure 457. H+22:10. Oil slick spreading as per the scenario Na-Aut-W-2.

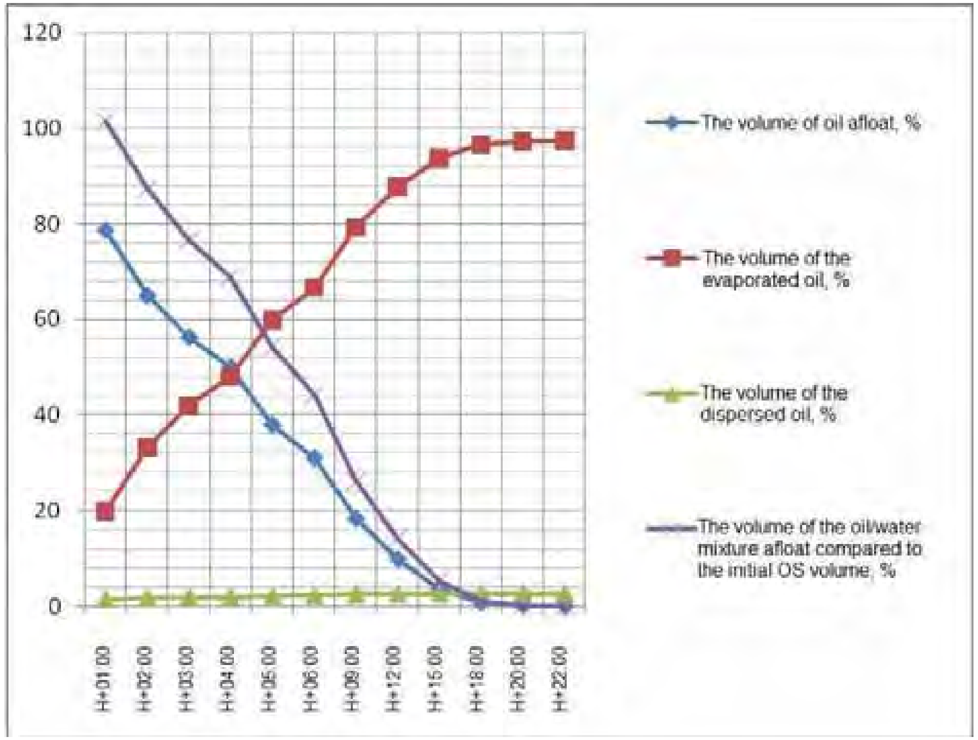


Figure 458. The chart of processes as per the scenario Na-Aut-W-2.

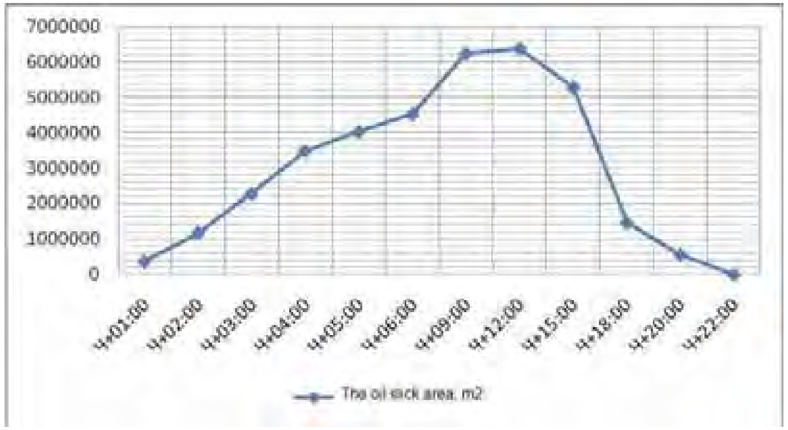


Figure 459. Oil slick area change dynamics as per the scenario GC-Aut-W-2.

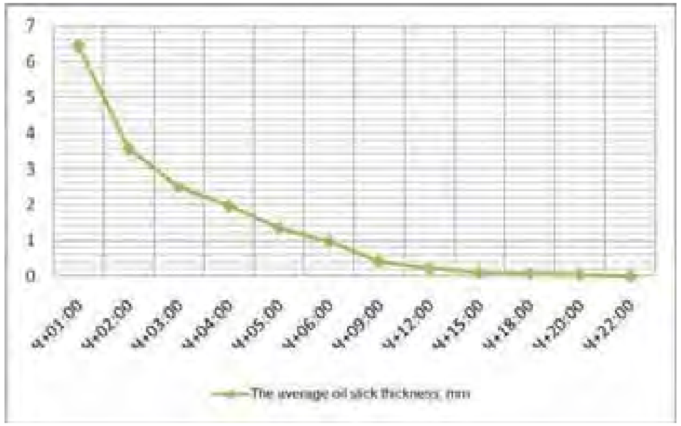


Figure 460. Oil slick thickness change dynamics as per the scenario GC-Aut-W-2.

2.4.5 The process dynamics typical for oil spill behavior in the White Sea under the autumn westward wind (Aut-W-2)

Figure 461-465 show the process dynamics typical for the oil behavior on water in the White Sea as per the scenarios Aut-W-2.

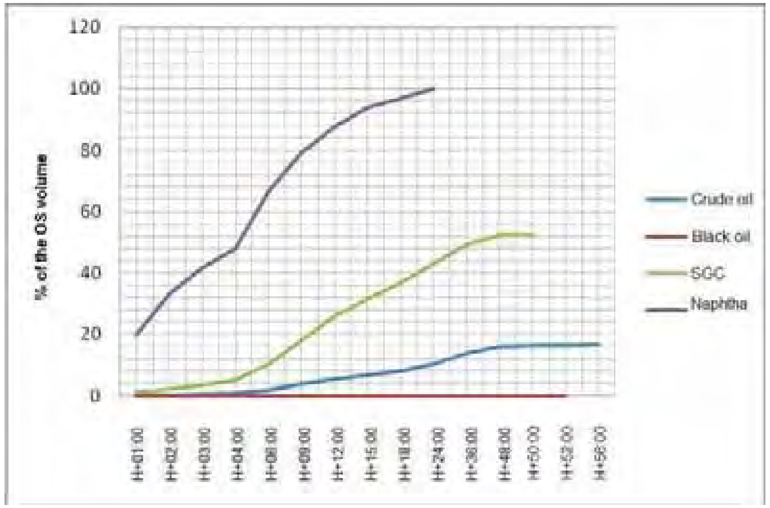


Figure 461. The evaporation process chart as per the scenarios Aut-W-2.

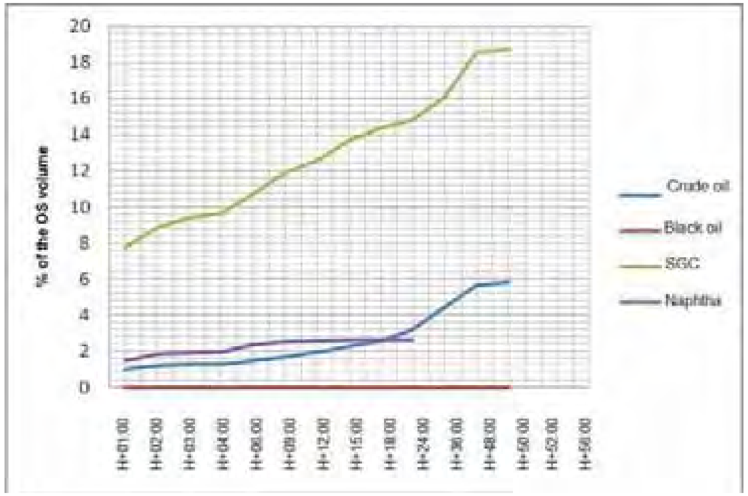


Figure 462. The dispersion process chart as per the scenarios Aut-W-2.

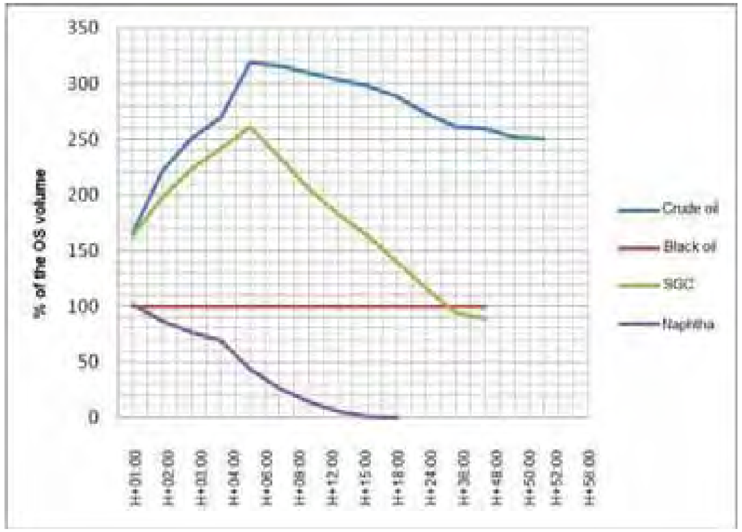


Figure 463. Oil/water mixturee volume change dynamics as per the scenarios по сценариям Aut-W-2.

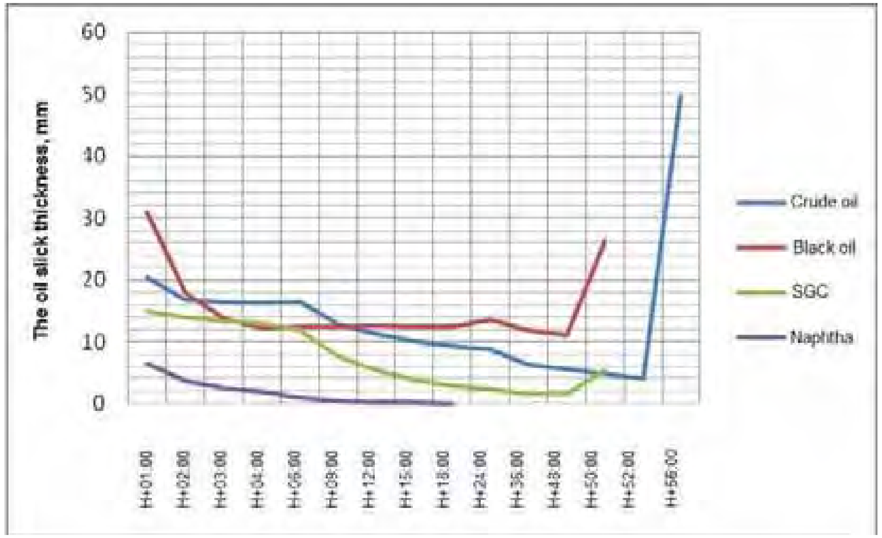


Figure 464. Oil slick thickness change dynamics as per the scenarios Aut-W-2.

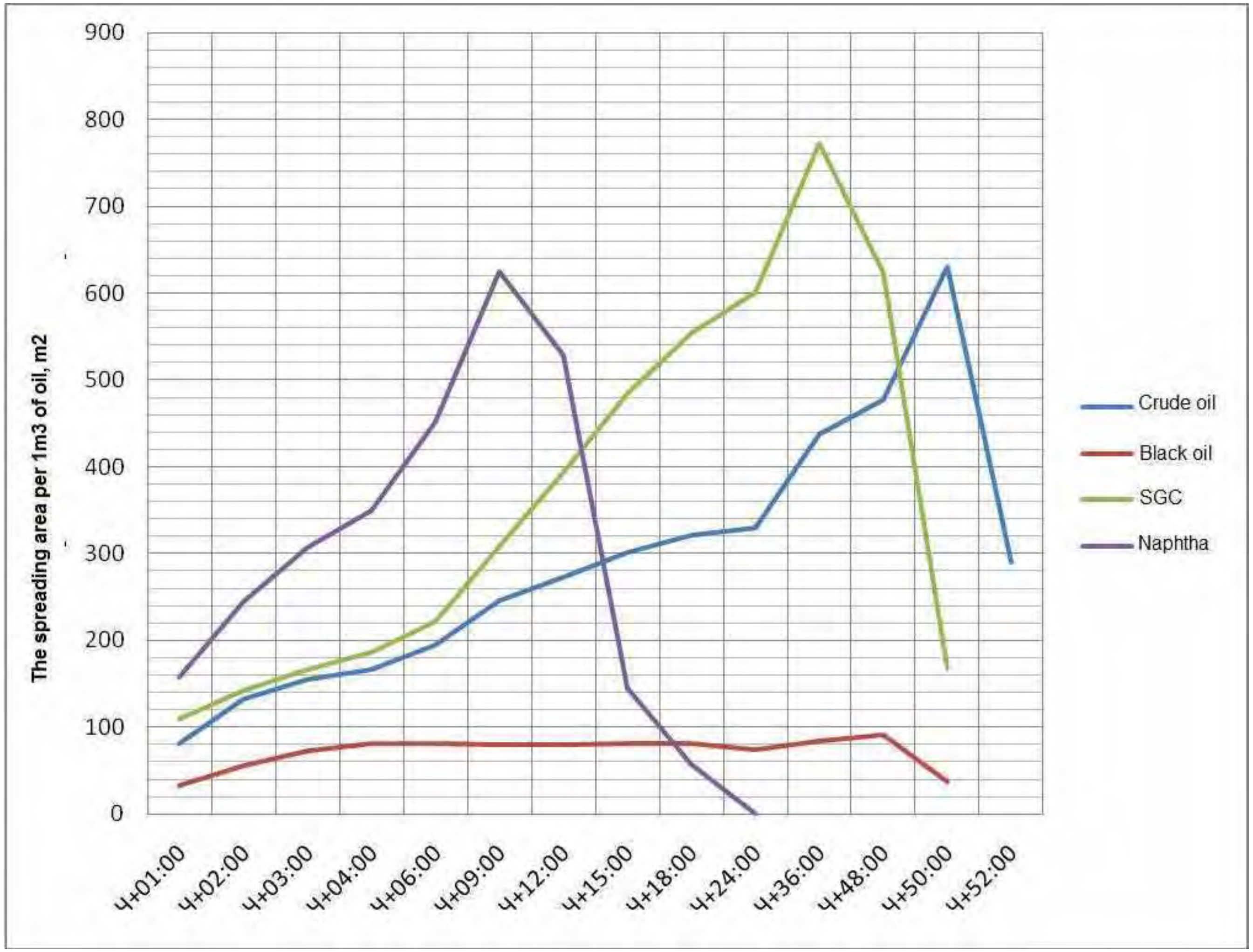


Figure 465. The spreading area change dynamics per 1 m^3 of various oil types as per the scenarios Aut-W-2.

2.5 Oil Spill behavior modeling in the White Sea under the winter southward wind

2.5.1 Oil slick behaviour modelling as per the scenario COU-Win-S-2

Table 2.4.1.1: Oil slick spreading parameters as per the scenario COU-Win-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil/water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3482	100	3026	86,9	0	0	0	0	456	13,1	3026	26,73	113188	18,3
H+02:00	6997	100	5207	74,4	0	0	0	0	1790	25,6	5207	16,15	322333	18,3
H+03:00	10484	100	6059	57,8	0	0	0	0	4425	42,2	6059	10,22	592717	18,3
H+04:00	13987	100	5169	37,0	0	0	0	0	8818	63,0	5169	5,91	874173	18,3
H+05:00	14000	100	2677	19,1	0	0	0	0	11334	80,9	2677	8,57	312239	18,3
H+06:00	14000	100	1486	10,6	0	0	0	0	12514	89,4	1486	9,16	162305	18,3
H+07:00	14000	100	838	5,99	0	0	0	0	13163	94,0	838	8,76	95683	18,3
H+08:00	14000	100	463	3,31	0	0	0	0	13538	96,7	463	7,84	59082	18,3
H+09:00	14000	100	194	1,39	0	0	0	0	13807	98,6	194	4,40	44114	18,3
H+10:00	14000	100	54,1	0,39	0	0	0	0	13946	99,6	54,1	4,46	12136	18,3
H+11:00	14000	100	17,9	0,13	0	0	0	0	13983	99,9	17,9	2,81	6363	18,3
H+12:00	14000	100	0	0	0	0	0	0	14000	100	0	0	0	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of wind and current. After 4 hours as pf the OA start the oil slick semi-perimeter makes 1657 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 63,0%, the average thickness of the free floating oil – 5,9 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the oil slick semi-perimeter of the oil afloat makes 714 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 89,4%, the average thickness of the free floating oil – 9,16 mm. After 8 hours as of the OS start the floating oil slick semi-perimeter makes 430 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 96,7%. To the moment of modelling completion (12 hours) the oil slick spreading on the water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 2,6 km^2.

The graphic display of oil slick spreading as per the scenario COU-Win-S-2 is shown in figures 466 – 476.

The charts of processes typical for oil behavior on water are shown in figures 477-479.

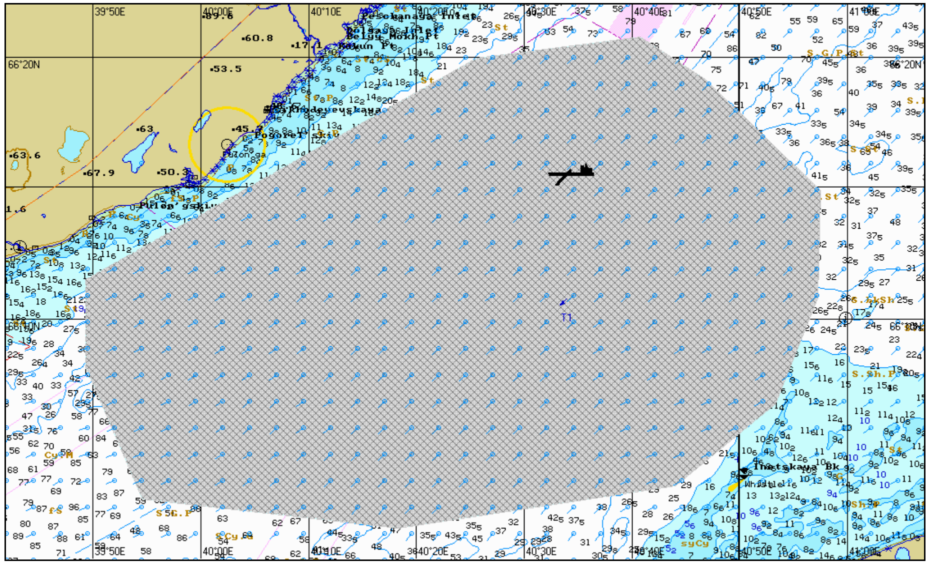


Figure 466. H+01:00. Oil slick spreading as per the scenario COU-Win-S-2.

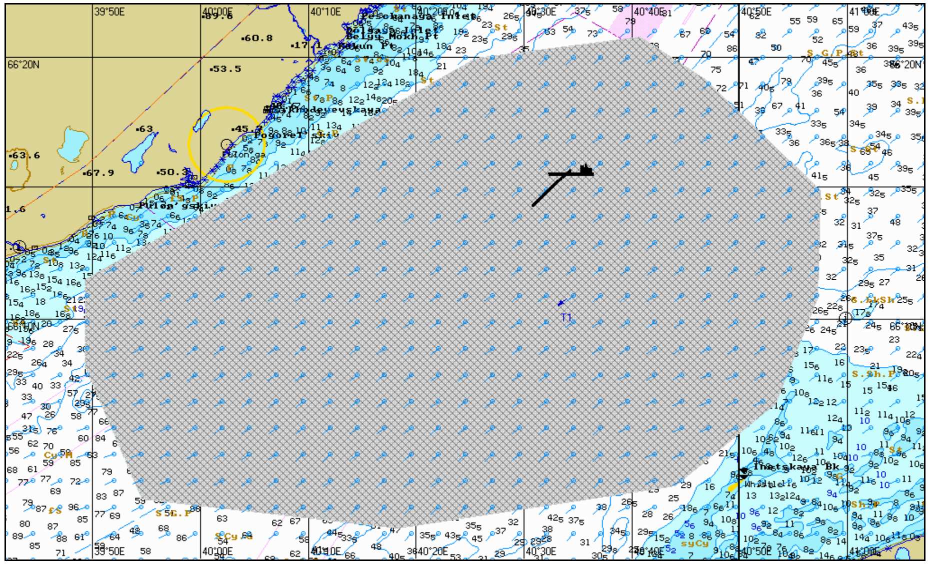


Figure 467. H+02:00. Oil slick spreading as per the scenario COU-Win-S-2.

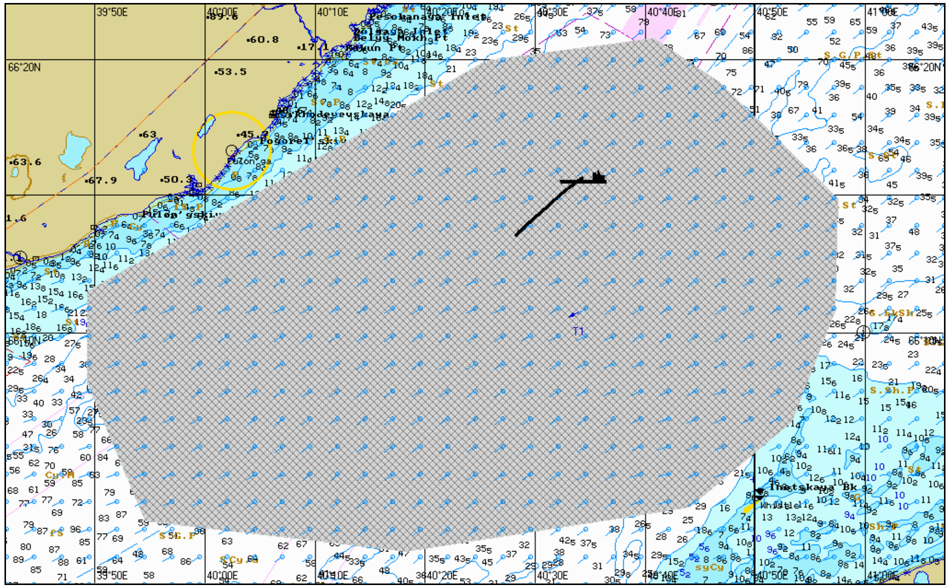


Figure 468. H+03:00. Oil slick spreading as per the scenario COU-Win-S-2.

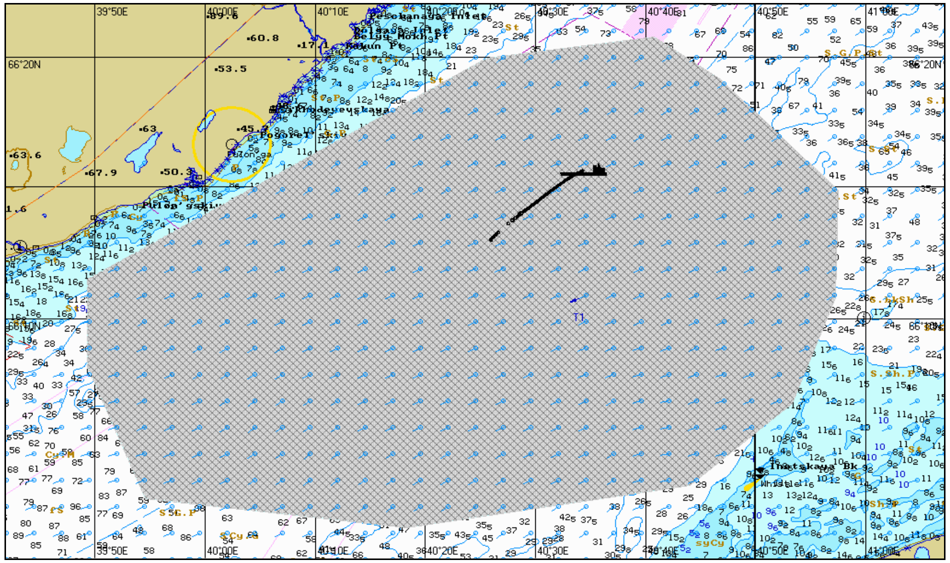


Figure 469. H+04:00. Oil slick spreading as per the scenario COU-Win-S-2.

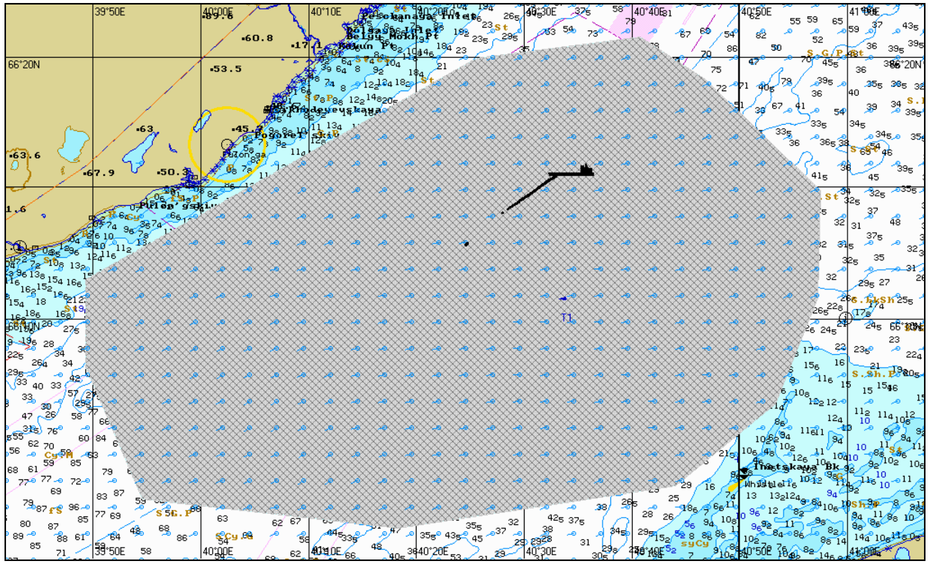


Figure 470. H+05:00. Oil slick spreading as per the scenario COU-Win-S-2.

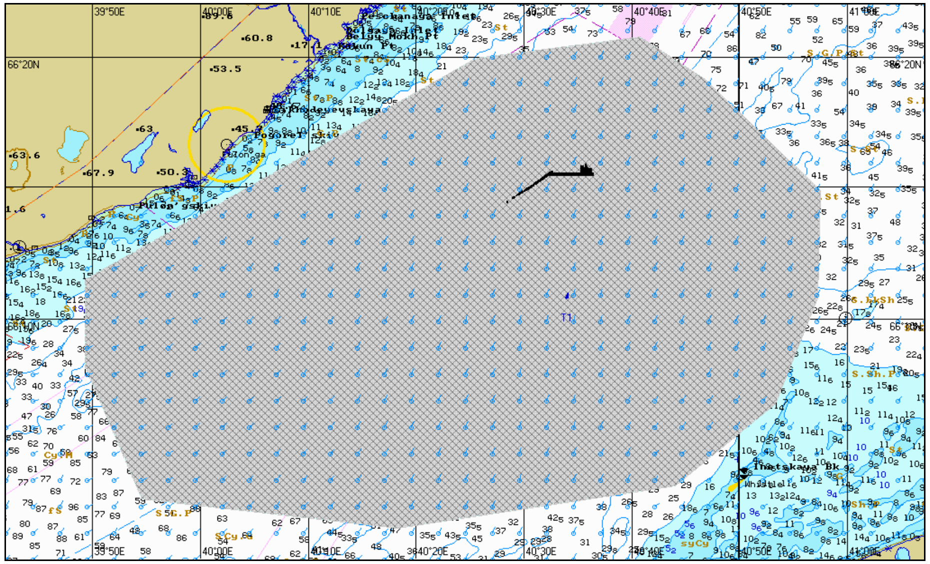


Figure 471. H+06:00. Oil slick spreading as per the scenario COU-Win-S-2.

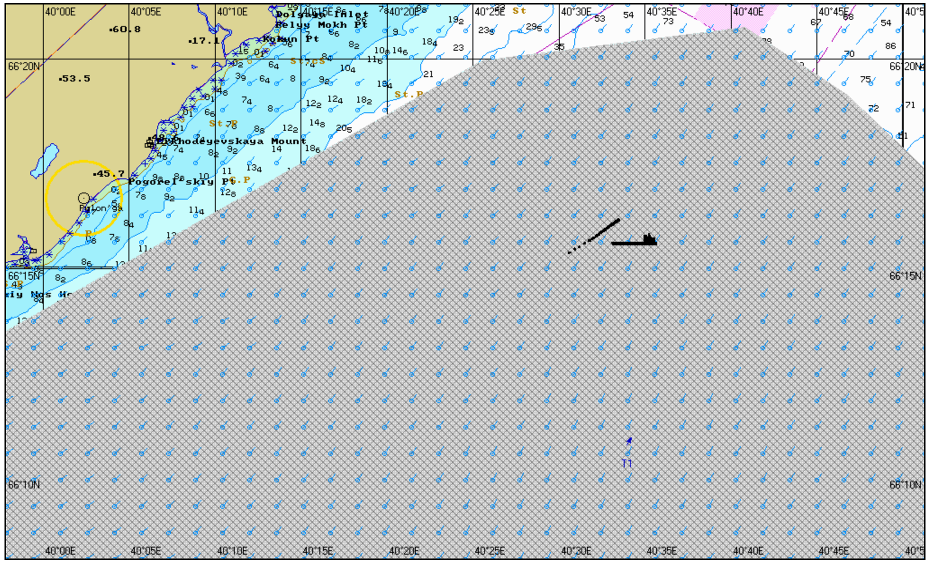


Figure 472. H+07:00. Oil slick spreading as per the scenario COU-Win-S-2.

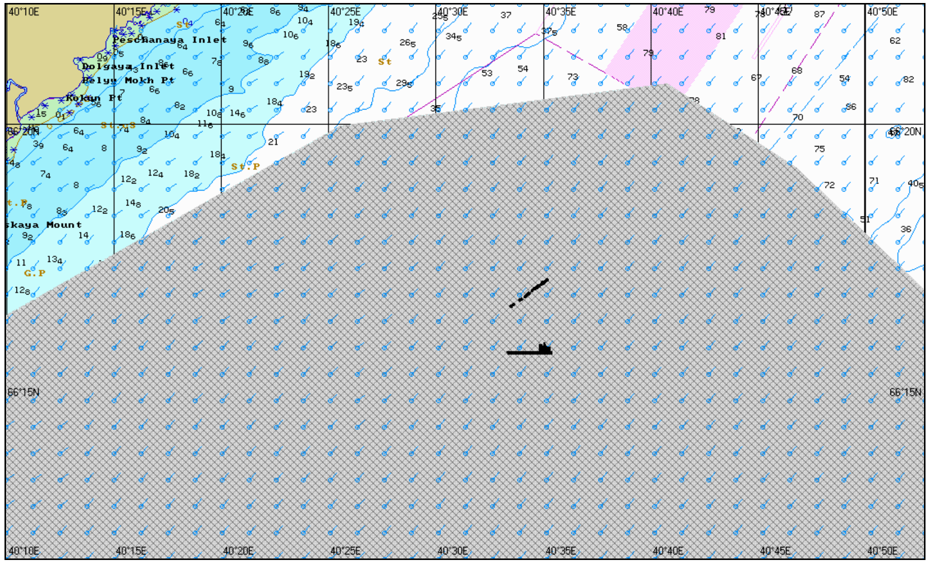


Figure 473. H+08:00. Oil slick spreading as per the scenario COU-Win-S-2.

