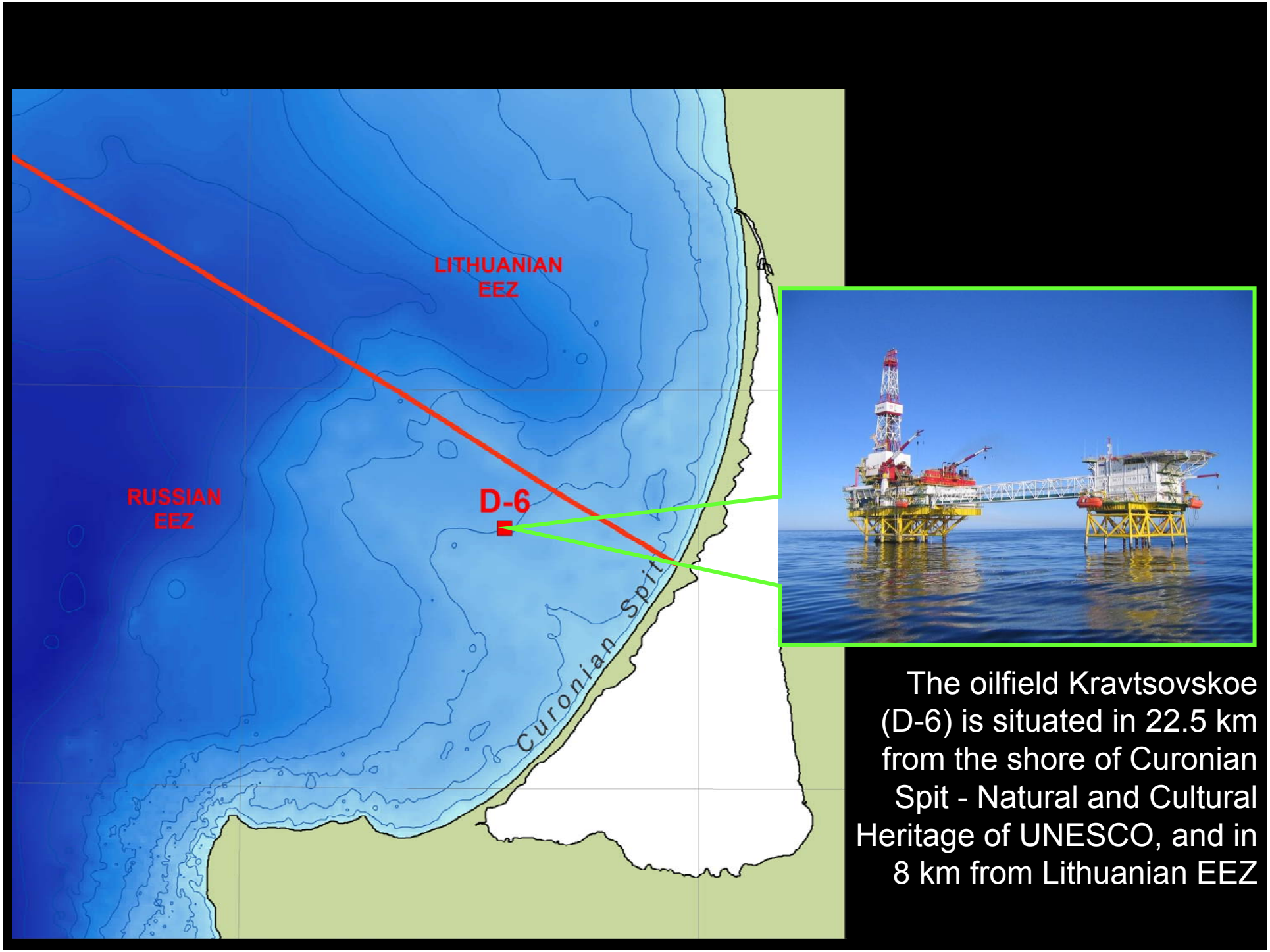
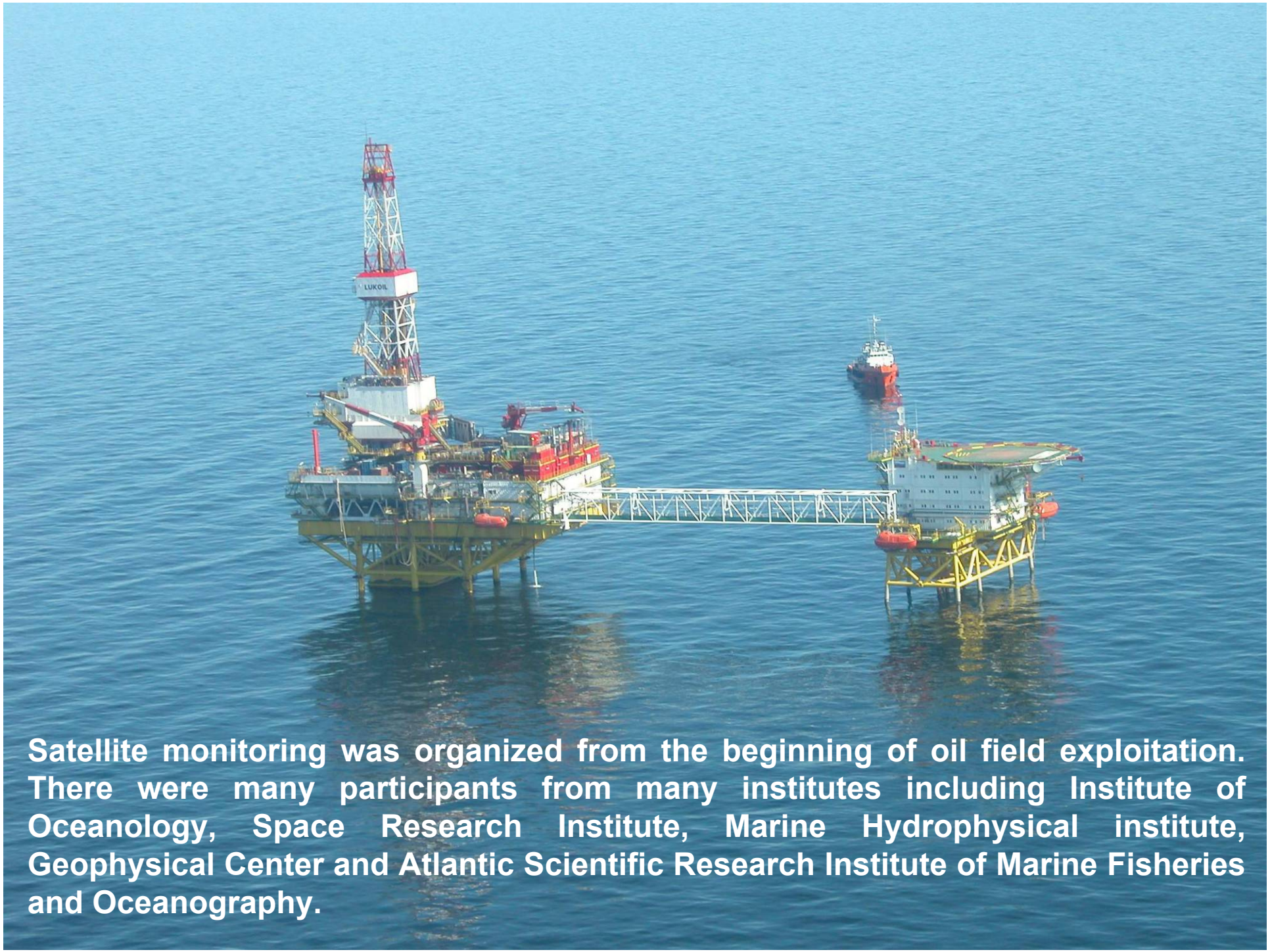
Operational satellite monitoring of oil pollution of the Southeastern Baltic

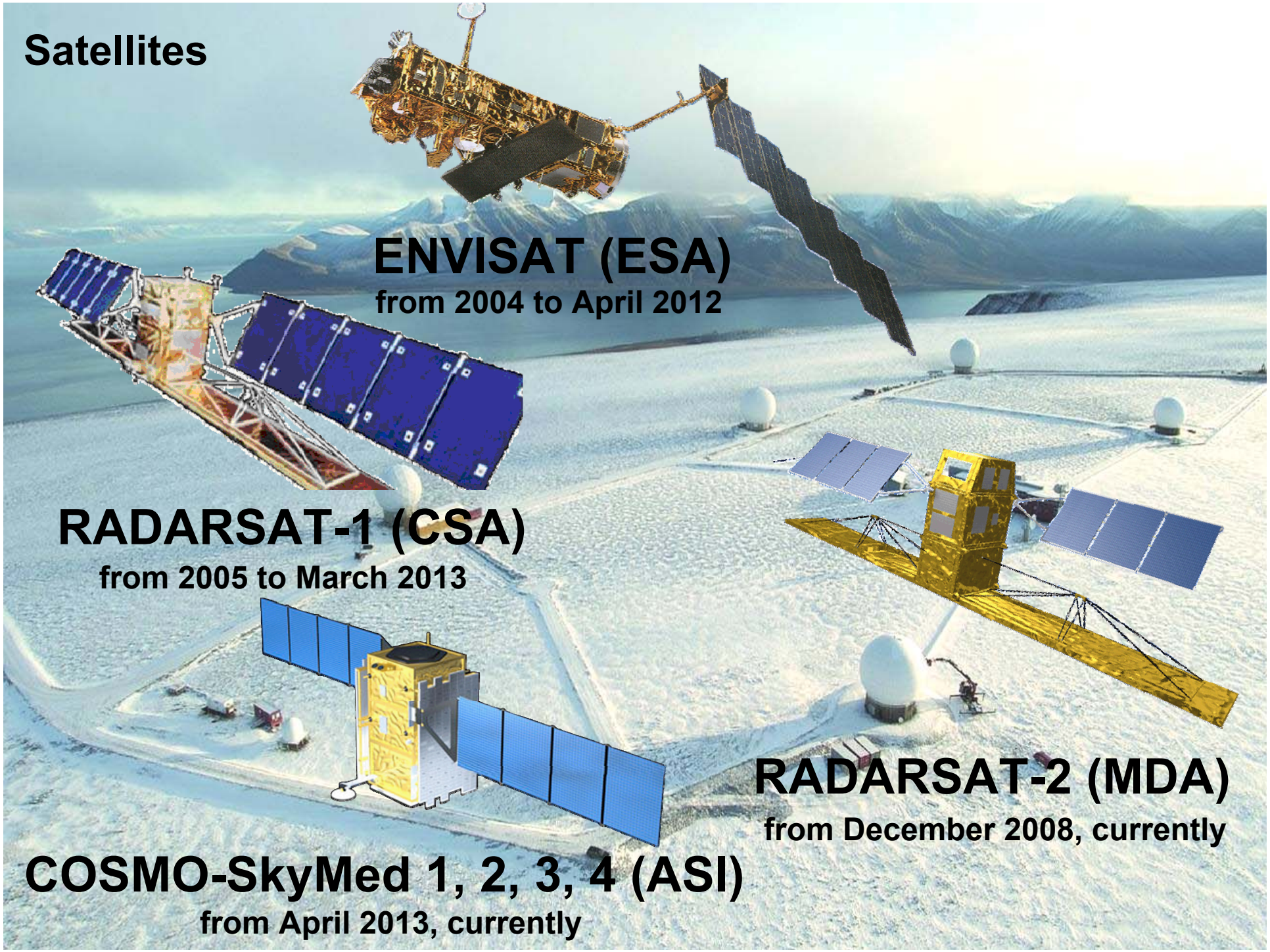
Elena Bulycheva
P.P. Shirshov Institute of oceanology of RAS, Atlantic Branch, Kaliningrad
Scientific Advisor A.G. Kostianoy
P.P. Shirshov Institute of oceanology of RAS, Moscow



The oilfield Kravtsovskoe (D-6) is situated in 22.5 km from the shore of Curonian Spit - Natural and Cultural Heritage of UNESCO, and in 8 km from Lithuanian EEZ



Satellite monitoring was organized from the beginning of oil field exploitation. There were many participants from many institutes including Institute of Oceanology, Space Research Institute, Marine Hydrophysical institute, Geophysical Center and Atlantic Scientific Research Institute of Marine Fisheries and Oceanography.

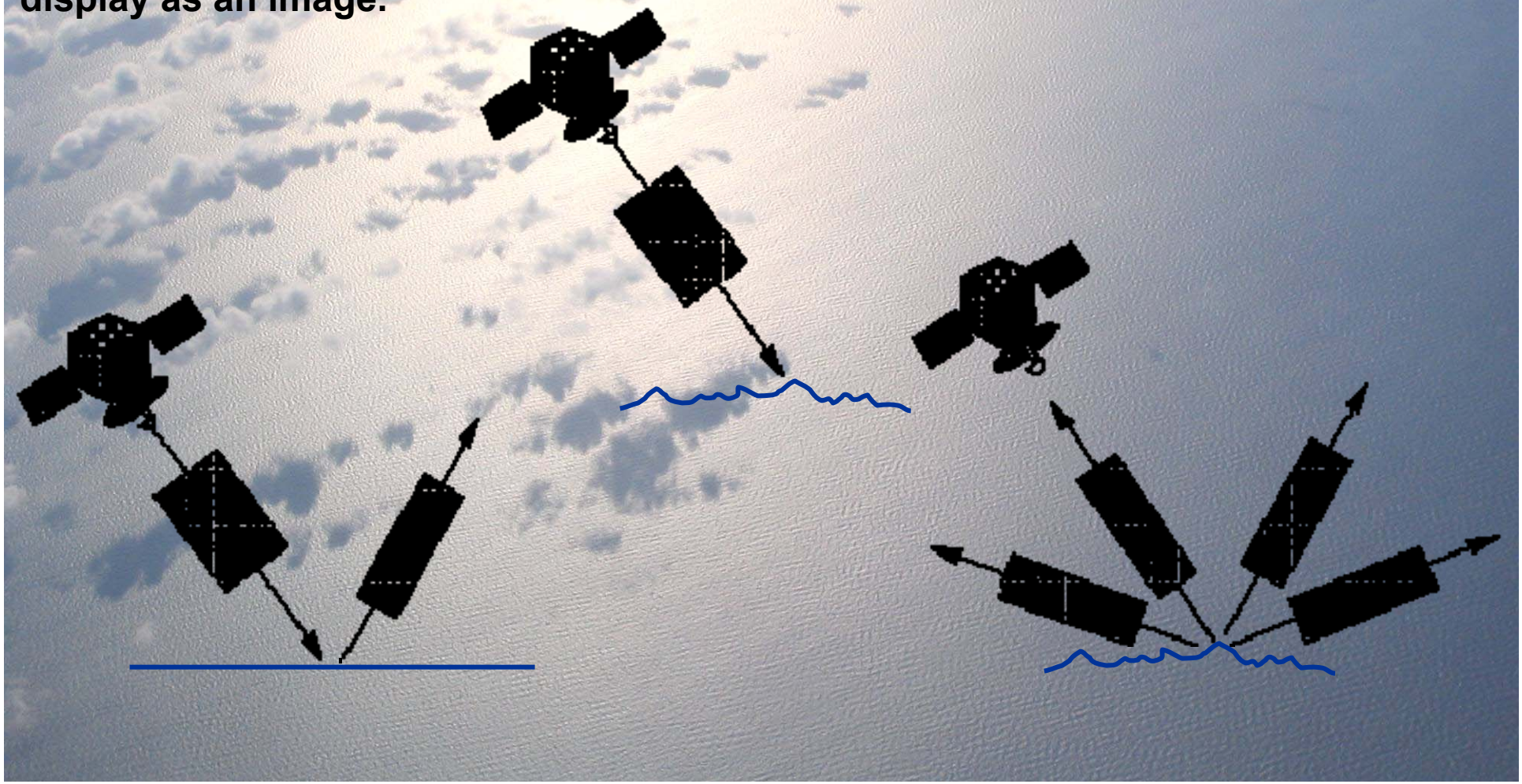

Satellites
ENVISAT (ESA)
from 2004 to April 2012
RADARSAT-1 (CSA)
from 2005 to March 2013
RADARSAT-2 (MDA)
from December 2008, currently
COSMO-SkyMed 1, 2, 3, 4 (ASI)
from April 2013, currently

Data

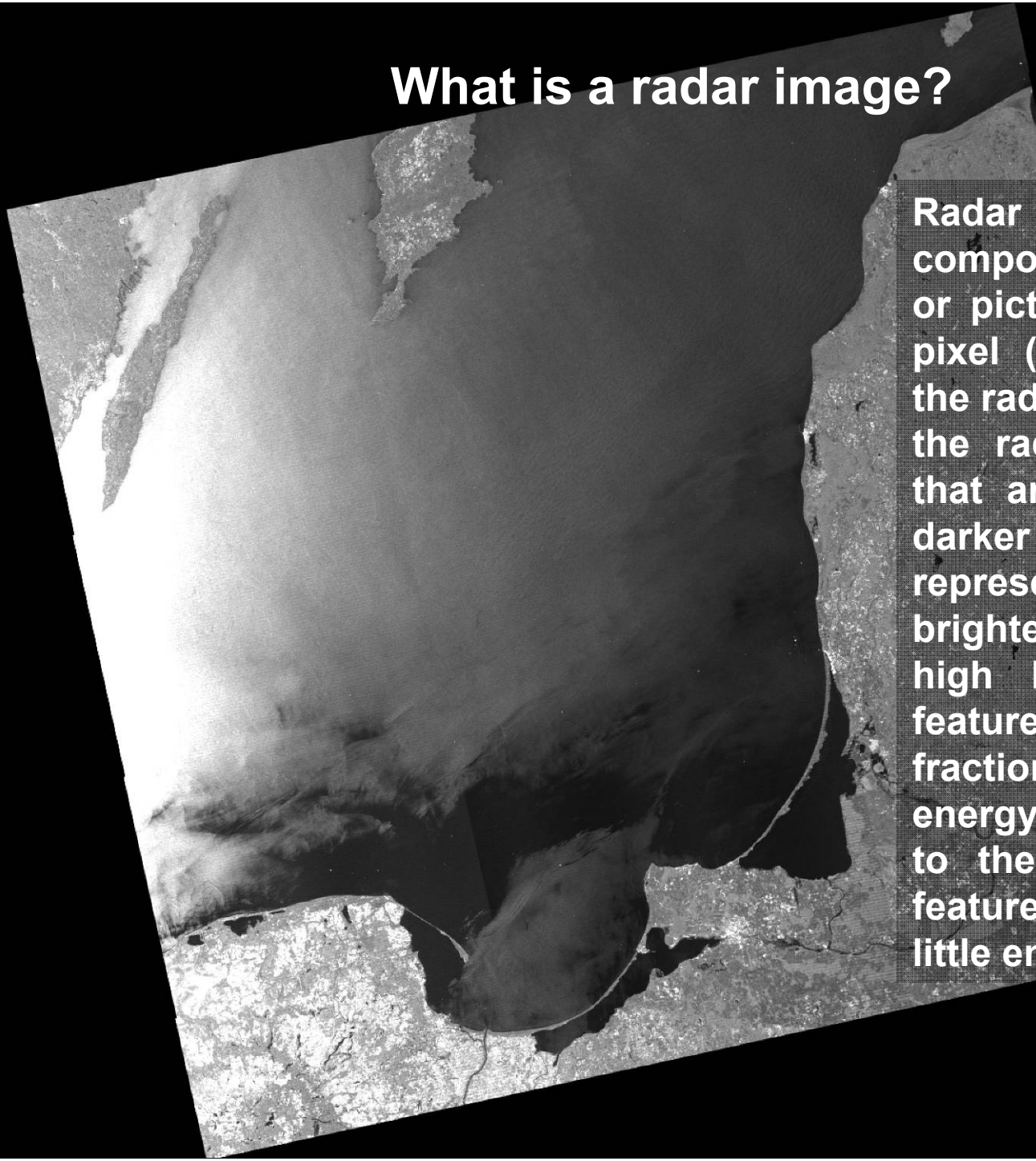
Tromsø Station coverage area

Principle of SAR method

At the Earth's surface, the energy in the radar pulse is scattered in all directions, with some reflected back toward the antenna. This backscatter returns to the radar as a weaker radar echo and is received by the antenna. These echoes are converted to digital data and passed to a data recorder for later processing and display as an image.



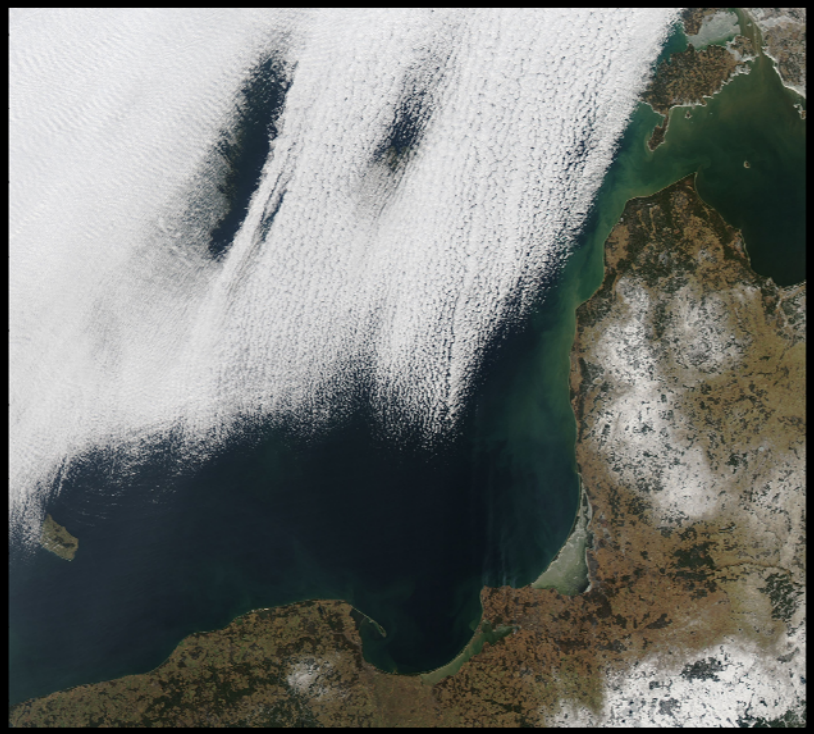
What is a radar image?

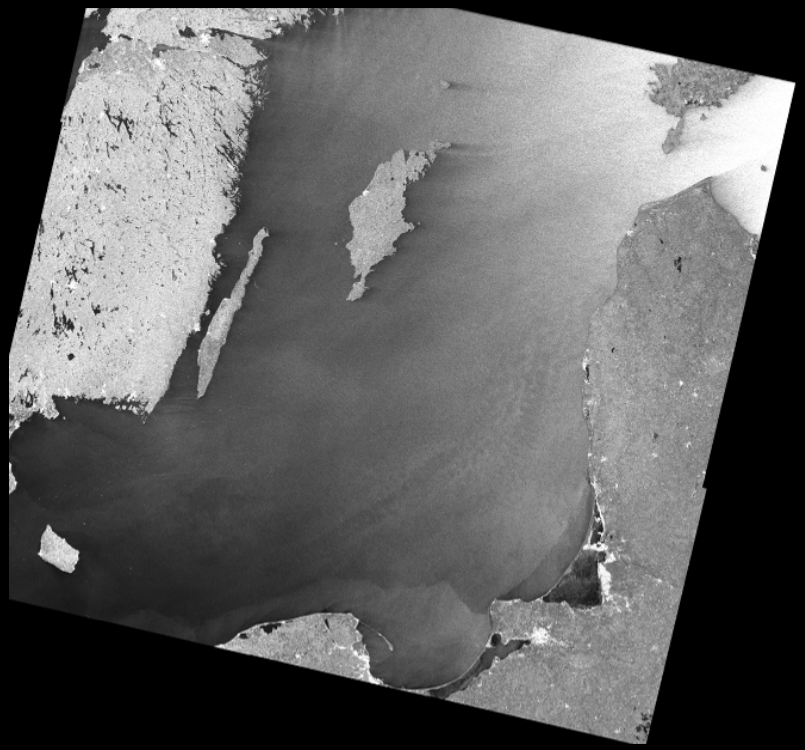


Radar images are composed of many dots, or picture elements. Each pixel (picture element) in the radar image represents the radar backscatter for that area on the ground: darker areas in the image represent low backscatter, brighter areas represent high backscatter. Bright features mean that a large fraction of the radar energy was reflected back to the radar, while dark features imply that very little energy was reflected.

