SELF-CLEANING CAPACITY OF SEA COASTS IN CASE OF OIL POLLUTION

Kuznetsov A.N., Fedorov Yu.A.

Southern Federal University, Rostov-on-Don, Russia

Fattal P., Ebner F.

University of Nantes, Nantes, France

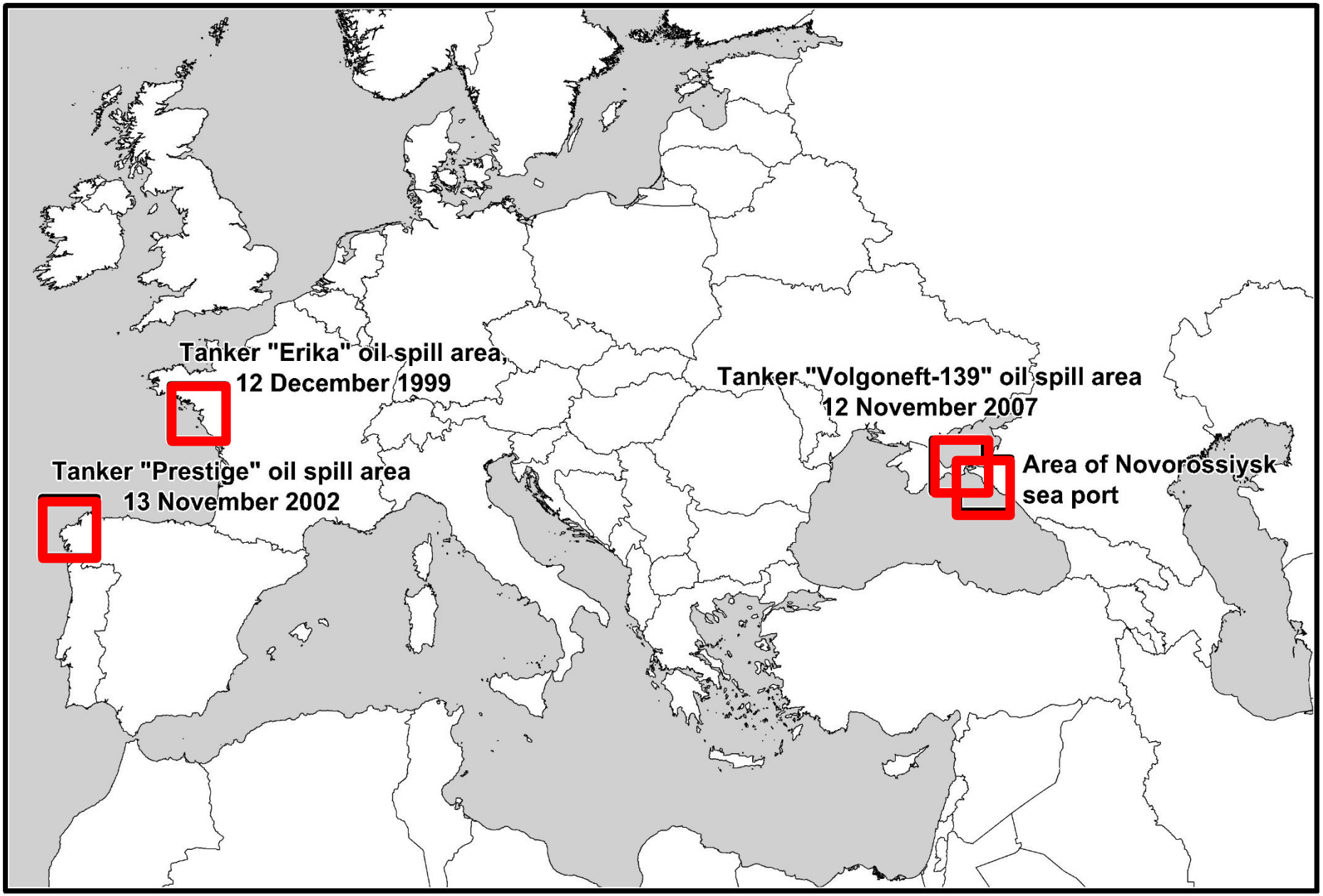
Objectives

The objective of the research is to evaluate:

- the **rates of spilled fuel oil natural destruction on geographically different sea coasts;**

- **their relationship with principal environmental factors** such as climatic and hydrological conditions, coast exposure and geomorphology, sediment types, intensity of biogeochemical cycles etc.