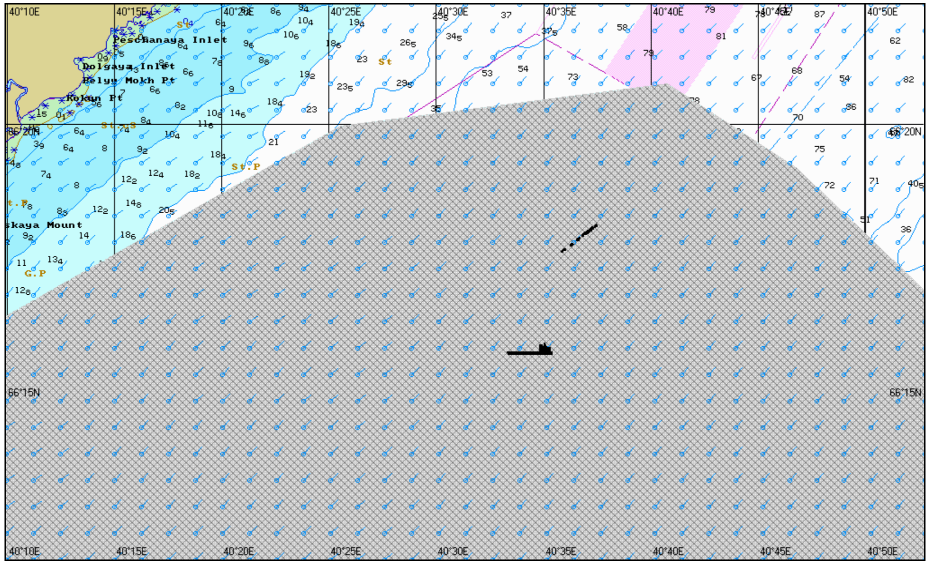


Figure 474. H+09:00. Oil slick spreading as per the scenario COU-Win-S-2.

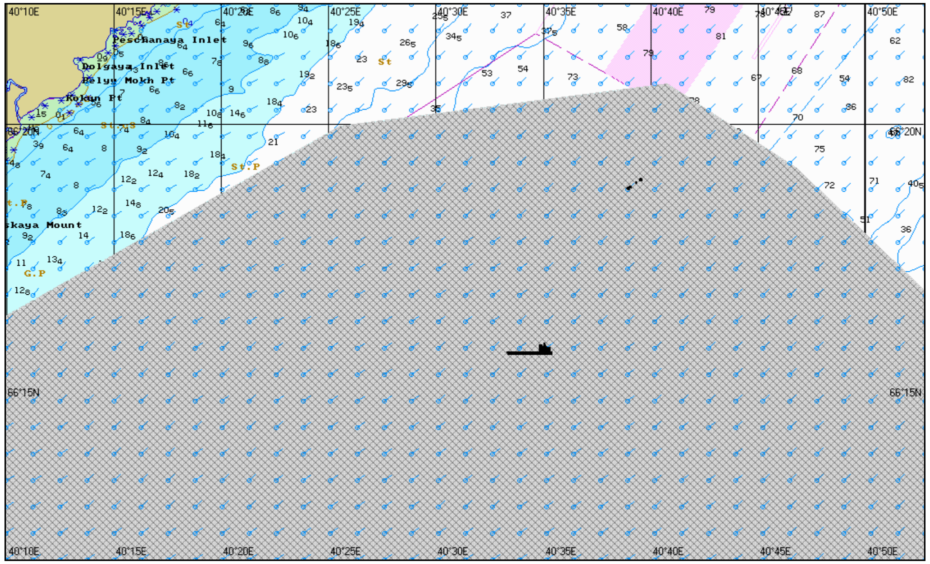


Figure 475. H+10:00. Oil slick spreading as per the scenario COU-Win-S-2.

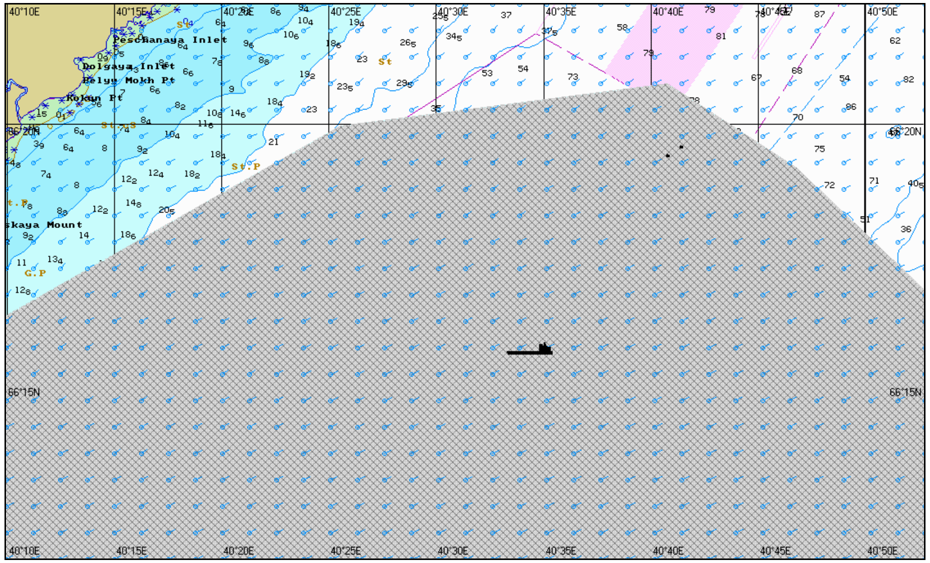


Figure 476. H+11:00. Oil slick spreading as per the scenario COU-Win-S-2.

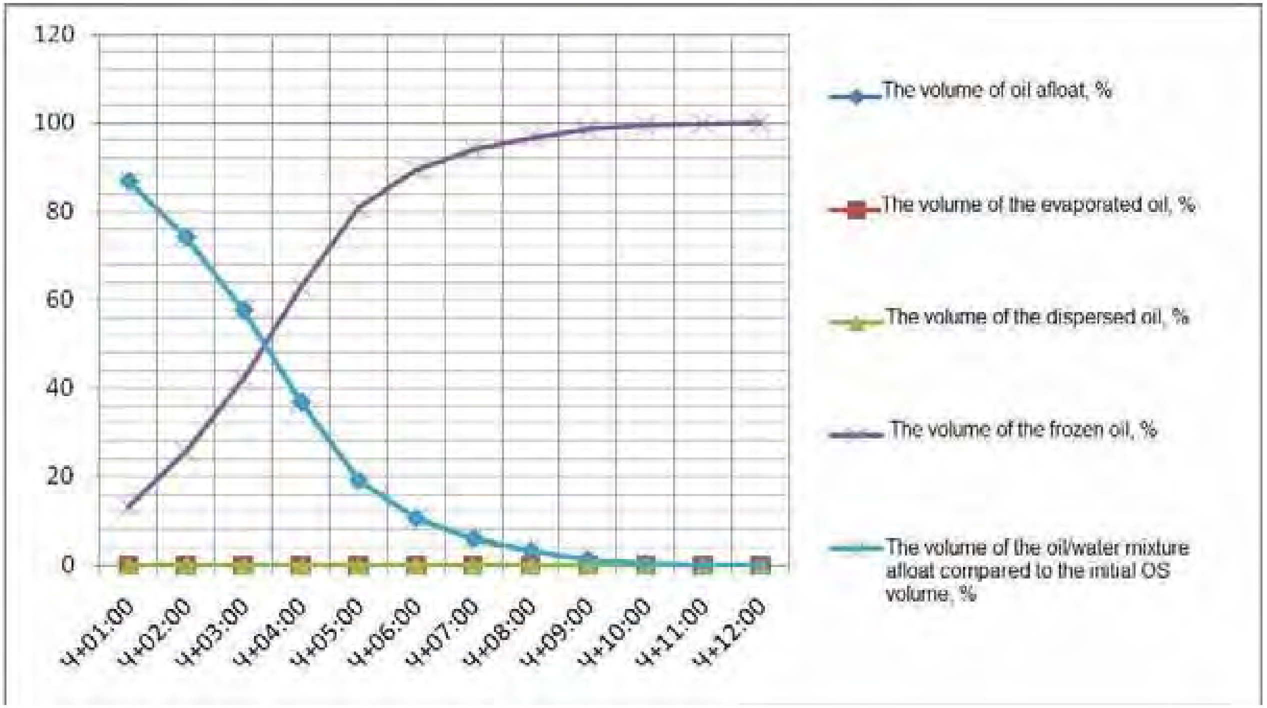


Figure 477. The chart of processes as per the scenario COU-Win-S-2.

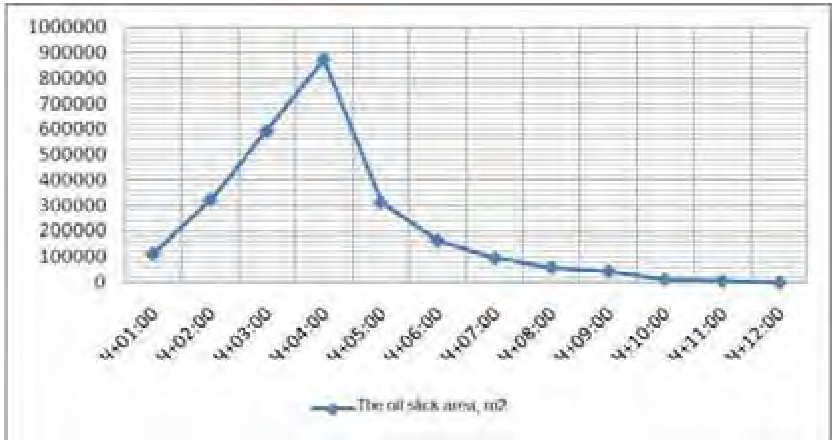


Figure 478. Oil slick area change dynamics as per the scenario COU-Win-S-2.

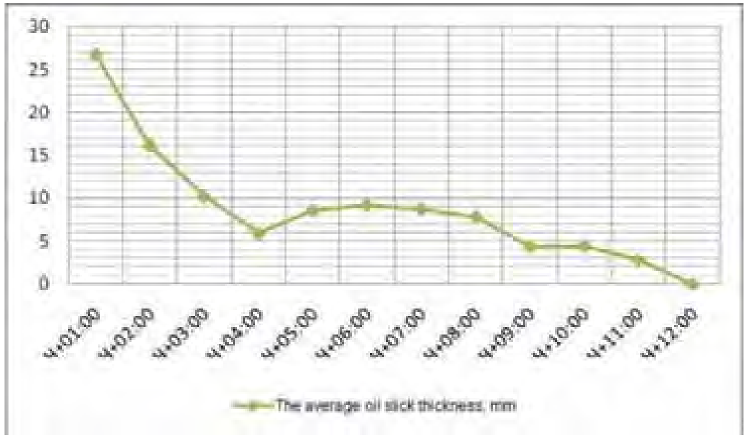


Figure 479. Oil slick thickness change dynamics as per the scenario COU-Win-S-2.

2.5.2 Oil slick behaviour modelling as per the scenario BO-Win-S-2

Table 2.4.2.1: Oil slick spreading parameters as per the scenario BO-Win-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3554	100	3165	89,1	0	0	0	0	389	10,9	3165	31,5	100464	21554
H+02:00	7136	100	5568	78,0	0	0	0	0	1568	22,0	5568	18,9	294128	21554
H+03:00	10683	100	6763	63,3	0	0	0	0	3920	36,7	6763	12,5	539178	21554
H+04:00	13977	100	6227	44,6	0	0	0	0	7750	55,4	6227	7,04	884621	21554
H+05:00	14000	100	3040	21,7	0	0	0	0	10960	78,3	3042	7,11	428074	21554
H+06:00	14000	100	1433	10,2	0	0	0	0	12567	89,8	1433	6,29	227653	21554
H+07:00	14000	100	665	4,75	0	0	0	0	13335	95,3	665	6,90	96349	21554
H+08:00	14000	100	311	2,22	0	0	0	0	13689	97,8	311	6,00	51834	21554
H+09:00	14000	100	112	0,80	0	0	0	0	13888	99,2	112	4,01	27918	21554
H+10:00	14000	100	26,9	0,19	0	0	0	0	13973	99,8	26,9	2,71	9916	21554
H+11:00	14000	100	0	0	0	0	0	0	14000	100	0	0	0	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1667 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 55,4%, the average thickness of the free floating oil – 7,04 mm. Further the oil slick drifts north-westward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 846 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 89,8%, the average thickness of the free floating oil – 6,29 mm. After 8 hours as of the OS start the floating oil slick semi-perimeter makes 403 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 97,8%. To the moment of modelling completion (11 hours) oil spreading on the water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 2,7 km^2.

The graphic display of oil slick spreading as per the scenario BO-Win-S-2 is shown in figures 480 – 490.

The charts of processes typical for black oil behavior on water are shown in figures 491-493.

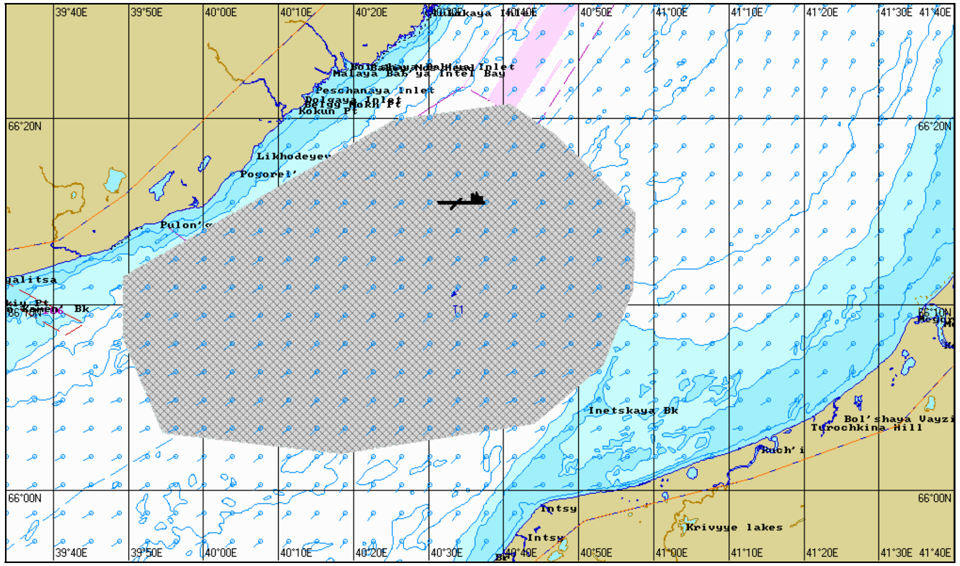


Figure 480. H+01:00. Oil slick spreading as per the scenario BO-Win-S-2.

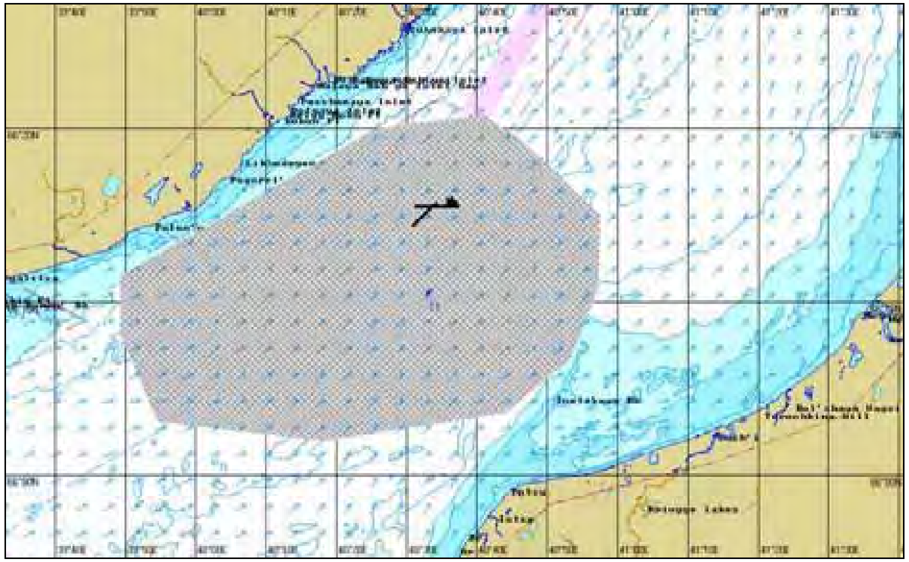


Figure 481. H+02:00. Oil slick spreading as per the scenario BO-Win-S-2.

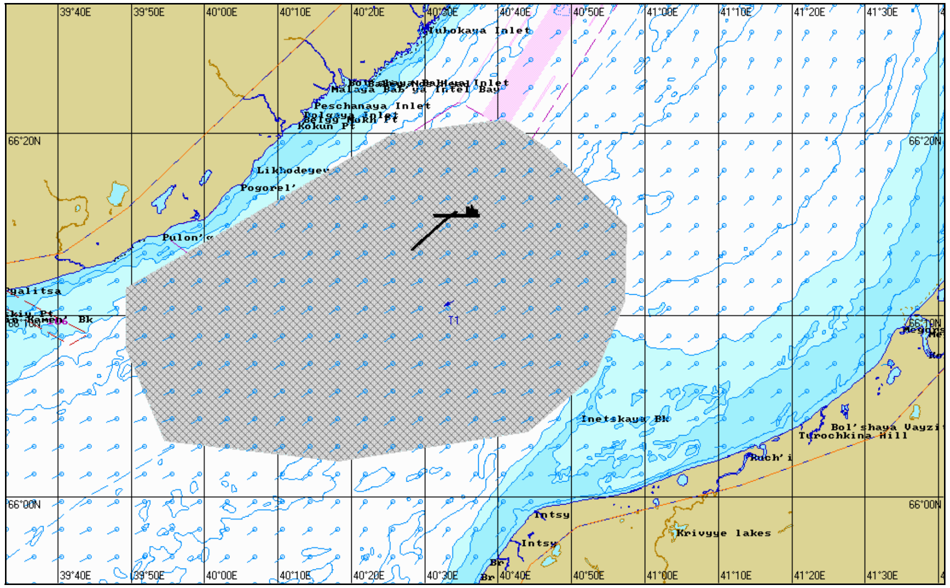


Figure 482. H+03:00. Oil slick spreading as per the scenario BO-Win-S-2.

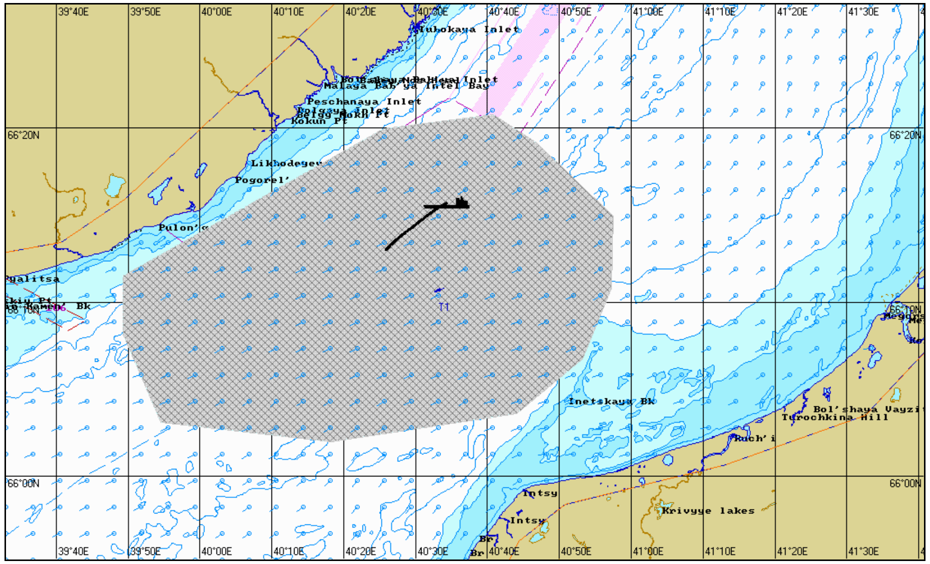


Figure 483. H+04:00. Oil slick spreading as per the scenario BO-Win-S-2.

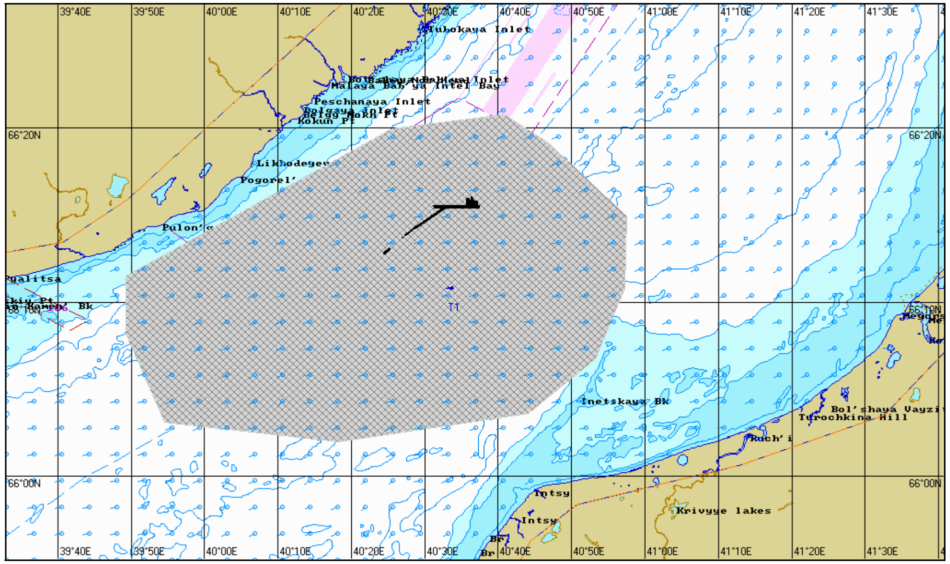


Figure 484. H+05:00. Oil slick spreading as per the scenario BO-Win-S-2.

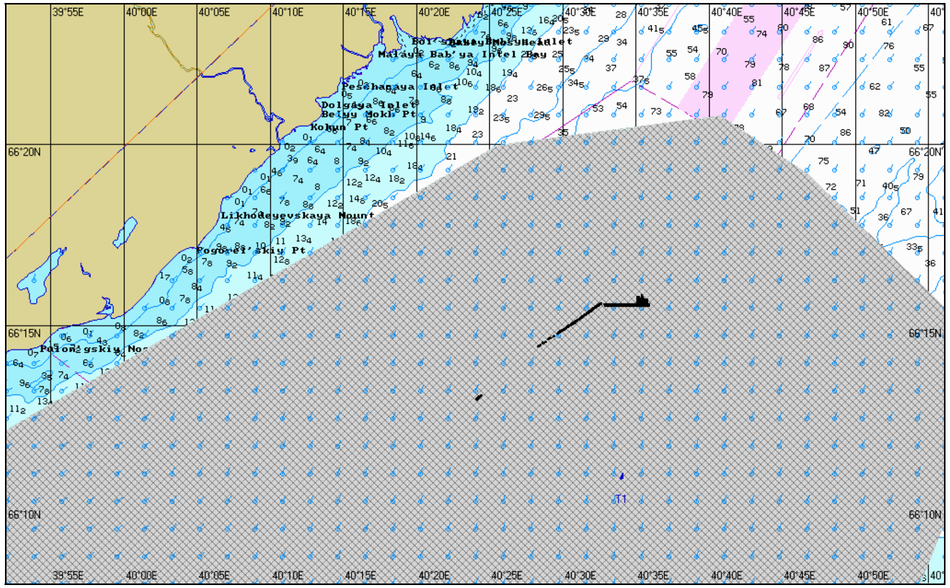


Figure 485. H+06:00. Oil slick spreading as per the scenario BO-Win-S-2.

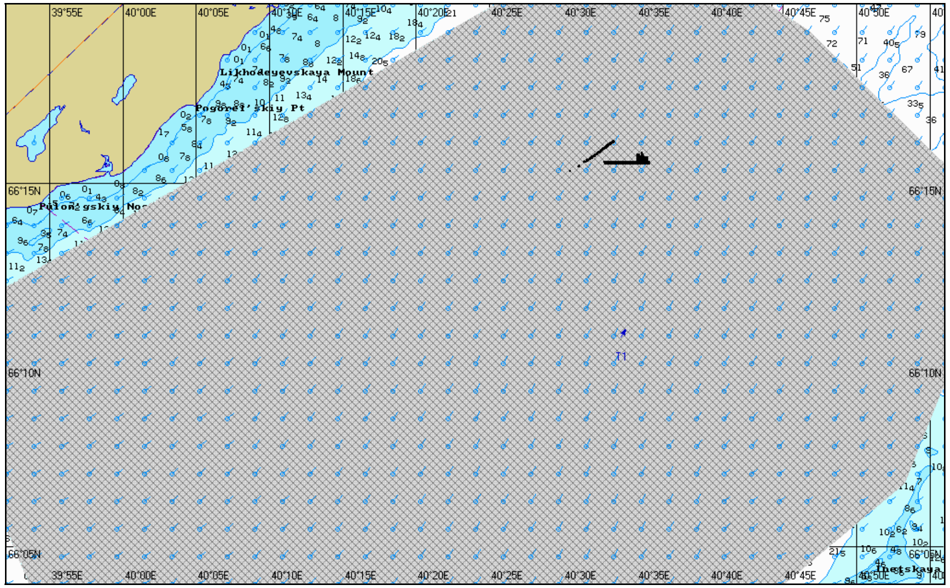


Figure 486. H+07:00. Oil slick spreading as per the scenario BO-Win-S-2.

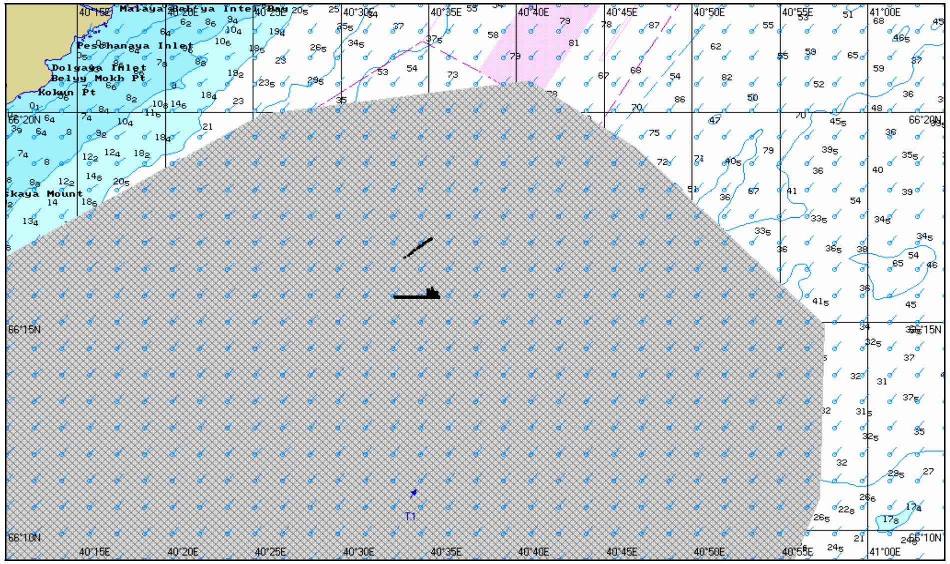


Рис 487. H+08:00. Oil slick spreading as per the scenario BO-Win-S-2.

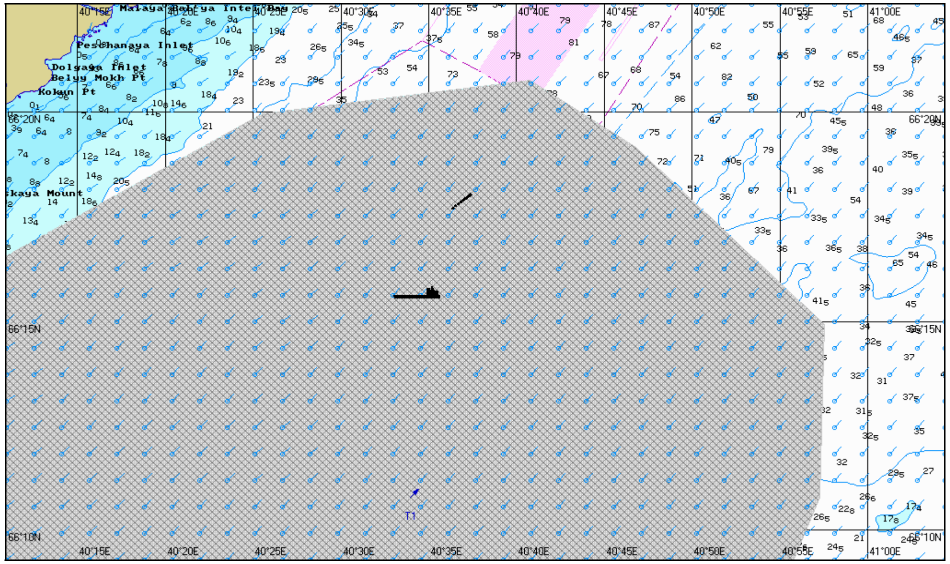


Figure 488. H+09:00. Oil slick spreading as per the scenario BO-Win-S-2.

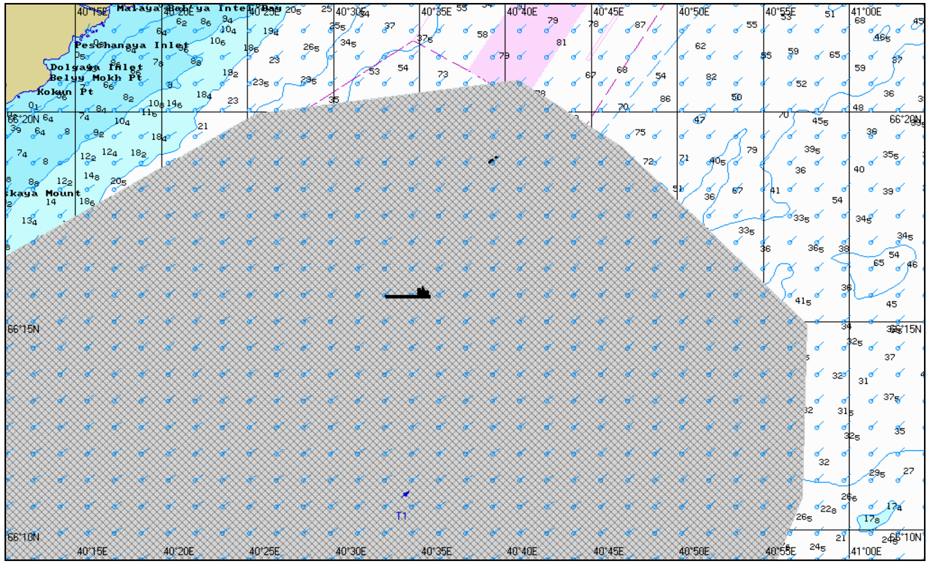


Figure 489. H+10:00. Oil slick spreading as per the scenario BO-Win-S-2.