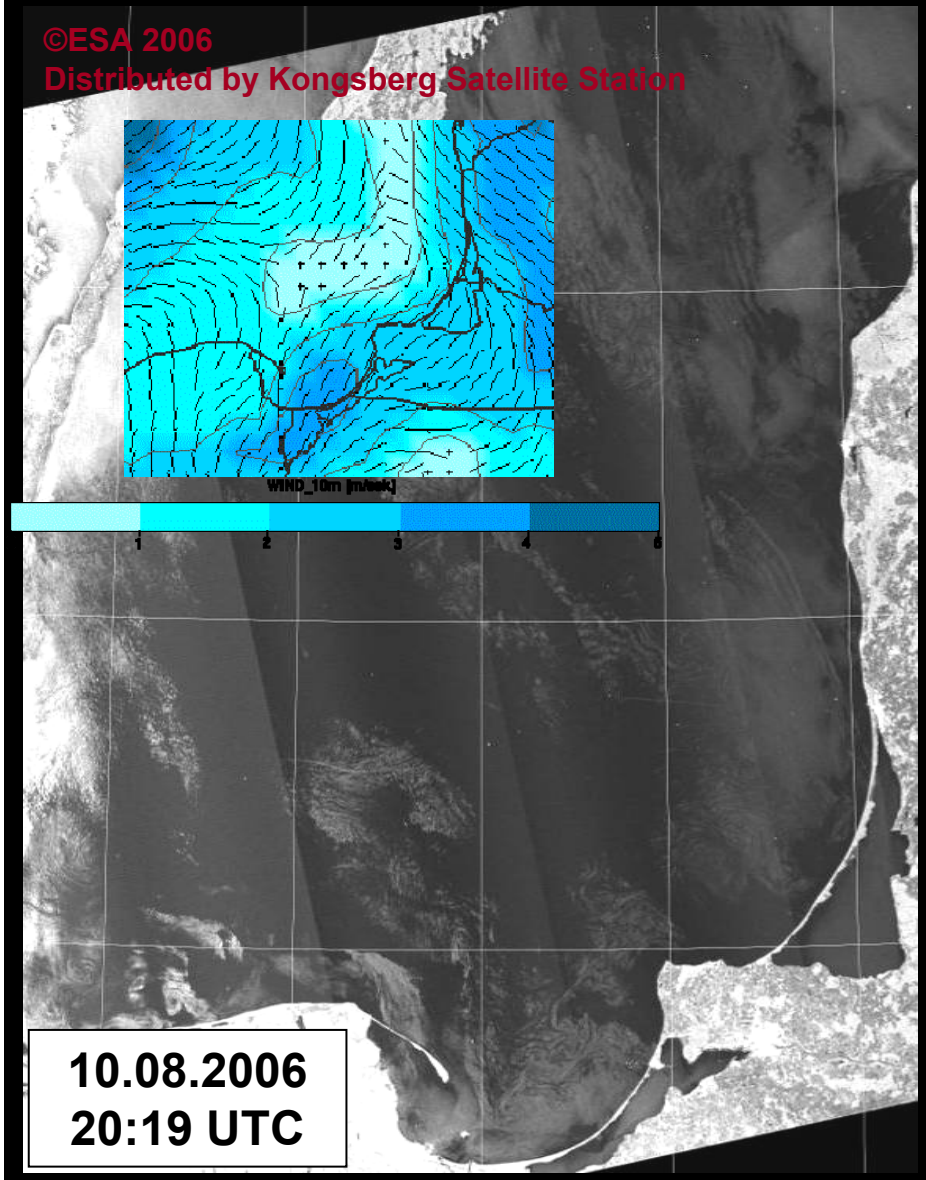
Advantages of SAR method

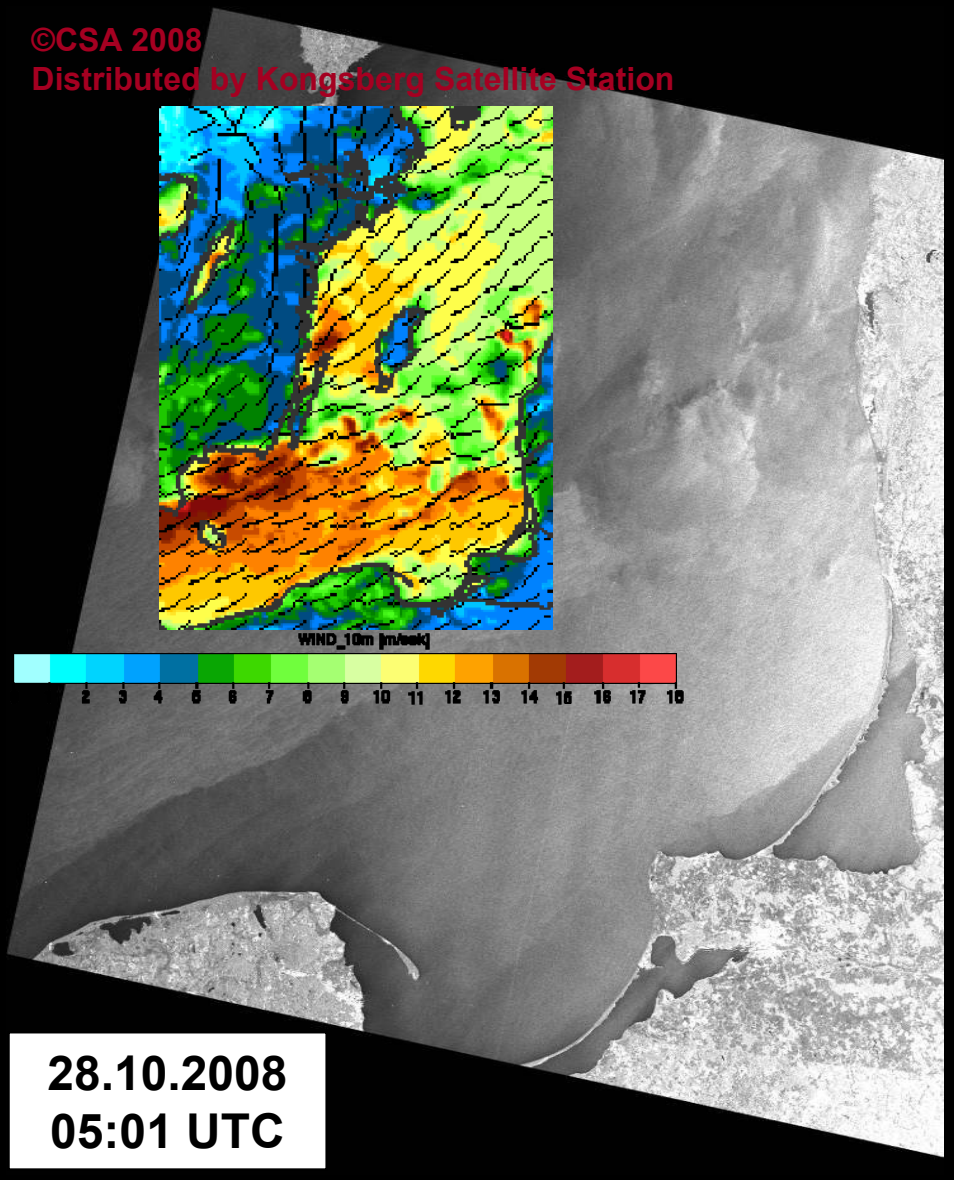
- Wide swath;
- Independence of day light and atmospheric complications such as clouds.





Disadvantages of SAR method





Oil spills

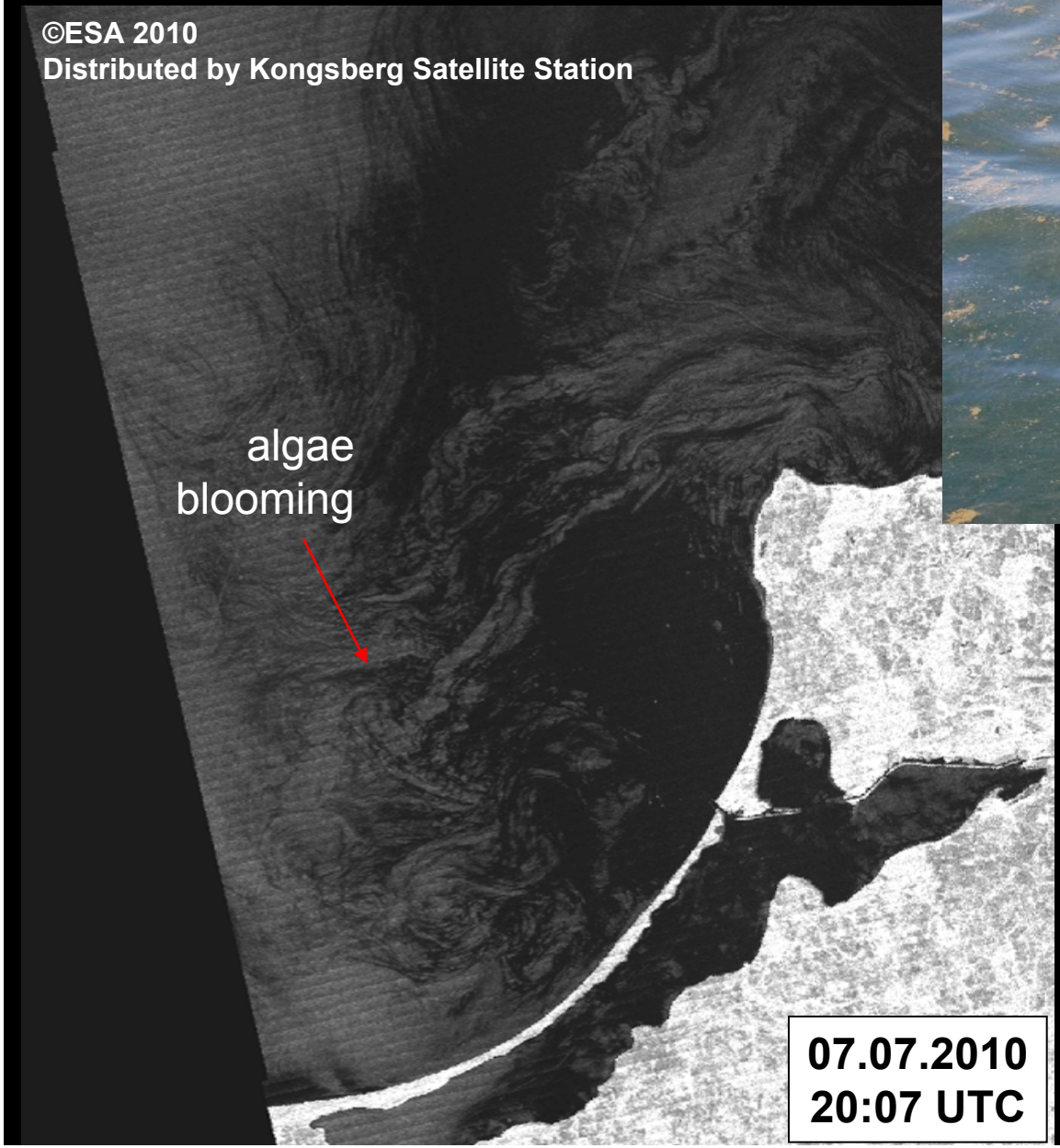
Lookalikes

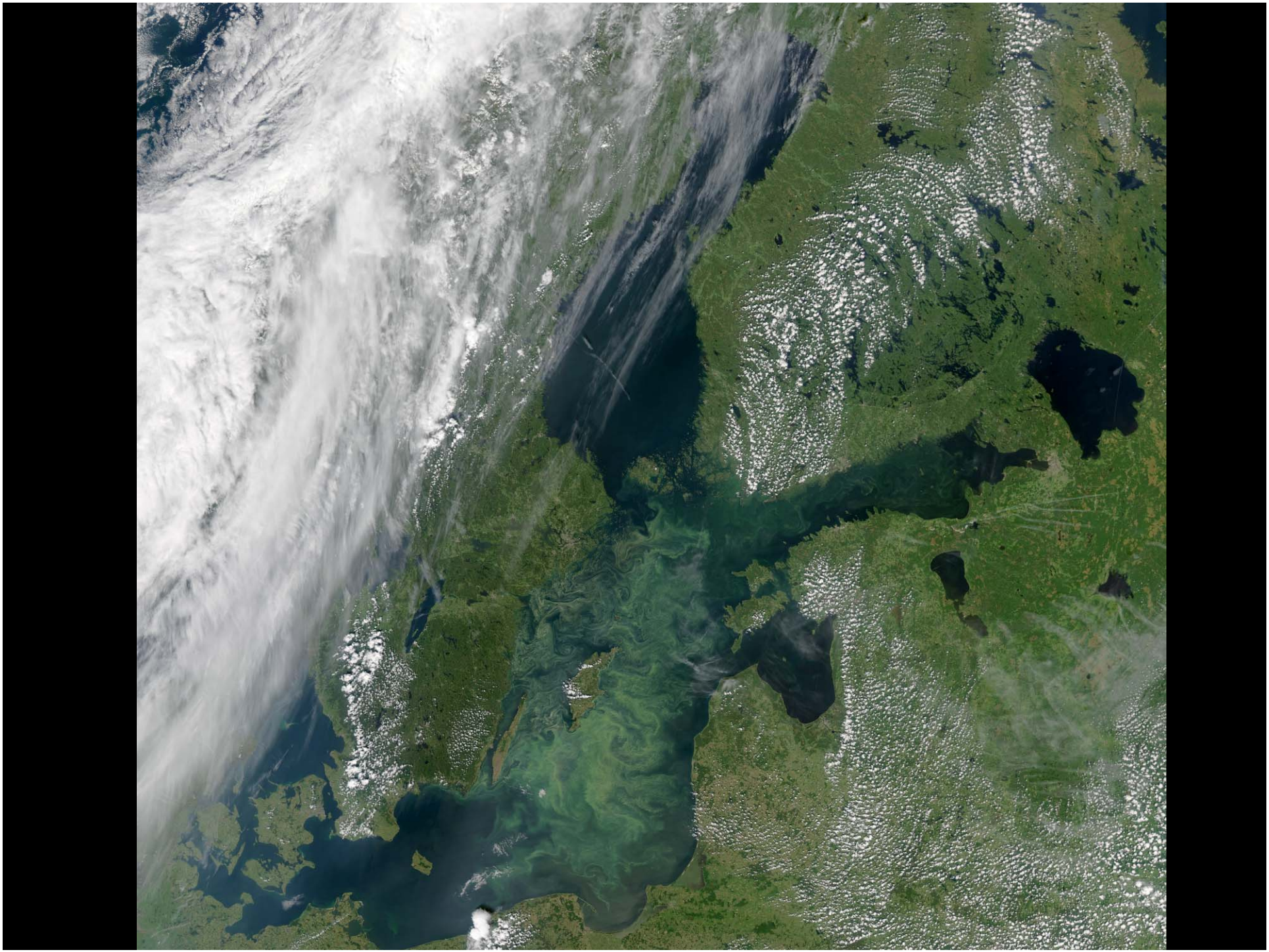
were reported
like oil spills

ice

11.02.2012
09:01 UTC

Lookalikes


©ESA 2010
Distributed by Kongsberg Satellite Station
algae
blooming
07.07.2010
20:07 UTC