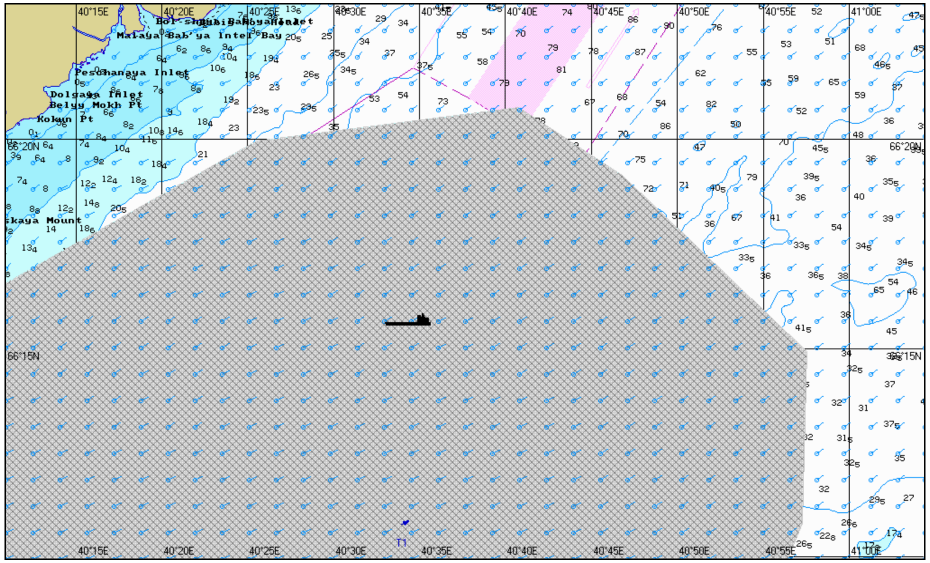


Figure 490. H+11:00. Oil slick spreading as per the scenario BO-Win-S-2.

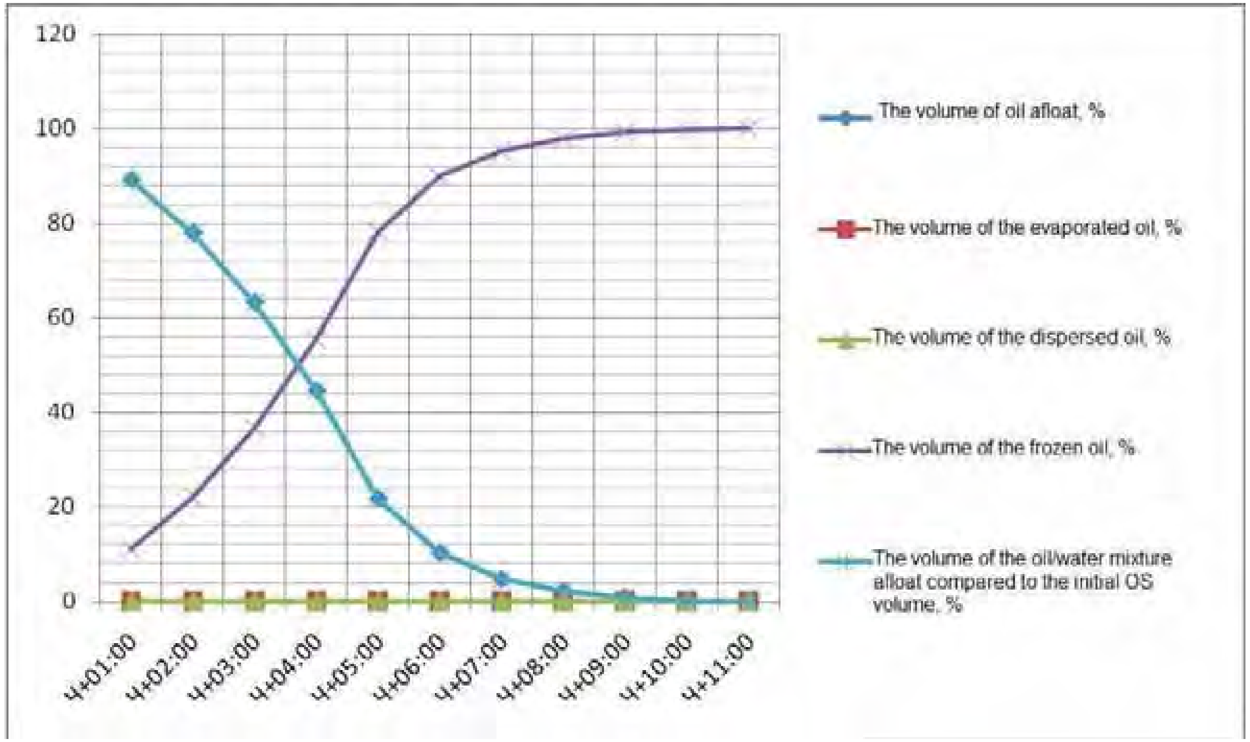


Figure 491. The chart of processes as per the scenario BO-Win-S-2.

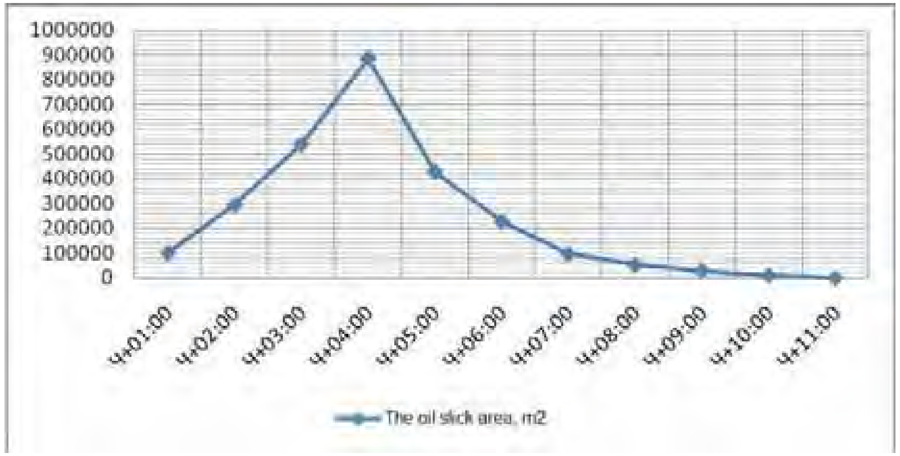


Figure 492. Oil slick area change dynamics as per the scenario BO-Win-S-2.

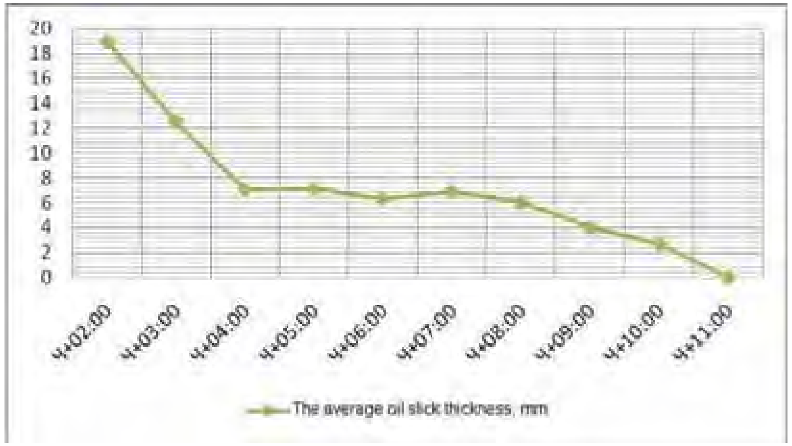


Figure 493. Oil slick thickness change dynamics as per the scenario BO-Win-S-2.

2.5.3 Oil slick behaviour modelling as per the scenario GC-Win-S-2

Table 2.4.3.1: Oil slick spreading parameters as per the scenario GC-Win-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil/water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3660	100	3060	83,6	89,3	2,44	116	3,17	395	10,8	5058	38,1	132734	10,7
H+02:00	7280	100	5328	73,2	344	4,73	298	4,09	1310	18,0	11660	30,2	385702	28,8
H+03:00	10427	100	6694	64,2	809	7,76	489	4,69	2835	27,2	16508	23,9	689342	52,2
H+04:00	13978	100	6969	49,9	1449	10,4	666	4,76	4894	35,0	18271	18,5	988680	81,6
H+05:00	14000	100	4657	33,3	1992	14,2	714	5,10	6637	47,4	14533	16,0	908360	187
H+06:00	14000	100	2886	20,6	2373	17,0	725	5,18	8017	57,3	9480	12,1	785505	278
H+07:00	14000	100	1547	11,1	2616	18,7	731	5,22	9106	65,0	5141	9,49	541950	338
H+08:00	14000	100	795	5,68	2740	19,6	734	5,24	9730	69,5	2648	9,14	289662	370
H+09:00	14000	100	389	2,78	2800	20,0	736	5,26	10075	72,0	1295	9,61	134726	386
H+10:00	14000	100	201	1,44	2828	20,2	737	5,26	10234	73,1	671	9,33	71944	392
H+11:00	14000	100	99,9	0,71	2842	20,3	737	5,26	10320	73,7	333	6,49	51339	393
H+12:00	14000	100	29,3	0,21	2850	20,4	738	5,27	10383	74,2	97,6	3,35	29176	392
H+13:00	14000	100	4,1	0,03	2853	20,4	738	5,27	10405	74,3	13,6	1,42	9592	389
H+13:30	14000	100	0	0	2853	20,4	738	5,27	10409	74,4	0	0	0	-

Within rthe first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1762 m, the volume of the evaporated oil – 10,4%, the volume of the dispersed oil – 4,76%, the volume of the frozen oil – 35%, the average thickness of the free floating oil – 18,5 mm. Further the oil slick drifts north-eastward. After 6 hours ass of the OS start the floating oil slick semi-perimeter makes 1571 m, the volume of the evaporated oil – 17%, the volume of the dispersed oil – 5,18%, the volume of the frozen oil – 57,3%, the average thickness of the free floating oil – 12,1 mm. After 8 hours a of the OS start the floating oil slick semi-perimeter makes 954 m, the volume of the evaporated oil – 19,6%, the volume of the dispersed oil – 5,25%, the volume of the frozen oil – 69,5%, the average thickness of the free floating oil – 9,4 mm. To the moment of modelling completion (13 hours and 30 minutes) oil spreading on the water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 5 km^2.

The graphic display of oil slick spreading as per the scenario GC-Win-S-2 is shown in figures 494 – 507.

The charts of processes typical for SGC behavior on water are shown in figures 508-510.

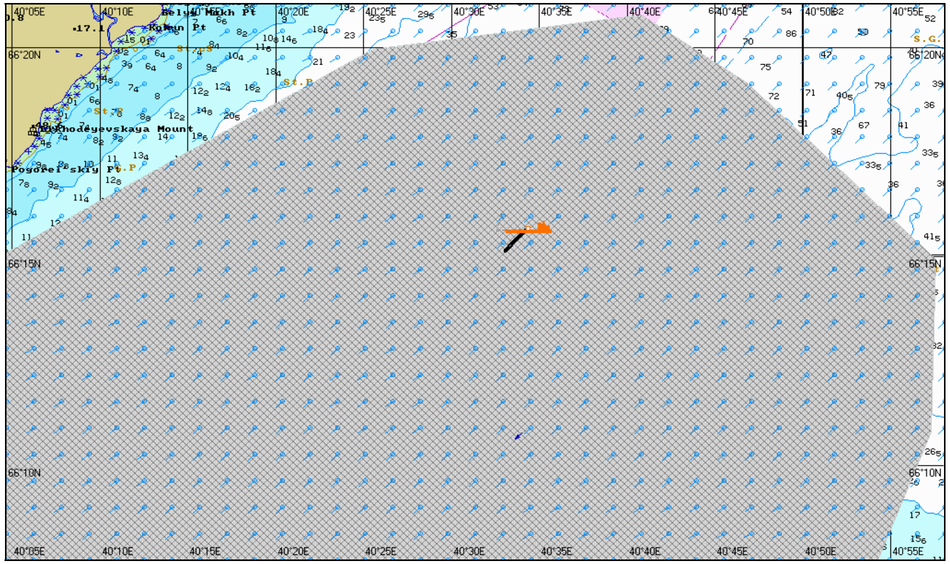


Figure 494. H+01:00. Oil slick spreading as per the scenario GC-Win-S-2.

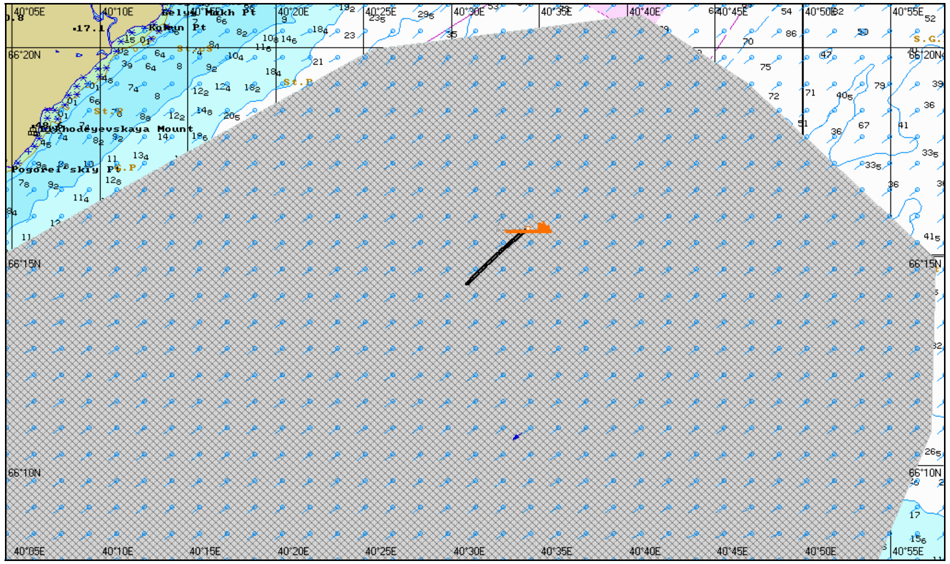


Figure 495. H+02:00. Oil slick spreading as per the scenario GC-Win-S-2.

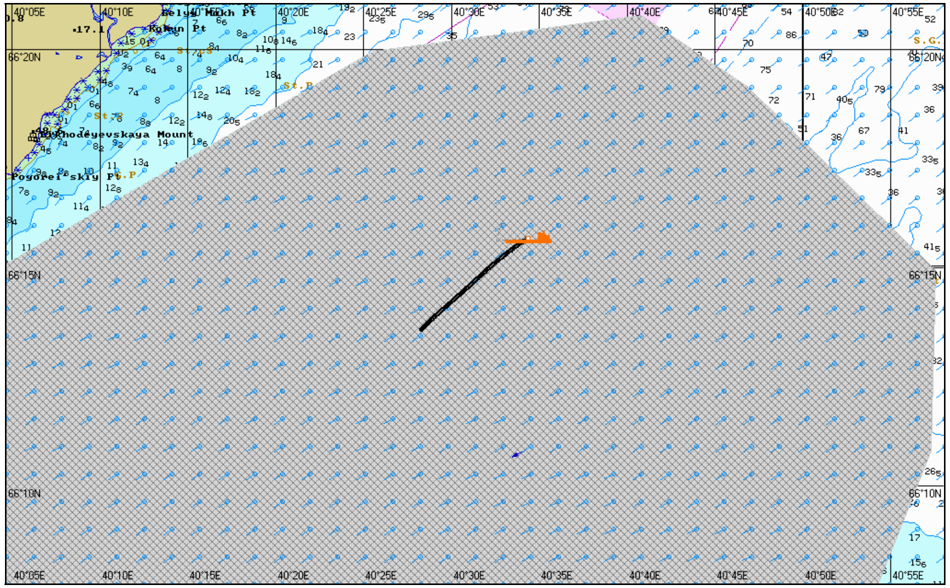


Figure 496. H+03:00. Oil slick spreading as per the scenario GC-Win-S-2.

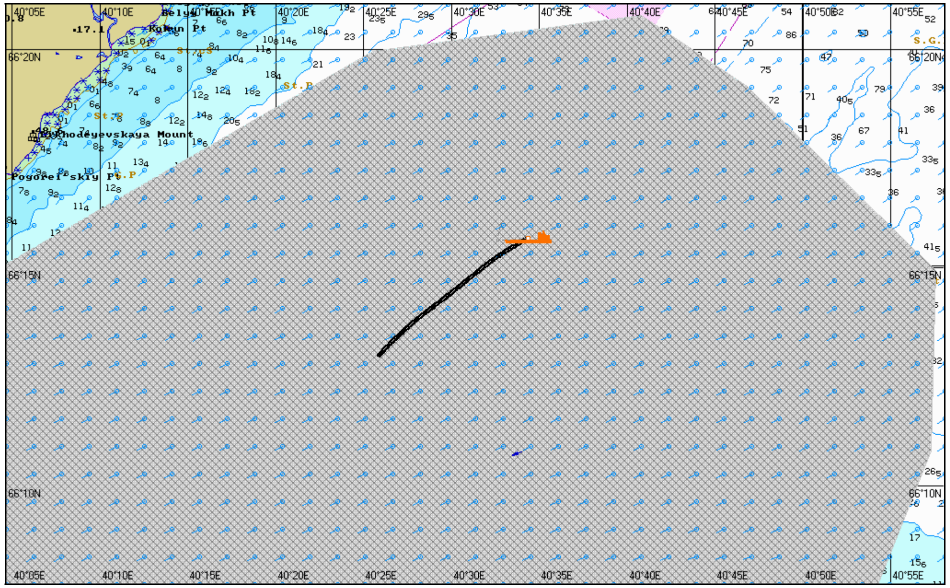


Figure 497. H+04:00. Oil slick spreading as per the scenario GC-Win-S-2.

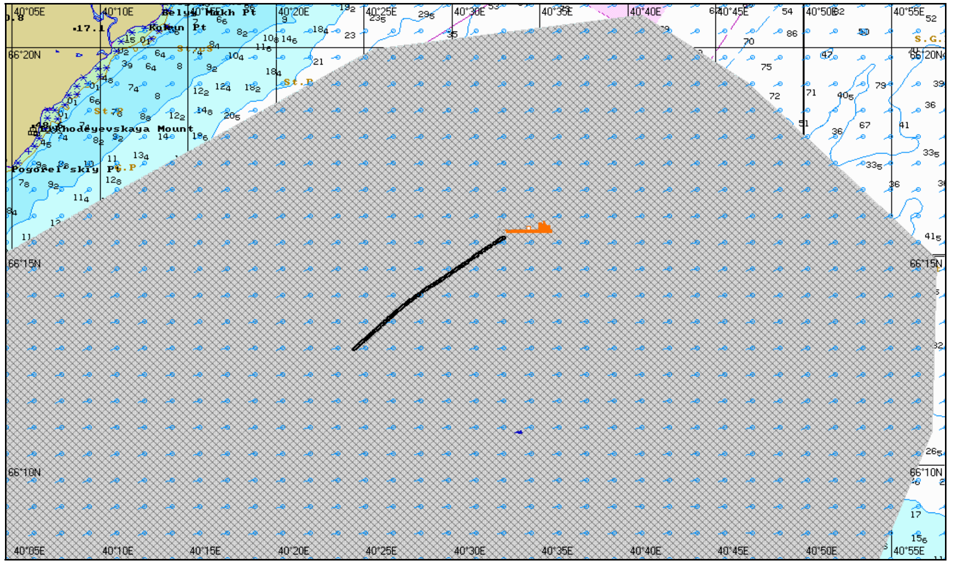


Figure 498. H+05:00. Oil slick spreading as per the scenario GC-Win-S-2.

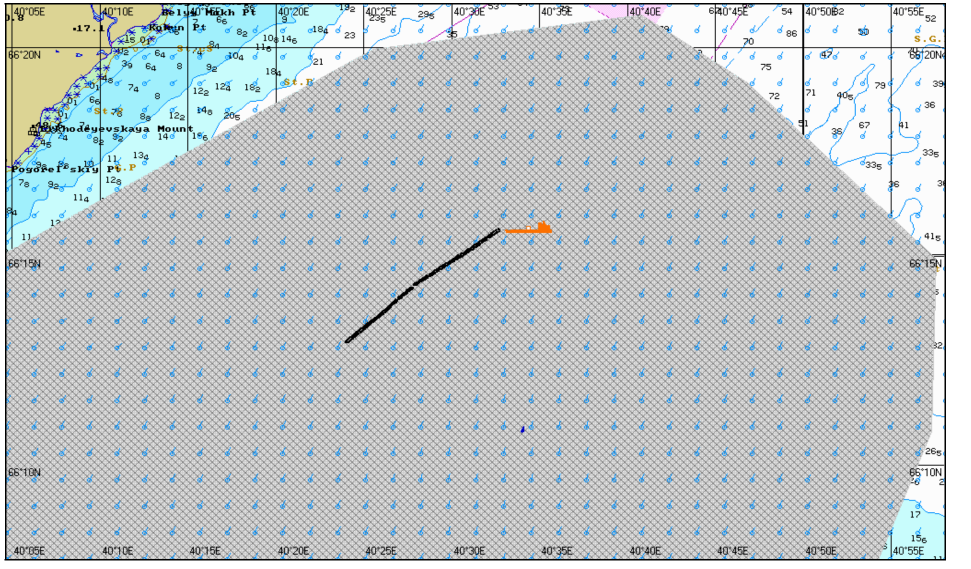


Figure 499. H+06:00. Oil slick spreading as per the scenario GC-Win-S-2.

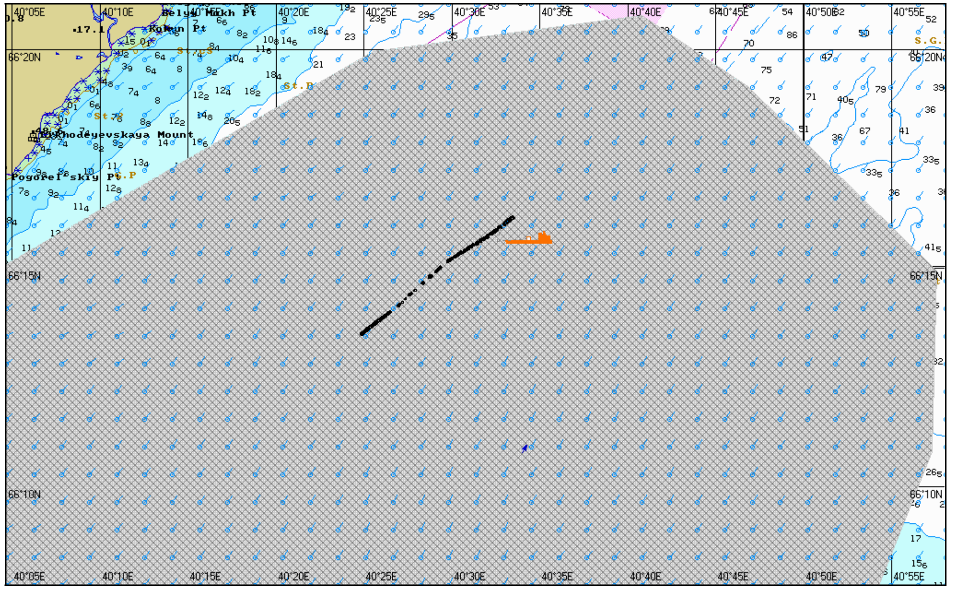


Figure 500. H+07:00. Oil slick spreading as per the scenario GC-Win-S-2.

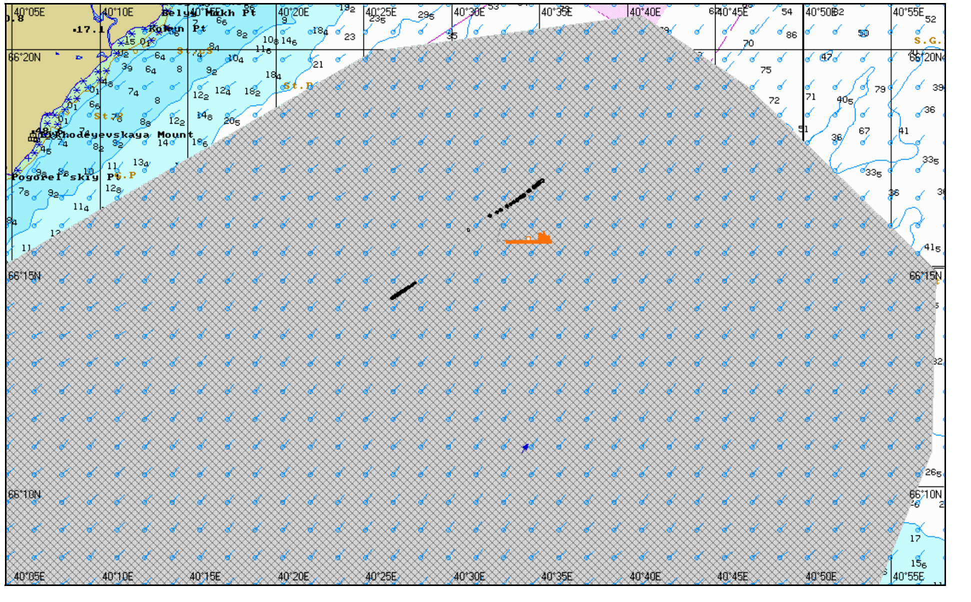


Figure 501. H+08:00. Oil slick spreading as per the scenario GC-Win-S-2.

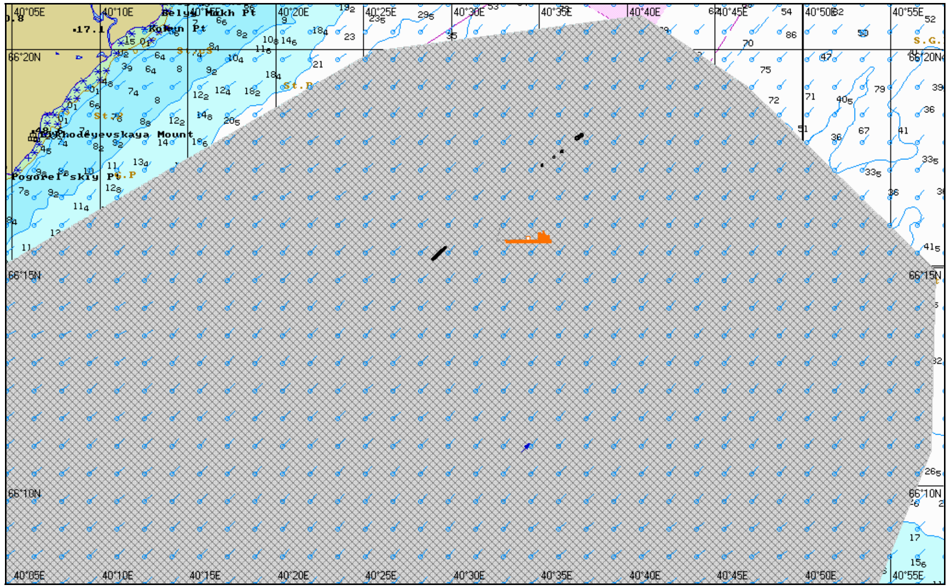


Figure 502. H+09:00. Oil slick spreading as per the scenario GC-Win-S-2.

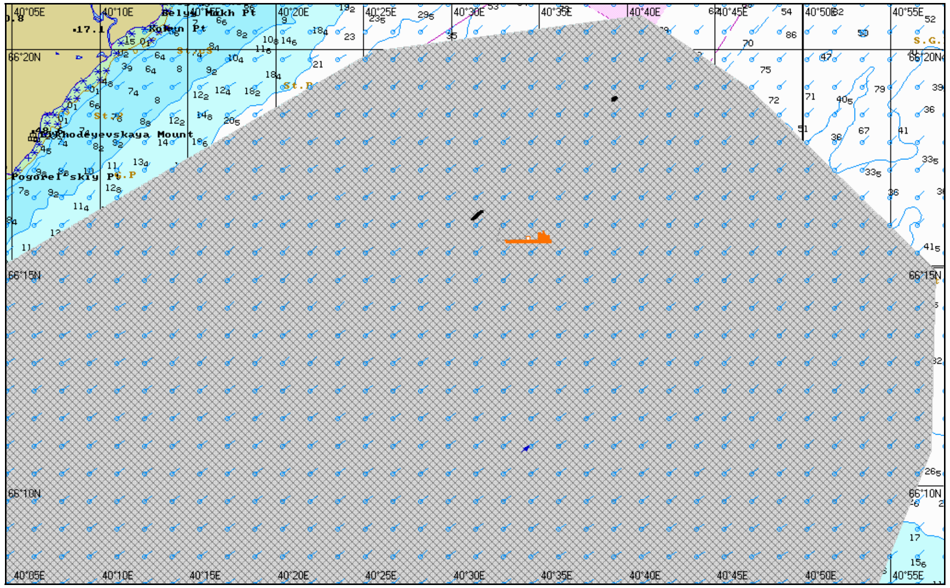


Figure 503. H+10:00. Oil slick spreading as per the scenario GC-Win-S-2.

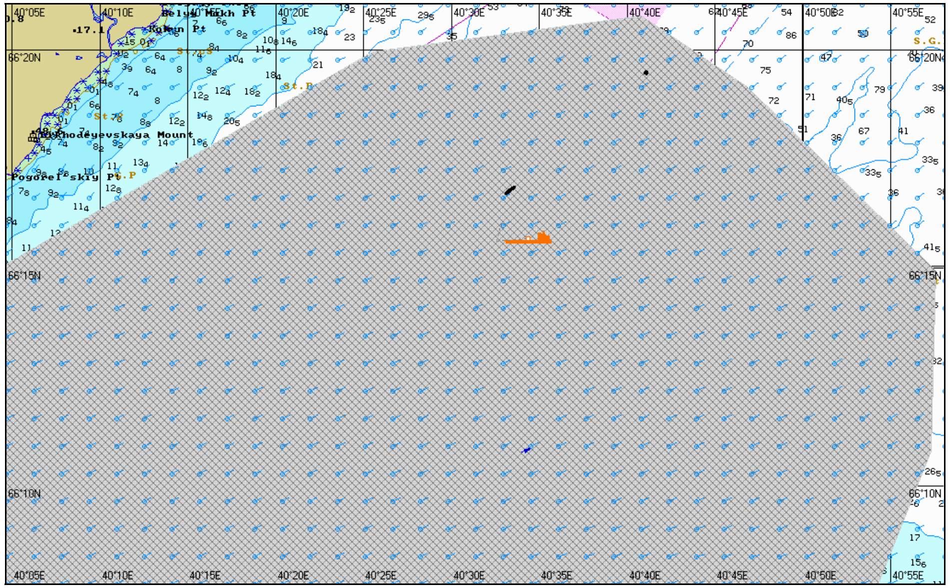


Figure 504. H+11:00. Oil slick spreading as per the scenario GC-Win-S-2.

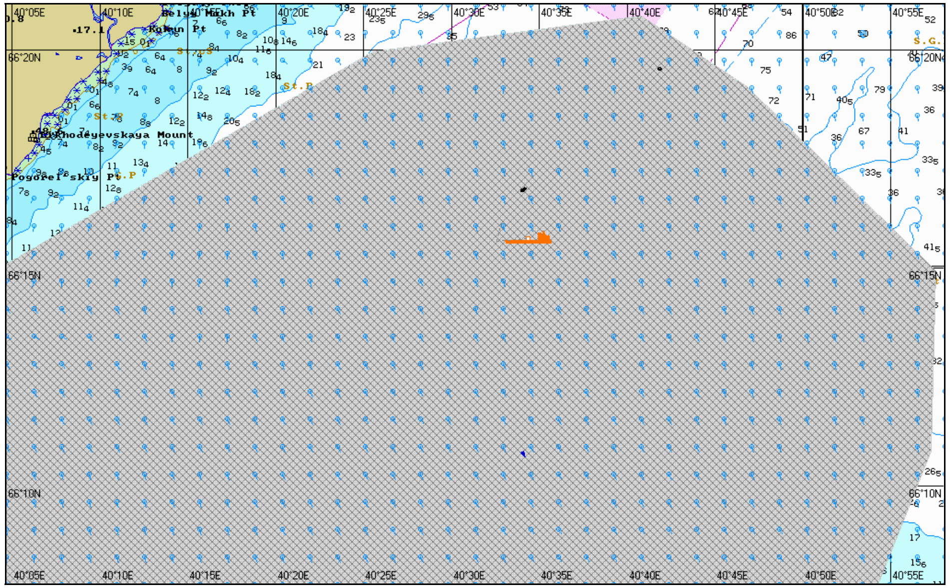


Figure 505. H+12:00. Oil slick spreading as per the scenario GC-Win-S-2.

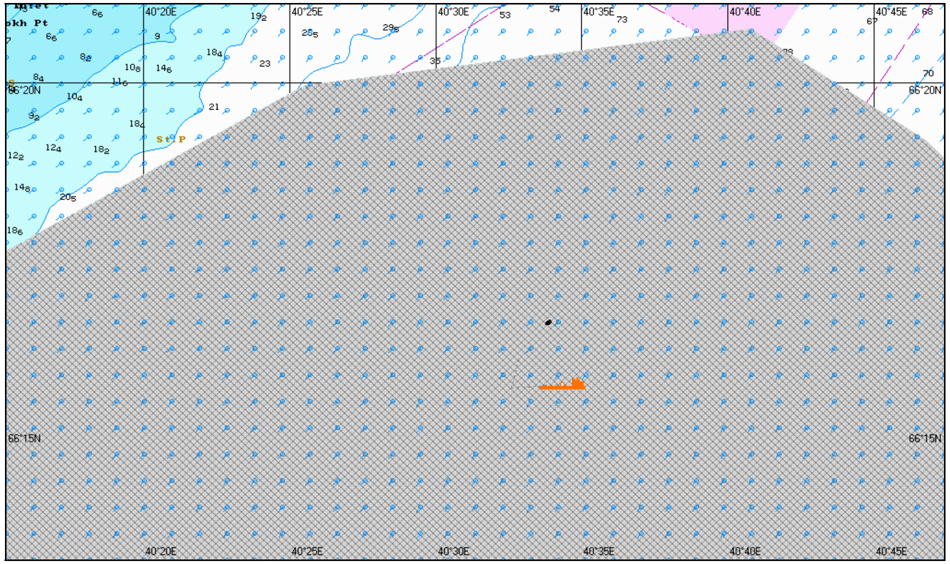


Figure 506. H+13:00. Oil slick spreading as per the scenario GC-Win-S-2.

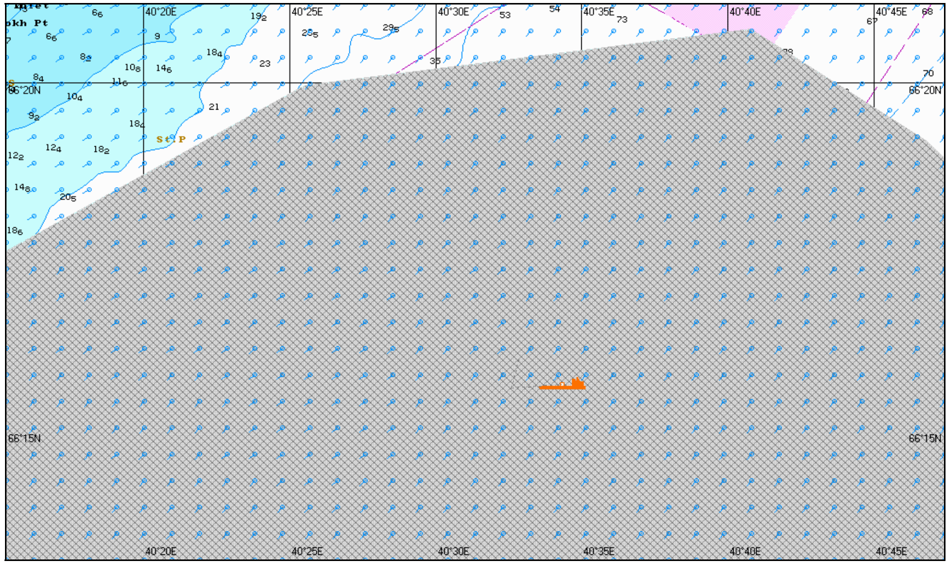


Figure 507. H+13:30. Oil slick spreading as per the scenario GC-Win-S-2.

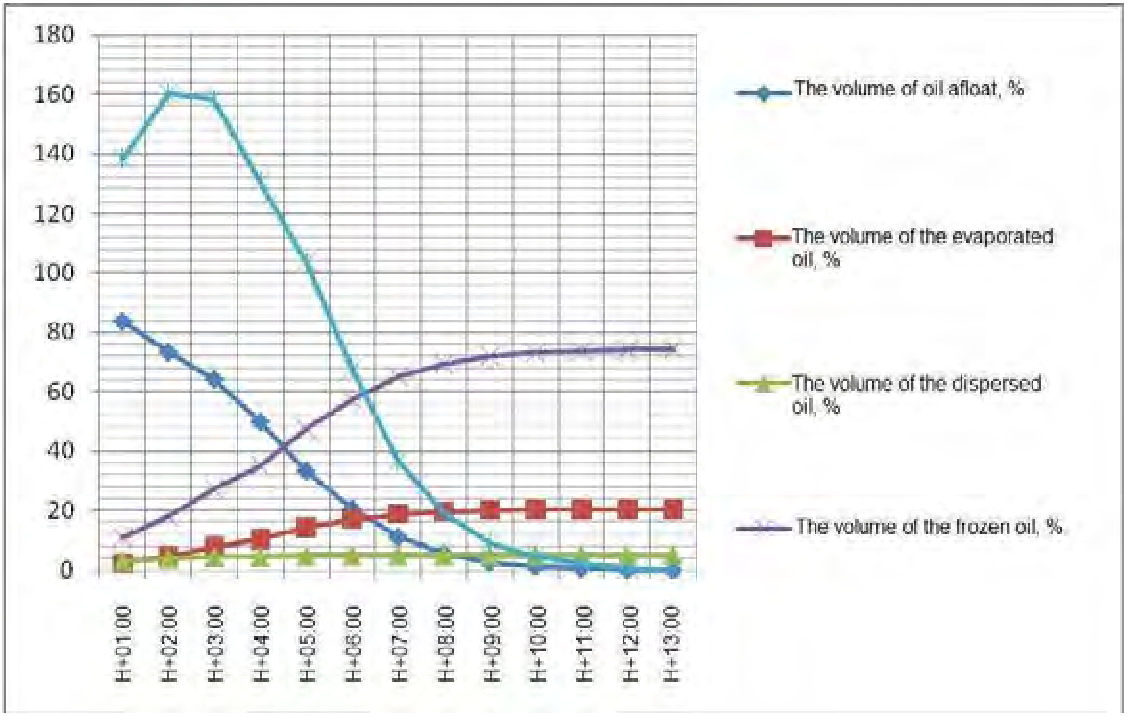


Figure 508. The chart of processes as per the scenario GC-Win-S-2.

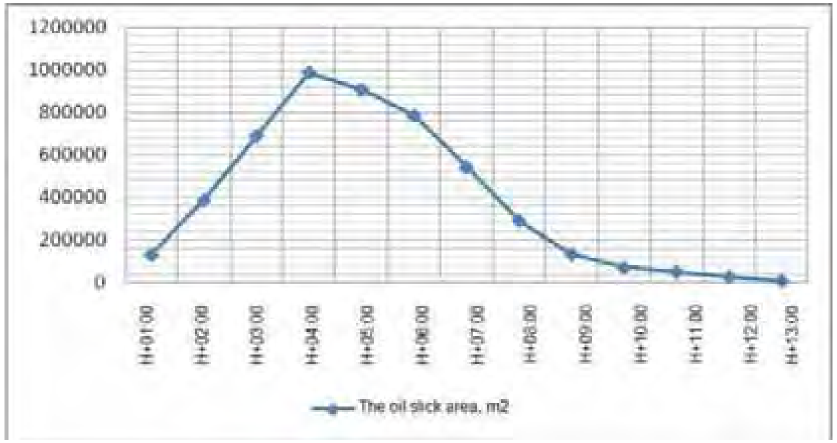


Figure 509. Oil slick area change dynamics as per the scenario GC-Win-S-2.

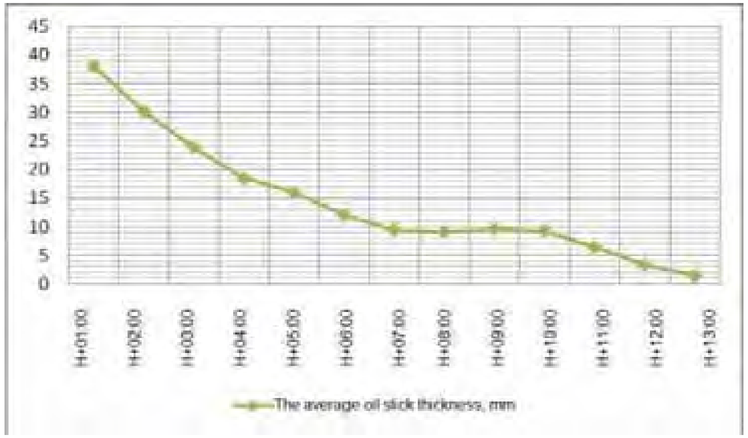


Figure 510. Oil slick thickness change dynamics as per the scenario GC-Win-S-2.

2.5.4 Oil slick behaviour modelling as per the scenario Na-Win-S-2

Table 2.4.4.1: Oil slick spreading parameters as per the scenario Na-Win-S-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	2346	100	1666	71,0	212	9,04	23,9	1,02	444	18,9	2138	13,8	155108	5,2
H+02:00	4811	100	2164	45,0	766	15,9	66,2	1,38	1815	37,7	2841	6,55	433807	10,9
H+03:00	7502	100	1973	26,3	1456	19,4	120	1,60	3951	52,7	2541	6,19	410473	14,7
H+04:00	10000	100	1900	19,0	2106	21,1	176	1,76	5818	58,2	2496	6,17	404306	18,2
H+05:00	10000	100	483	4,83	2437	24,4	201	2,01	6878	68,8	690	3,59	192423	30,9
H+06:00	10000	100	19,9	0,20	2517	25,2	207	2,07	7256	72,6	29,9	0,88	33827	32,7
H+08:30	10000	100	0,0	0	2518	25,2	207	2,07	7274	72,7	0	-	-	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. TAfter 4 hours as of the OS start the oil slick semi-perimeter makes 1127 m, the volume of the evaporated oil – 21,1%, the volume of the dispersed oil – 1,76%, the volume of the frozen oil – 58,2%, the average thickness of the free floating oil – 6,17 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 326 m, the volume of the evaporated oil – 25,2%, the volume of the dispersed oil – 2,07%, the volume of the frozen oil – 72,6%, the average thickness of the free floating oil – 0,88 mm. To the moment of modelling completion (8 hours and 30 minutes) the oil spreading on water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 1,6 кm^2.

The graphic display of oil slick spreading as per the scenario Na-Win-S-2 is shown in figures 511 – 517.

The charts of processes typical for naphtha behavior on water are shown in figures 518-520.

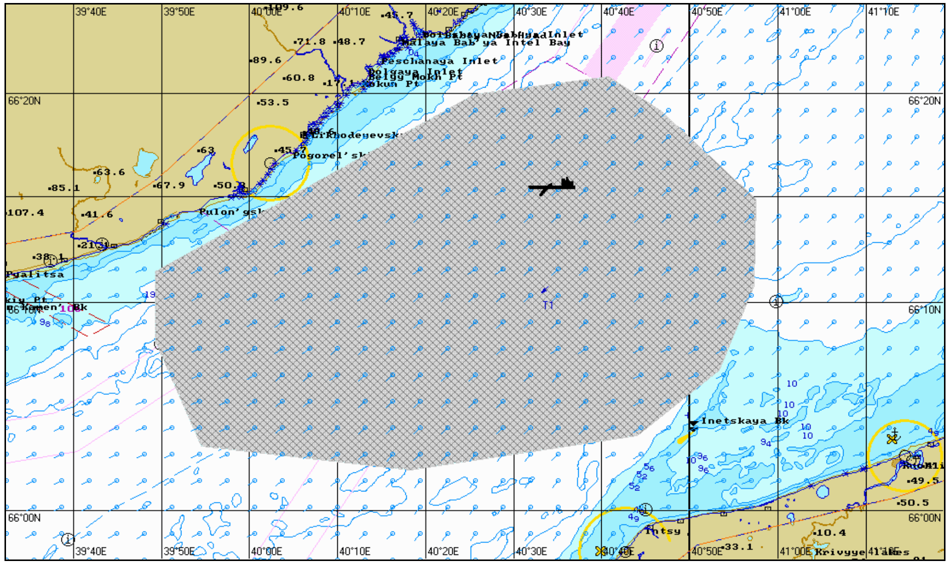


Figure 511. H+01:00. Oil slick spreading as per the scenario Na-Win-S-2.

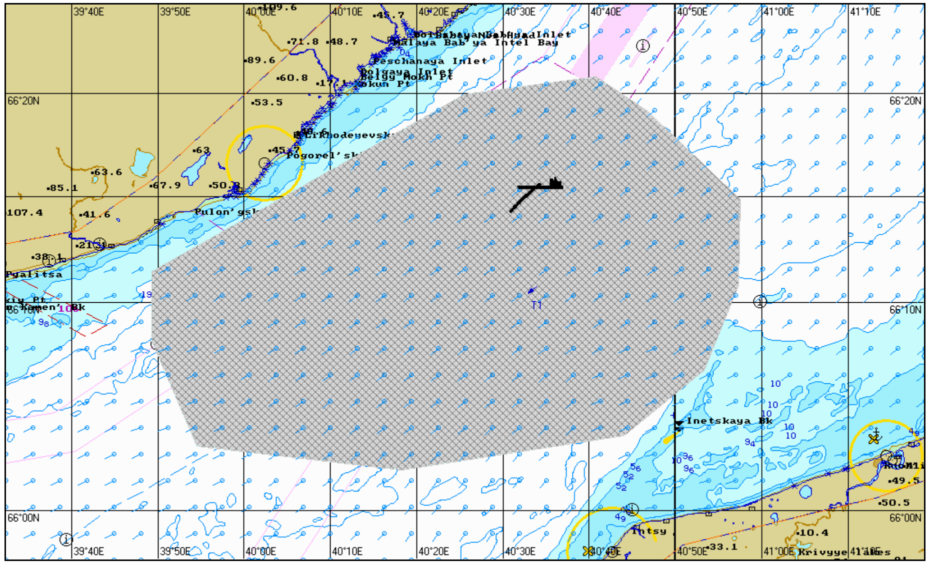


Figure 512. H+02:00. Oil slick spreading as per the scenario Na-Win-S-2.

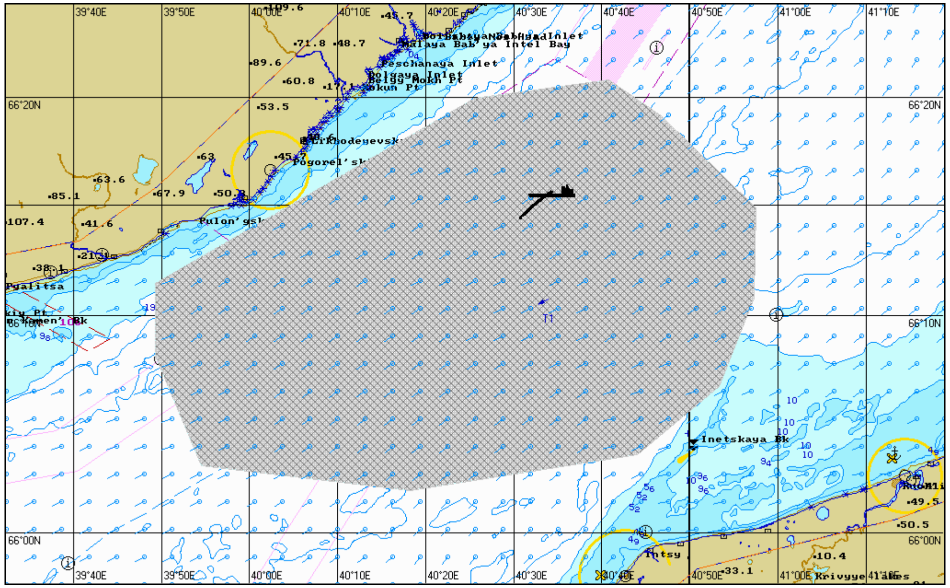


Figure 513. H+03:00. Oil slick spreading as per the scenario Na-Win-S-2.

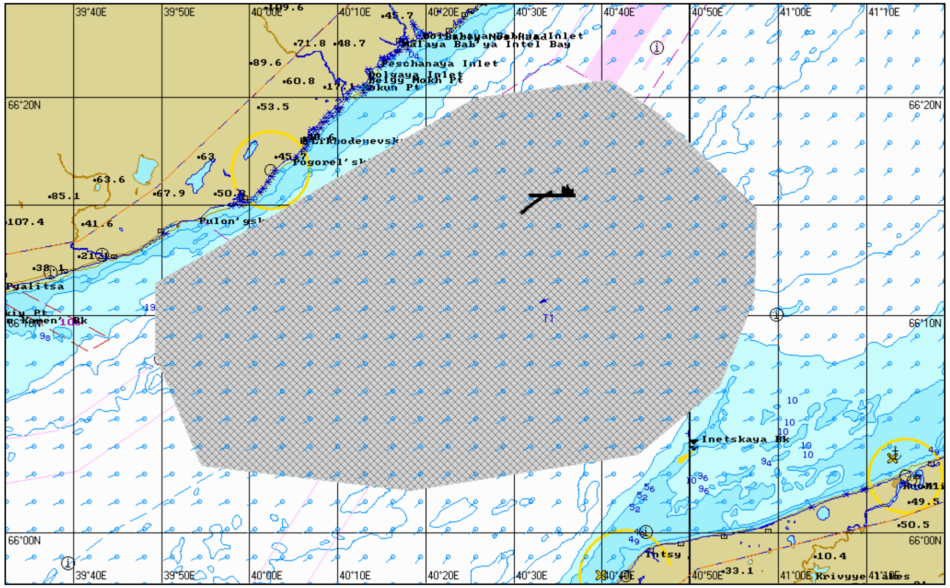


Figure 514. H+04:00. Oil slick spreading as per the scenario Na-Win-S-2.

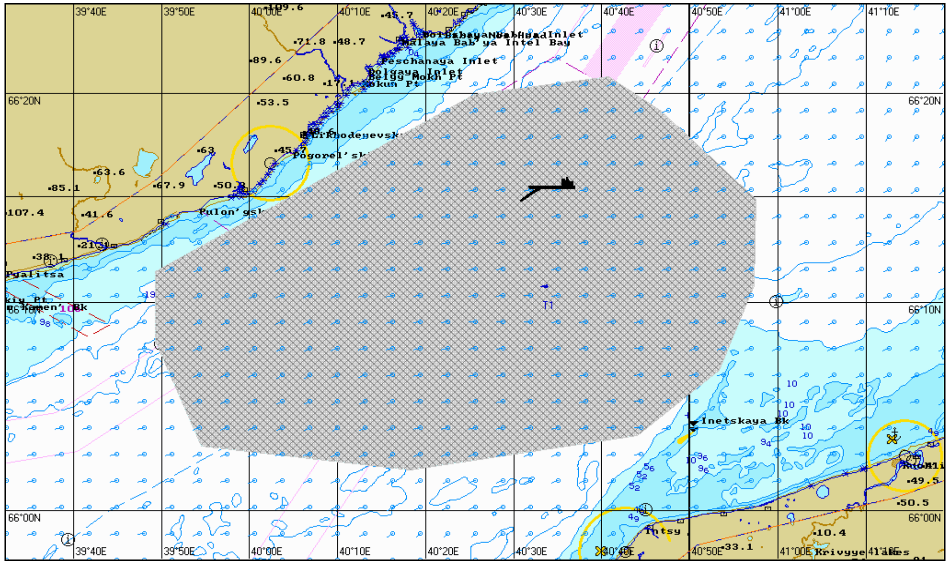


Figure 515. H+05:00. Oil slick spreading as per the scenario Na-Win-S-2.

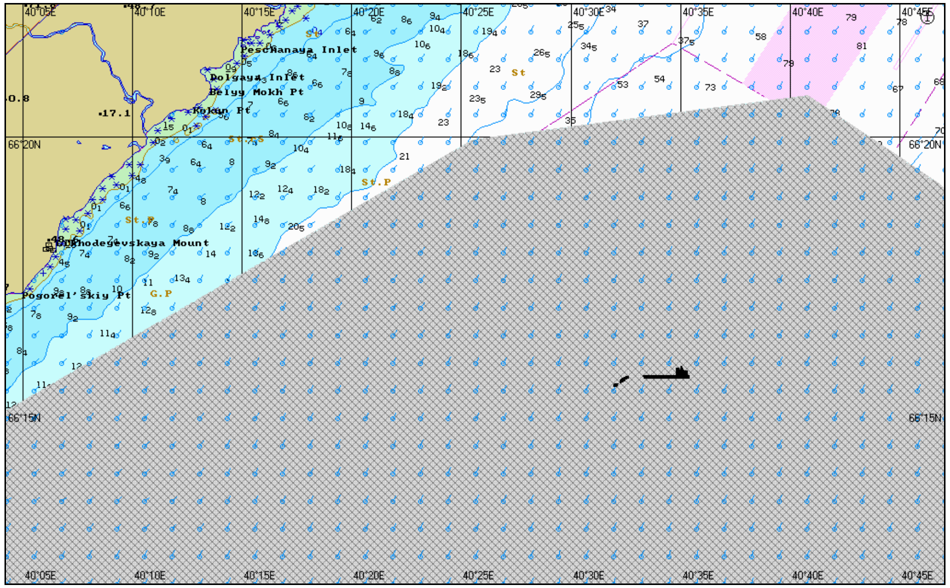


Figure 516. H+06:00. Oil slick spreading as per the scenario Na-Win-S-2.

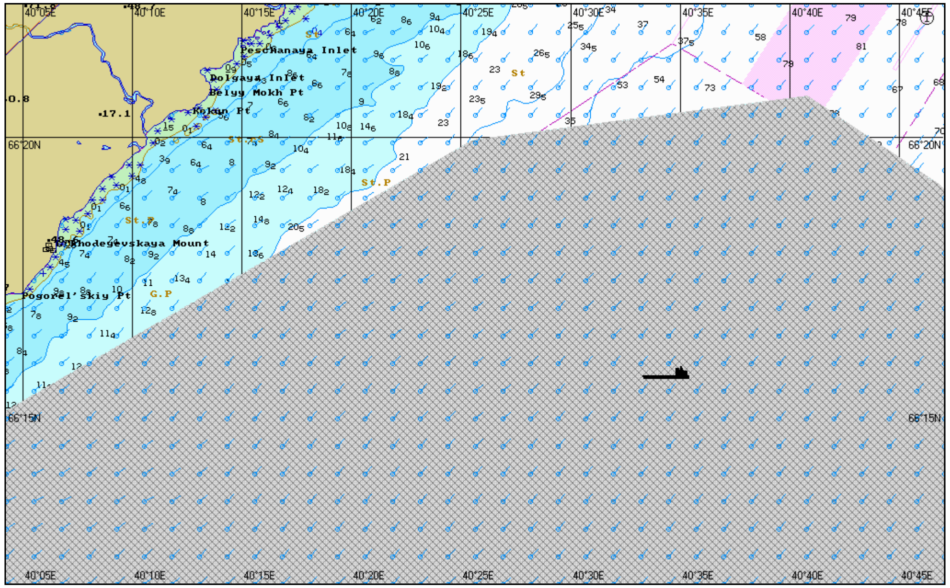


Figure 517. H+08:30. Oil slick spreading as per the scenario Na-Win-S-2.

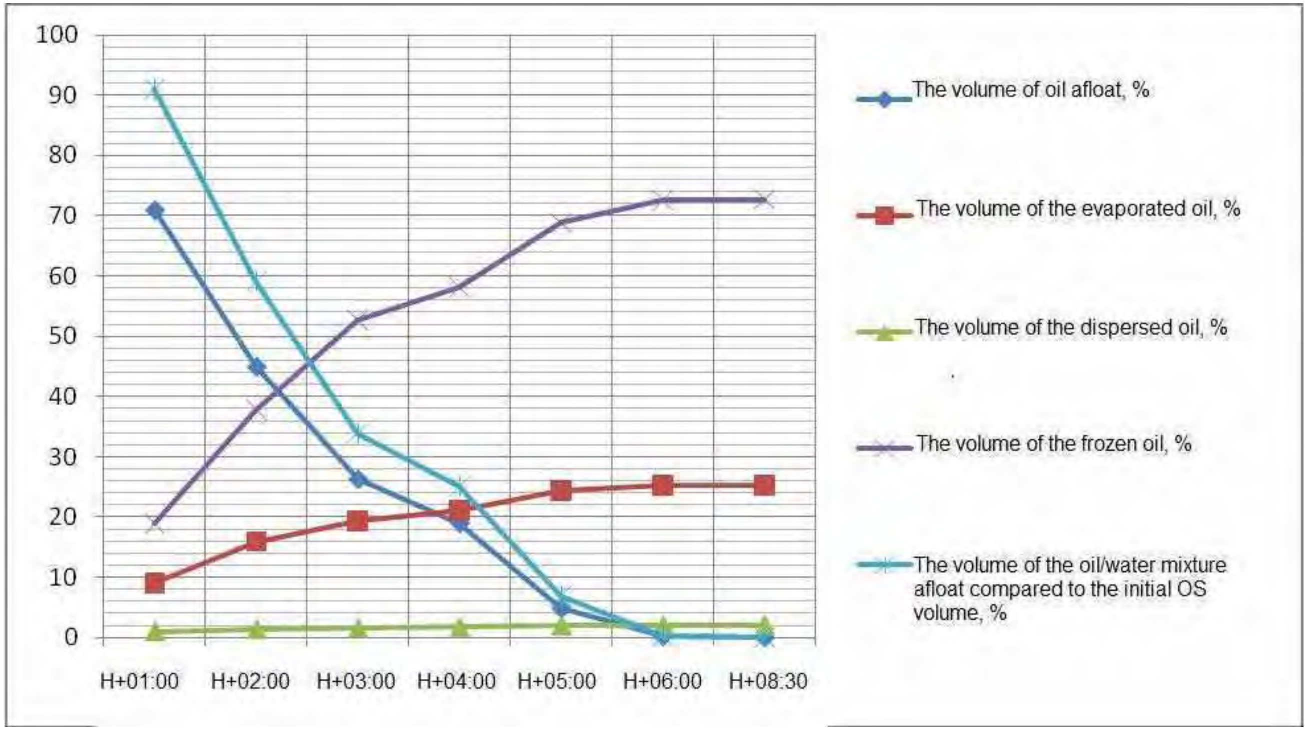


Figure 518. The chart of processes as per the scenario Na-Win-S-2.

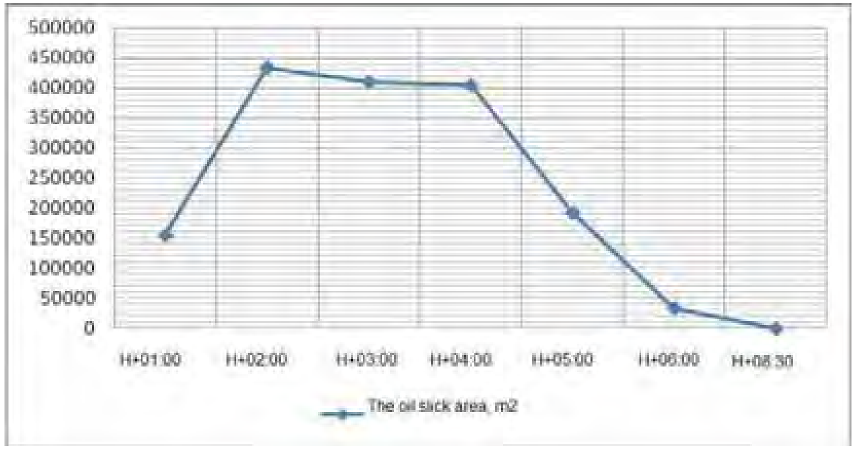


Figure 519. Oil slick area change dynamics as per the scenario Na-Win-S-2.

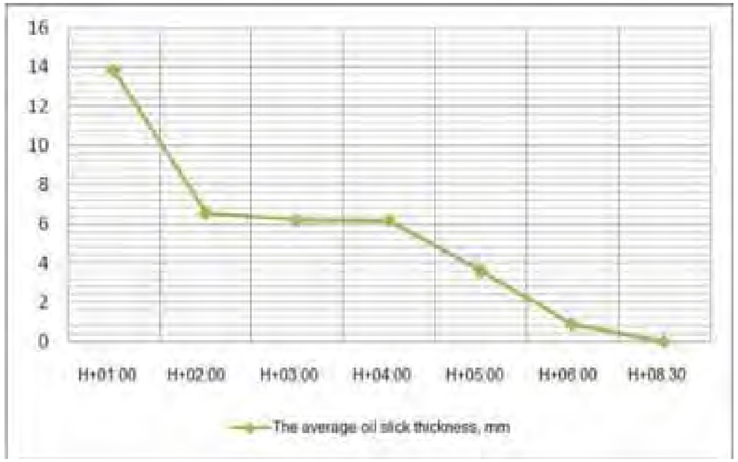


Figure 520. Oil slick thickness change dynamics as per the scenario Na-Win-S-2.

2.5.5 The process dynamics typical for oil spill behavior in the White Sea under the winter southward wind (Win-S-2)

Figures 521-524 show the dynamics of processes typical for oil behavior in the White Sea as per the scenarios Win-S-2.