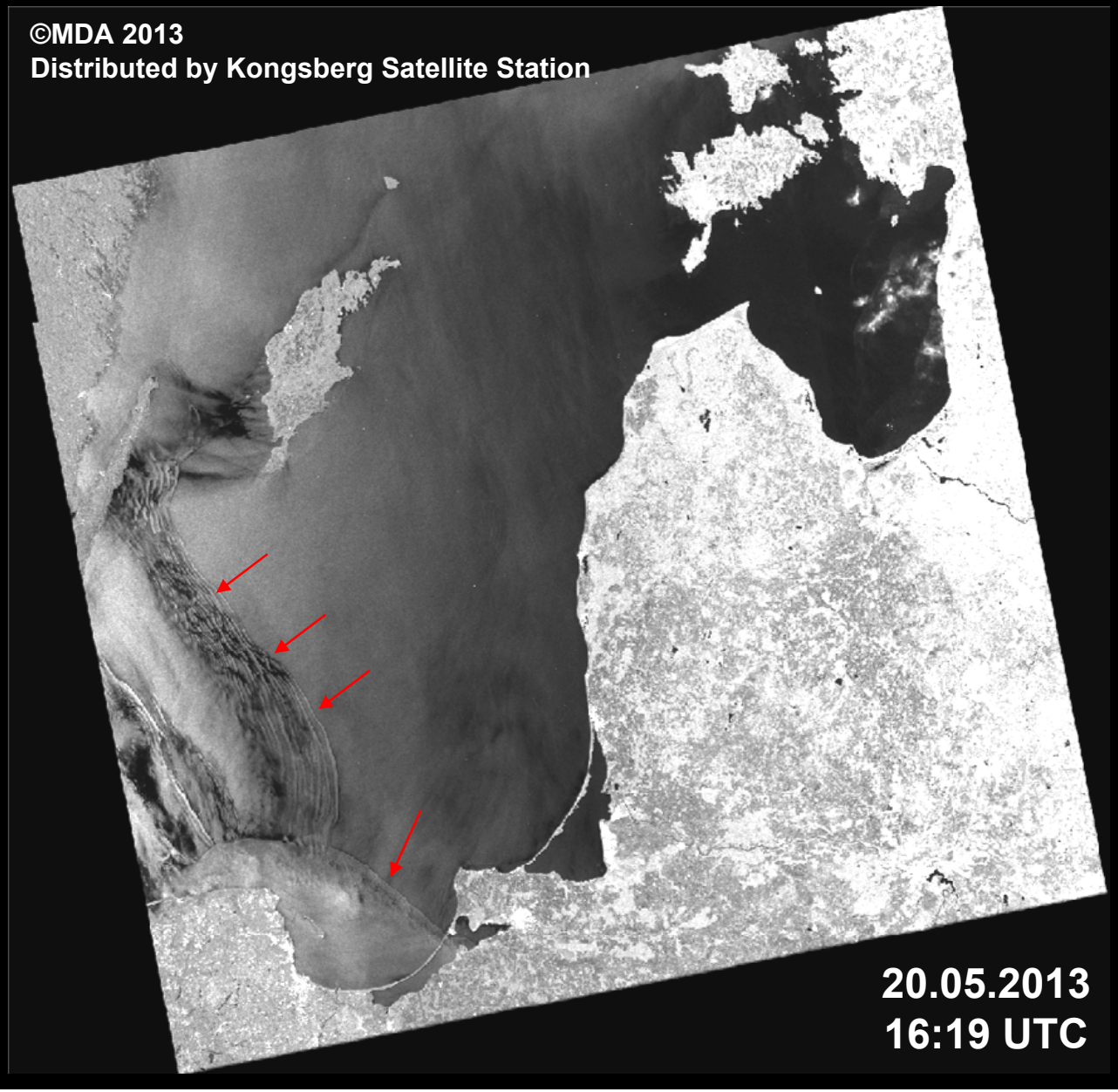

12.07.2010


23.06.2013

Other natural phenomena: rain cells

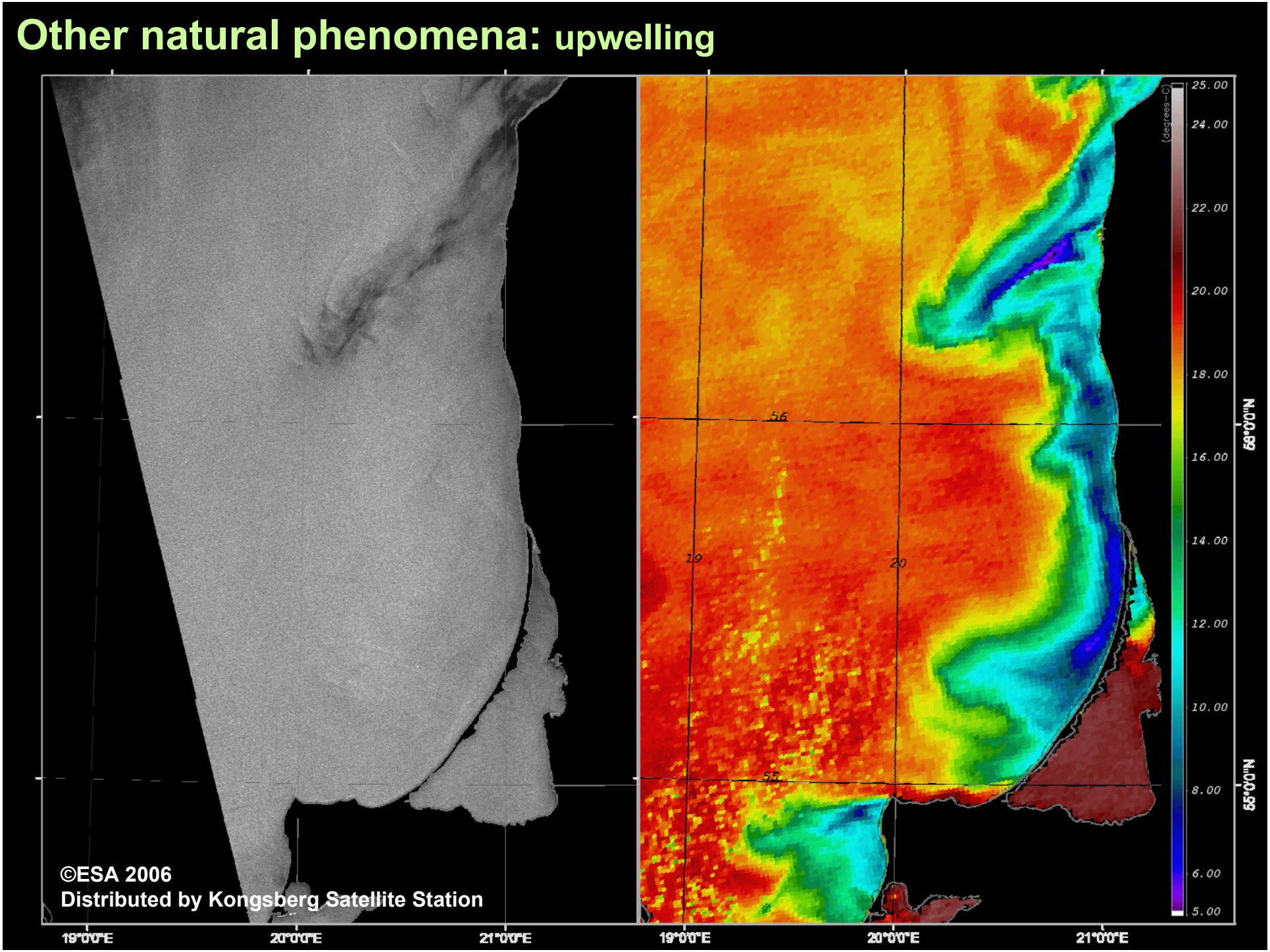
31.06.2014
04:04 UTC

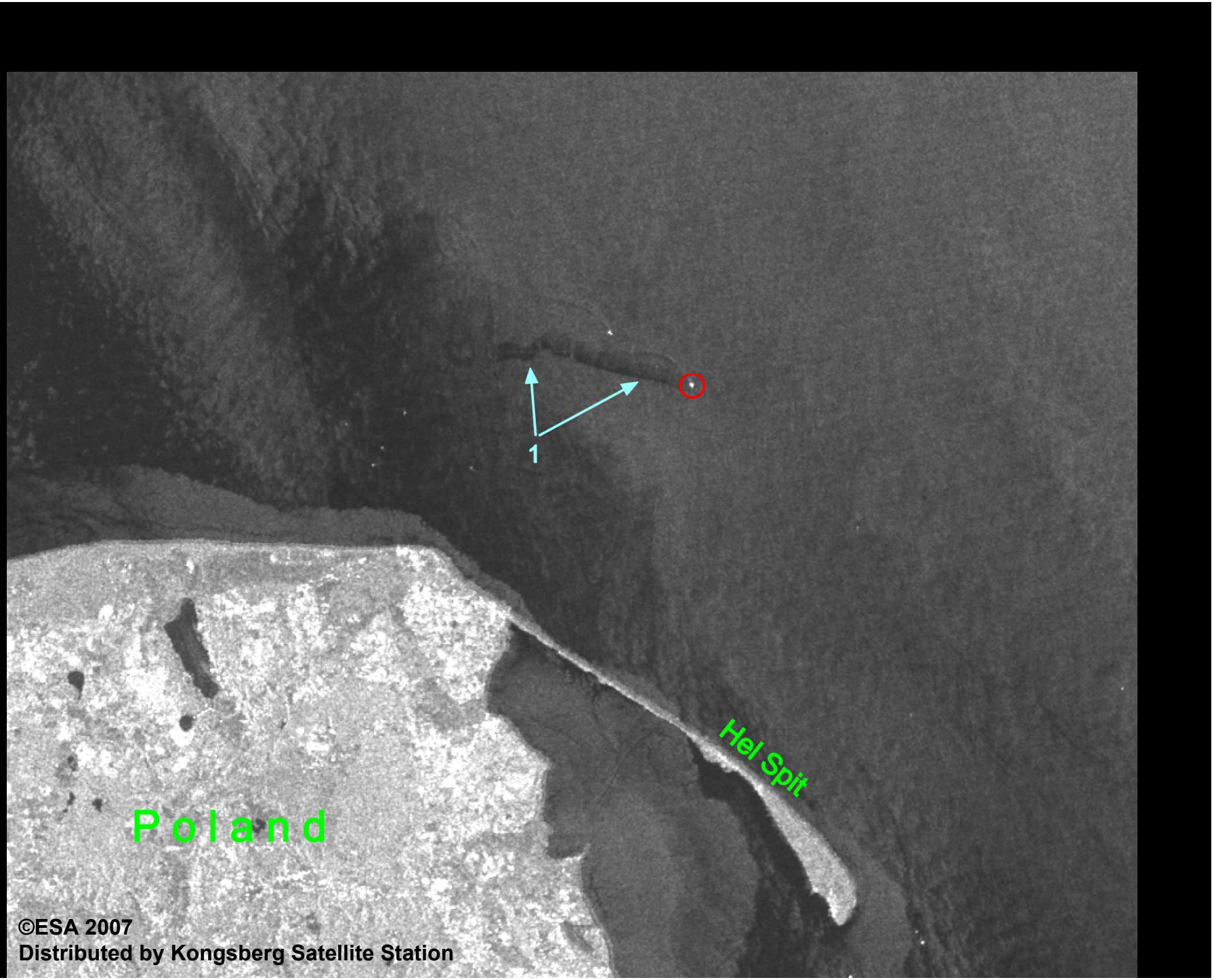
Other natural phenomena: fronts, internal gravity waves



Other natural phenomena: wind shadows

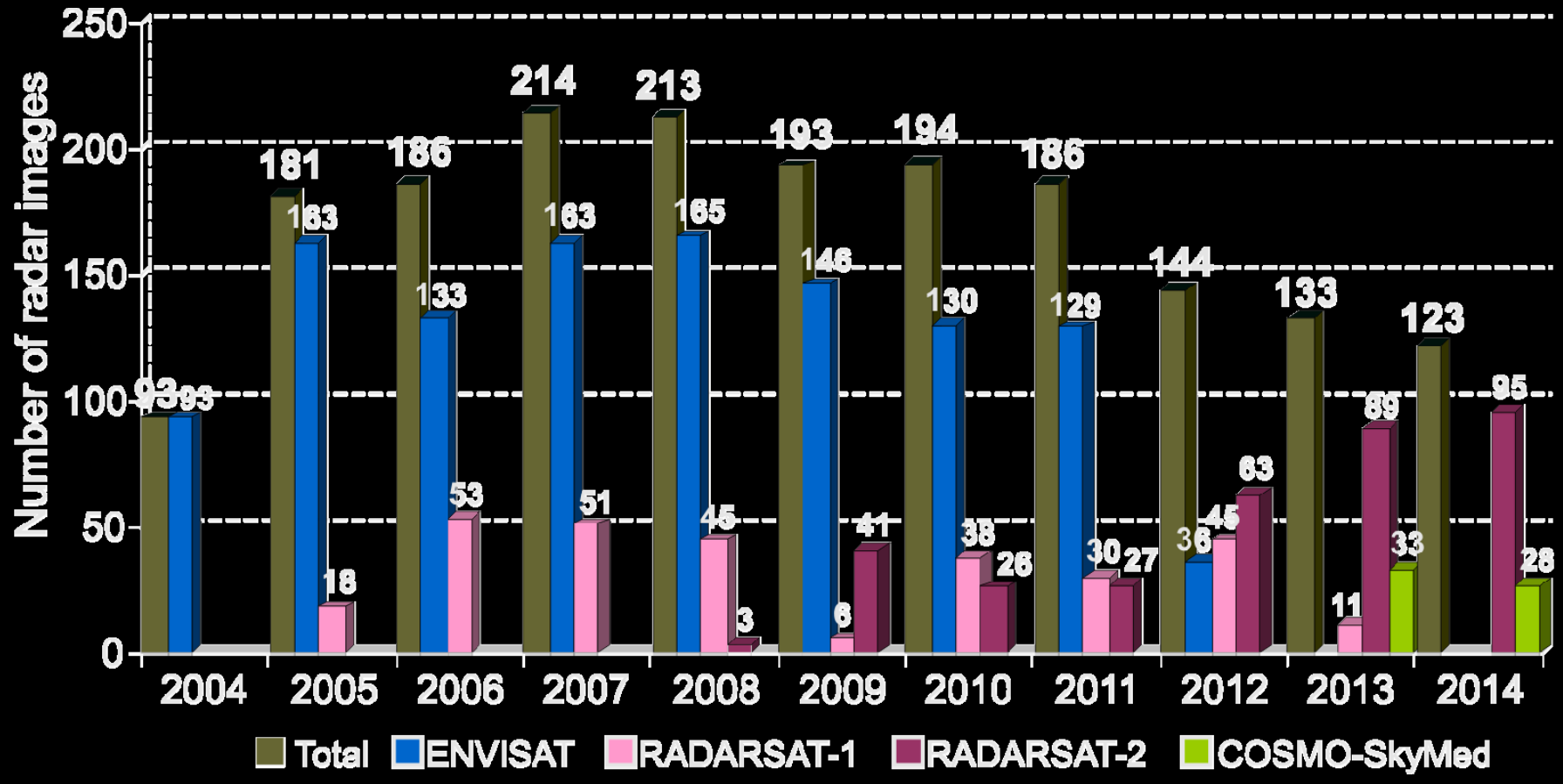
Other natural phenomena: upwelling




1
Hel Spit
Poland
©ESA 2007
Distributed by Kongsberg Satellite Station

Data

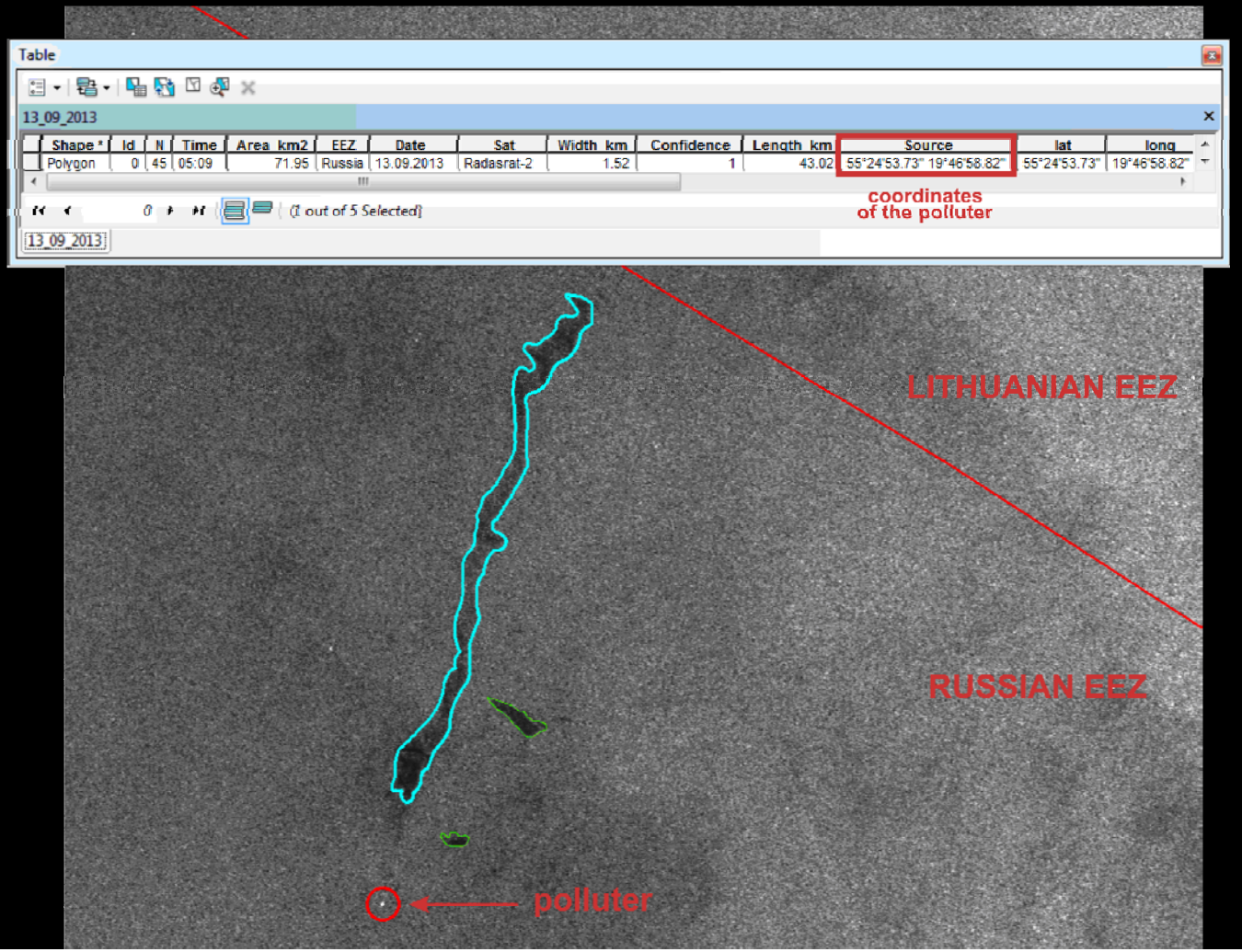
From 12.06.2004 to 31.12.2014, in total, 1844 radar images were received and analyzed, including 1158 images from ENVISAT (ESA), 297 images from RADARSAT-1 (CSA), 344 images from RADARSAT-2 (MDA), and 61 images from COSMO-SkyMed (ASI).



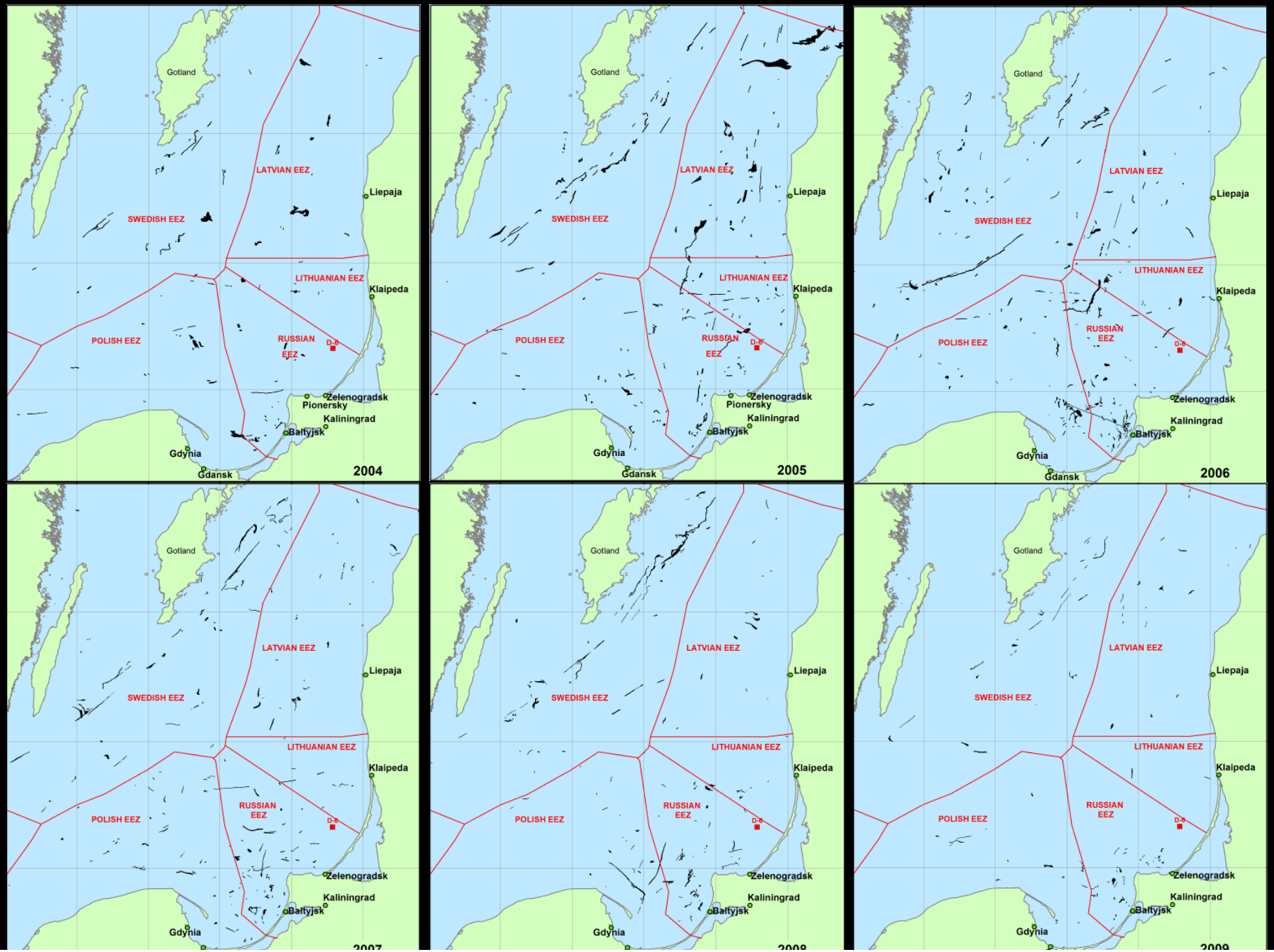
Number of radar images received from 12.06.2004 to 31.12.2014

Data

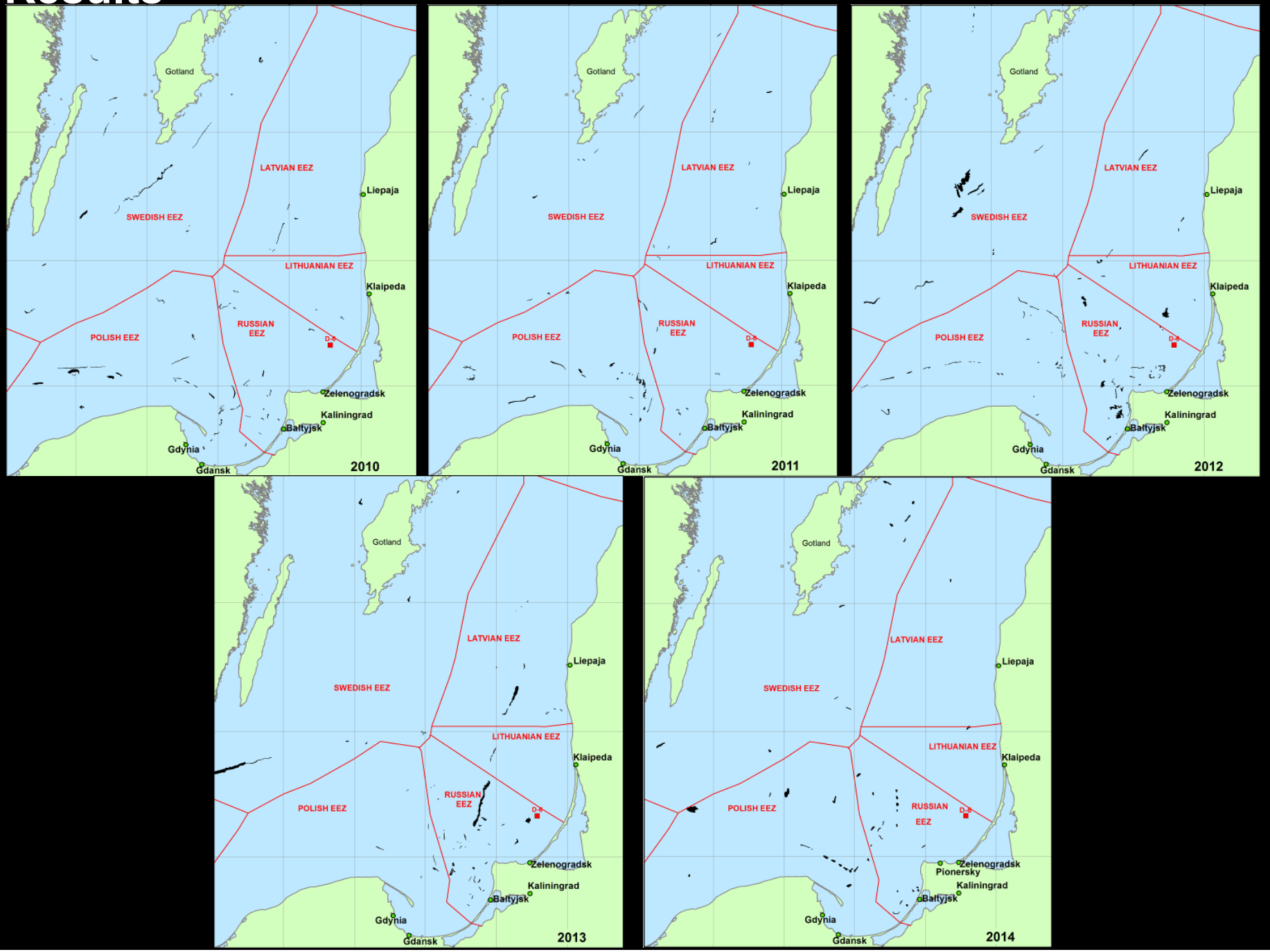
All the detected oil spills were digitized using ArcGIS 9.2 software and collected to the database. The attribute table includes all the relevant information including date and time of oil spill detection, satellite, coordinates, length and width of the spill, area of oil pollution, confidence level according to KSAT methodology, and coordinates of possible polluter.