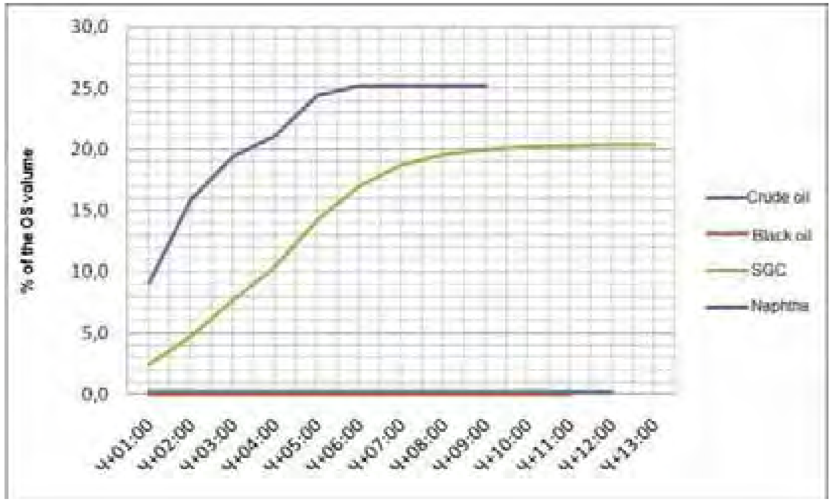


Figure 521. The evaporation process chart as per the scenarios Win-S-2.

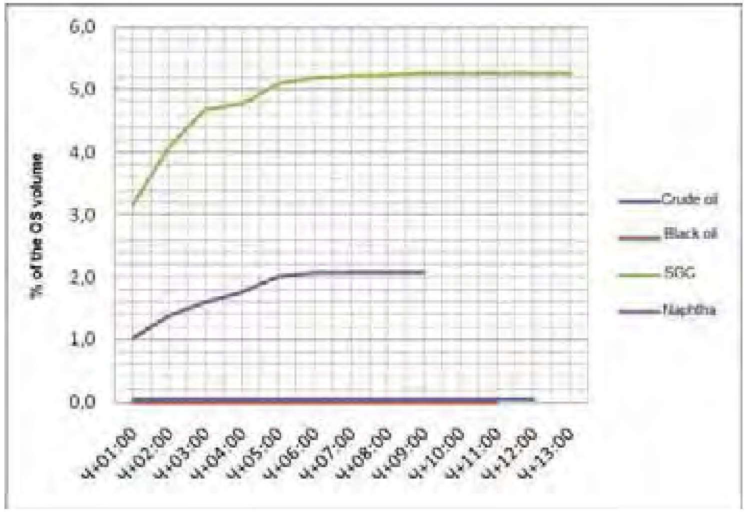


Figure 522. The dispersion process chart as per the scenarios Win-S-2.

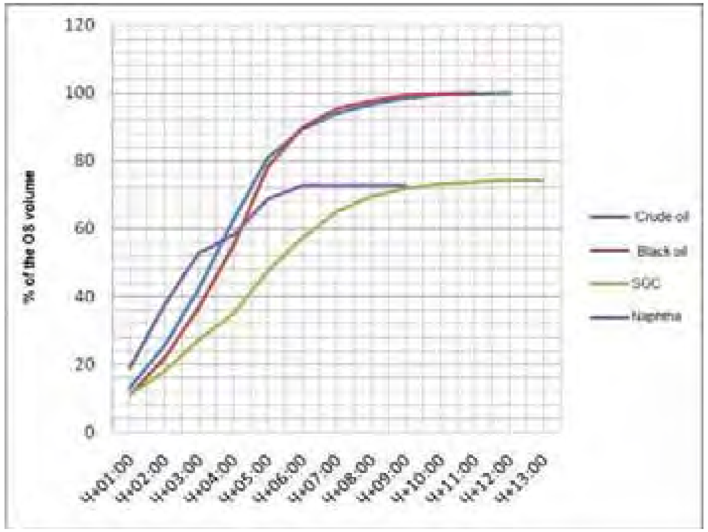


Figure 523. The oil freezing process chart as per the scenarios Win-S-2.

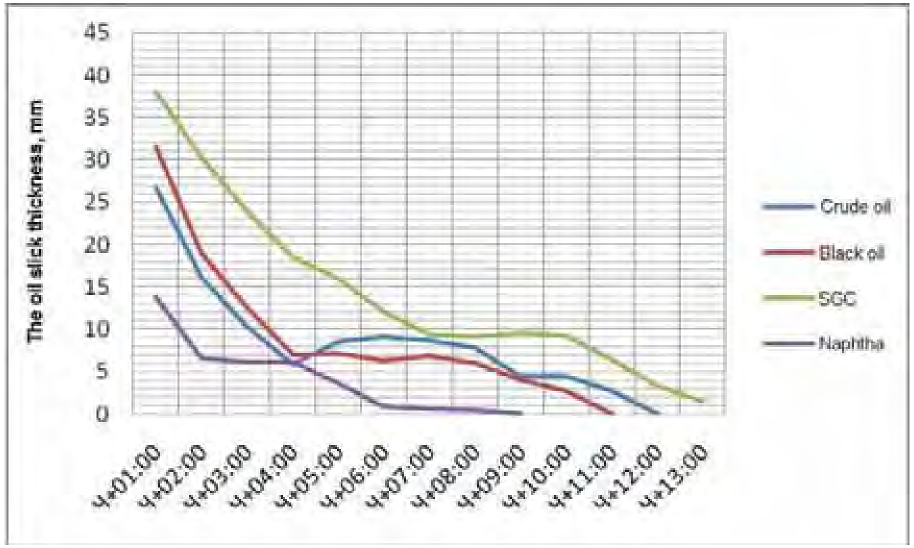


Figure 524. Oil slick thickness change dynamics as per the scenarios Win-S-2.

2.6 Oil spill behavoiur modeling in the White Sea under the winter westward wind

2.6.1 Oil slick behaviour modelling as per the scenario COU-Win-W-2

Table 2.5.1.1: Oil slick spreading parameters as per the scenario COU-Win-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3467	100	3012	86,9	0	0	0	0	455	13,1	3012	27,1	110947	18,3
H+02:00	6967	100	5189	74,5	0	0	0	0	1778	25,5	5189	16,3	318447	18,3
H+03:00	10470	100	6099	58,3	0	0	0	0	4371	41,7	6099	10,4	585990	18,3
H+04:00	13972	100	5171	37,0	0	0	0	0	8802	63,0	5171	5,49	942237	18,3
H+05:00	14000	100	2664	19,0	0	0	0	0	11336	81,0	2664	7,82	340880	18,3
H+06:00	14000	100	1431	10,2	0	0	0	0	12569	89,8	1431	8,84	161857	18,3
H+07:00	14000	100	784	5,60	0	0	0	0	13215	94,4	784	7,83	100080	18,3
H+08:00	14000	100	395	2,82	0	0	0	0	13605	97,2	395	6,92	57090	18,3
H+09:00	14000	100	157	1,12	0	0	0	0	13842	98,9	157	4,61	34065	18,3
H+10:00	14000	100	52,2	0,37	0	0	0	0	13947	99,6	52,2	5,20	10039	18,3
H+11:00	14000	100	19,3	0,14	0	0	0	0	13981	99,9	19,3	5,87	3287	18,3
H+12:00	14000	100	4,9	0,04	0	0	0	0	13995	100	4,9	1,76	2791	18,3
H+13:00	14000	100	0	0	0	0	0	0	14000	100	0	0	0	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours ass of the OS start the oil slick semi-perimeter makes 1720 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 63,0%, the average thickness of the free floating oil – 5,49 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 713 m, the evaporation and sipsersion [rocesses are not detected by the programme, the volume of the frozen oil – 89,8%, the average thickness of the free floating oil – 8,84 mm. After 8 hours as of the OS start the floating oil slick semi-perimeter makes 423 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 97,2%. To the moment of modelling completion (13 hours) oil spreading omn water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 2,7 km^2.
The graphic display of oil slick spreading as per the scenario COU-Win-W-2 is shown in figures 525 – 536.
The charts of processes typical for oil behavior on water are shown in figures 537-539.

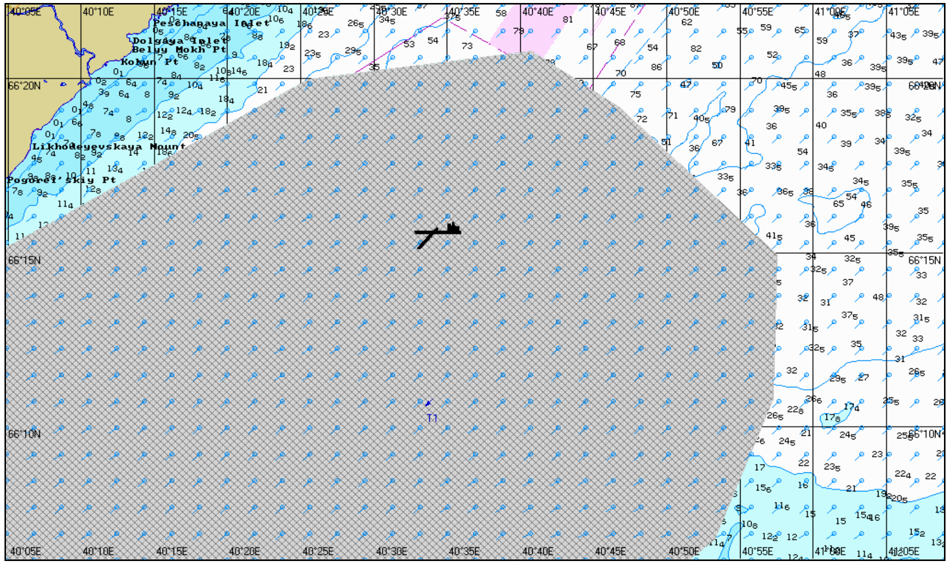


Figure 525. H+01:00. Oil slick spreading as per the scenario COU-Win-W-2.

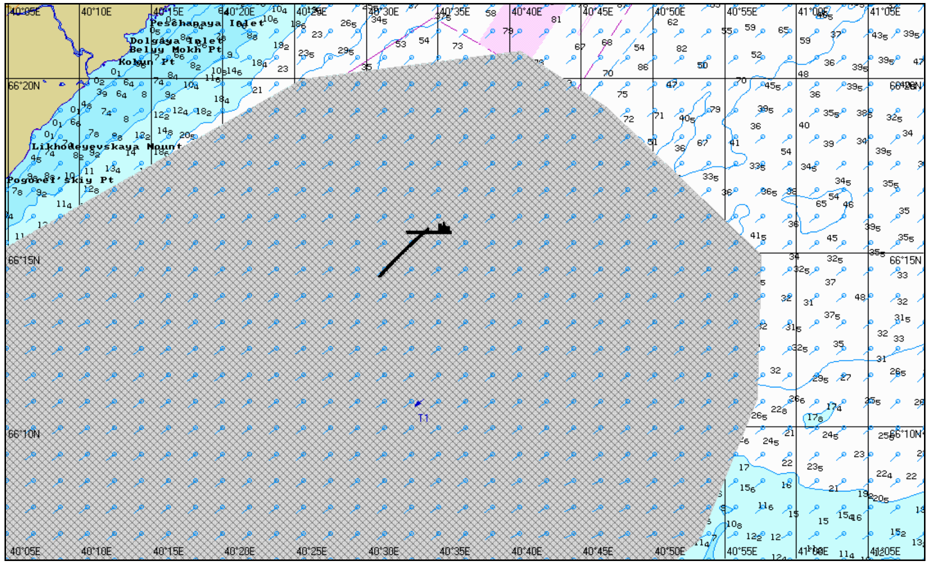


Figure 526. H+02:00. Oil slick spreading as per the scenario COU-Win-W-2.

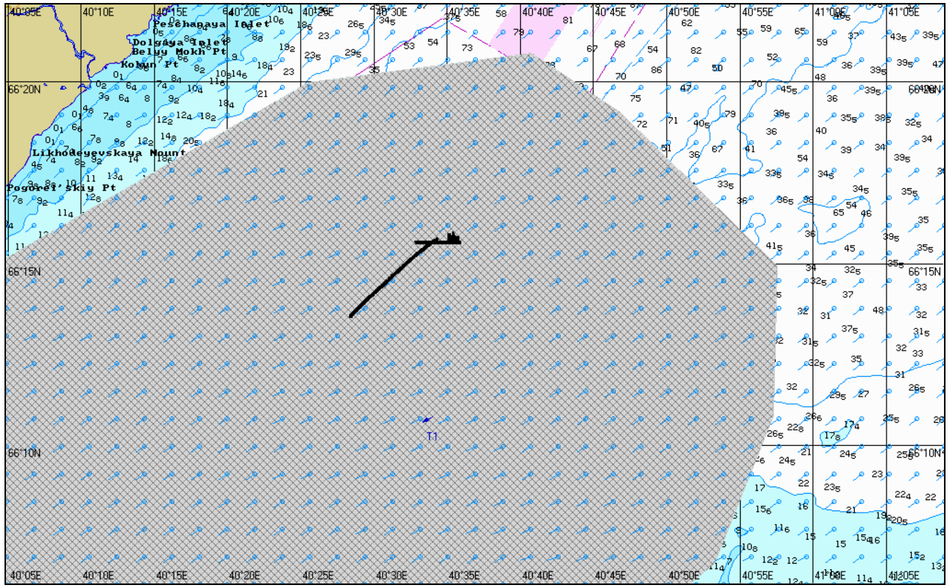


Figure 527. H+03:00. Oil slick spreading as per the scenario COU-Win-S-2.

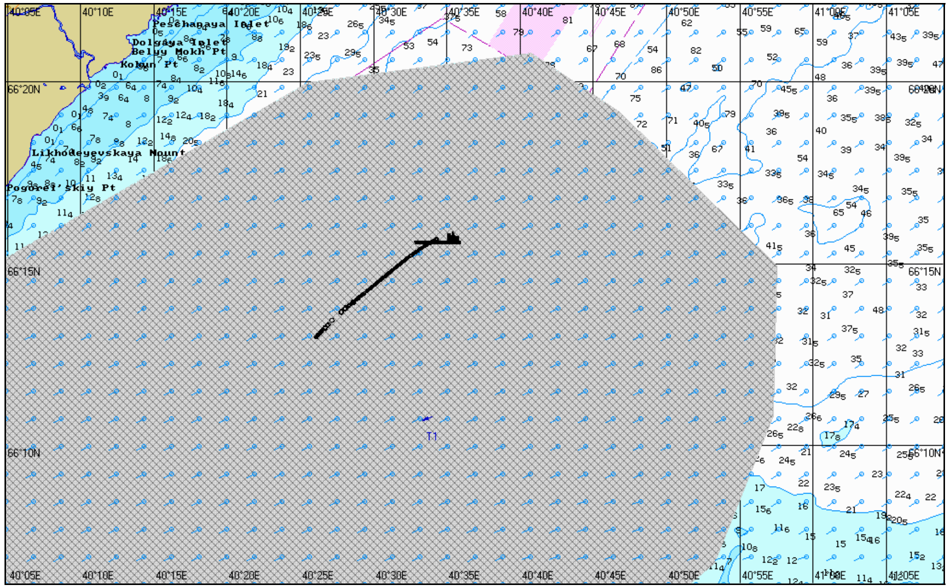


Figure 528. H+04:00. Oil slick spreading as per the scenario COU-Win-S-2.

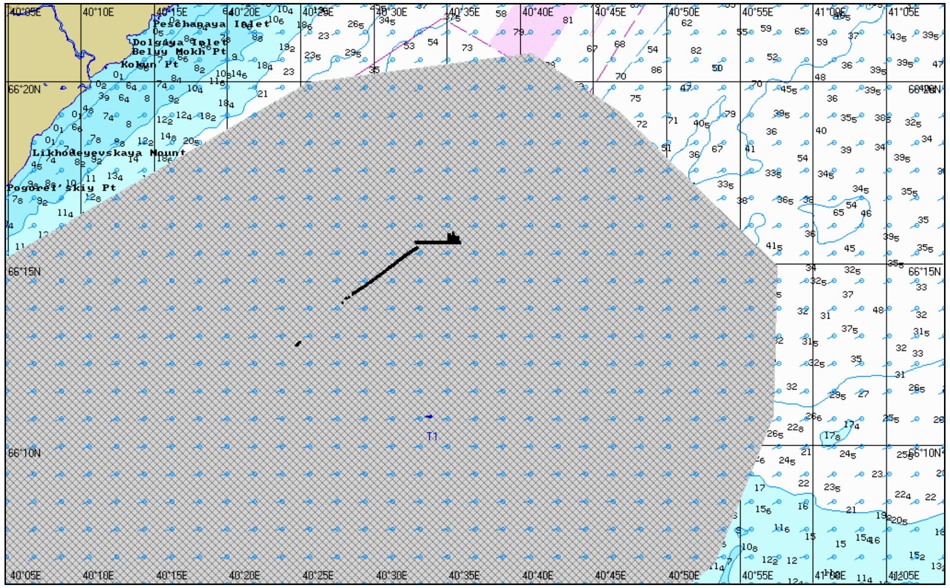


Figure 529. H+05:00. Oil slick spreading as per the scenario COU-Win-W-2.

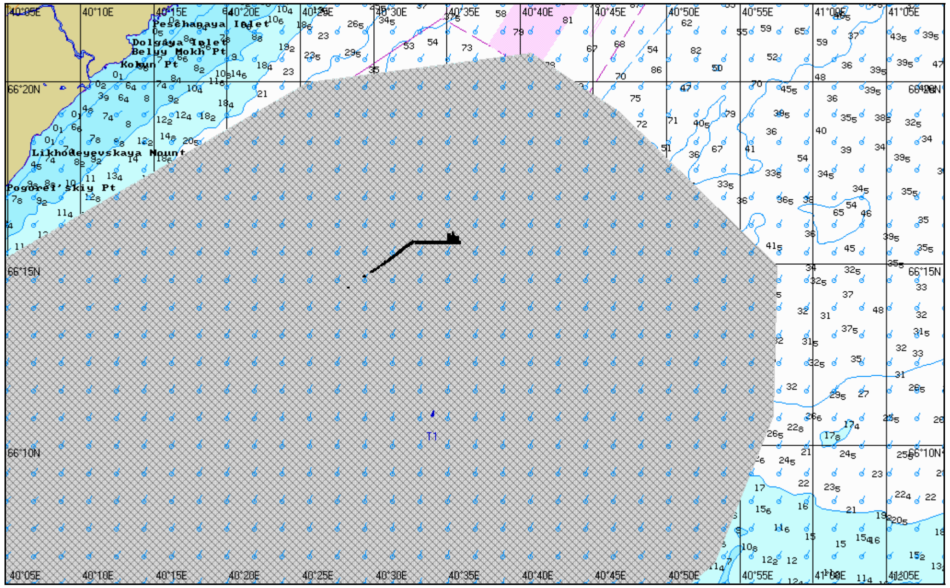


Figure 530. H+06:00. Oil slick spreading as per the scenario COU-Win-W-2.

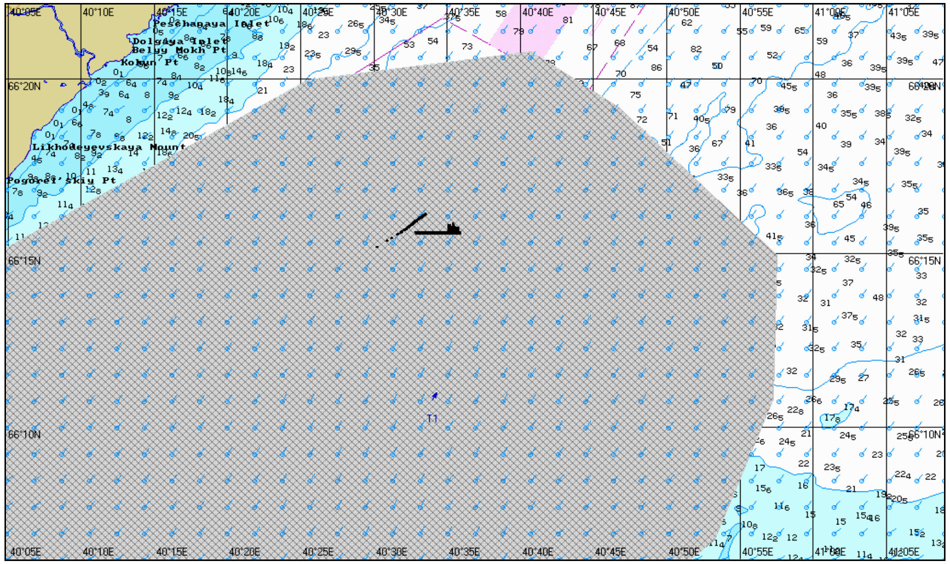


Figure 531. H+07:00. Oil slick spreading as per the scenario COU-Win-W-2.

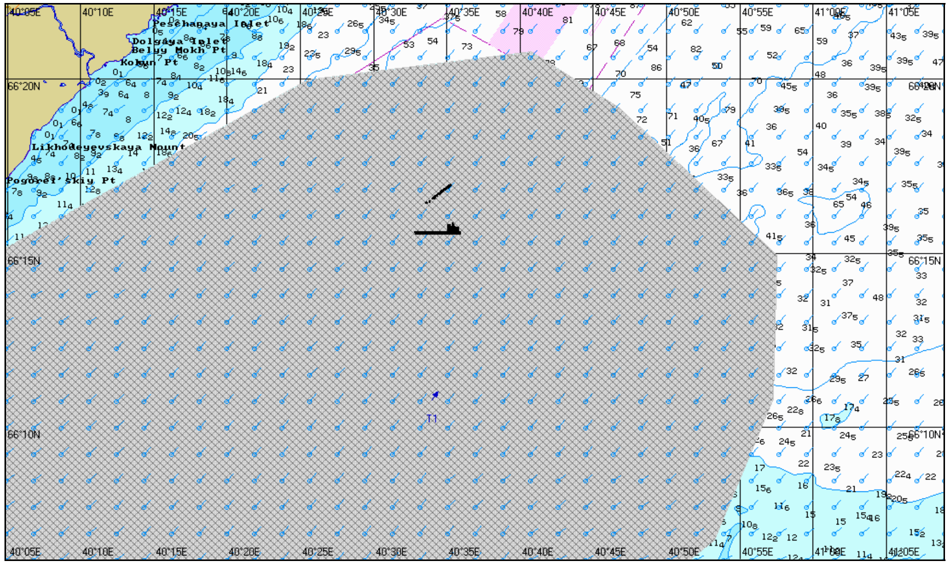


Figure 532. H+08:00. Oil slick spreading as per the scenario COU-Win-W-2.

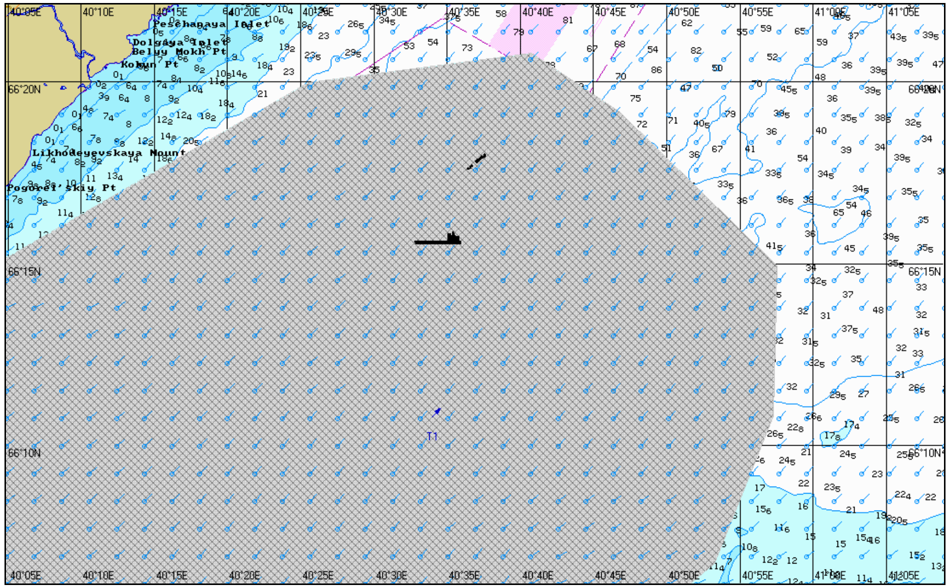


Figure 533. H+09:00. Oil slick spreading as per the scenario COU-Win-W-2.

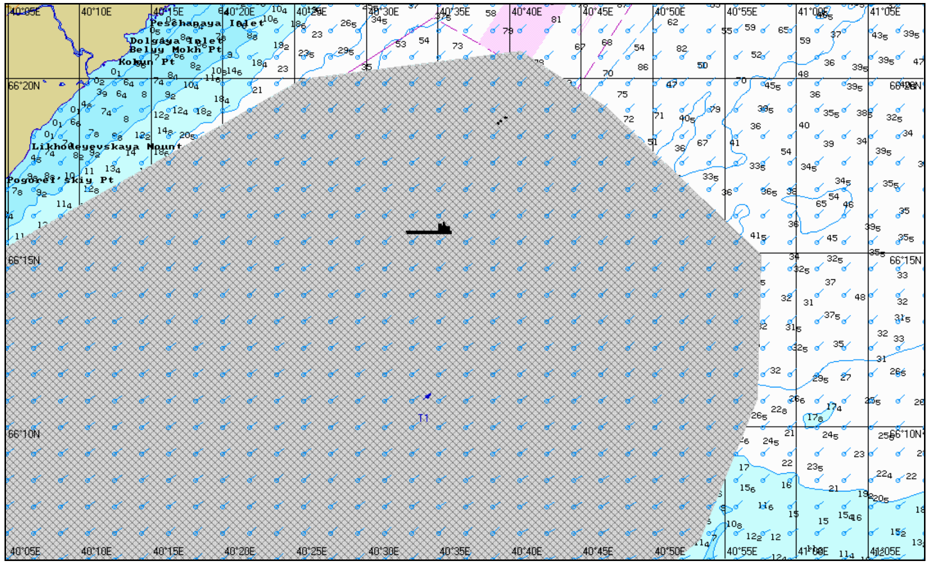


Figure 534. H+10:00. Oil slick spreading as per the scenario COU-Win-W-2.

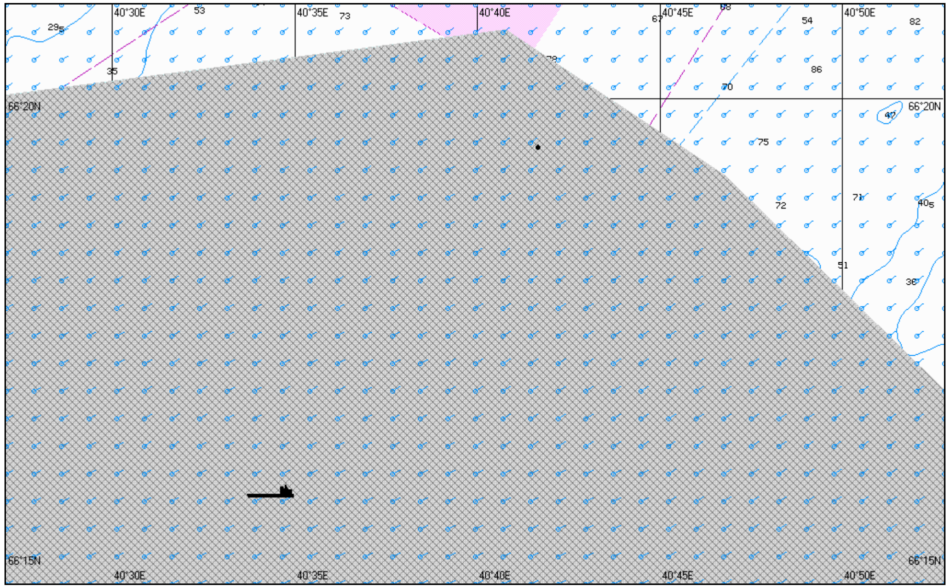


Figure 535. H+11:00. Oil slick spreading as per the scenario COU-Win-W-2.

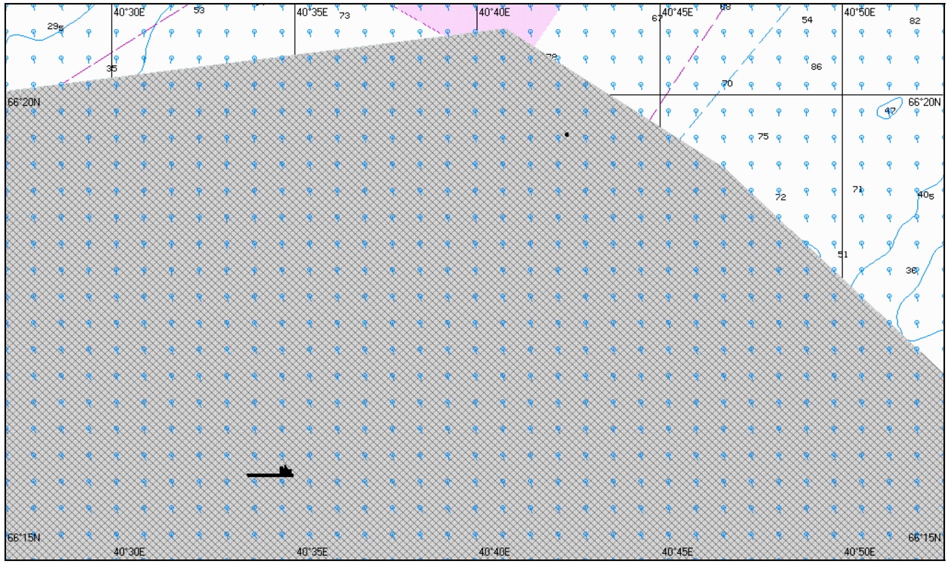


Figure 536. H+12:00. Oil slick spreading as per the scenario COU-Win-W-2.

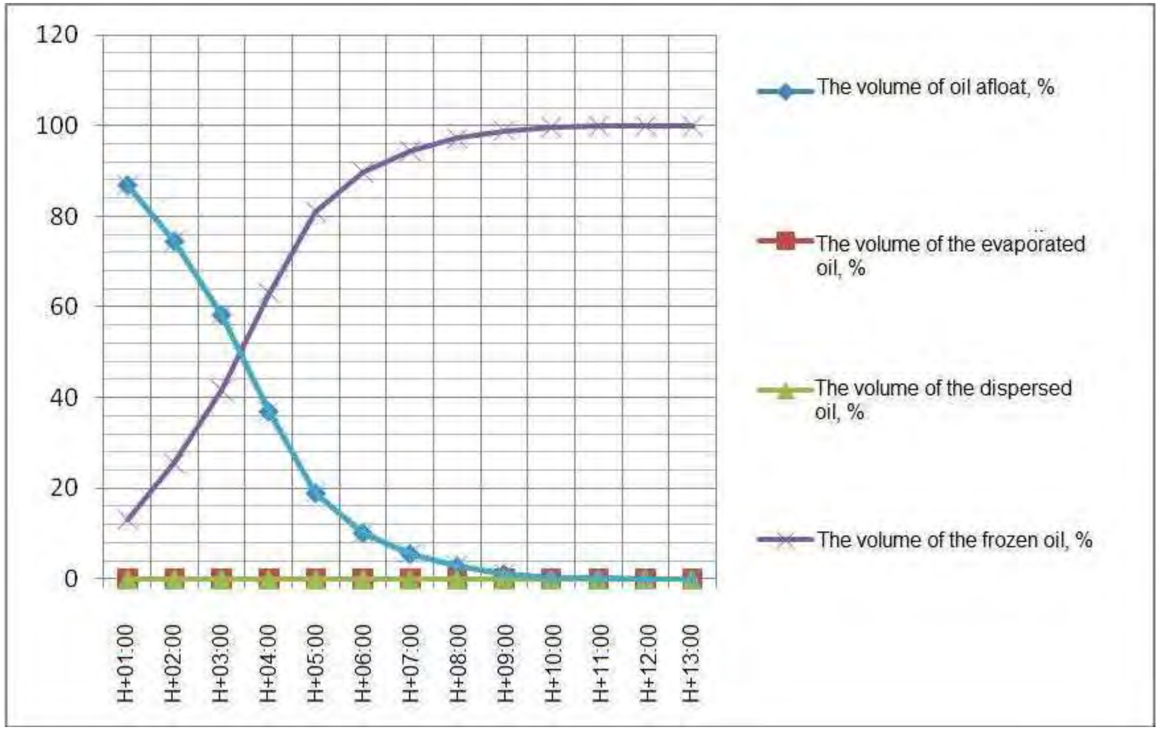


Figure 537. The chart of processes as per the scenario COU-Win-W-2.

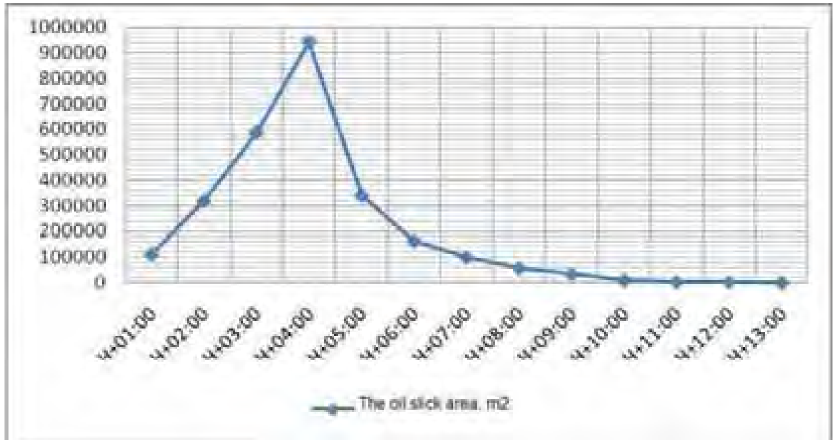


Figure 538. Oil slick area change dynamics as per the scenario COU-Win-W-2.

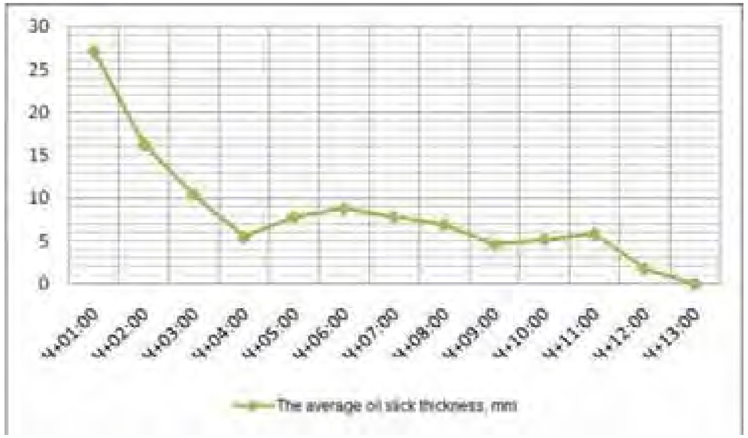


Figure 539. Oil slick thickness change dynamics as per the scenario COU-Win-W-2.

2.6.2 Oil slick behaviour modelling as per the scenario BO-Win-W-2

Table 2.5.2.1: Oil slick spreading parameters as per the scenario BO-Win-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3554	100	3164	89,0	0	0	0	0	390	11,0	3164	31,4	100670	21554
H+02:00	7136	100	5567	78,0	0	0	0	0	1569	22,0	5567	18,9	294651	21554
H+03:00	10683	100	6755	63,2	0	0	0	0	3928	36,8	6755	12,5	542168	21554
H+04:00	13977	100	6283	45,0	0	0	0	0	7694	55,0	6283	6,85	917233	21554
H+05:00	14000	100	2970	21,2	0	0	0	0	11032	78,8	2970	6,66	445642	21554
H+06:00	14000	100	1389	9,92	0	0	0	0	12613	90,1	1389	6,77	205252	21554
H+07:00	14000	100	645	4,61	0	0	0	0	13357	95,4	645	6,35	101654	21554
H+08:00	14000	100	292	2,09	0	0	0	0	13710	97,9	292	5,69	51296	21554
H+09:00	14000	100	106	0,76	0	0	0	0	13896	99,3	106	5,66	18738	21554
H+10:00	14000	100	40,4	0,29	0	0	0	0	13962	99,7	40,4	4,17	9684	21554
H+11:00	14000	100	13,3	0,10	0	0	0	0	13989	99,9	13,3	4,54	2932	21554
H+12:00	14000	100	0	0	0	0	0	0	13990	99,9	0	0	0	21554

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1697 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 55%, the average thickness of the free floating oil – 6,85 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 803 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 90,1%, the average thickness of the free floating oil – 6,77 mm. After 8 hours as of the OS start the floating oil slick semi-perimeter makes 401 m, the evaporation and dispersion processes are not detected by the programme, the volume of the frozen oil – 97,9%. To the moment of modelling completion (12 hours) oil spreading on water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 2,7 km^2.
The graphic display of oil slick spreading as per the scenario BO-Win-W-2 is show nin figures 540 – 551.
The charts of processes typical for black oil behavior on water are shown in figures 552-554.

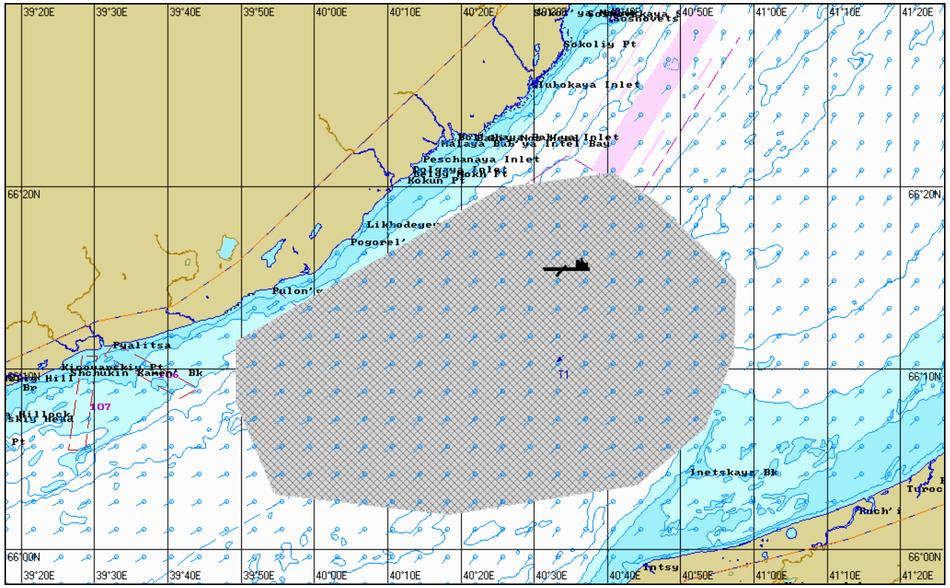


Figure 540. H+01:00. Oil slick spreading as per the scenario BO-Win-W-2.

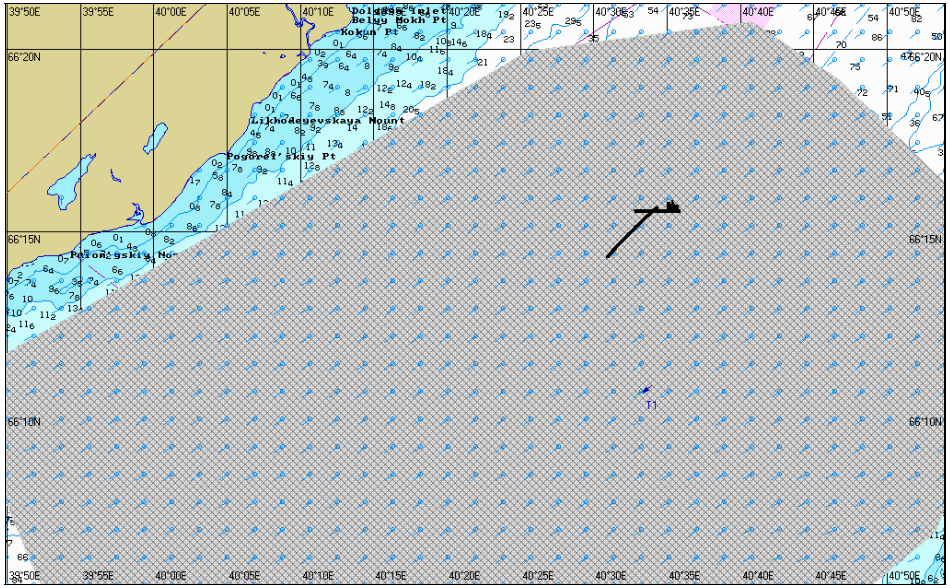


Figure 541. H+02:00. Oil slick spreading as per the scenario BO-Win-W-2.

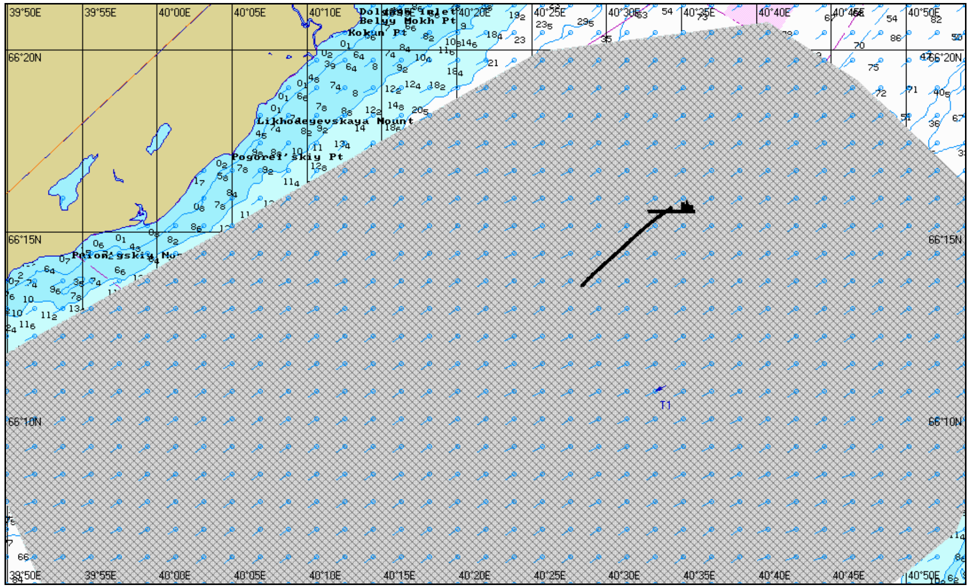


Figure 542. H+03:00. Oil slick spreading as per the scenario BO-Win-W-2.

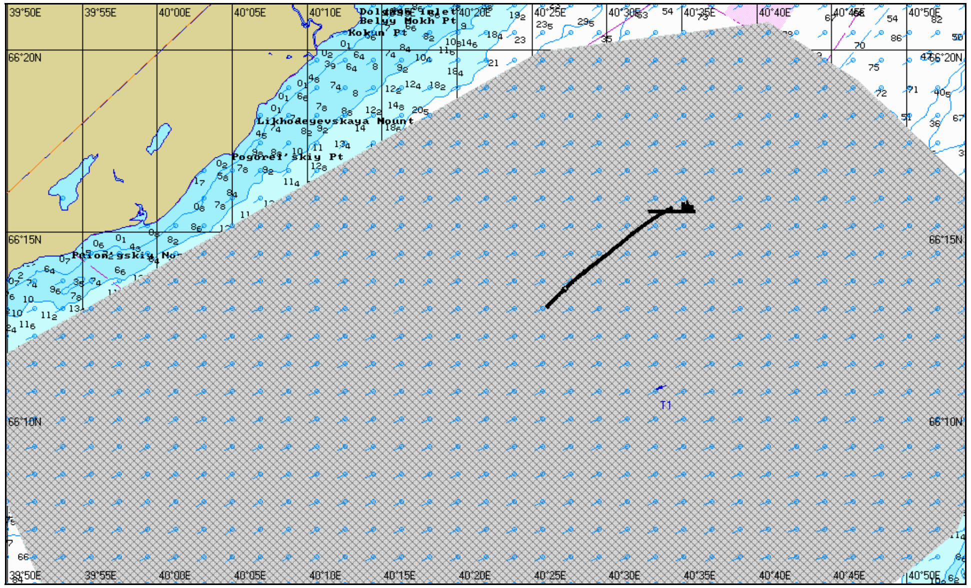


Figure 543. H+04:00. Oil slick spreading as per the scenario BO-Win-W-2.

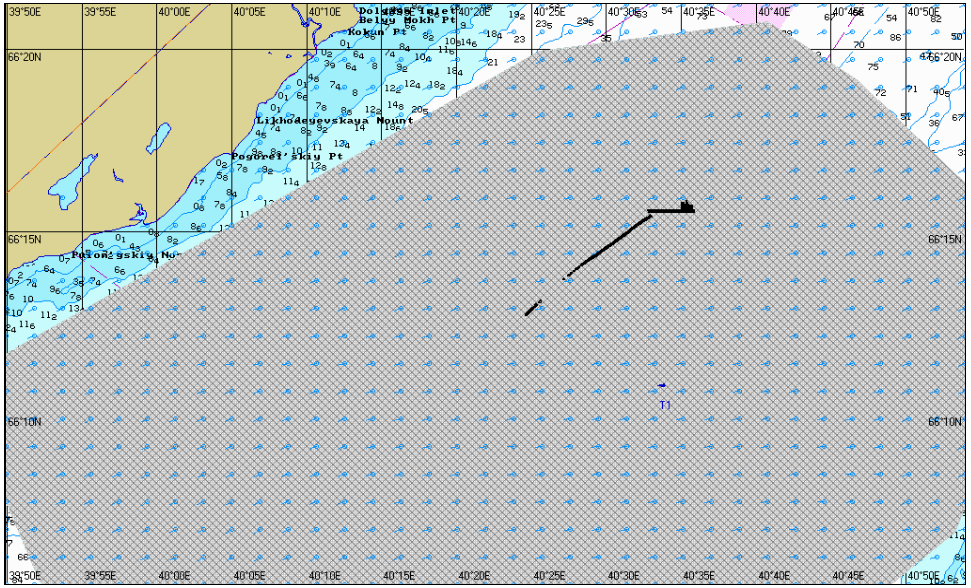


Figure 544. H+05:00. Oil slick spreading as per the scenario BO-Win-W-2.

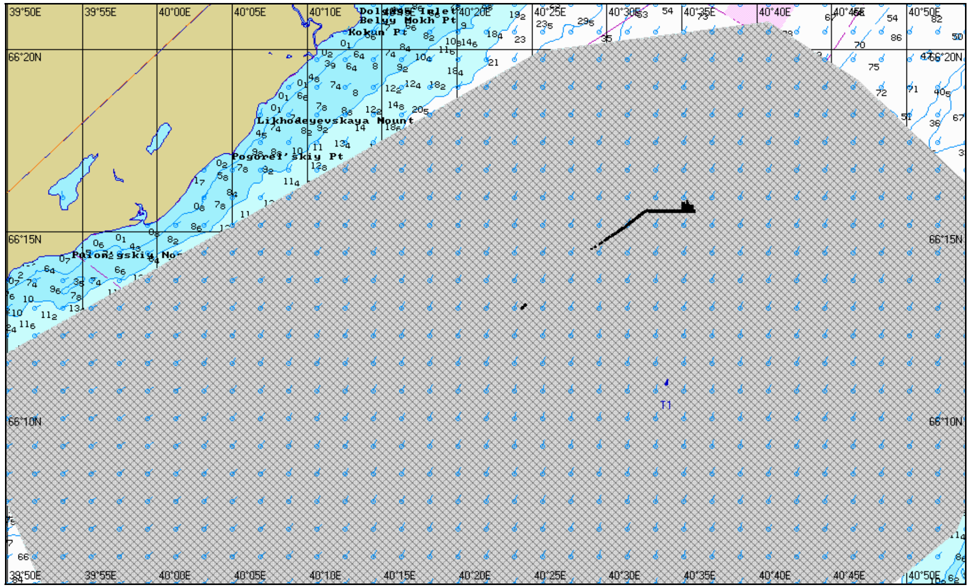


Figure 545. H+06:00. Oil slick spreading as per the scenario BO-Win-W-2.

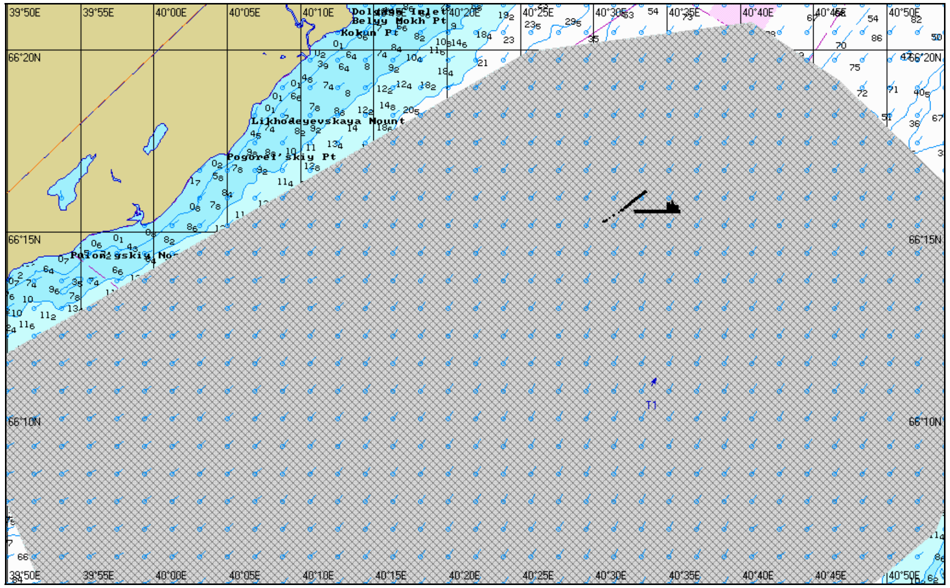


Figure 546. H+07:00. Oil slick spreading as per the scenario BO-Win-W-2.

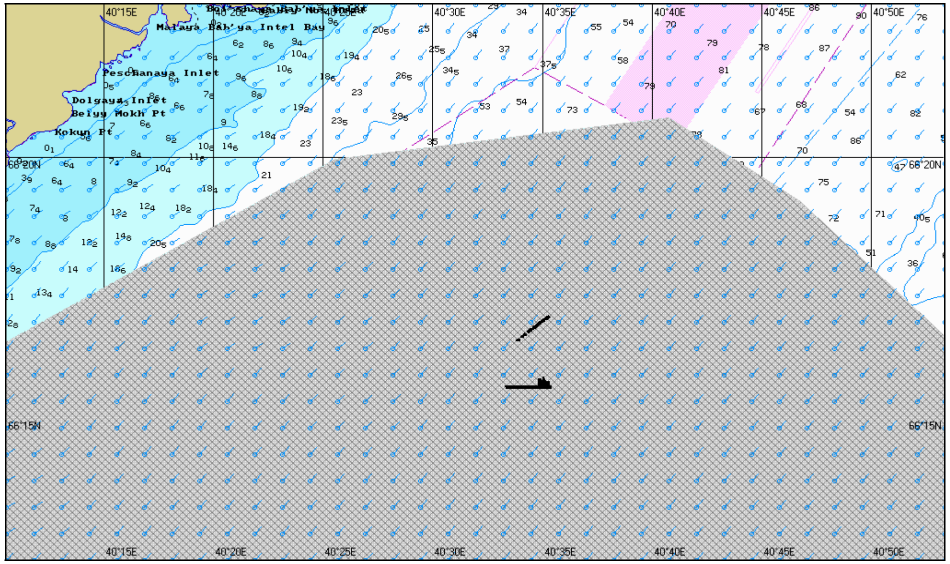


Figure 547. H+08:00. Oil slick spreading as per the scenario BO-Win-W-2.

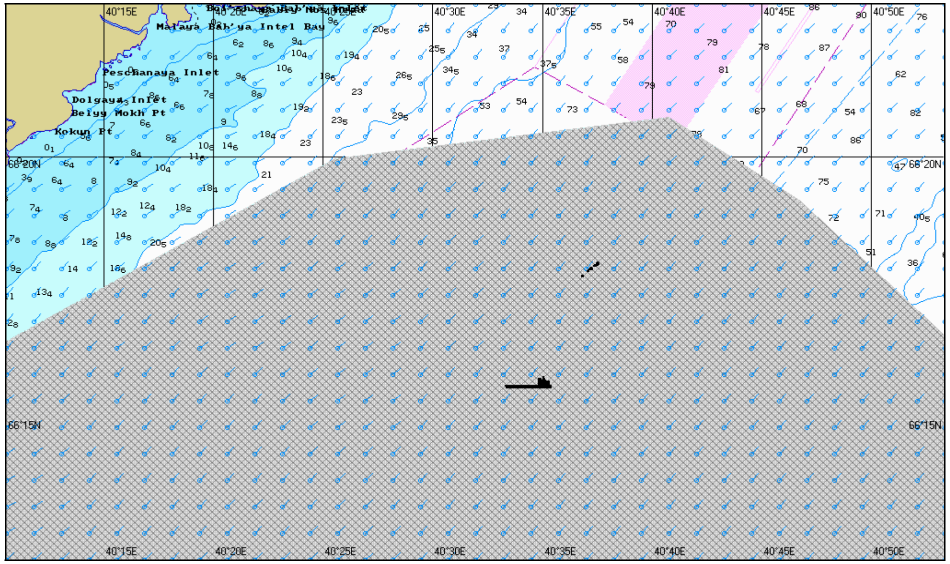


Figure 548. H+09:00. Oil slick spreading as per the scenario BO-Win-W-2.

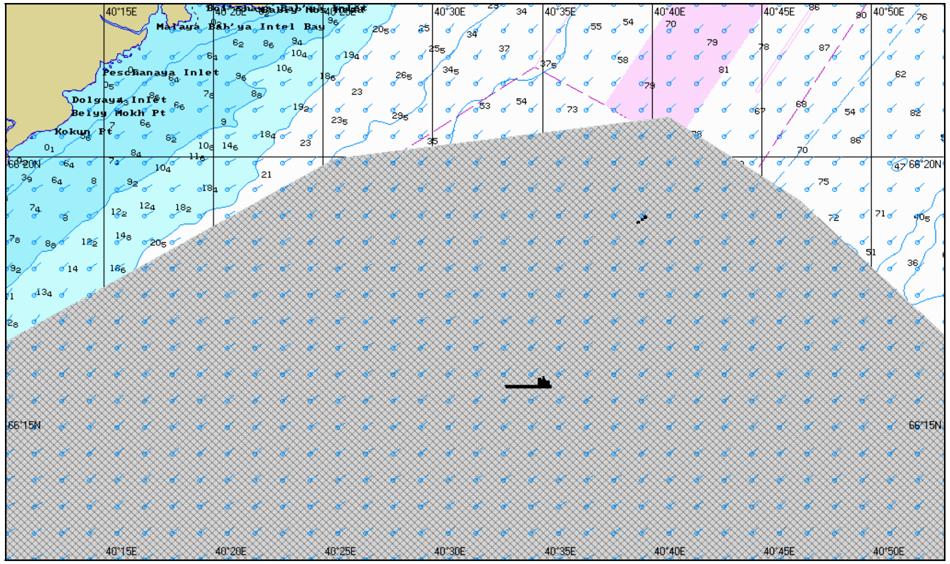


Figure 549. H+10:00. Oil slick spreading as per the scenario BO-Win-W-2.

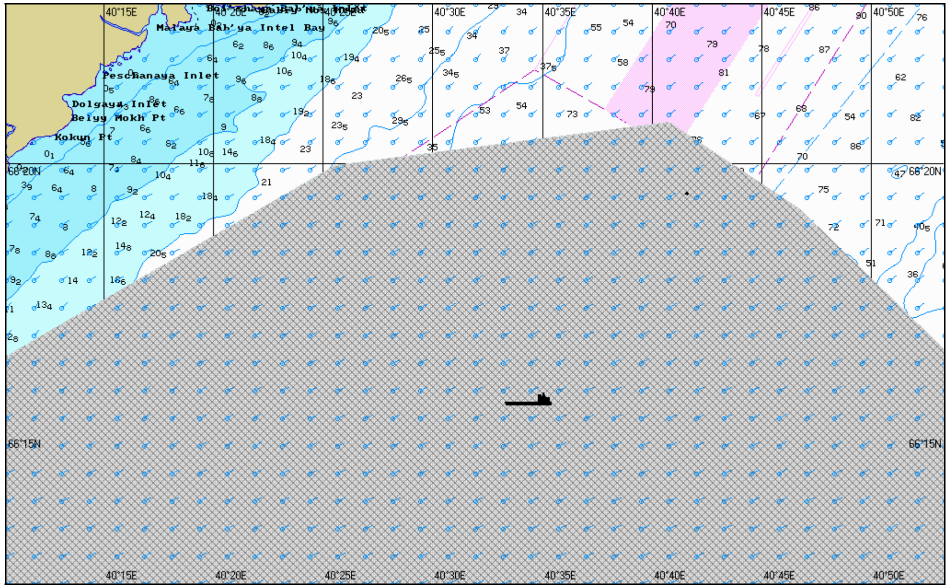


Figure 550. H+11:00. Oil slick spreading as per the scenario BO-Win-W-2.

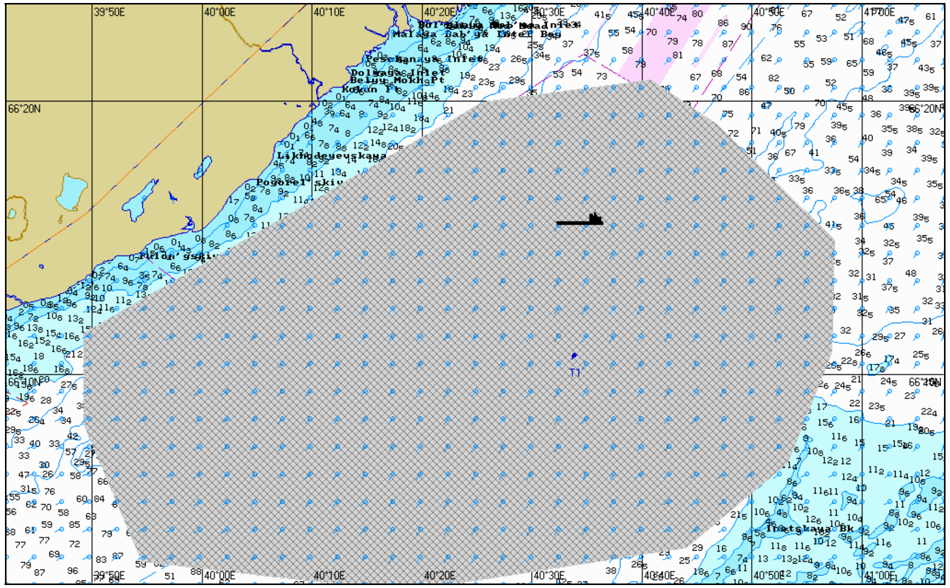


Figure 551. H+12:00. Oil slick spreading as per the scenario BO-Win-W-2.

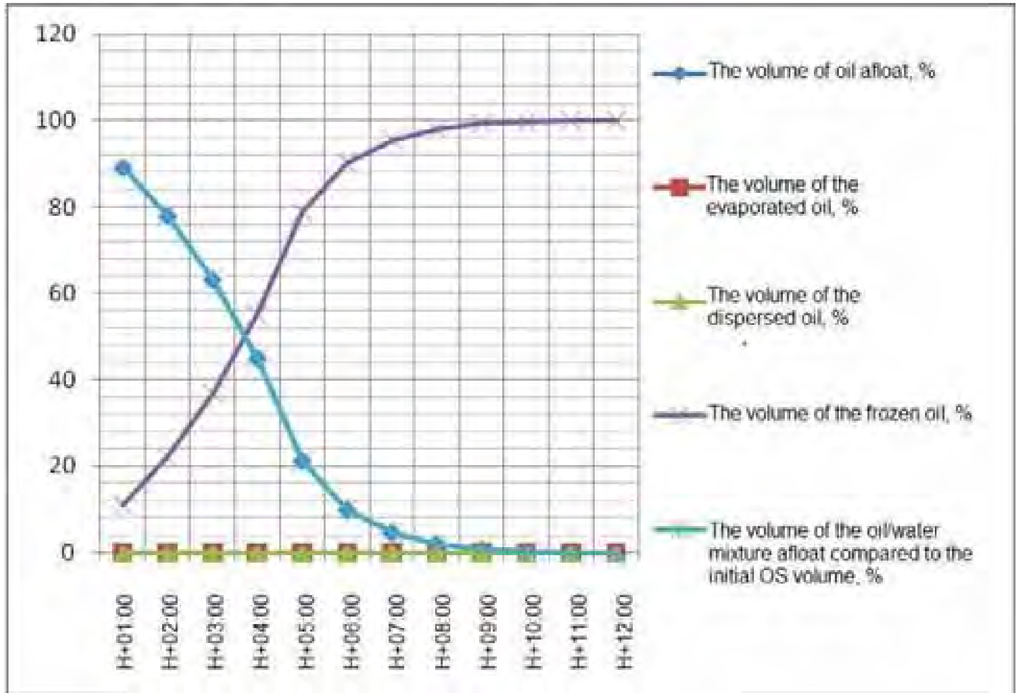


Figure 552. The chart of processes as per the scenario BO-Win-W-2.