Results


Gotland
LATVIAN EEZ
Liepaja
SWEDISH EEZ
LITHUANIAN EEZ
Klaipeda
POLISH EEZ
RUSSIAN EEZ
D-6
Zelenogradsk
Pionersky
Kaliningrad
Baltyjsk
Gdynia
Gdansk
2004
2005
2006
2007
2008
2009

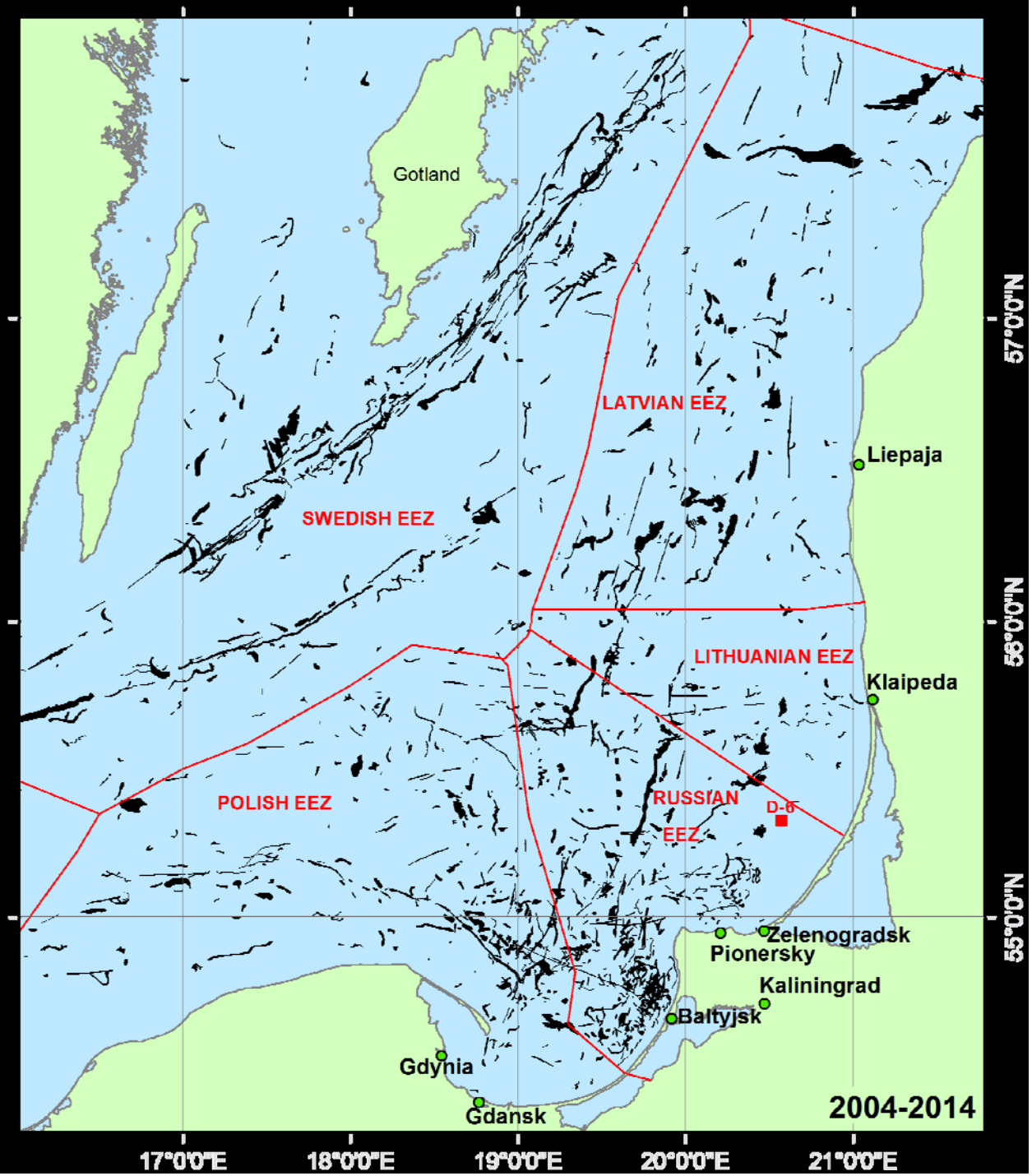
Results


Gotland
LATVIAN EEZ
Liepaja
SWEDISH EEZ
LITHUANIAN EEZ
Klaipeda
RUSSIAN EEZ
POLISH EEZ
D-6
Zelenogradsk
Kaliningrad
Baltyjsk
Gdynia
Gdansk
2010
2011
2012
2013
Pionersky
2014

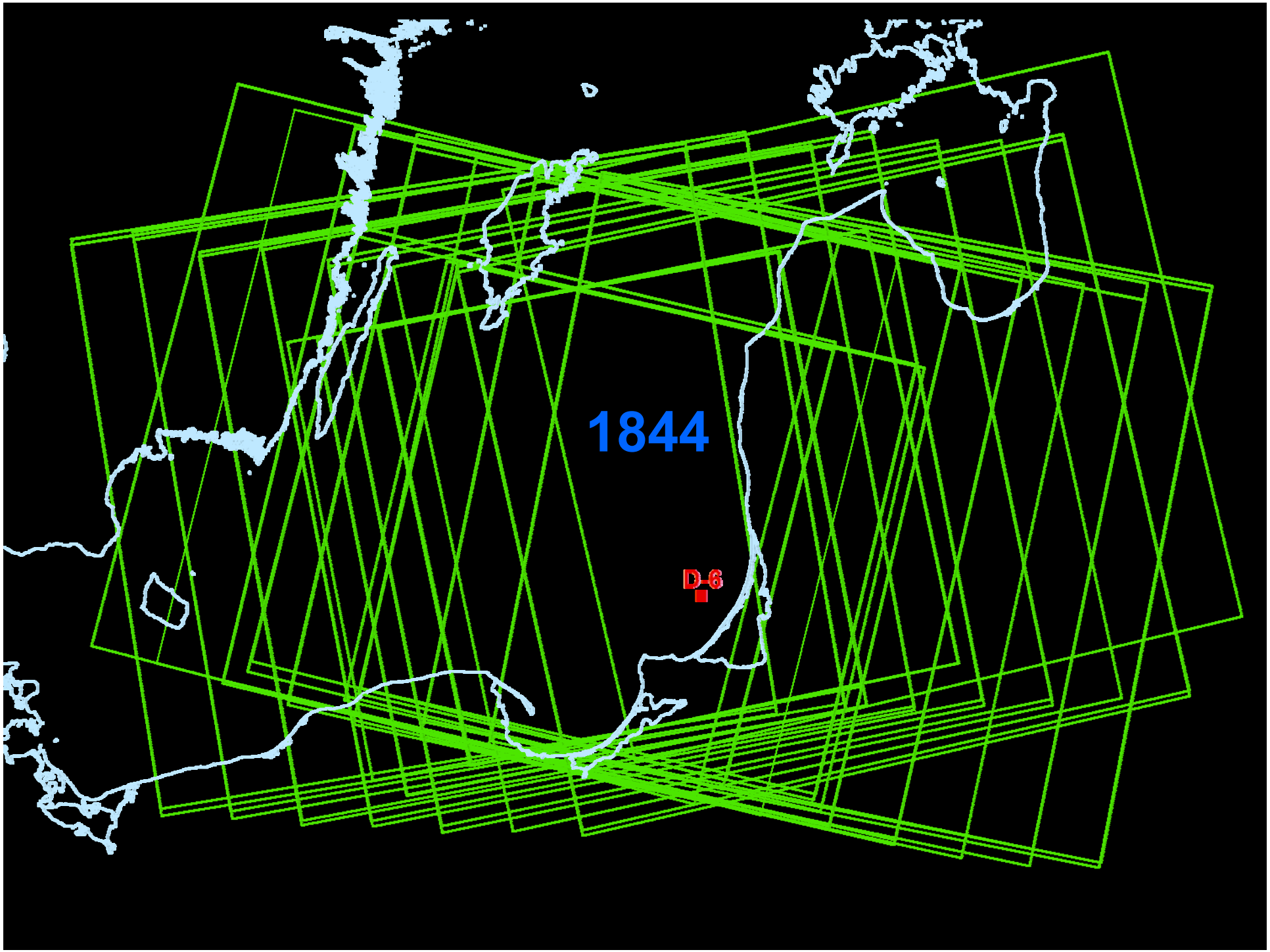
Results

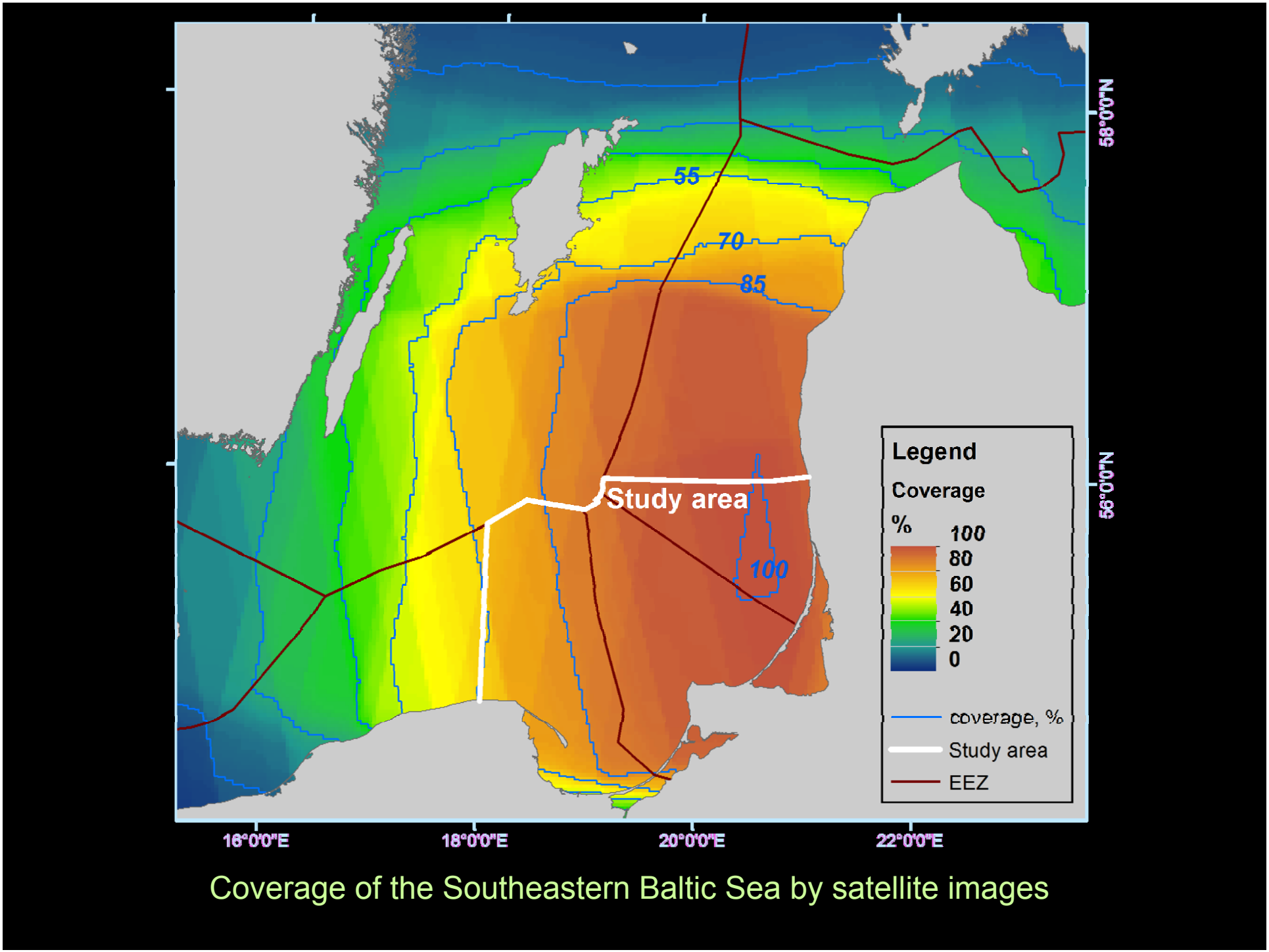
1844
SAR images

1193
oil spills



Summary map of all oil spills detected from 12.06.2004 to 31.12.2014 in the result of radar images analysis


1844
D-6

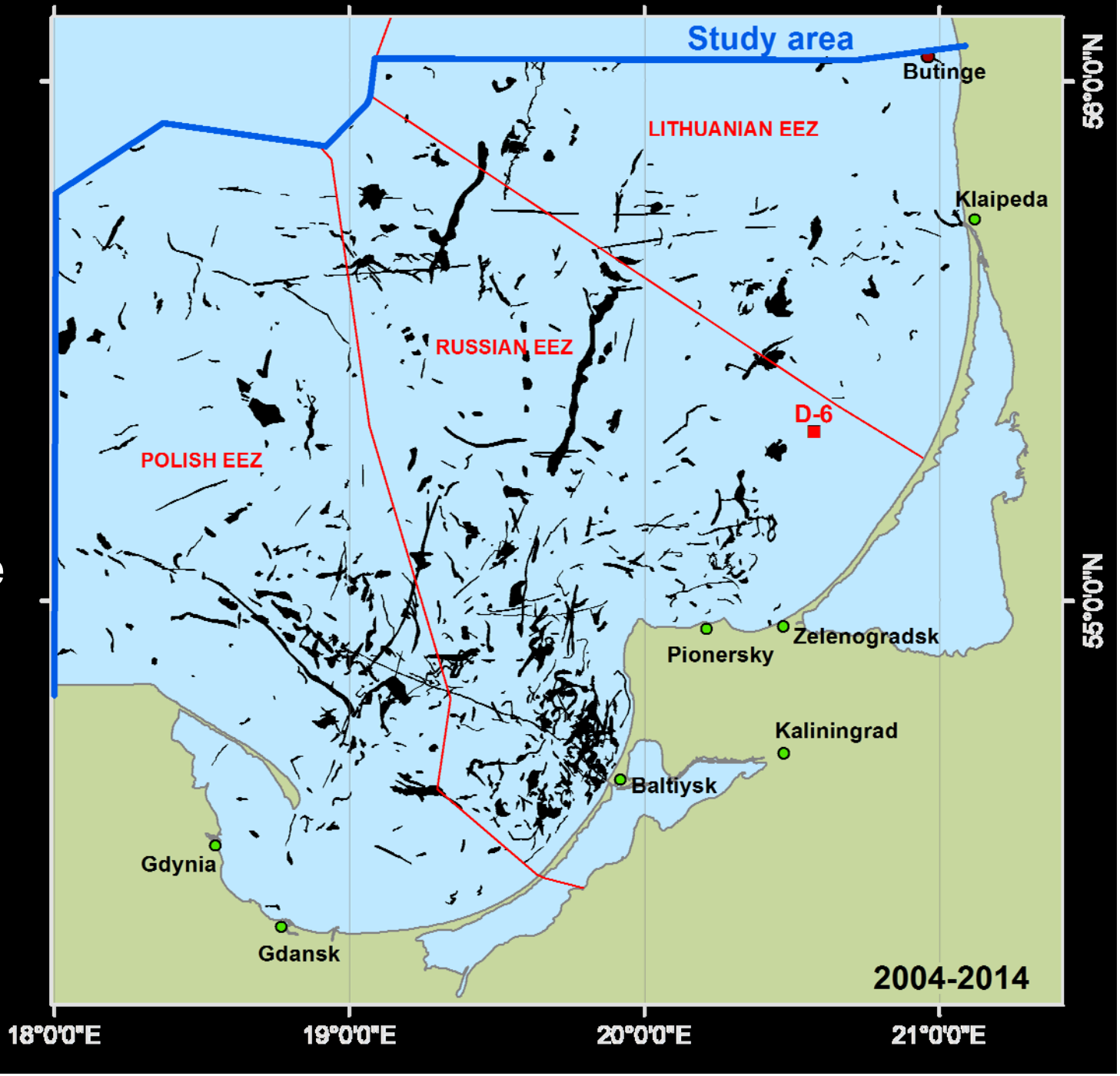


Coverage of the Southeastern Baltic Sea by satellite images

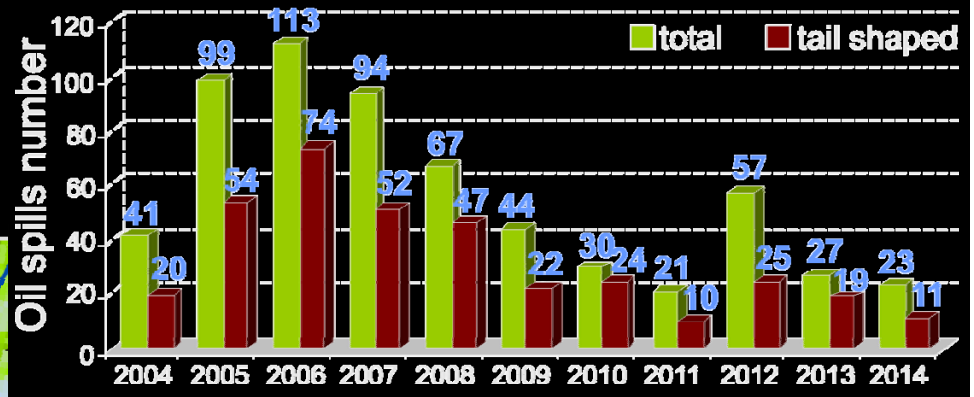
Results

1844
SAR images

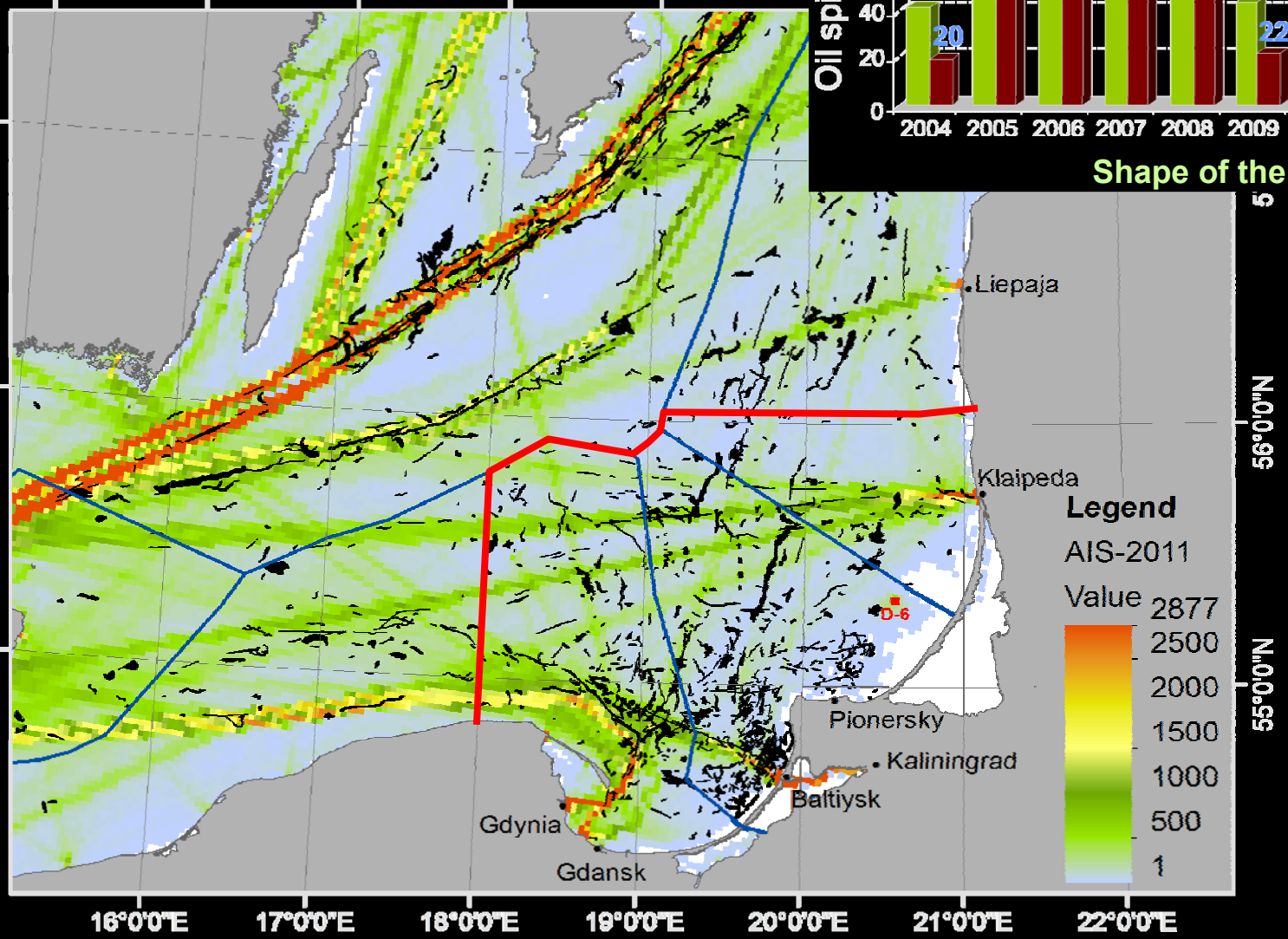
616
oil spills in the Study area



Results

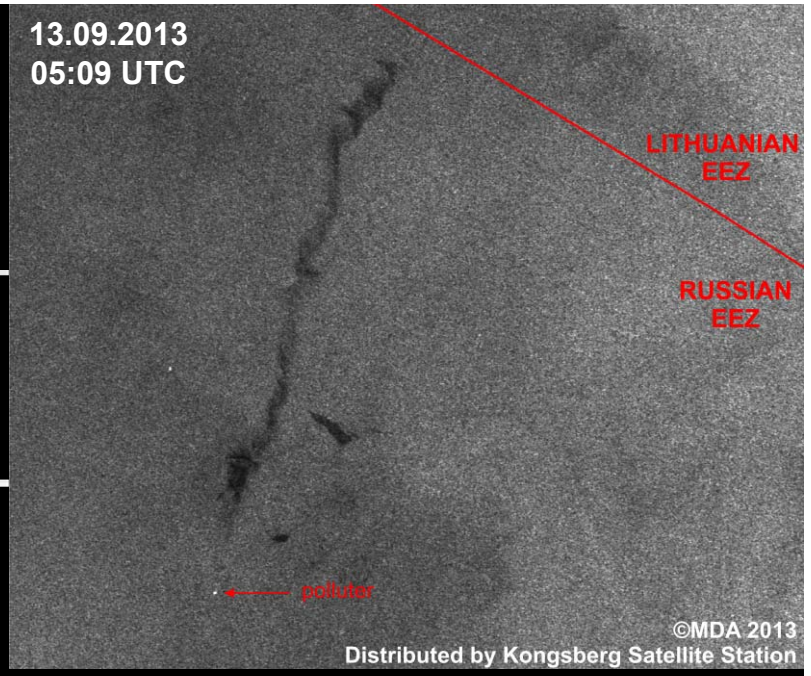


Shape of the oil spills



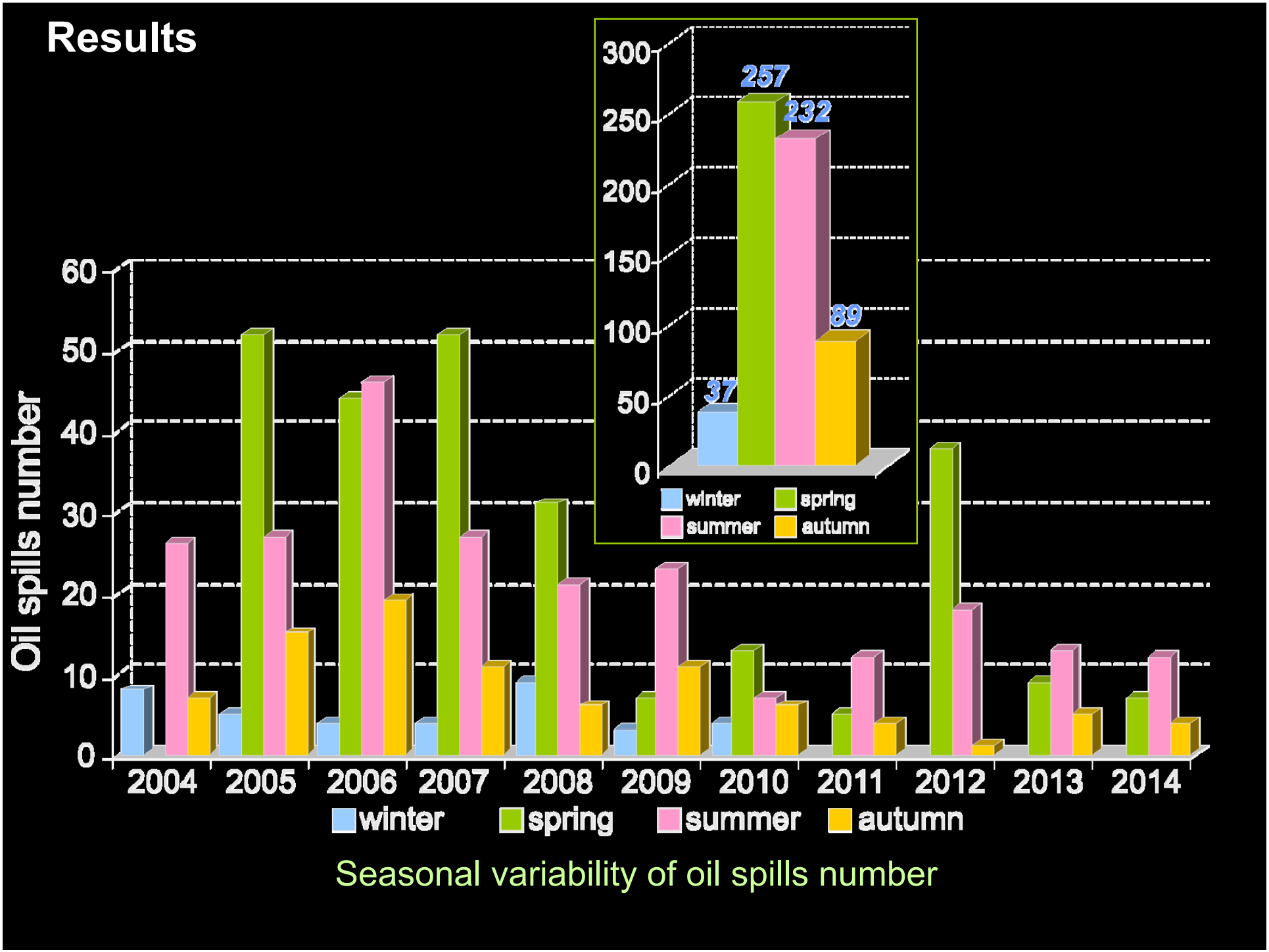
Combination of average monthly ship traffic density (from 2011) and detected oil spills from 2004-2014

Results



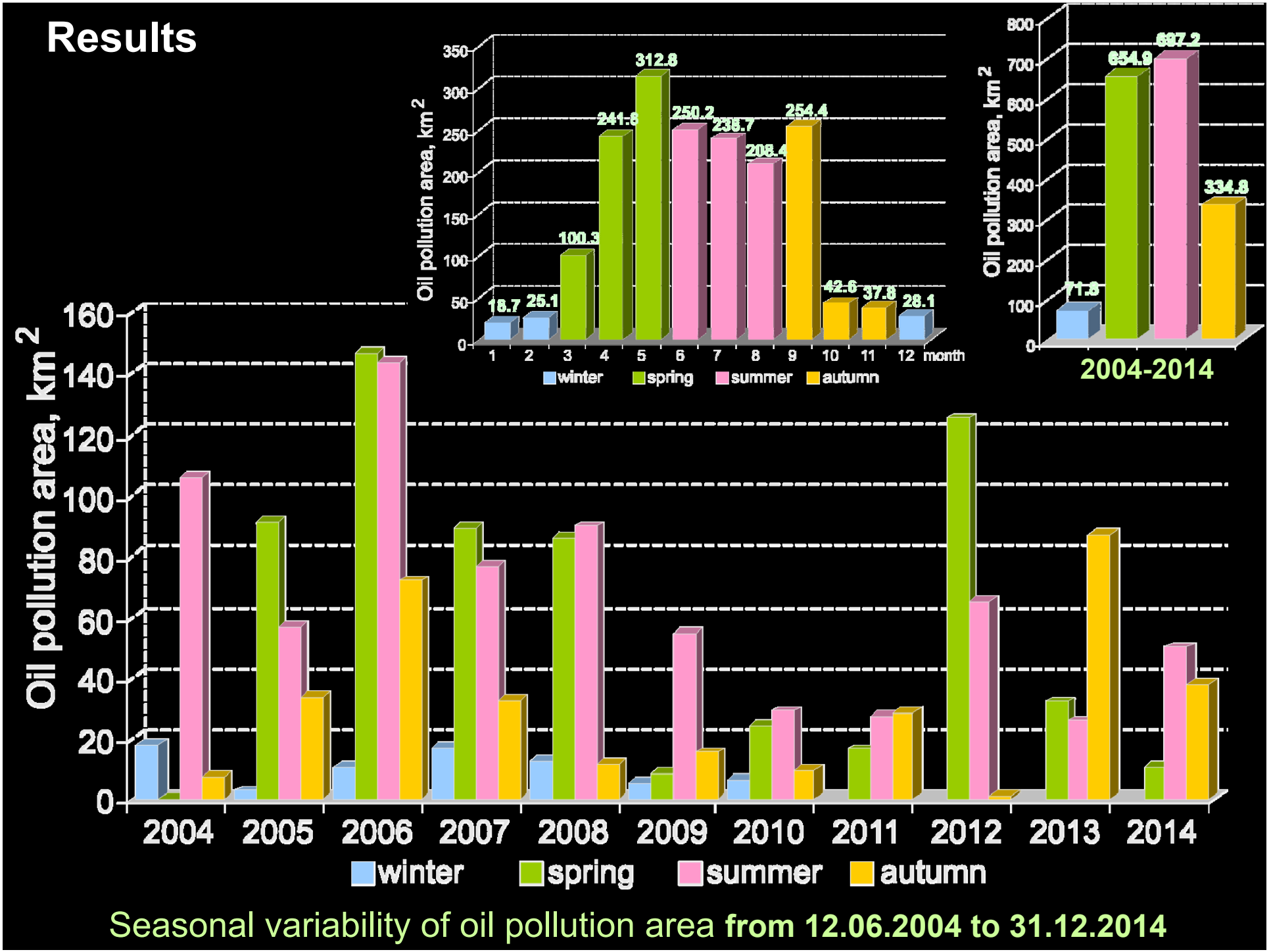
Dynamics of oil pollution area in the Study area
from 12.06.2004 to 31.12.2014

Results

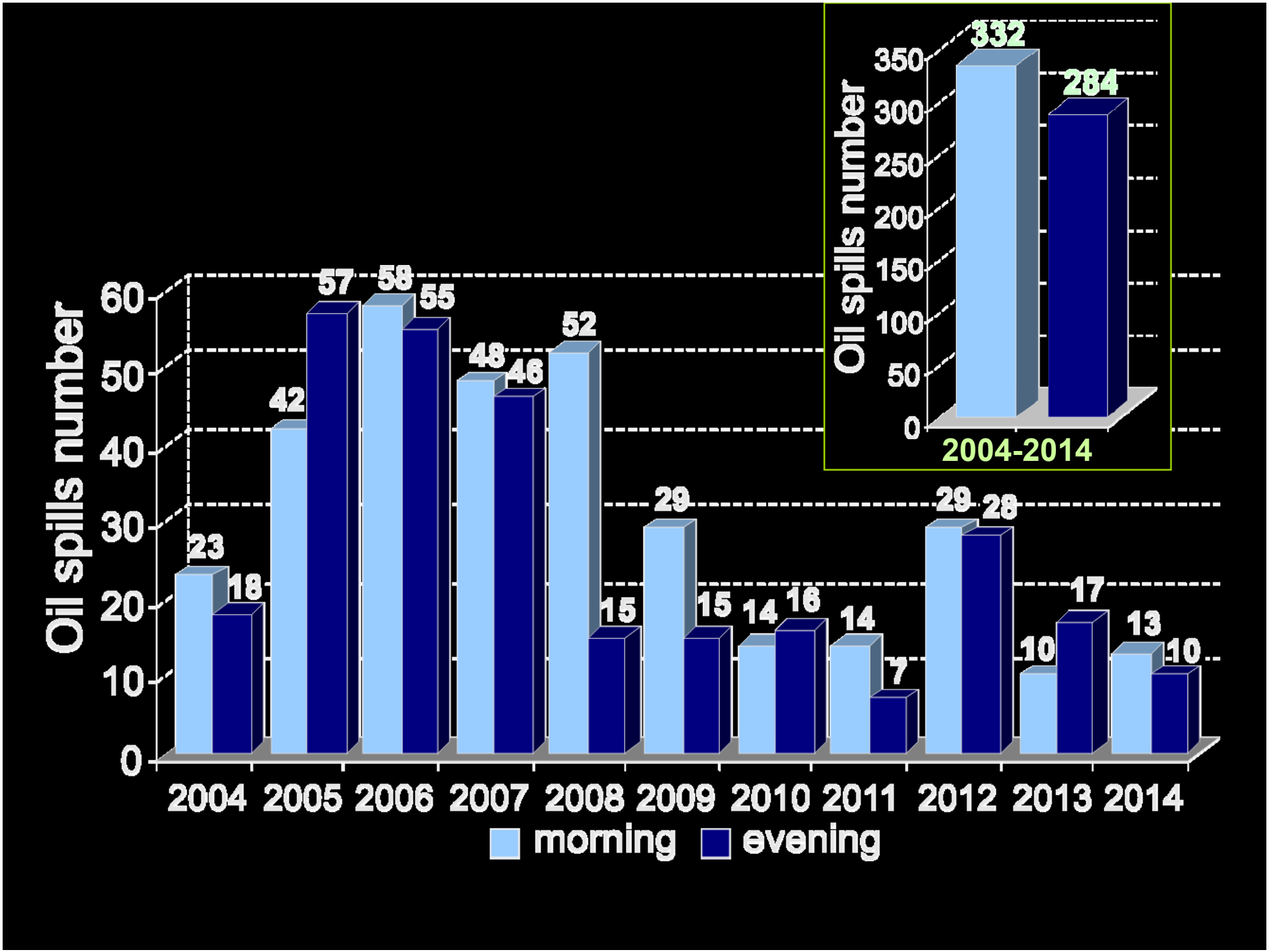


Seasonal variability of oil spills number

Results



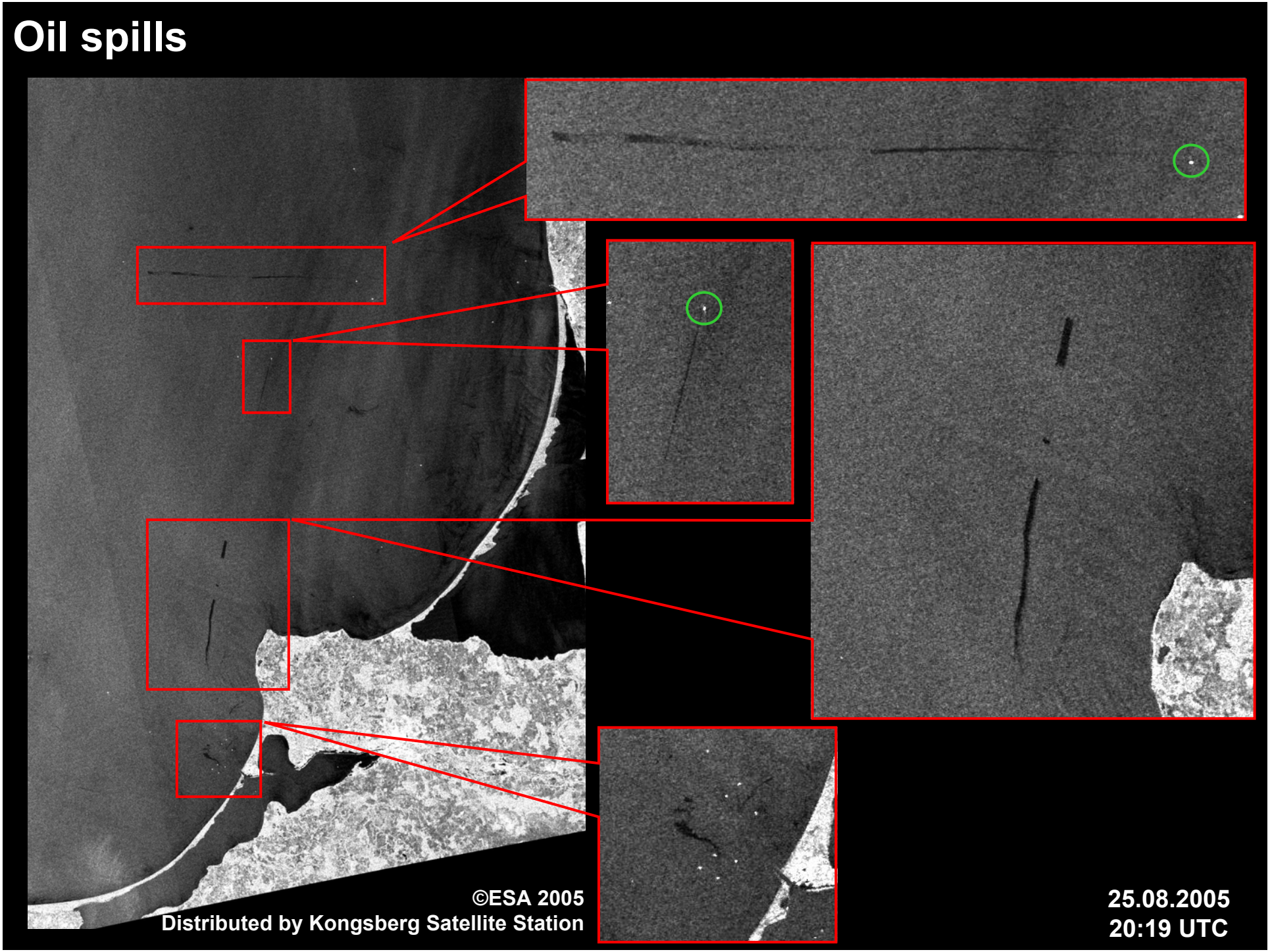
Seasonal variability of oil pollution area **from 12.06.2004 to 31.12.2014**


Oil spills number
60
50
40
30
20
10
0
23
18
42
57
58
55
48
46
52
15
29
15
14
16
14
7
29
28
10
17
13
10
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
morning
evening
Oil spills number
350
300
250
200
150
100
50
0
332
284
2004-2014