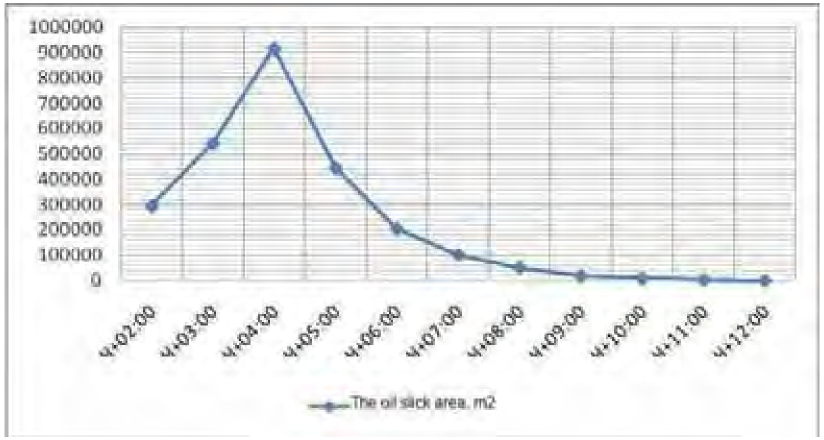


Figure 553. Oil slick area change dynamics as per the scenario BO-Win-W-2.

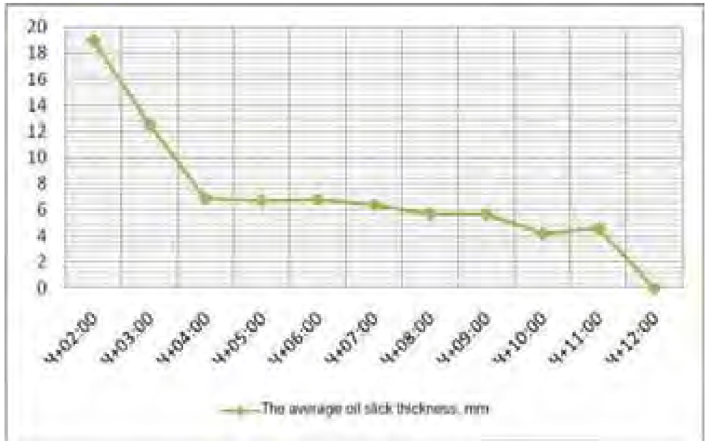


Figure 554. Oil slick thickness change dynamics as per the scenario BO-Win-W-2.

2.6.3 Oil slick behaviour modelling as per the scenario GC-Win-W-2

Table 2.5.3.1: Oil slick spreading parameters as per the scenario GC-Win-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil / water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	3660	100	3062	83,7	89,1	2,43	115	3,14	394	10,8	5062	37,5	135095	10,7
H+02:00	7280	100	5332	73,2	343	4,71	296	4,07	1309	18,0	11669	30,4	384279	28,8
H+03:00	10827	100	6693	61,8	809	7,47	485	4,48	2840	26,2	16515	24,0	689356	52,3
H+04:00	13978	100	6950	49,7	1453	10,4	656	4,69	4918	35,2	18210	18,5	983292	81,6
H+05:00	14000	100	4651	33,2	1994	14,2	704	5,03	6651	47,5	14495	16,1	898397	187
H+06:00	14000	100	2892	20,7	2372	16,9	715	5,11	8021	57,3	9495	12,1	785667	278
H+07:00	14000	100	1571	11,2	2611	18,7	721	5,15	9097	65,0	5219	9,53	547679	337
H+08:00	14000	100	845	6,04	2732	19,5	724	5,17	9699	69,3	2815	12,3	229022	369
H+09:00	14000	100	479	3,42	2793	20,0	726	5,19	10002	71,4	1596	10,2	156829	383
H+10:00	14000	100	233	1,66	2829	20,2	728	5,20	10210	72,9	776	7,33	105831	391
H+11:00	14000	100	87,2	0,62	2847	20,3	728	5,20	10337	73,8	291	6,04	48157	394
H+12:00	14000	100	34,7	0,25	2854	20,4	728	5,20	10384	74,2	116	4,87	23798	394
H+13:00	14000	100	8,2	0,06	2856	20,4	728	5,20	10407	74,3	27,4	2,85	9599	392
H+13:30	14000	100	0	0	2857	20,4	728	5,20	10415	74,4	0	0	0	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1757 m, the volume of the evaporated oil – 10,4%, the volume of the dispersed oil – 4,69%, the volume of the frozen oil – 35%, the average thickness of the free floating oil – 18,5 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 1571 m, the volume of the evaporated oil – 16,9%, the volume of the dispersed oil – 5,11%, the volume of the frozen oil – 57,3%, the average thickness of the free floating oil – 12,1 mm. After 8 hours ass of the OS start the floating oil slick semi-perimeter makes 848 m, the volume of the evaporated oil – 19,5%, the volume of the dispersed oil – 5,17%, the volume of the frozen oil – 69,3%, the average thickness of the free floating oil – 12,3 mm. To the moment of modelling completion (13 hours and 30 minutes) oil spreading on water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 5 km^2.

The graphic display of oil slick spreading as per the scenario GC-Win-W-2 is shown in figures 555 – 568.

The charts of processes typical for SGC behavior on water are shown in figures 569-571.

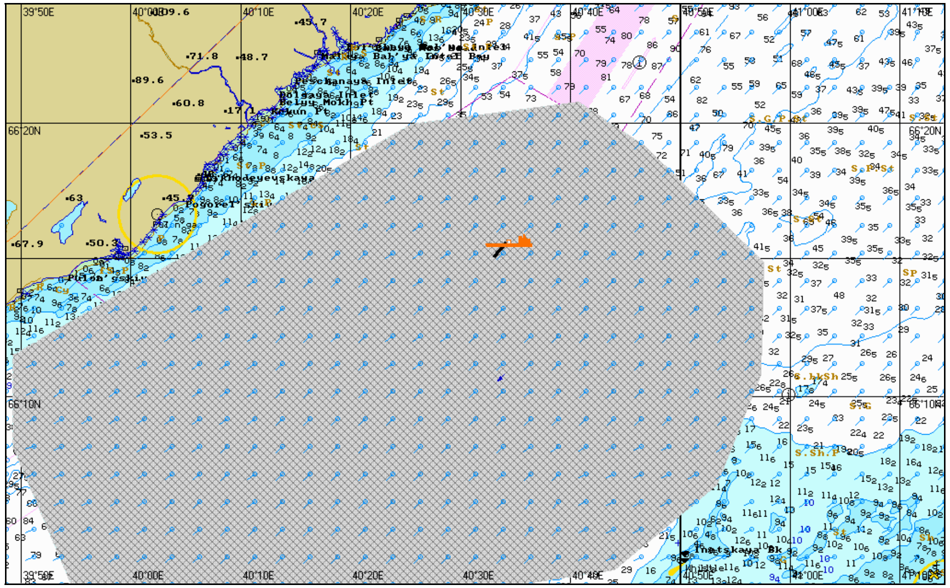


Figure 555. H+01:00. Oil slick spreading as per the scenario GC-Win-W-2.

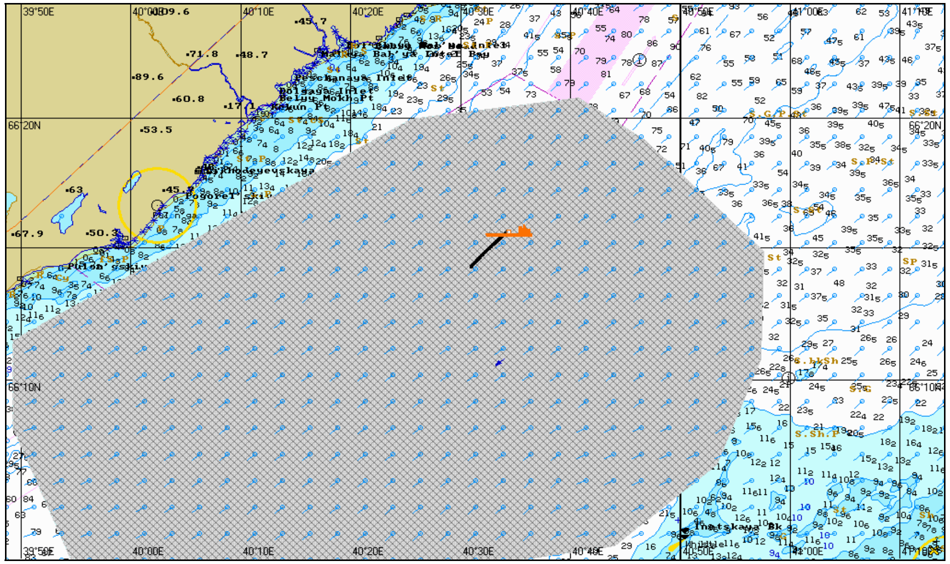


Figure 556. H+02:00. Oil slick spreading as per the scenario GC-Win-W-2.

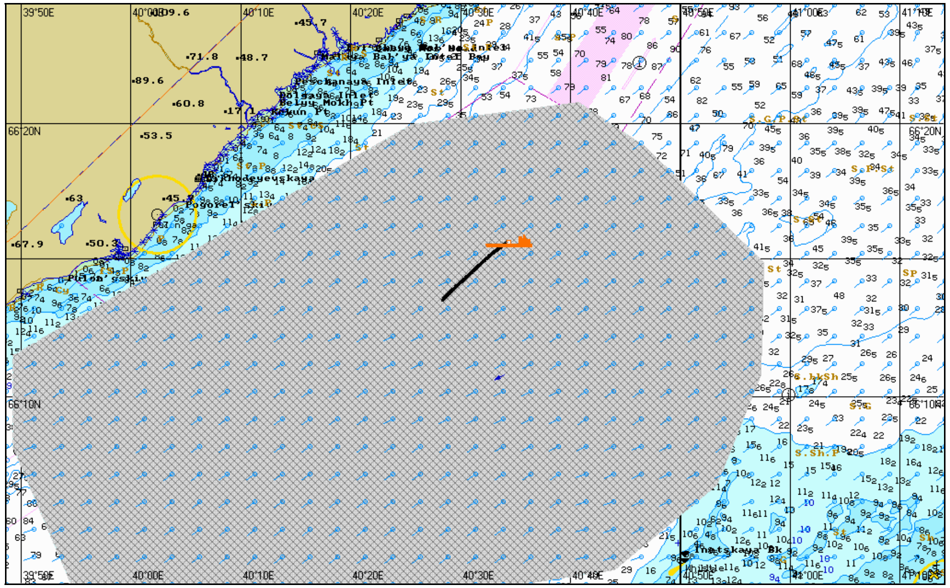


Figure 557. H+03:00. Oil slick spreading as per the scenario GC-Win-W-2.

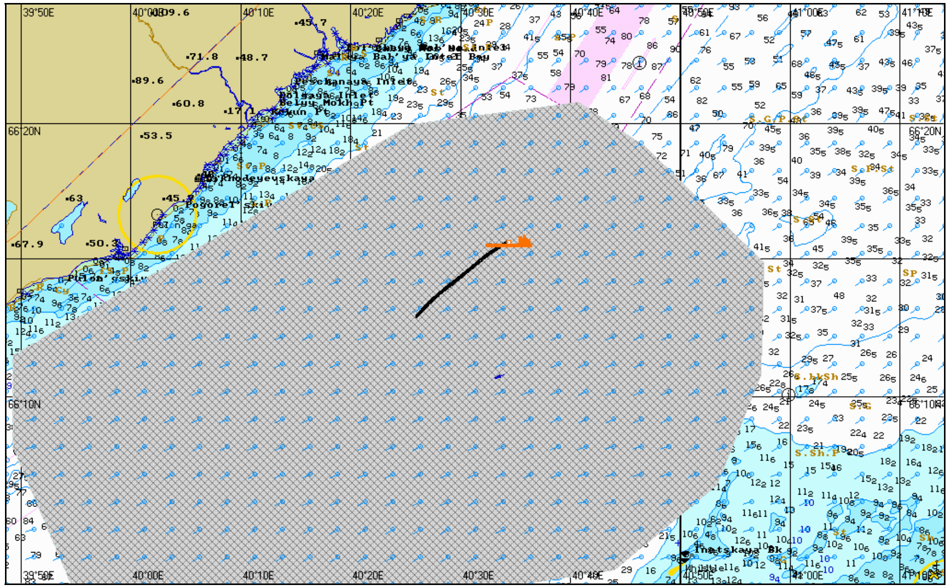


Figure 558. H+04:00. Oil slick spreading as per the scenario GC-Win-W-2.

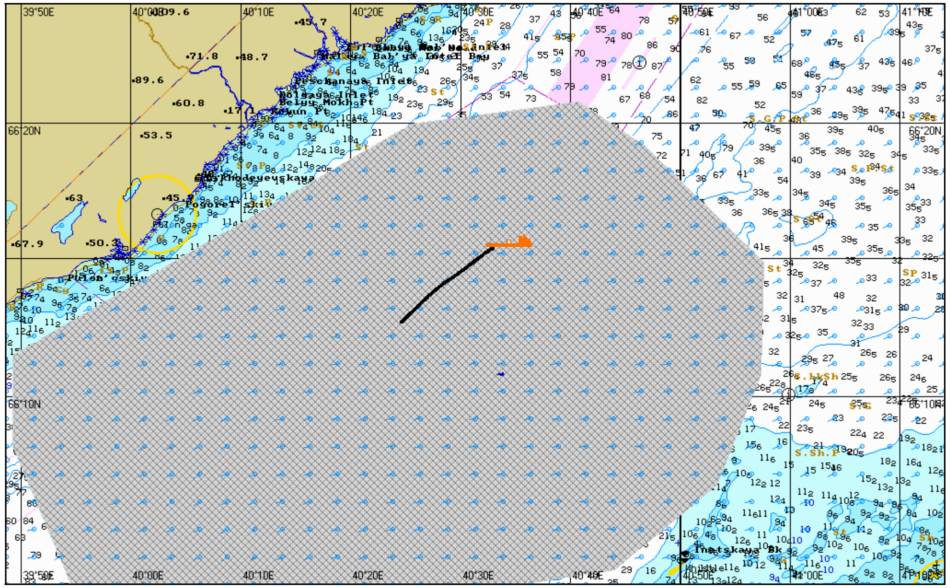


Figure 559. H+05:00. Oil slick spreading as per the scenario GC-Win-W-2.

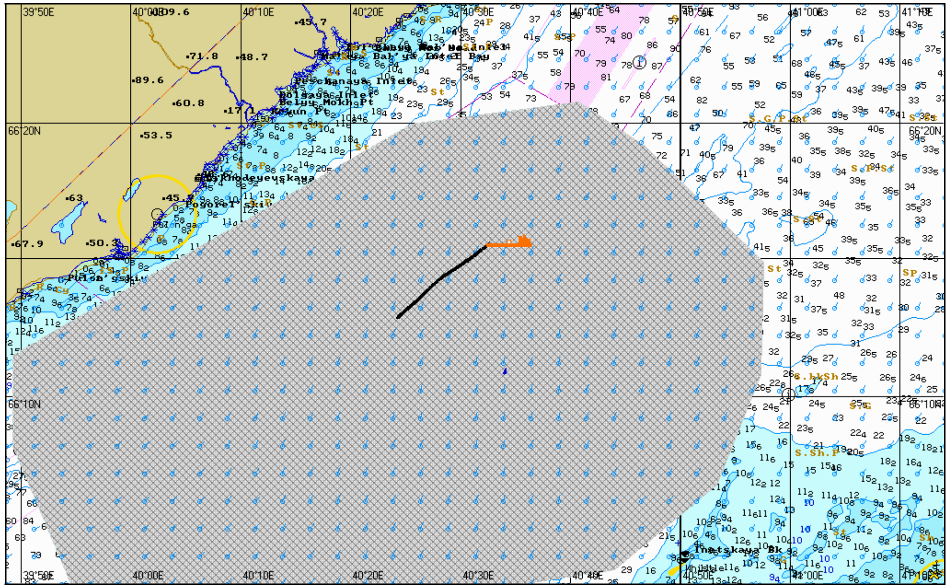


Figure 560. H+06:00. Oil slick spreading as per the scenario GC-Win-W-2.

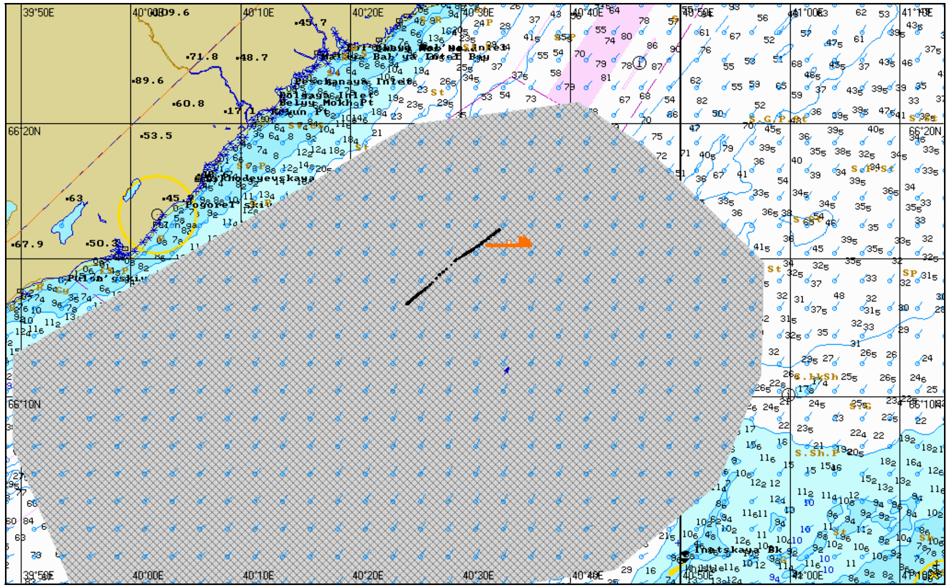


Figure 561. H+07:00. Oil slick spreading as per the scenario GC-Win-S-2.

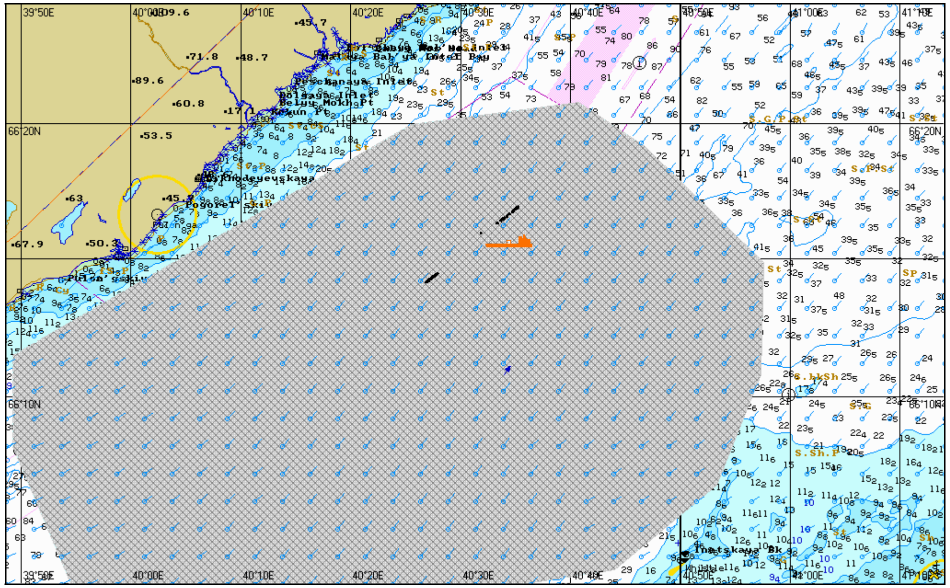


Figure 562. H+08:00. Oil slick spreading as per the scenario GC-Win-W-2.

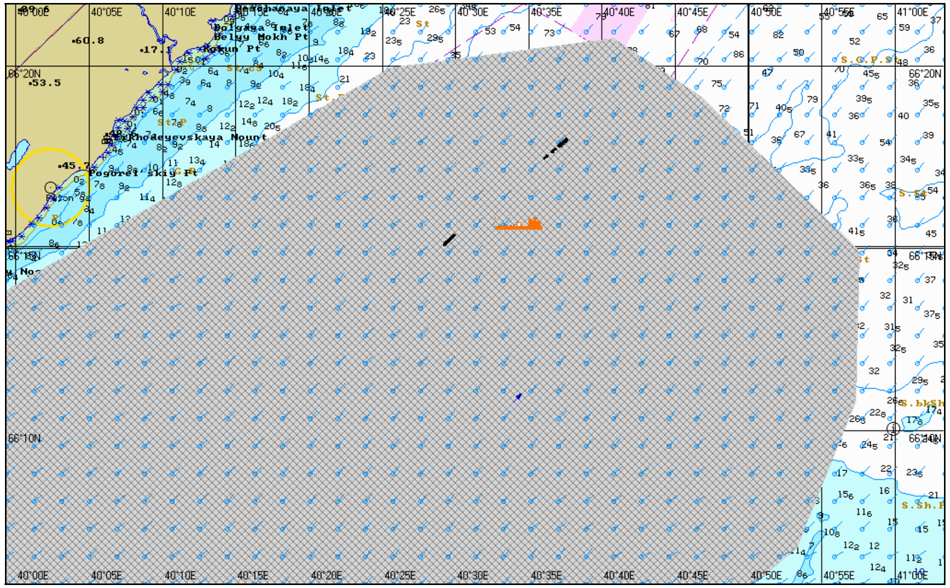


Figure 563. H+09:00. Oil slick spreading as per the scenario GC-Win-W-2.

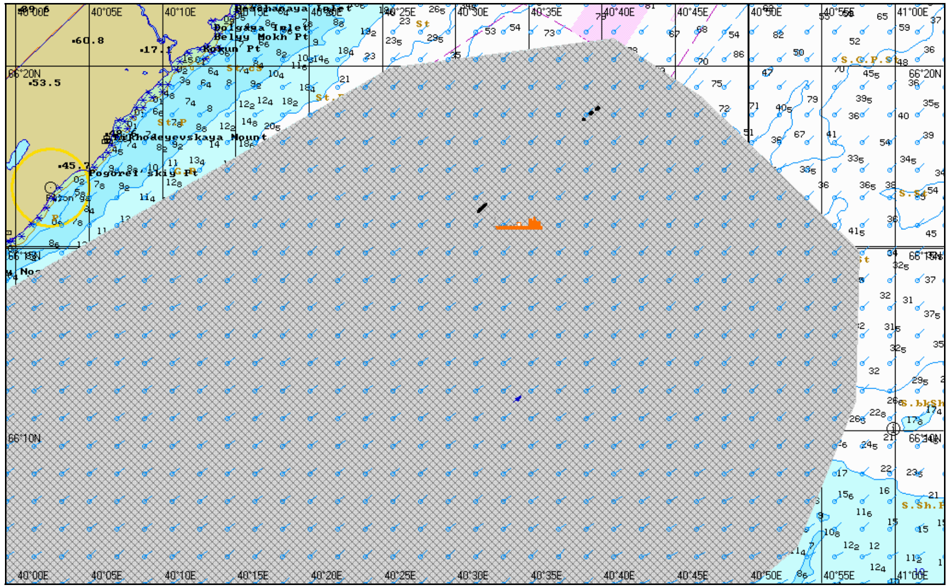


Figure 564. H+10:00. Oil slick spreading as per the scenario GC-Win-W-2.

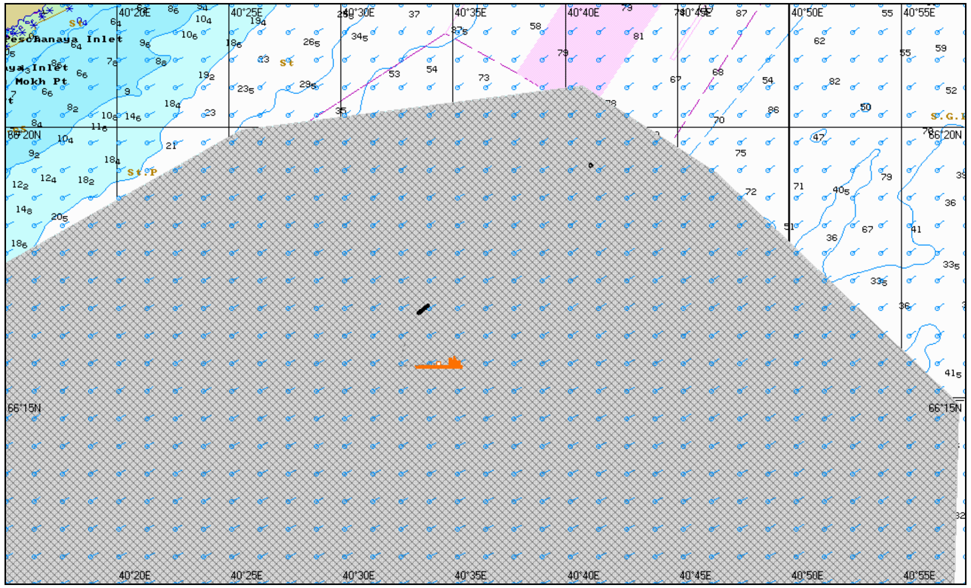


Figure 565. H+11:00. Oil slick spreading as per the scenario GC-Win-W-2.

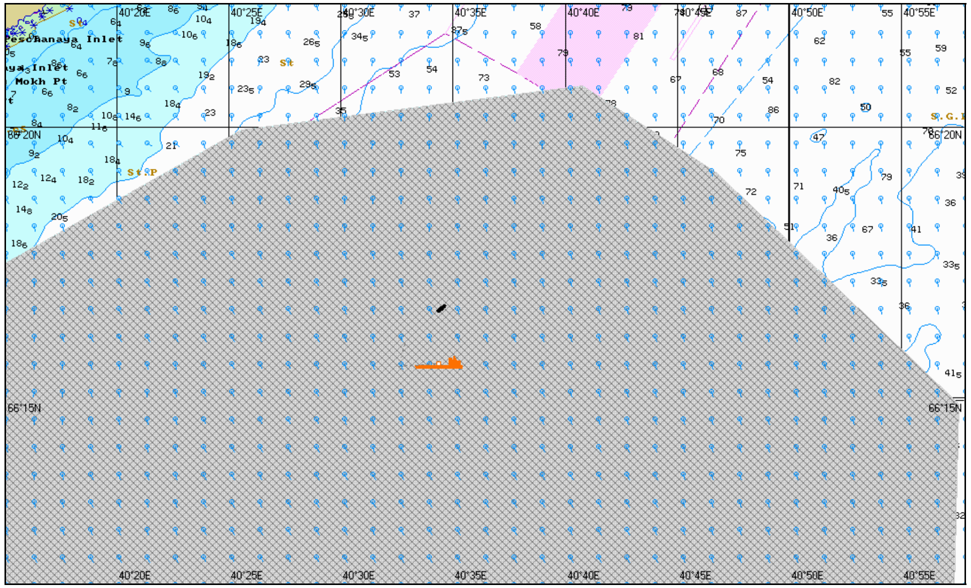


Figure 566. H+12:00. Oil slick spreading as per the scenario GC-Win-W-2.

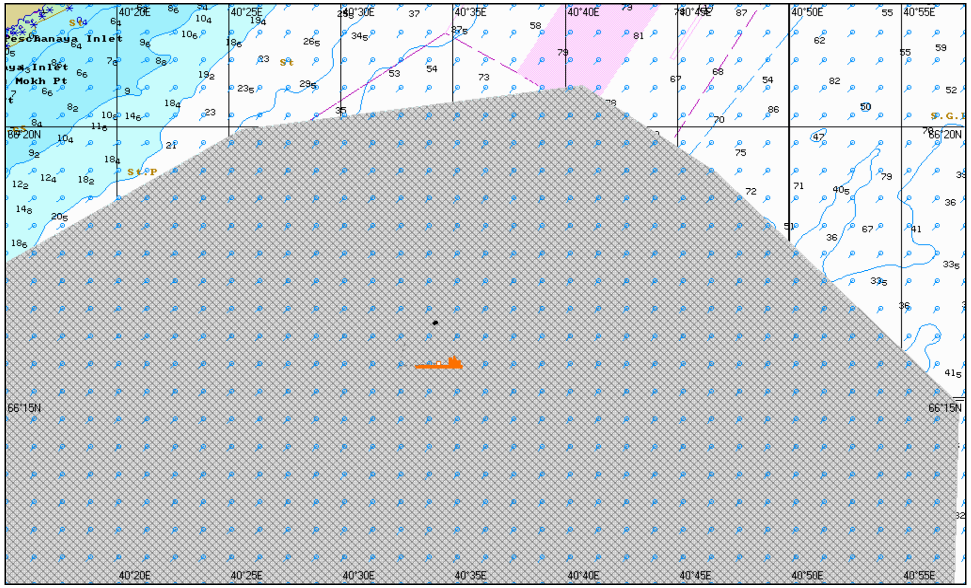


Figure 567. H+13:00. Oil slick spreading as per the scenario GC-Win-W-2.

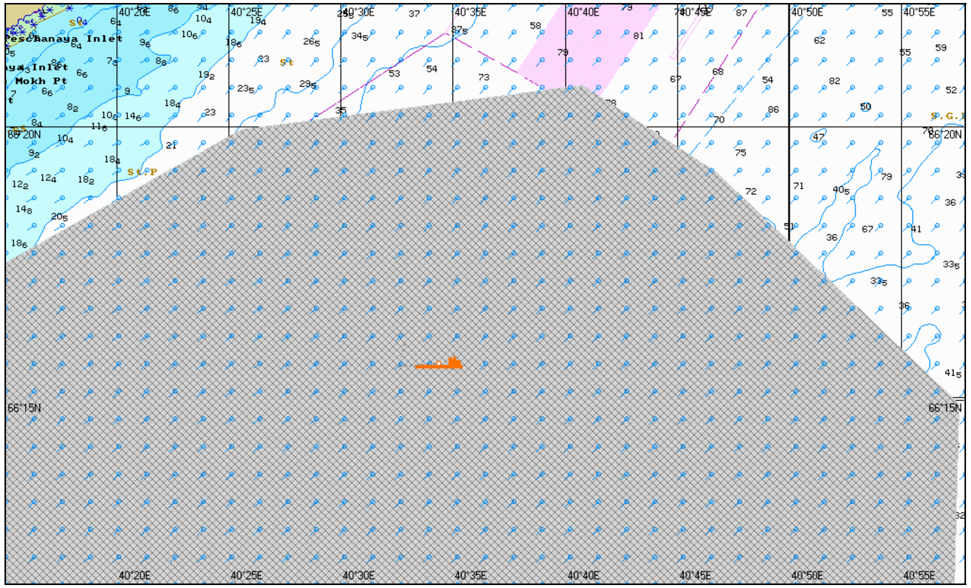


Figure 568. H+13:30. Oil slick spreading as per the scenario GC-Win-W-2.