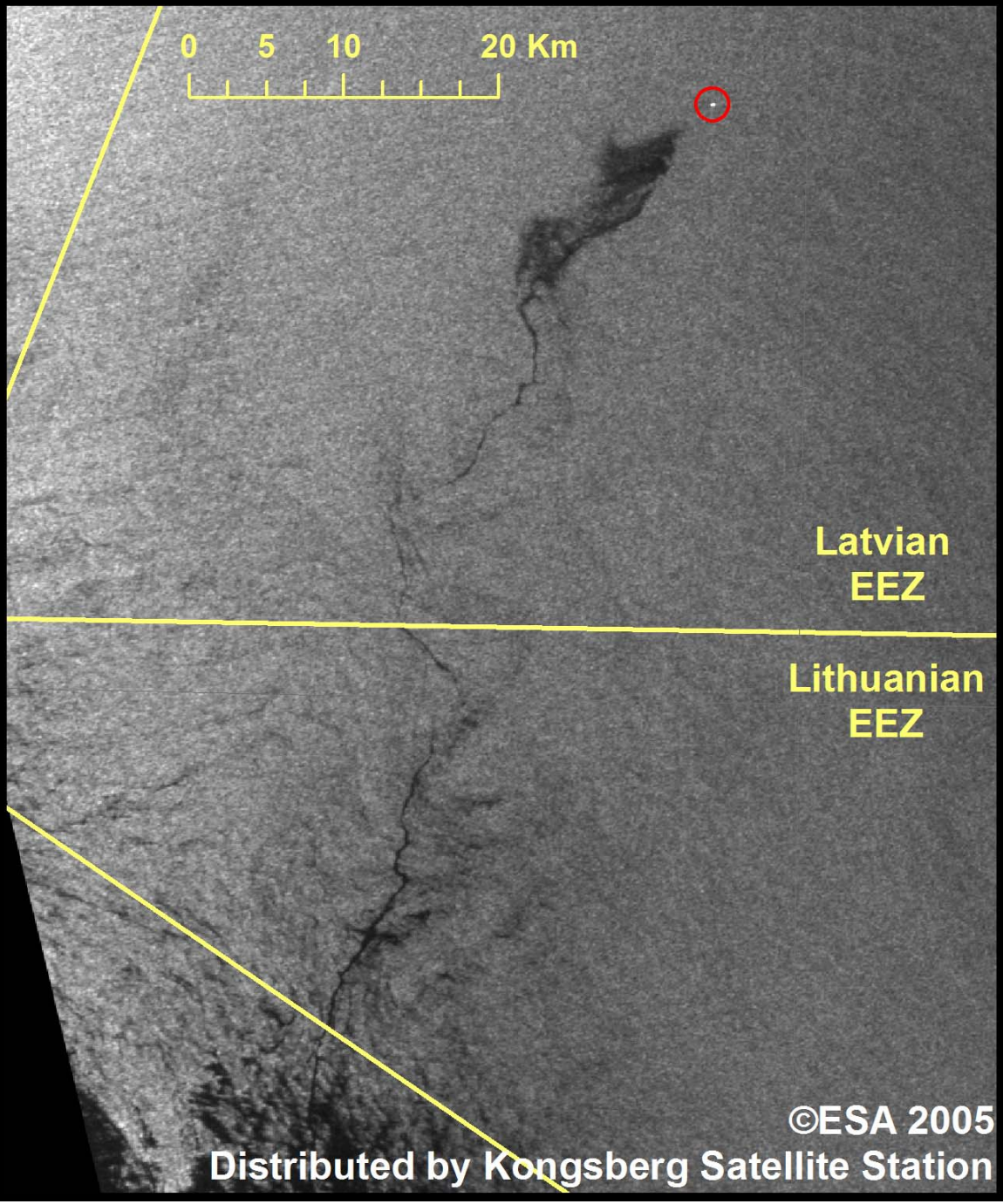
Oil spills

28.05.2005
20:16 UTC

Oil spills

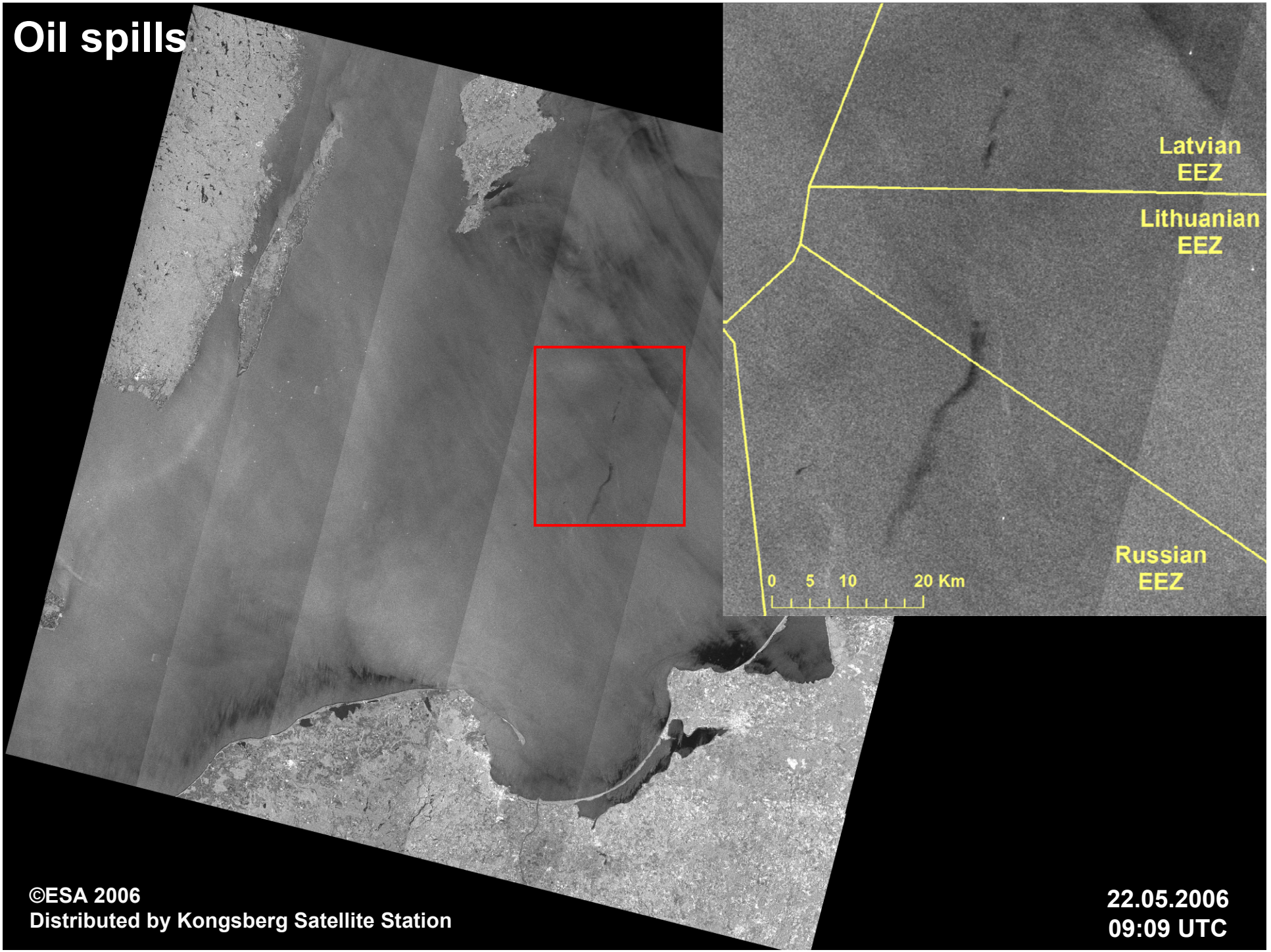

©ESA 2005
Distributed by Kongsberg Satellite Station
25.08.2005
20:19 UTC

Oil spills



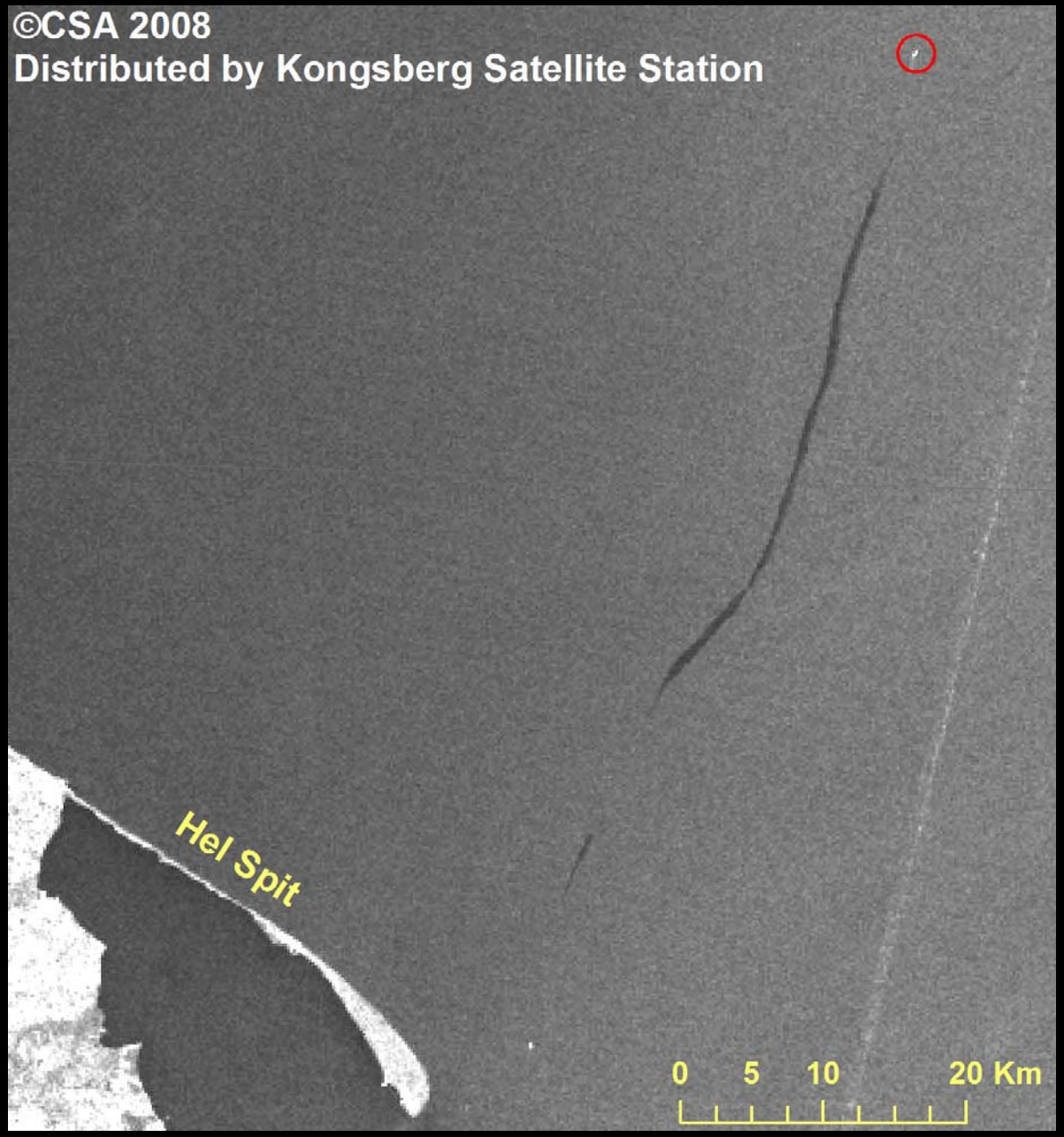
04.09.2005
20:05 UTC

Oil spills



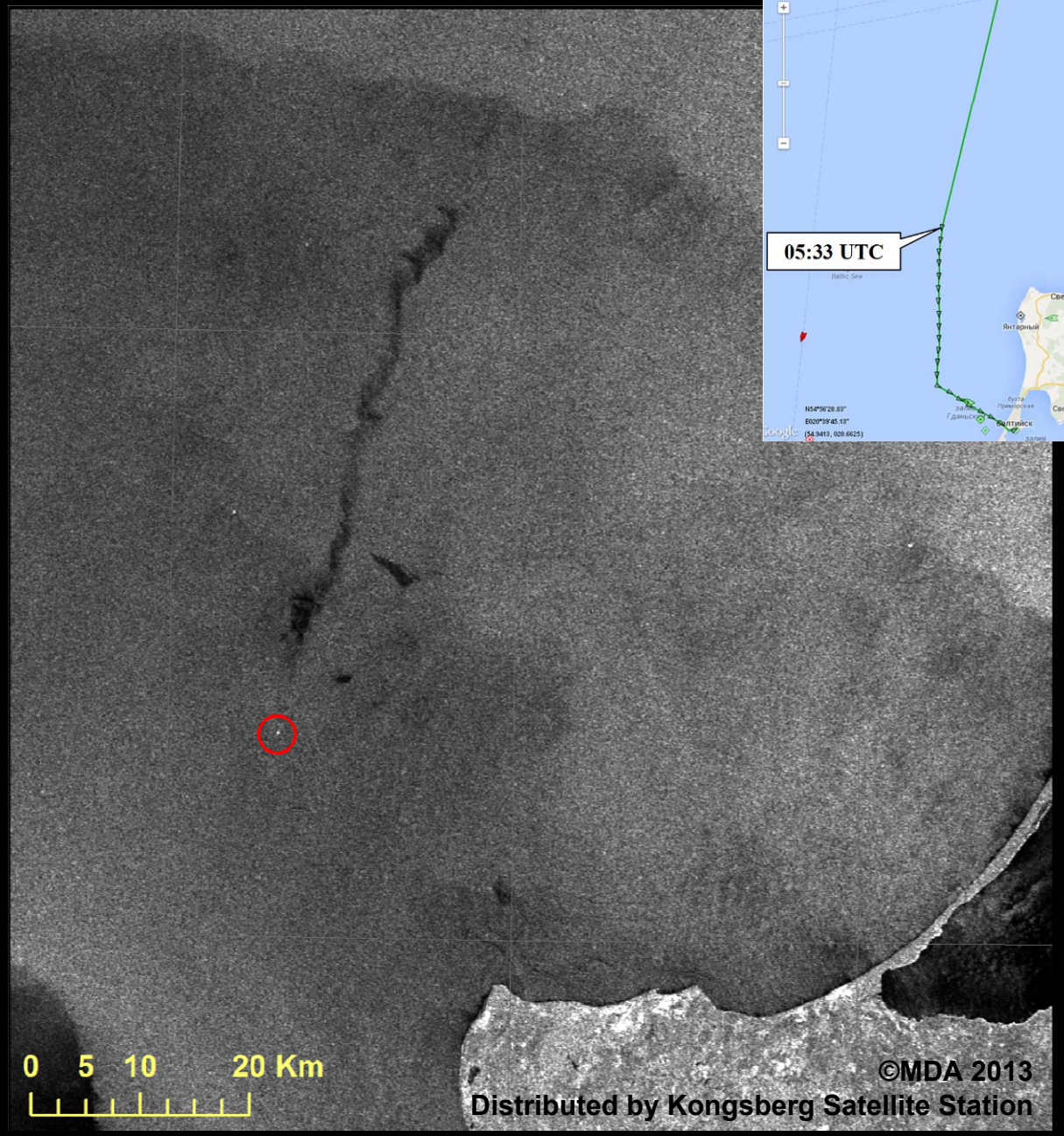
22.05.2006
09:09 UTC

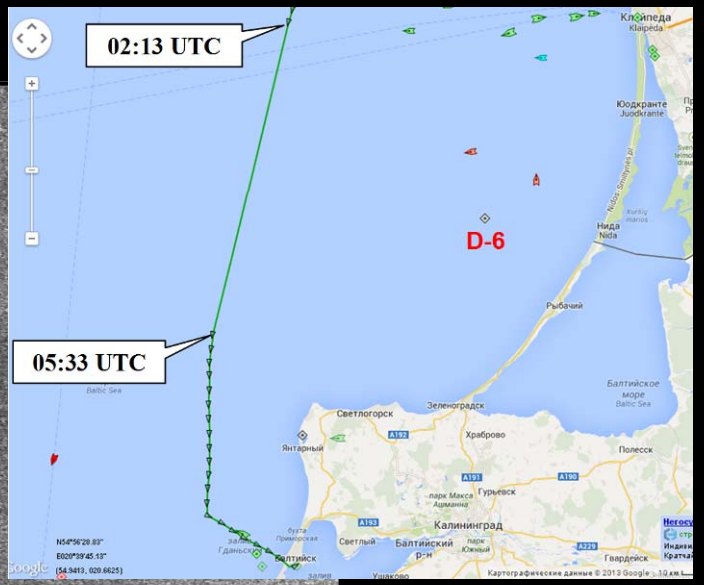
Oil spills



24.07.2008
05:04 UTC

Oil spills





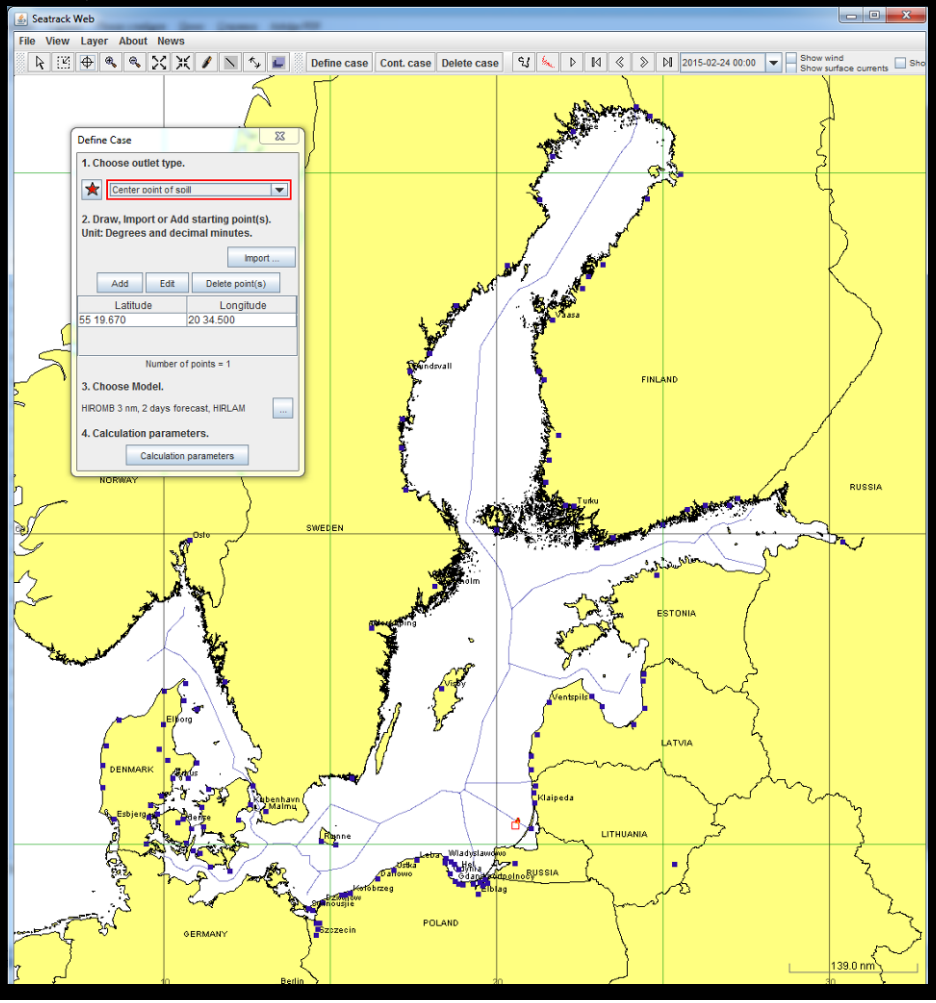
13.09.2013
05:09 UTC

Oil spills

20.09.2013
05:05 UTC

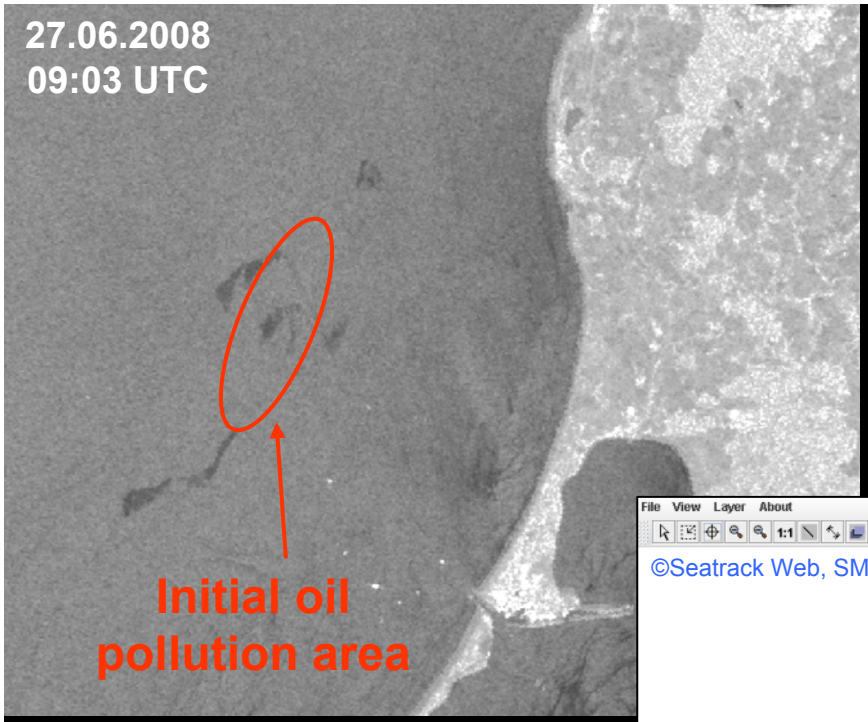
Seatrack Web, SMHI

- Official HELCOM oil drift forecasting system
- 3D calculation model
- Forecasts and backtracks drift and spreading of oil, floating objects, algae, passive tracers
- Resolution is 1 or 3 nm; 15 min

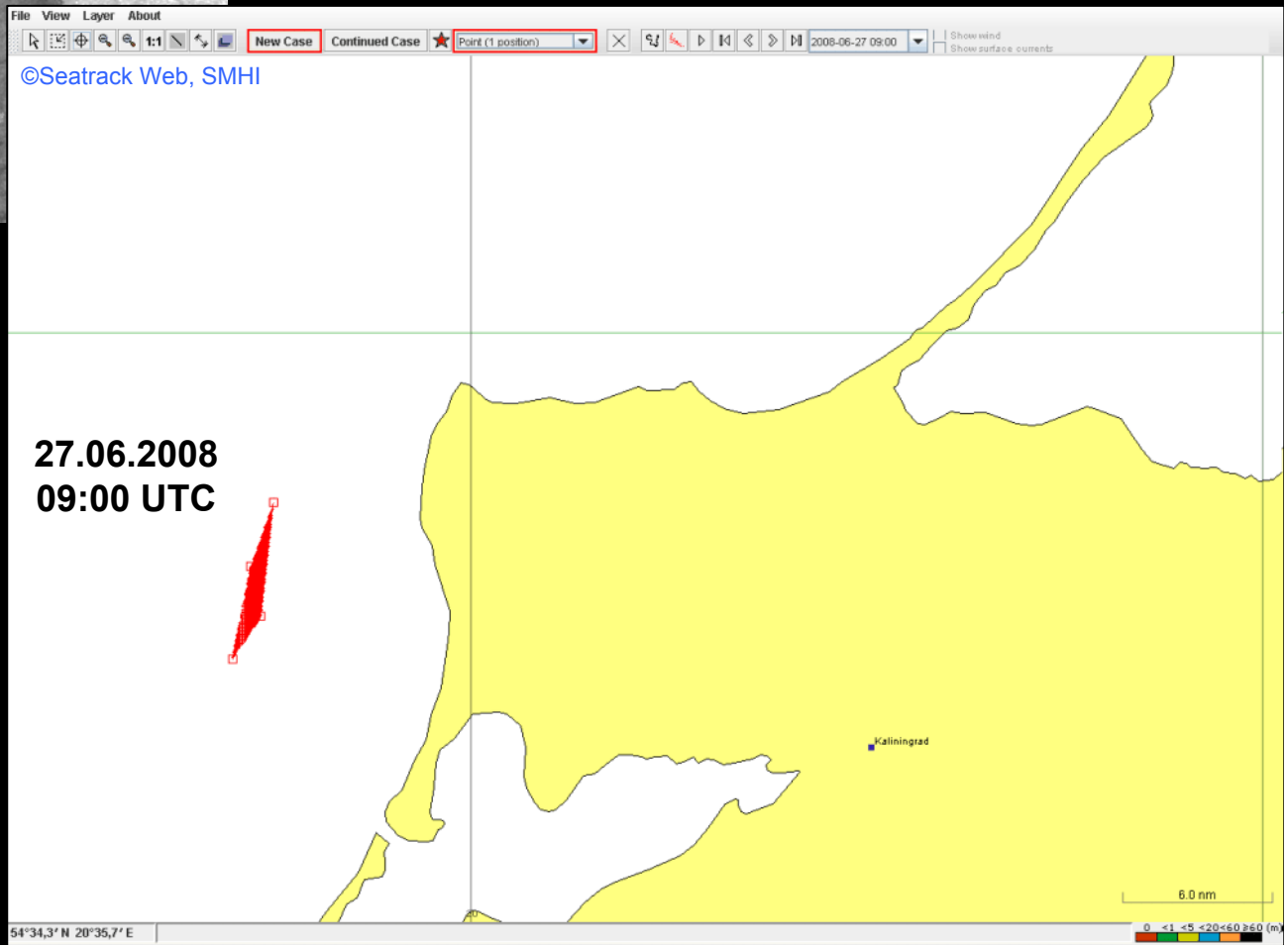


Curonian Spit beach, 22 July 2008

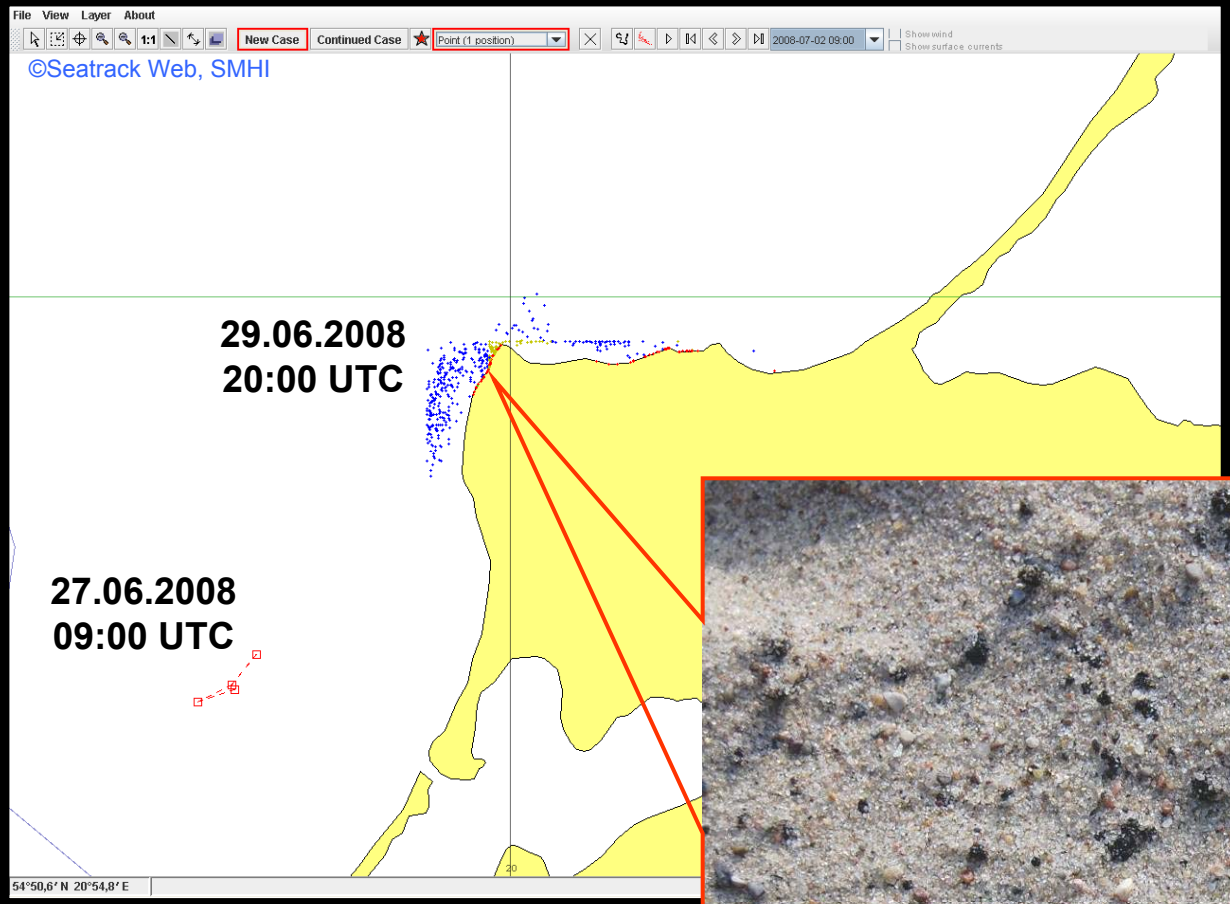
Possible source of oil pollution



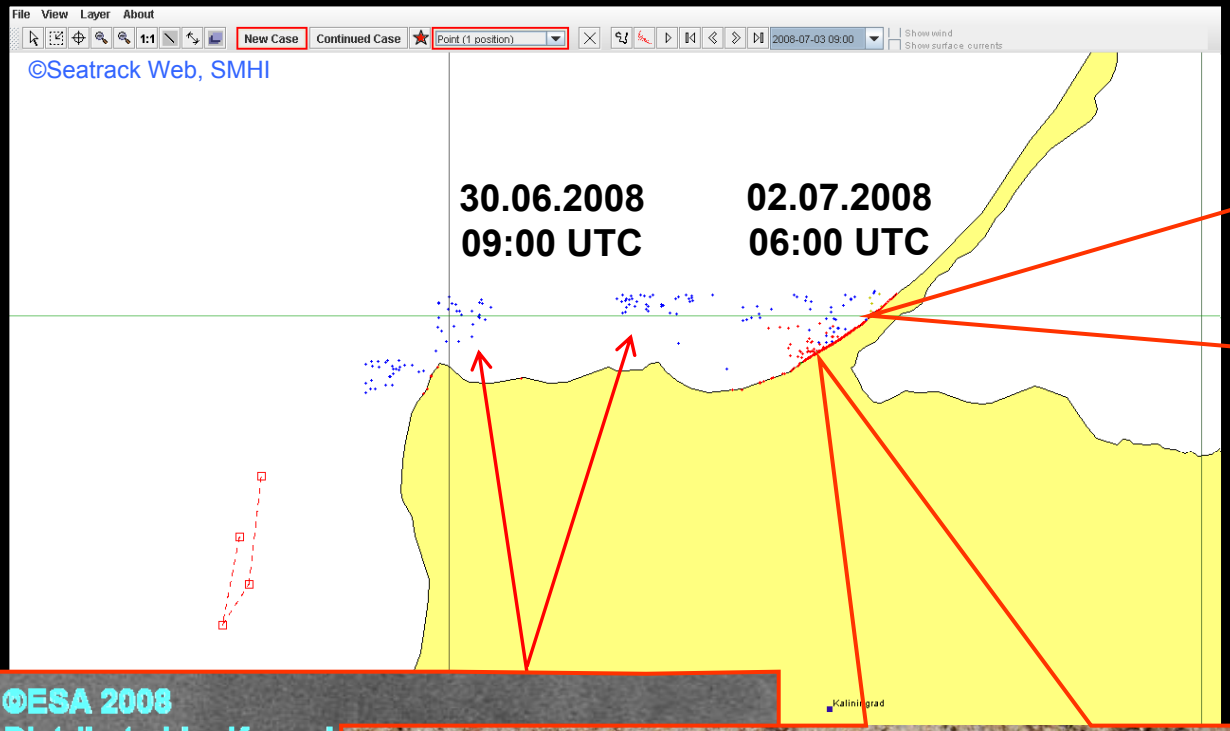
Oil spill drift forecast with step of 24h

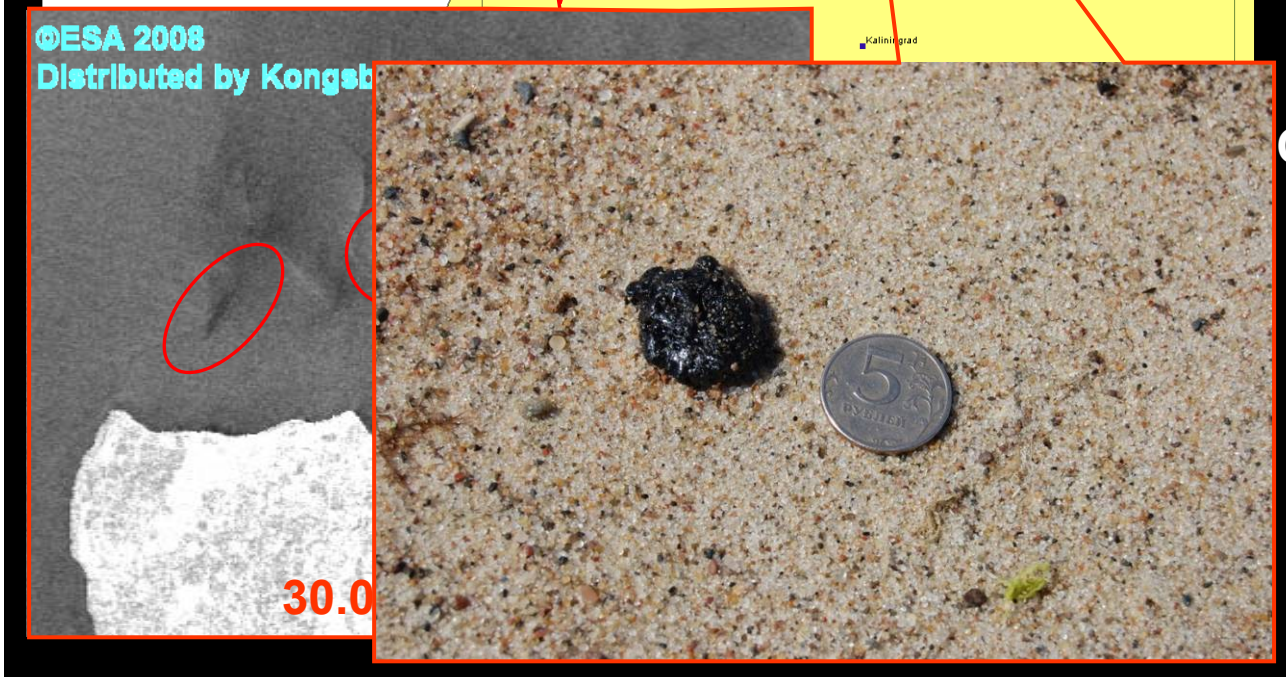


Contamination of the coast

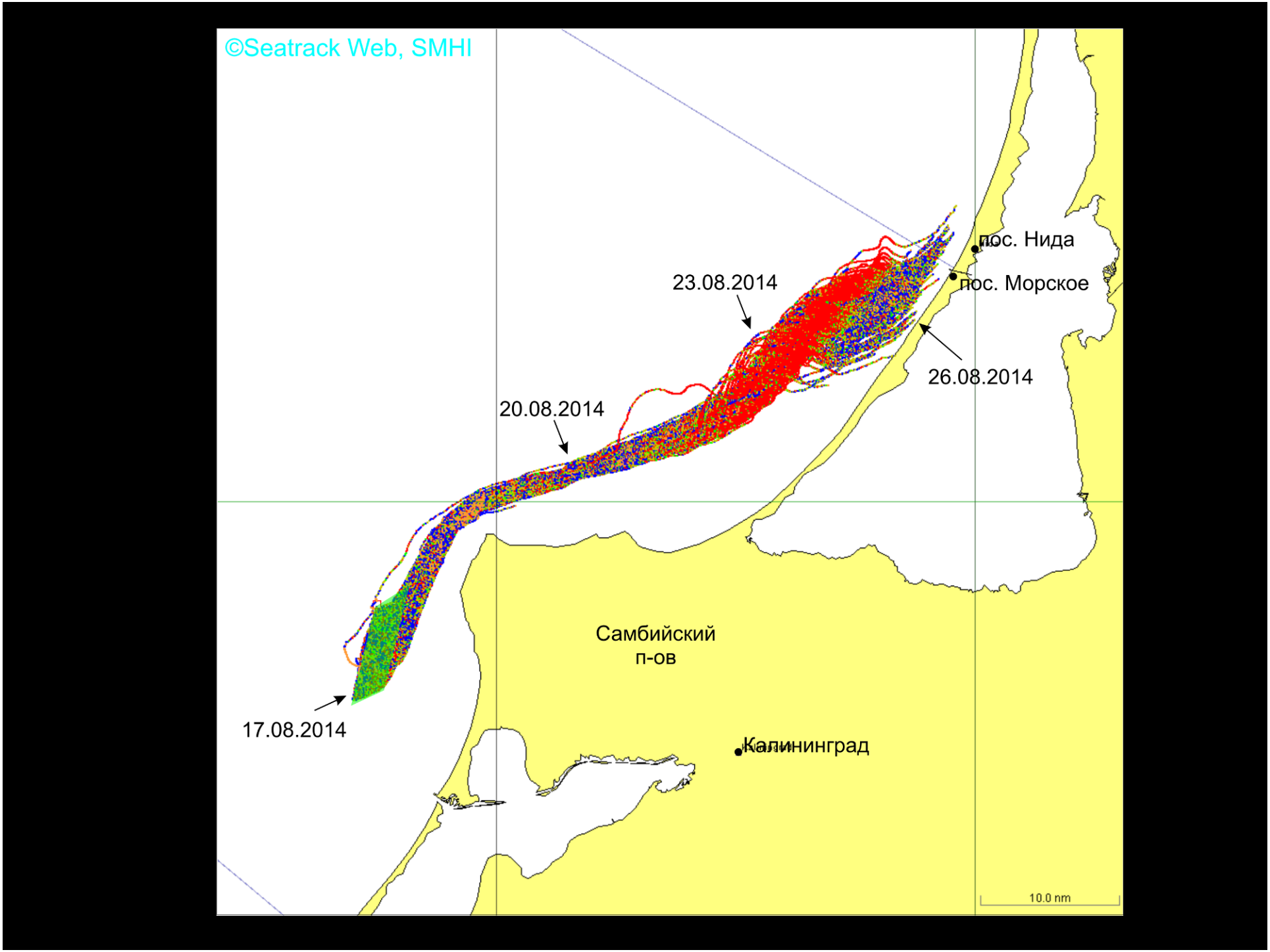


End of the forecast – the Curonian Spit beach

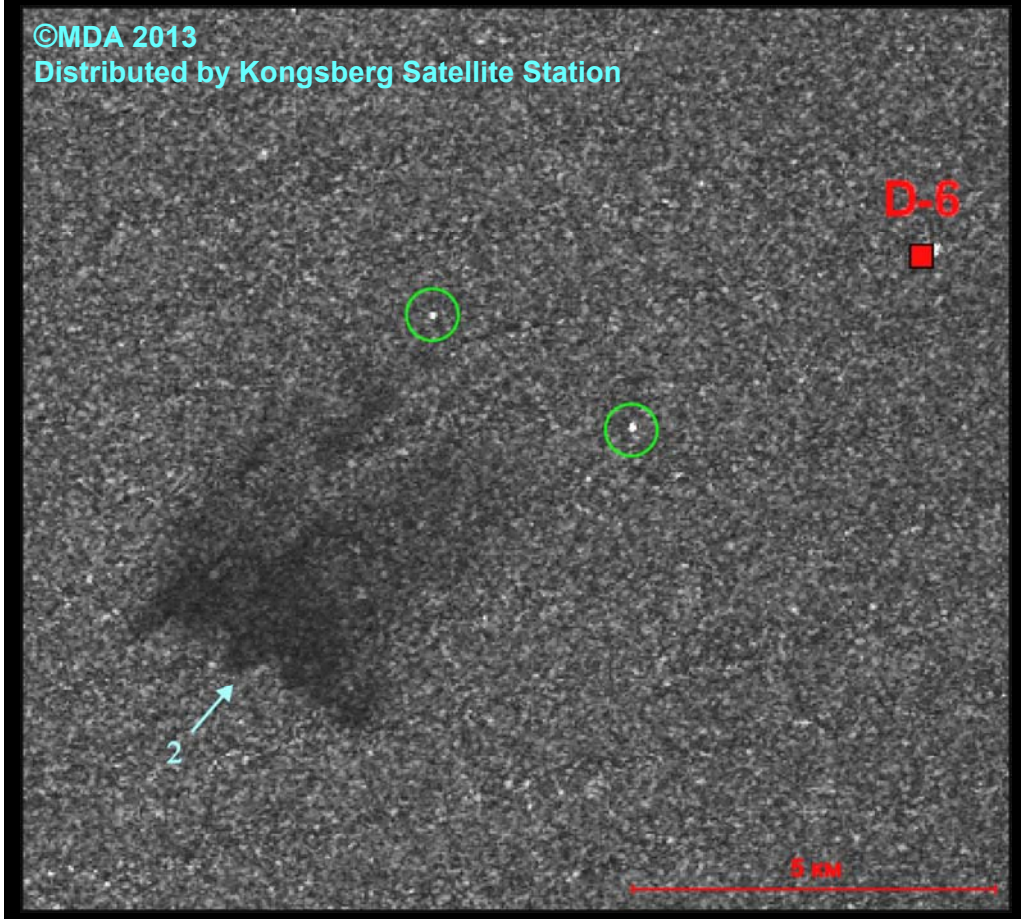




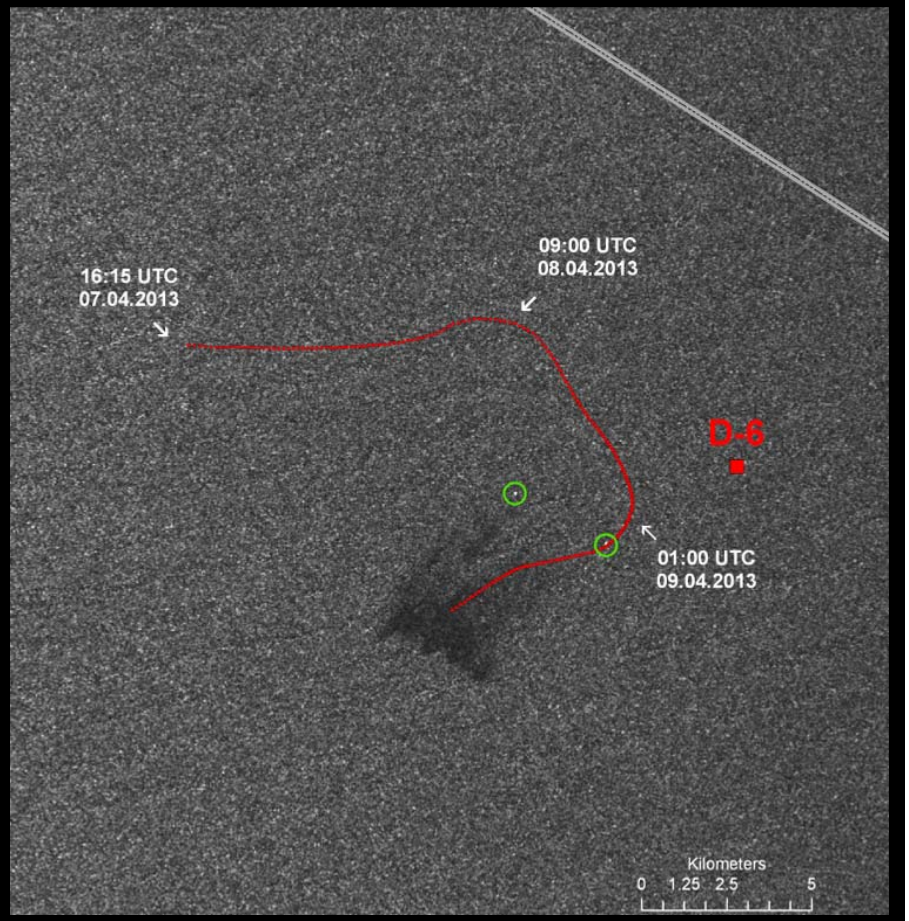
Oil clots in the sample of the bottom sediments
9 July 2008


©Seatrack Web, SMHI
пос. Нида
пос. Морское
23.08.2014
26.08.2014
20.08.2014
Самбийский
п-ов
17.08.2014
Калининград
10.0 nm

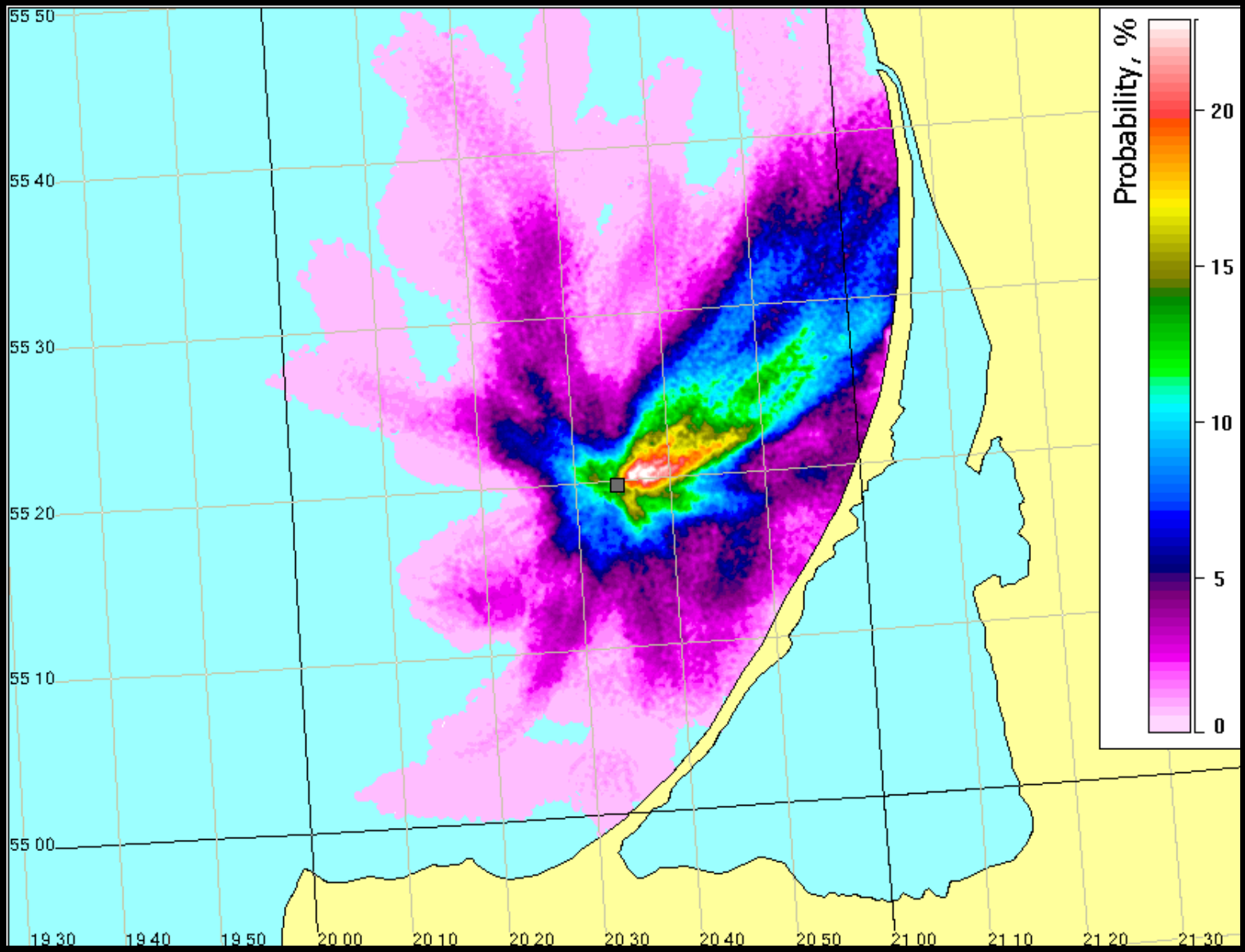
Detection of oil spill sources



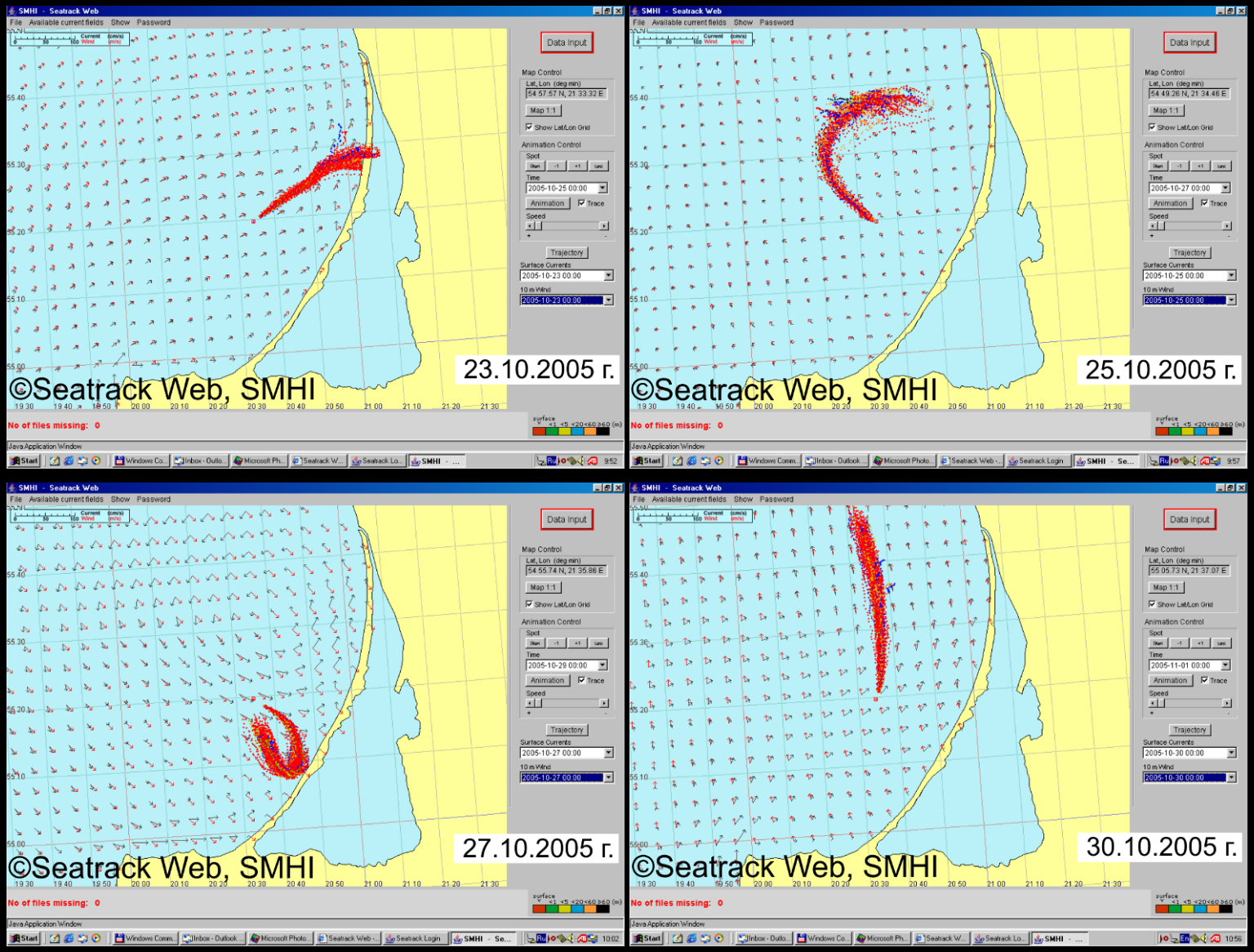
09.04.2013
(16:15 UTC)



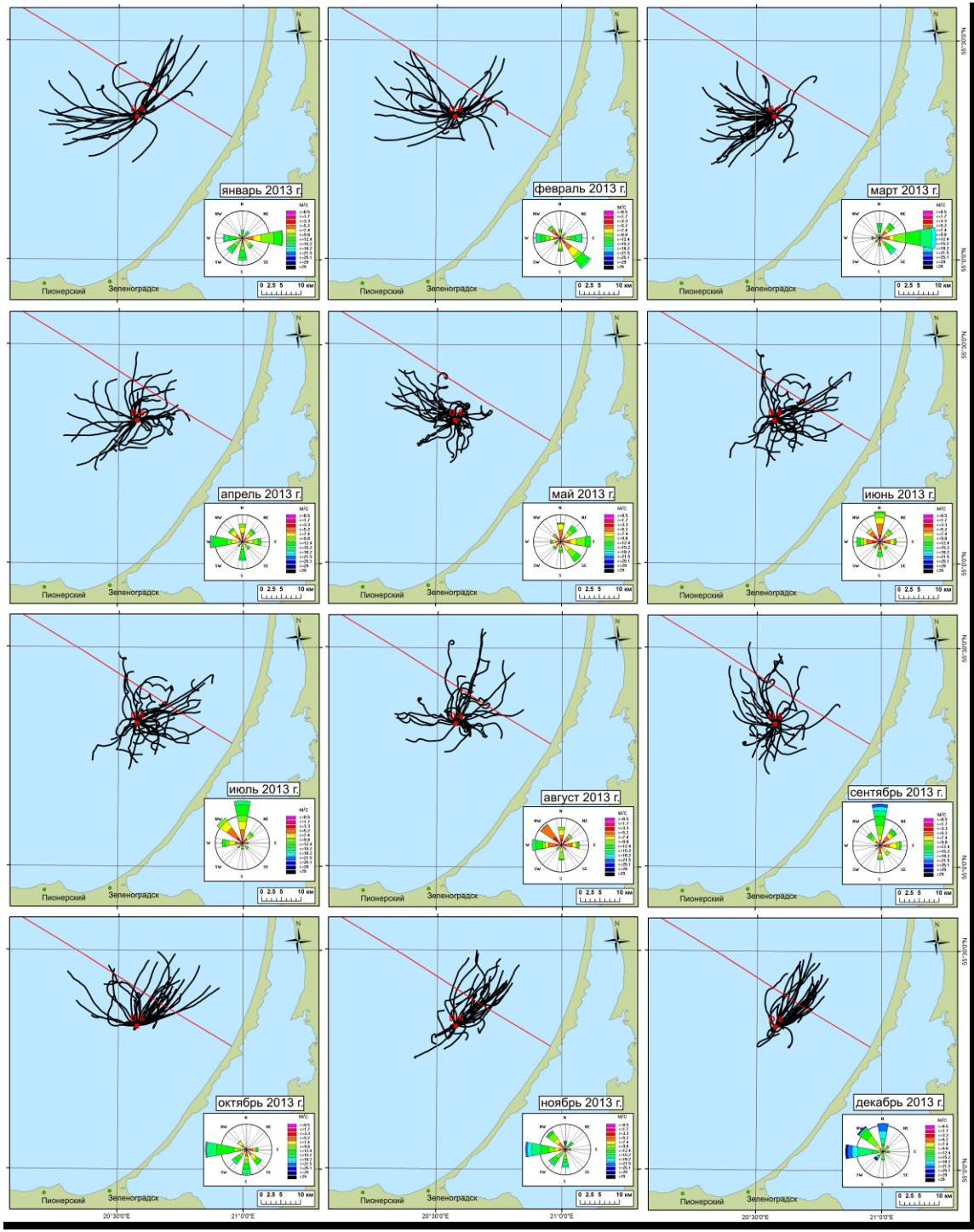
No AIS data

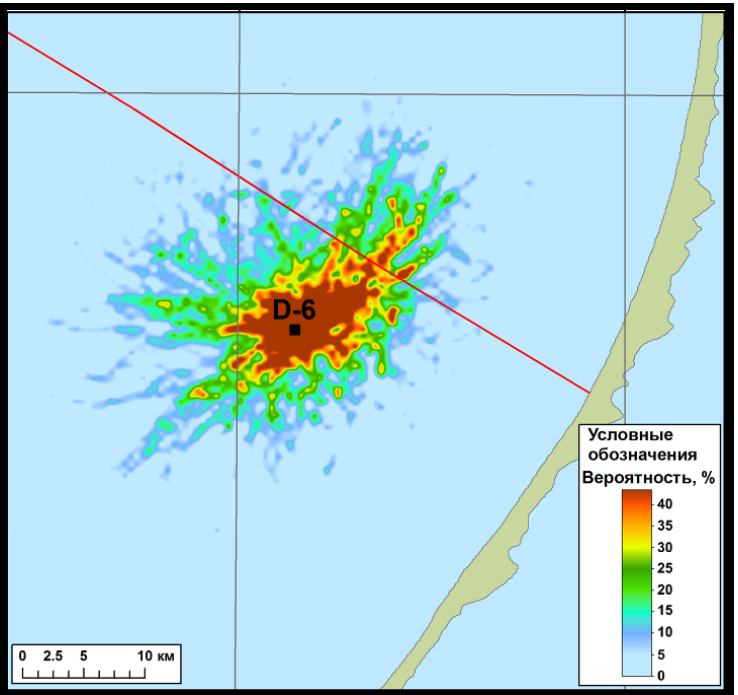


Вероятность распространения (%) в течение 48 часов потенциального нефтяного загрязнения с платформы D-6 с июля по декабрь 2004 г.