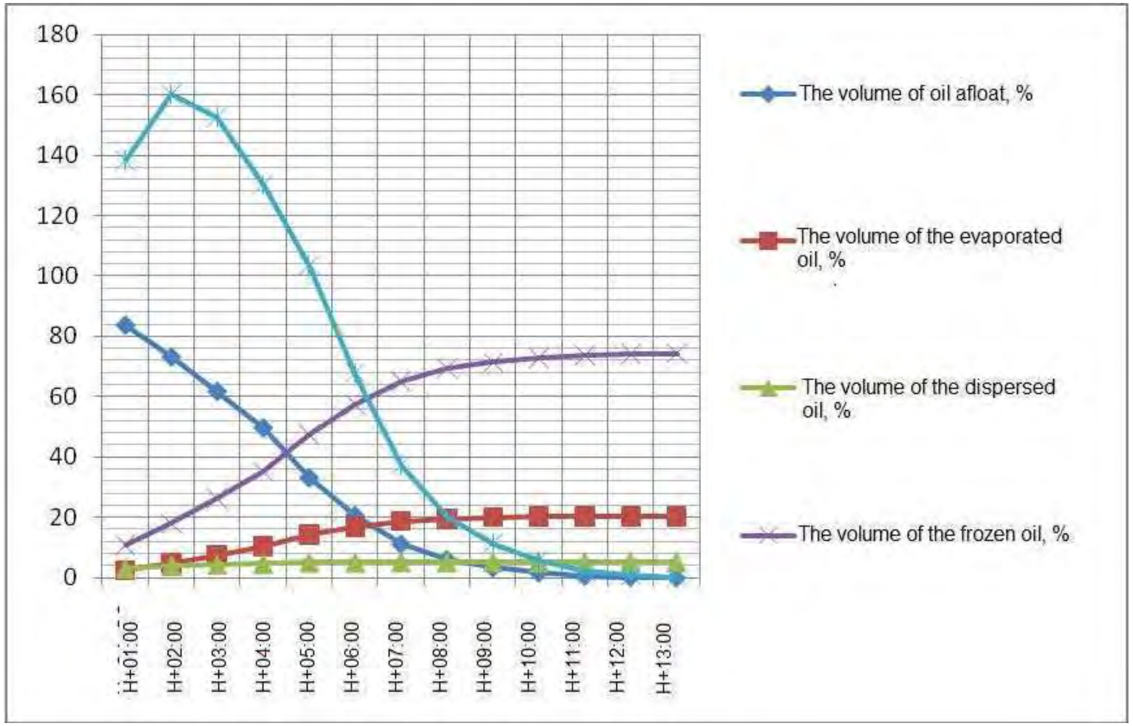


Figure 569. The chart of processes as per the scenario GC-Win-S-2.

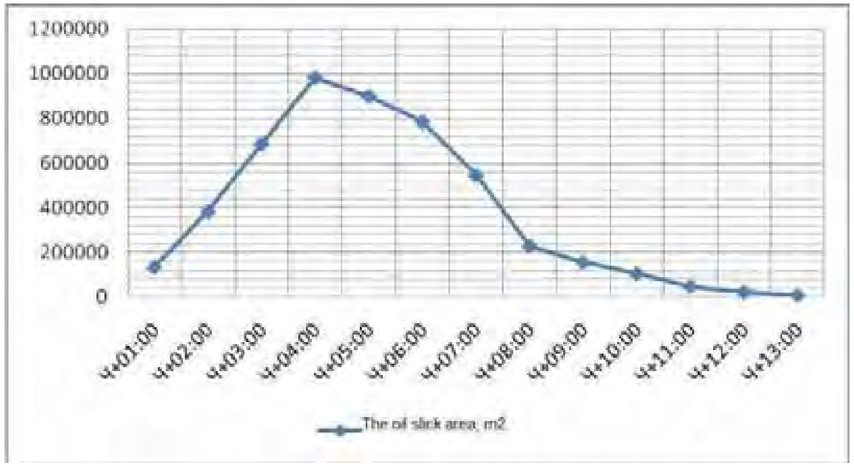


Figure 570. Oil slick area change dynamics as per the scenario GC-Win-W-2.

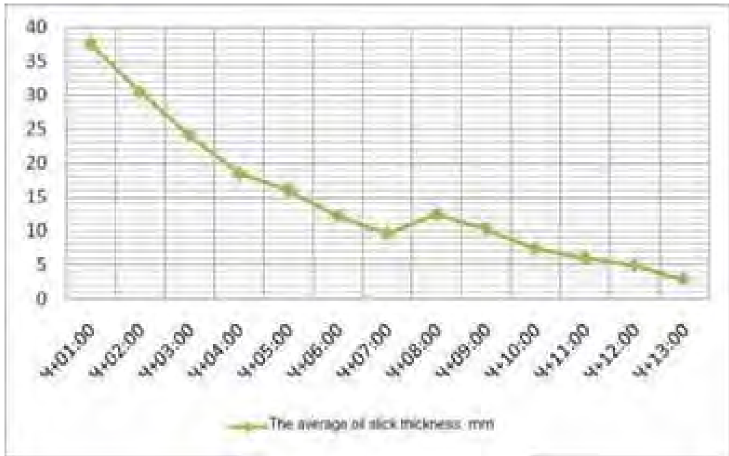


Figure 571. Oil slick thickness change dynamics as per the scenario GC-Win-S-2.

2.6.4 Oil slick behaviour modelling as per the scenario Na-Win-W-2

Table 2.5.4.1: Oil slick spreading parameters as per the scenario Na-Win-W-2

Modelling interval	Oil spill volume		Oil volume afloat		Evaporated oil volume		Dispersed oil volume		Frozen oil volume		Oil/water mixture volume afloat	Average slick thickness	Oil slick area	Viscosity
Units	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3	mm	m^2	cSt
H+01:00	2346	100	1667	71,1	212	9,04	23,5	1,00	443	18,9	2139	13,9	153454	5,2
H+02:00	4811	100	2174	45,2	764	15,9	66,0	1,37	1807	37,6	2857	6,59	433661	10,8
H+03:00	7513	100	1973	26,3	1461	19,4	119	1,58	3960	52,7	2541	6,11	415634	14,7
H+04:00	10000	100	1934	19,3	2104	21,0	173	1,73	5790	57,9	2534	6,44	393482	18,1
H+05:00	10000	100	472	4,72	2445	24,5	199	1,99	6884	68,8	674	3,46	194879	31,1
H+06:00	10000	100	12,5	0,13	2522	25,2	205	2,05	7261	72,6	17,9	0,72	24929	33,0
H+09:00	10000	100	0,0	0	2524	25,2	205	2,05	7272	72,7	0	-	-	-

Within the first 4 hours as of the OS start the oil slick spreads south-westward of the OS point under the action of the wind and current. After 4 hours as of the OS start the oil slick semi-perimeter makes 1112 m, the volume of the evaporated oil – 21%, the volume of the dispersed oil – 1,73%, the volume of the frozen oil – 57,9%, the average thickness of the free floating oil – 6,44 mm. Further the oil slick drifts north-eastward. After 6 hours as of the OS start the floating oil slick semi-perimeter makes 280 m, the volume of the evaporated oil – 25,2%, the volume of the dispersed oil – 2,05%, the volume of the frozen oil – 72,6%, the average thickness of the free floating oil – 0,72 mm. To the moment of modelling completion (9 hours) oil spreading on water surface stops, the programme detects 100% of the frozen oil. The area of the polluted ice field makes about 1,6 km^2.

The graphic display of oil slick spreading as per the scenario Na-Win-W-2 is shown in figures 572 – 578.

The charts of processes typical for naphtha behavior on water are shown in figures 579-581.

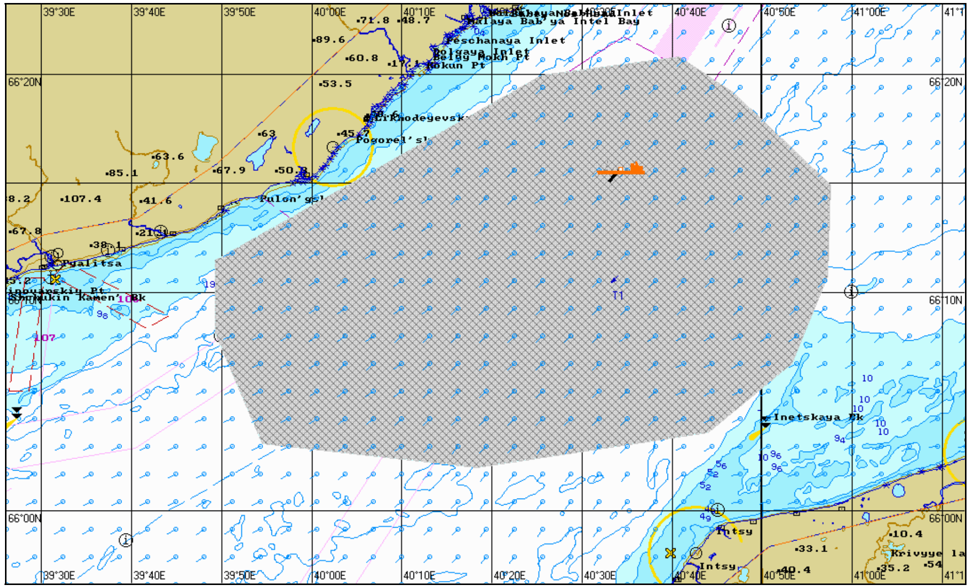


Figure 572. H+01:00. Oil slick spreading as per the scenario Na-Win-W-2.

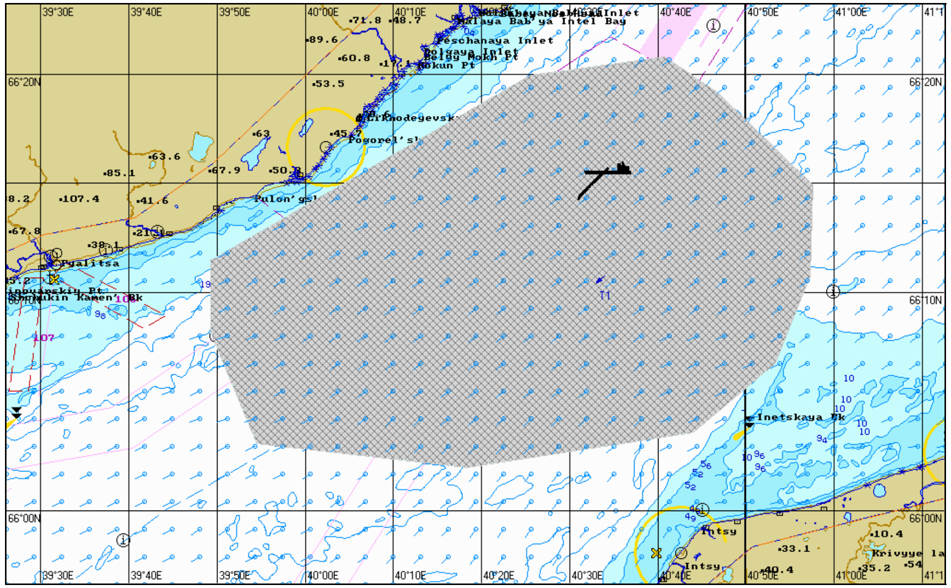


Figure 573. H+02:00. Oil slick spreading as per the scenario Na-Win-W-2.

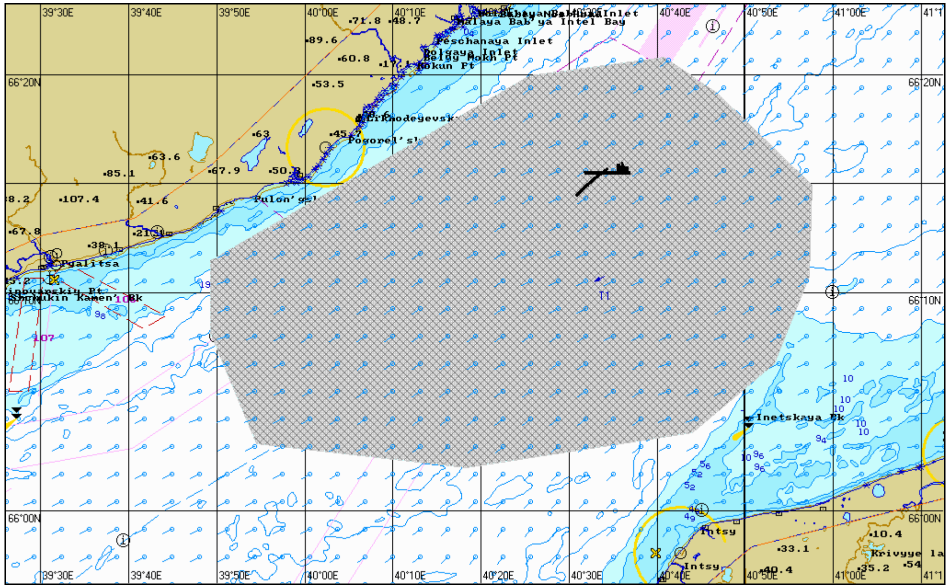


Figure 574. H+03:00. Oil slick spreading as per the scenario Na-Win-W-2.

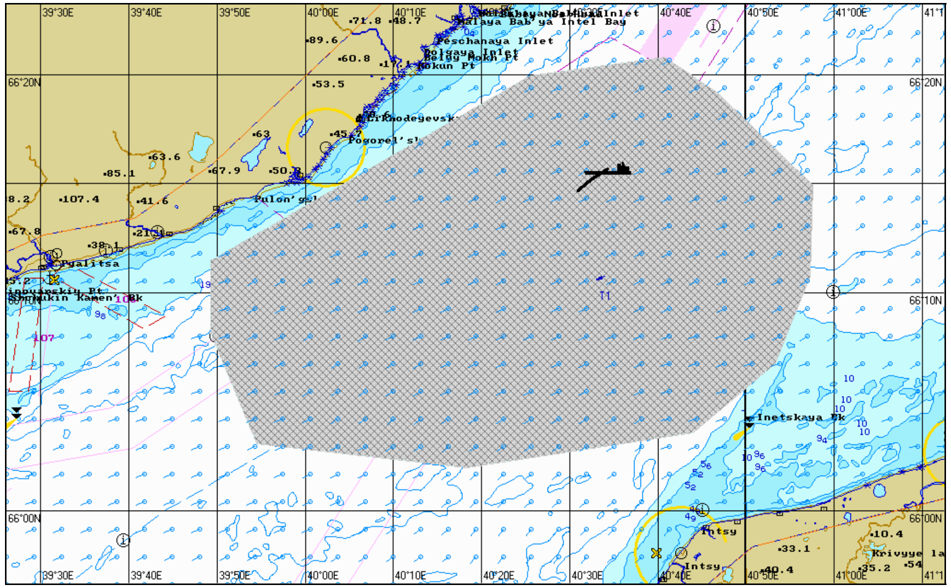


Figure 575. H+04:00. Oil slick spreading as per the scenario Na-Win-W-2.

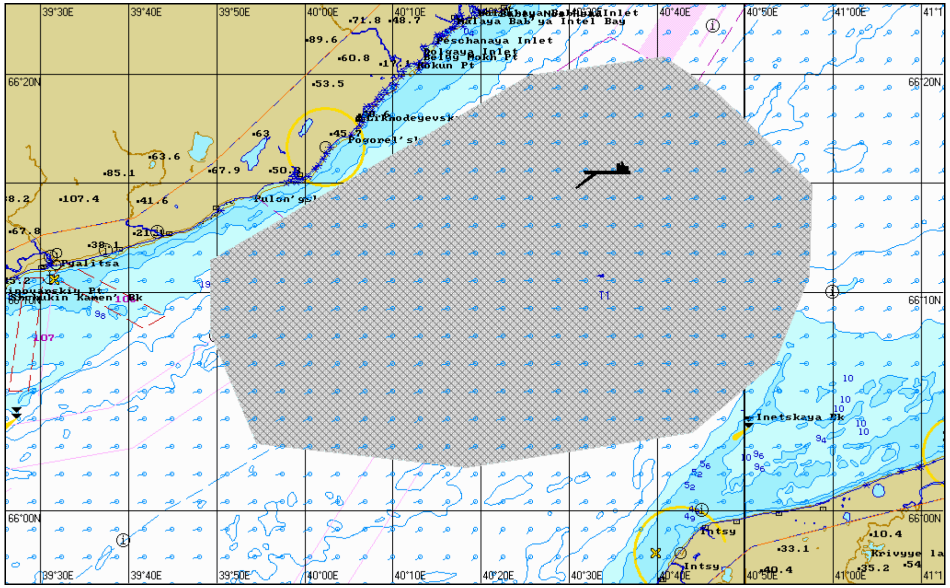


Figure 576. H+05:00. Oil slick spreading as per the scenario Na-Win-W-2.

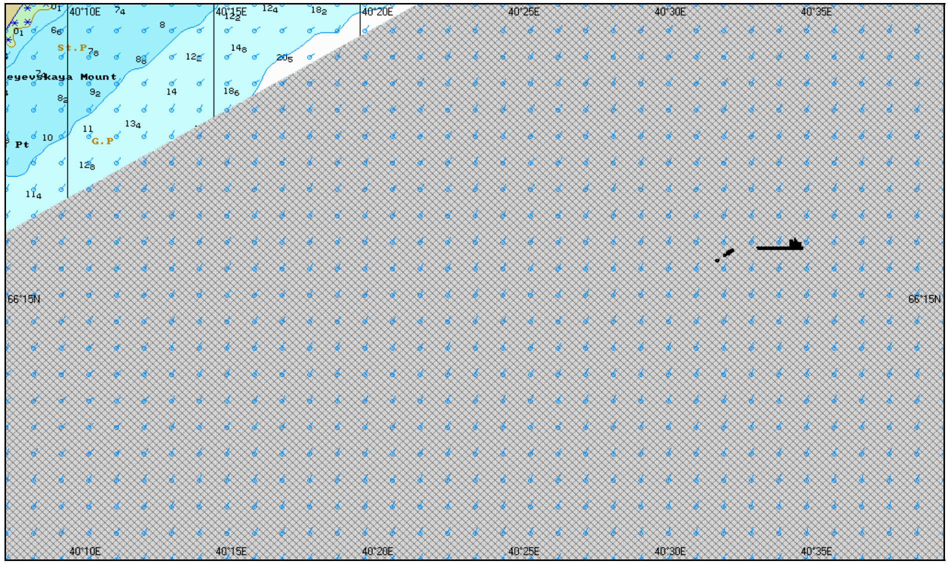


Figure 577. H+06:00. Oil slick spreading as per the scenario Na-Win-W-2.

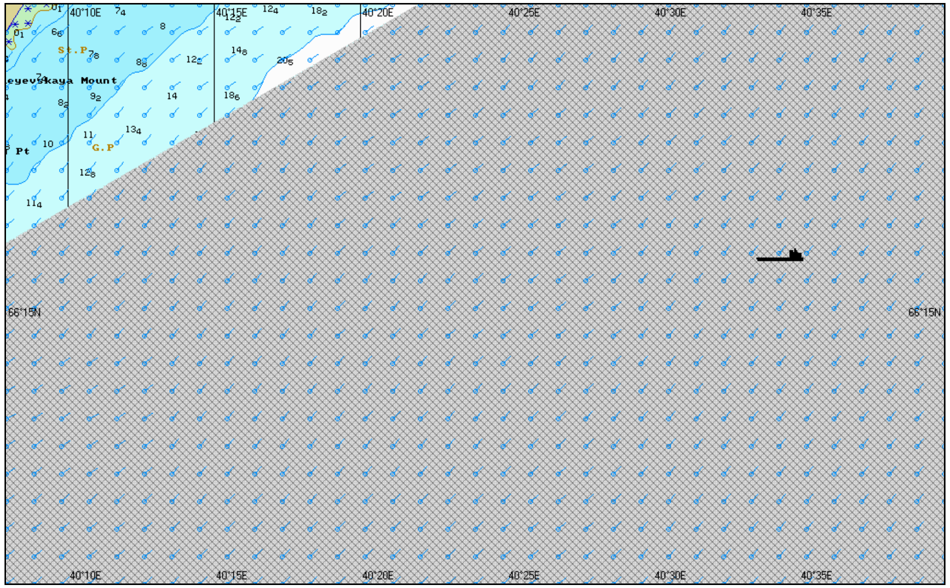


Figure 578. H+09:00. Oil slick spreading as per the scenario Na-Win-W-2.

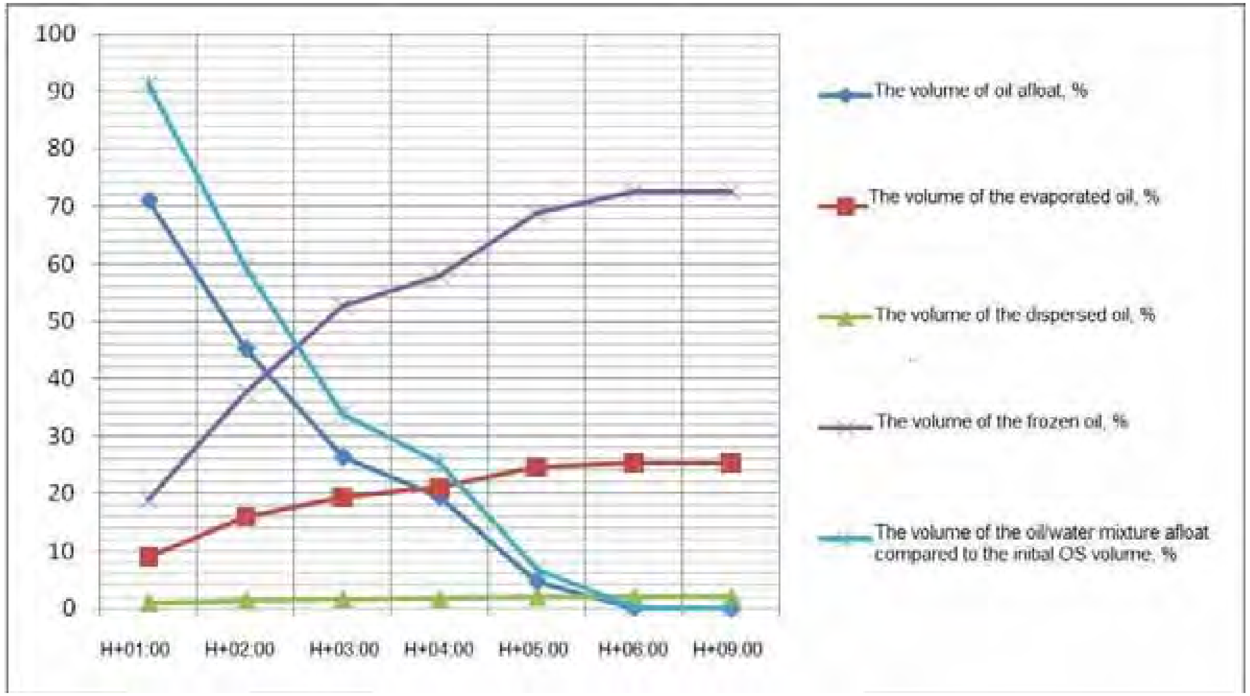


Figure 579. The chart of processes as per the scenario Na-Win-W-2.

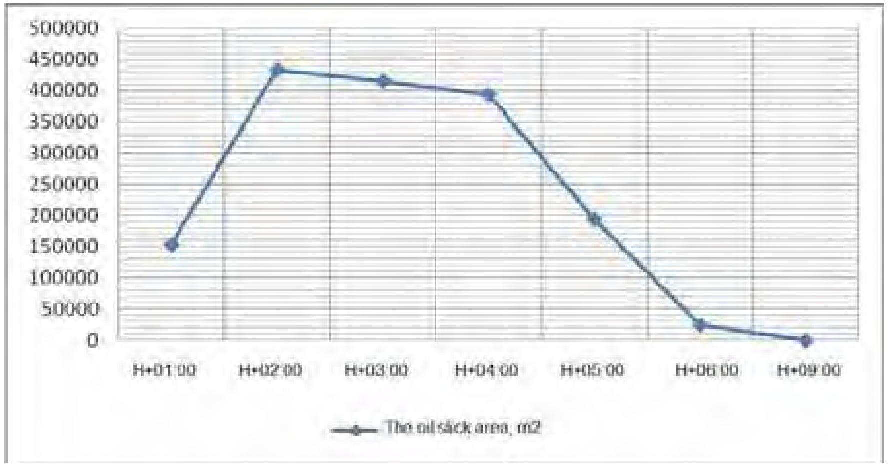


Figure 580. Oil slick area change dynamics as per the scenario Na-Win-W-2.

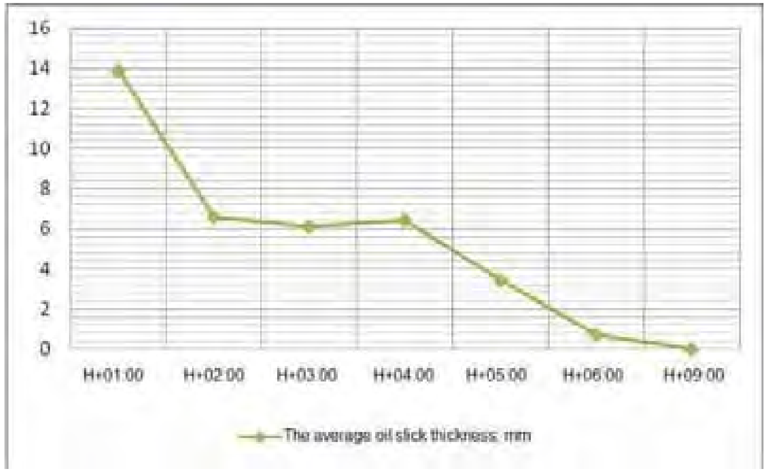


Figure 581. Oil slick thickness change dynamics as per the scenario Na-Win-W-2.

2.6.5 The process dynamics typical for oil spill behavior in the White Sea uner the winter westward wind (Win-W-2)

Figures 582-585 show dynamics of processes typical for oil behavior in the White Sea as per the scenarios Win-W-2.

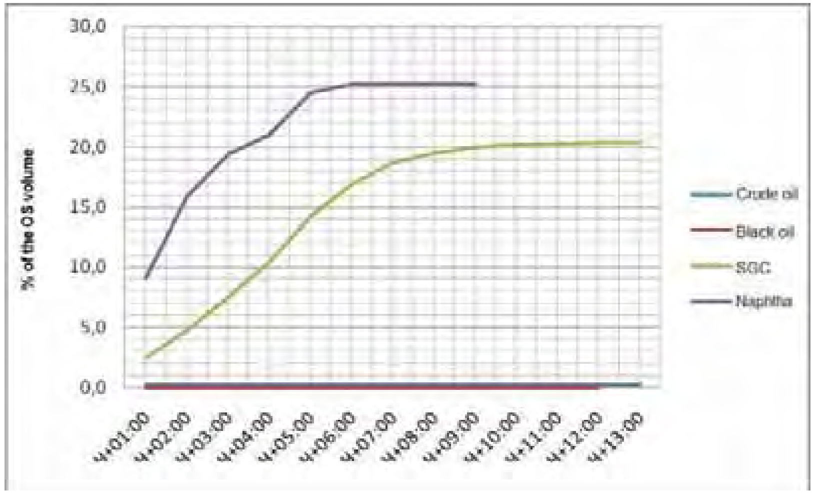


Figure 582. The evaporation process chart as per the scenarios Win-W-2.

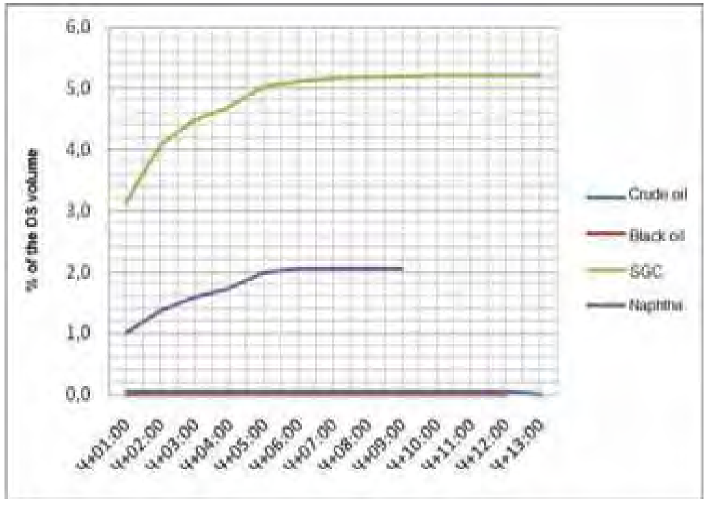


Figure 583. The dispersion process chart as per the scenarios Win-W-2.

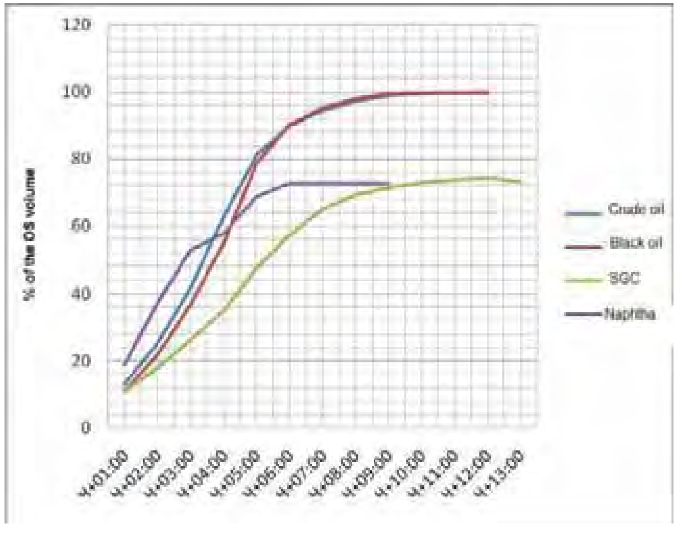


Figure 584. Oil slick freeze-in chart as per the scenarios Win-W-2.

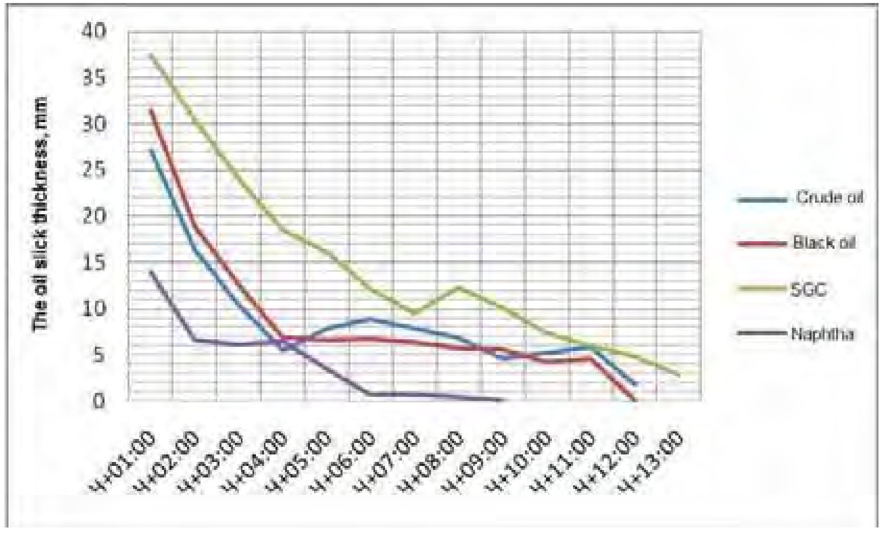


Figure 585. Oil slick thickness change dynamics as per the scenarios Win-W-2.