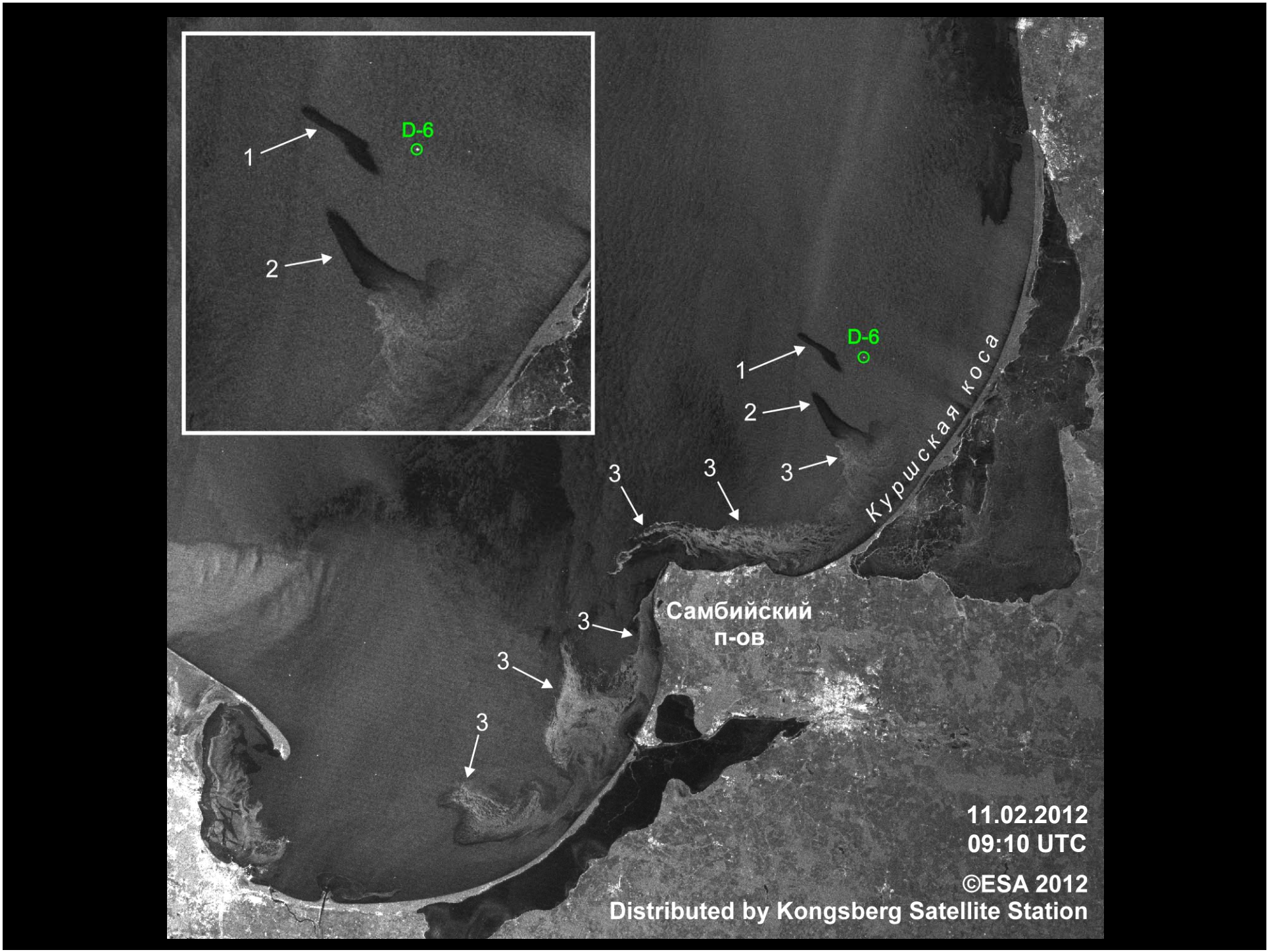
Прогноз дрейфа виртуального нефтяного пятна с платформы D-6 в октябре 2005 г.

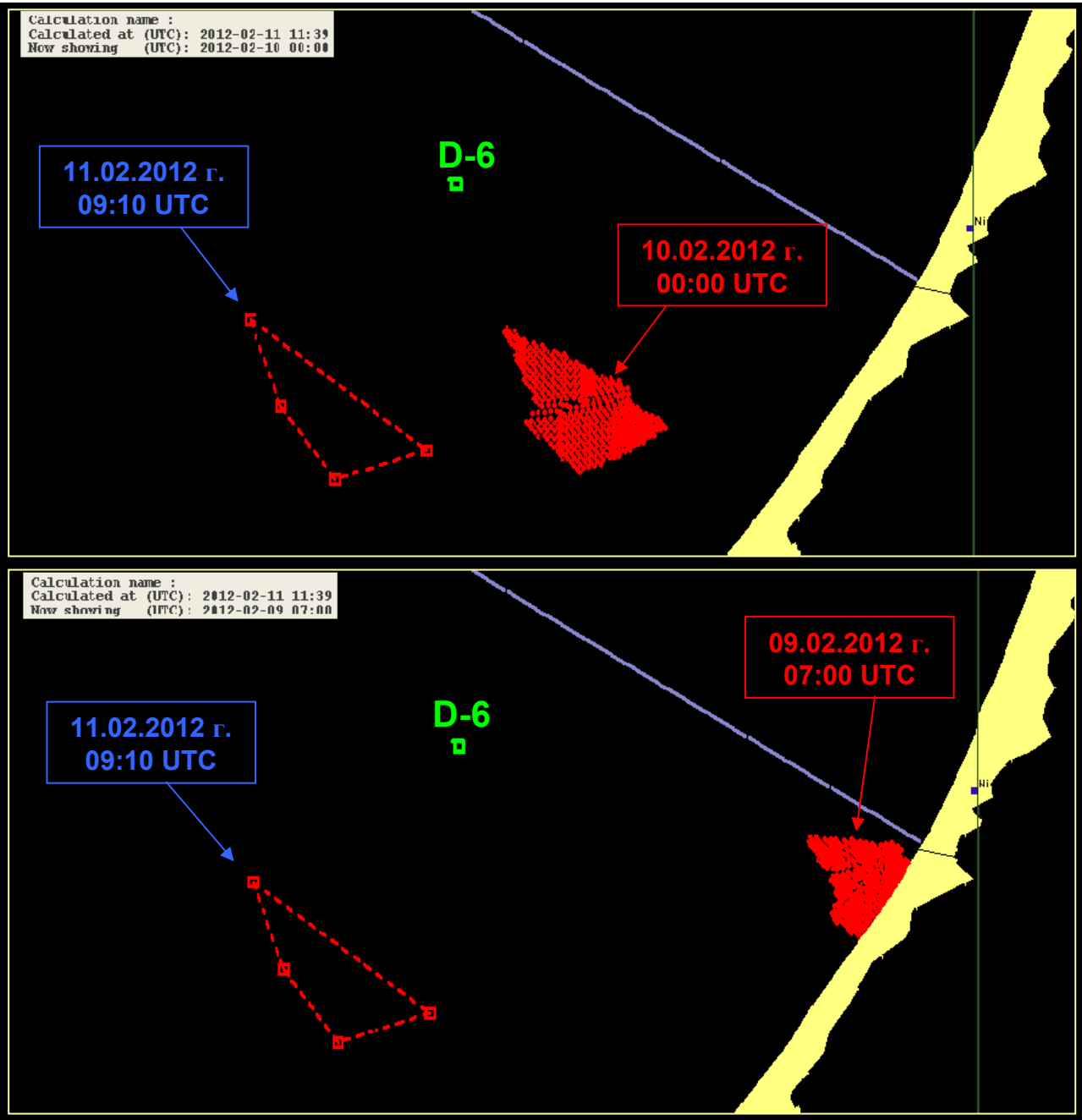




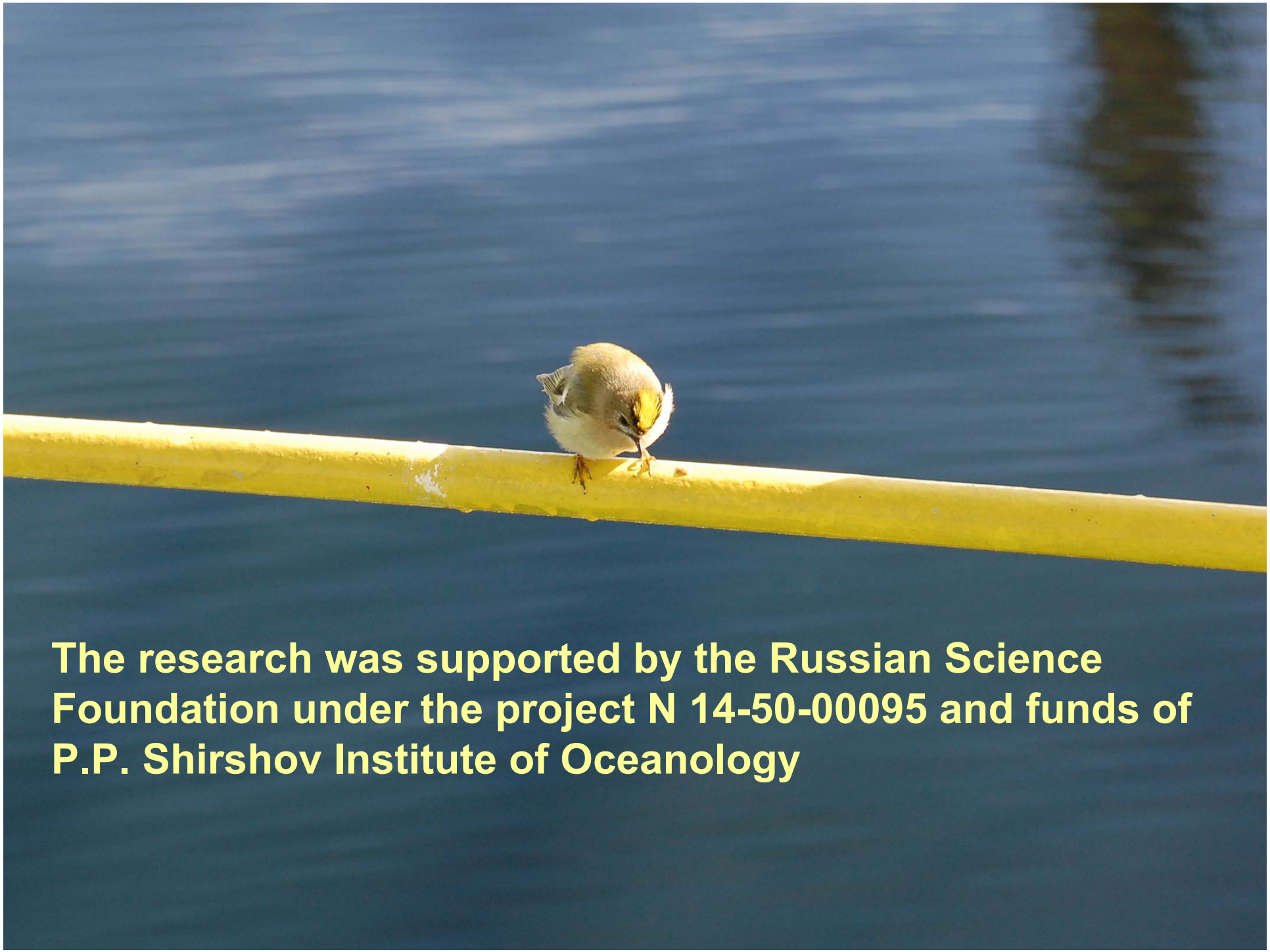
Вероятность распространения (%) в течение 48 часов потенциального нефтяного загрязнения с платформы D-6 в 2013 г.

Ежемесячные кумулятивные траектории распространения потенциального нефтяного пятна, образовавшегося от МЛСП D-6 по данным STW для 2013 г.


D-6
1
2
D-6
1
2
3
3
3
Куршская коса
Самбийский
п-ов
3
3
3
11.02.2012
09:10 UTC
©ESA 2012
Distributed by Kongsberg Satellite Station

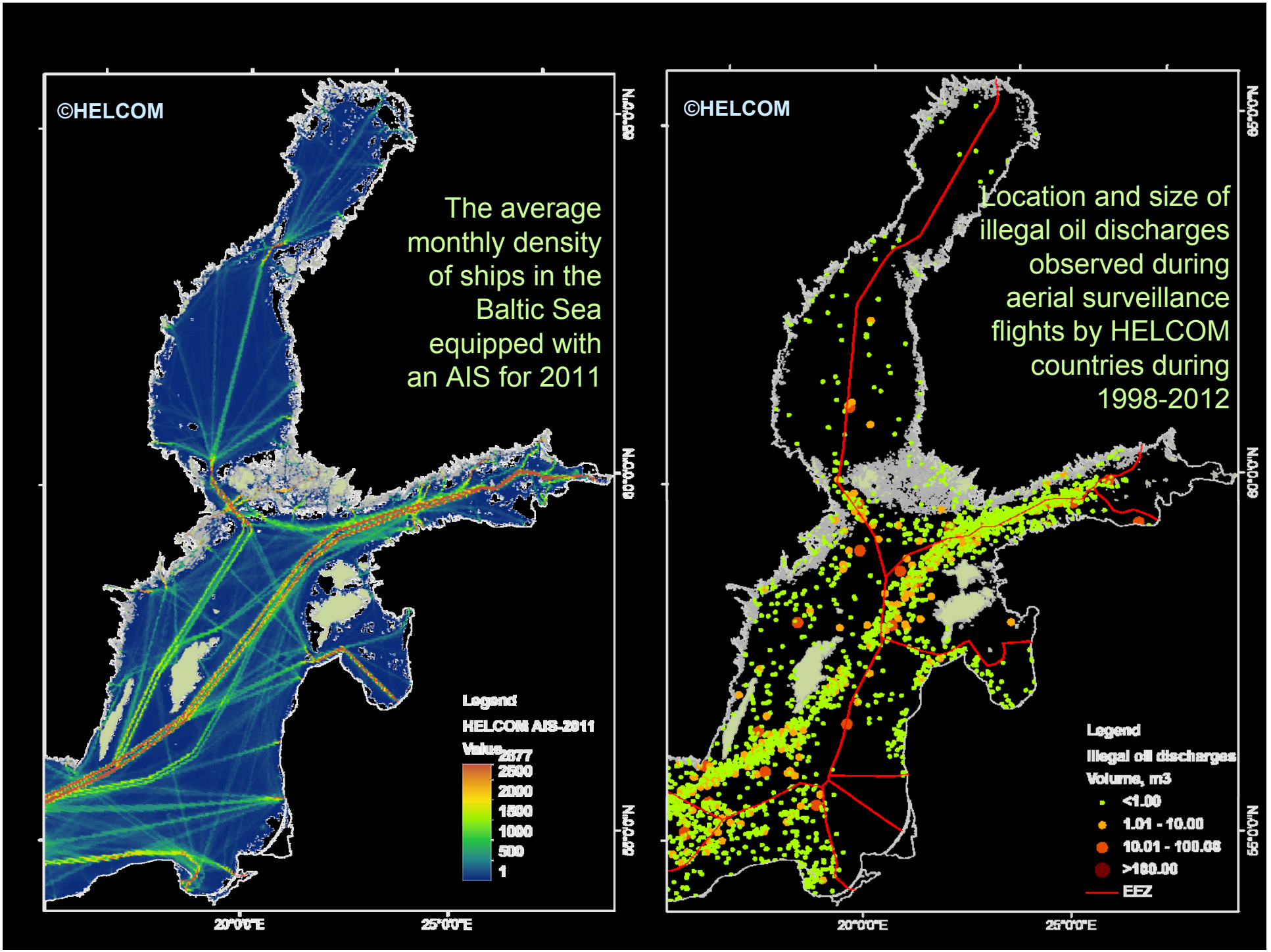


Прогноз дрейфа пятна №2 «назад во времени».
Красным пунктиром показано положение пятна на снимке



The research was supported by the Russian Science Foundation under the project N 14-50-00095 and funds of P.P. Shirshov Institute of Oceanology

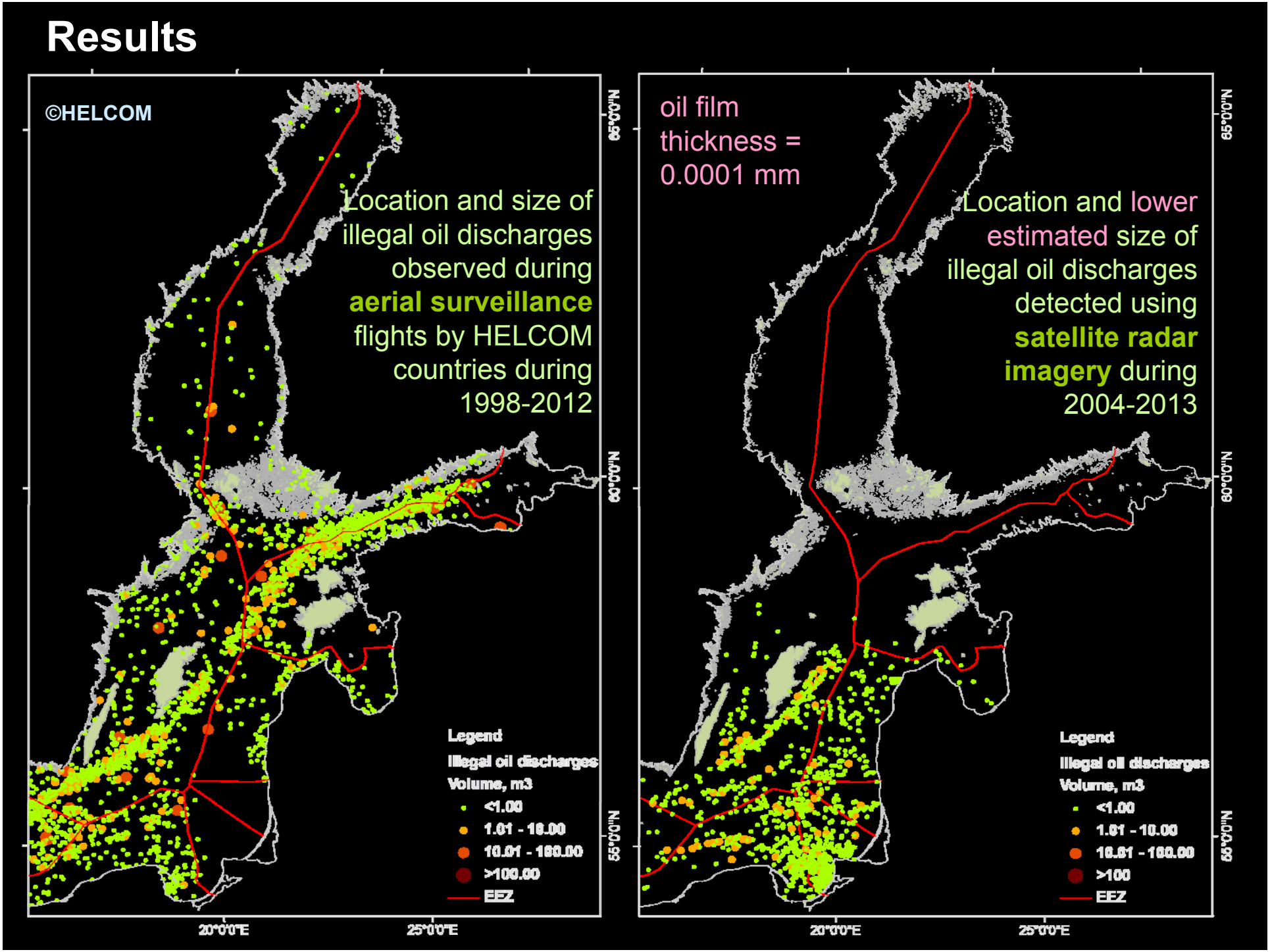

Thank you for attention


©HELCOM
The average monthly density of ships in the Baltic Sea equipped with an AIS for 2011
Legend
HELCOM AIS-2011
Value
2877
2500
2000
1500
1000
500
1
20°00'E
25°00'E
©HELCOM
Location and size of illegal oil discharges observed during aerial surveillance flights by HELCOM countries during 1998-2012
Legend
Illegal oil discharges
Volume, m3
<1.00
1.01 - 10.00
10.01 - 100.00
>100.00
EEZ
20°00'E
25°00'E

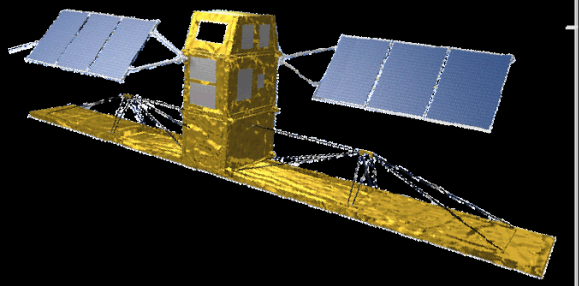
Annual aerial surveillance data for the Baltic Sea in 2013. ©HELCOM

Country	No. of flight hours			No. of detections by countries (incl. in other countries EEZ)			Detections confirmed/ observed as oil spills in own waters (incl. reports by other countries)			Estimated volume m^3 (in own waters)	No. of polluters (including reports from other countries)			
	Daylight	Darkness	Total	Daylight	Dark-ness	Total	Daylight	Dark-ness	Total		Rigs	Ships	Unknown	Total
Denmark	197.05	10	207.05	34	11	45	14	0	14	0.54	0	1	13	14
Estonia	271	56	327	12	3	15	8	0	8	1.01	0	1	7	8
Finland	570	55	625	14	2	16	9	0	9	0.11	0	3	6	9
Germany	314.9	154.6	469.5	13	3	16	7	0	7	0.56	0	0	7	7
Latvia	0	0	0	0	0	0	1	0	1	0.98	0	0	1	1
Lithuania	19	0	19	0	0	0	0	0	0	0	0	0	0	0
Poland	386.5	0	386.5	31	0	31	27	0	27	2.62	0	0	27	27
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	1928	355	2283	134	8	142	64	0	64	5.33	1	10	53	64
Total	**3686.45**	**630.60**	**4317.05**	**238**	**27**	**265**	**130**	**0**	**130**	**11.16**	**1**	**15**	**114**	**130**

Results


©HELCOM
Location and size of illegal oil discharges observed during aerial surveillance flights by HELCOM countries during 1998-2012
Legend
Illegal oil discharges
Volume, m3
<1.00
1.01 - 10.00
10.01 - 100.00
>100.00
EEZ
20°0'0"E
25°0'0"E
65°0'0"N
60°0'0"N
55°0'0"N
oil film thickness = 0.0001 mm
Location and lower estimated size of illegal oil discharges detected using satellite radar imagery during 2004-2013
Legend
Illegal oil discharges
Volume, m3
<1.00
1.01 - 10.00
10.01 - 100.00
>100
EEZ
20°0'0"E
25°0'0"E
65°0'0"N
60°0'0"N
55°0'0"N

Results



Combination of detected oil discharges observed during **aerial surveillance (1998-2012) and satellite observations (2004-2013)**