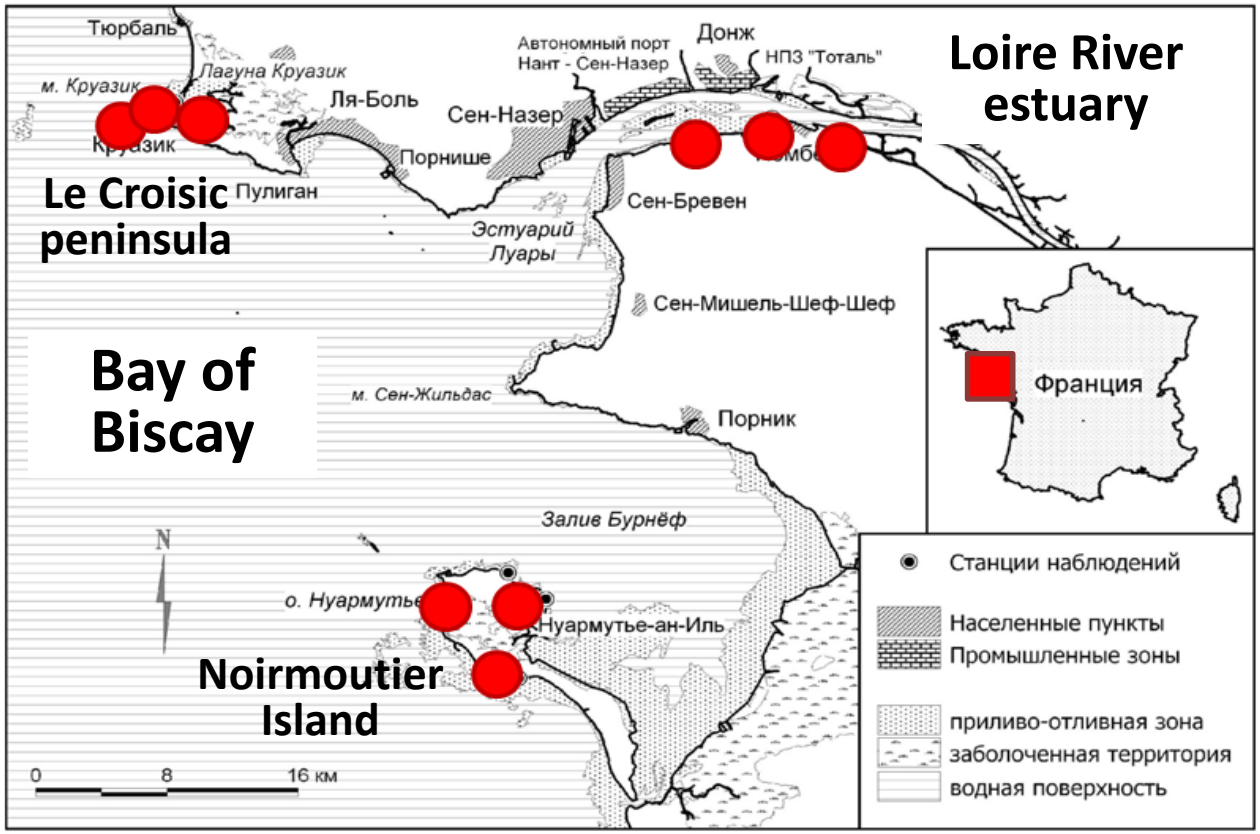
Study areas: geographically different oiled sea coasts



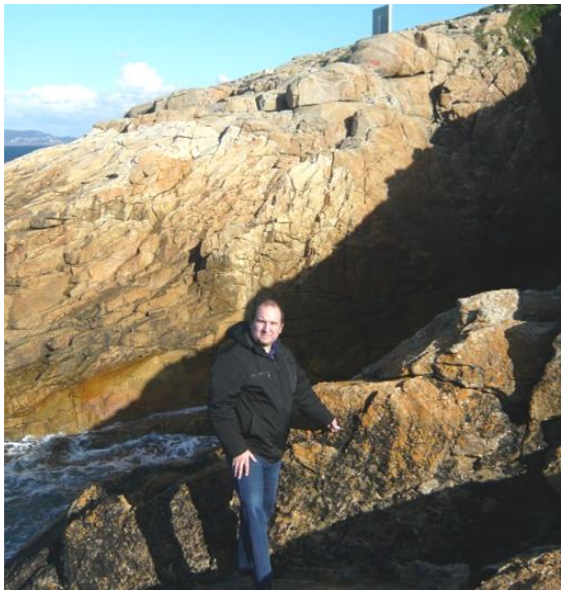
Materials and methods

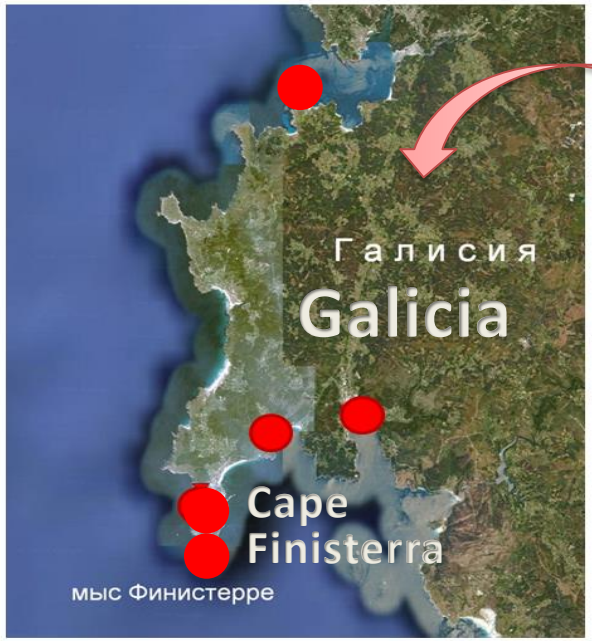
- **24 expeditions** were carried out;
- **320 samples of oil slicks** and 48 sediment cores up to 50 cm thick divided into 178 samples were taken, described and analyzed.
- The samples were analyzed with the use of thin layer chromatography, infrared and ultraviolet spectrophotometry, luminescent and gravimetric methods in order to determine separately the concentrations of three groups of petroleum components:
  - the aliphatic, naphthenic, mono- and di-aromatic hydrocarbons (**HC**);
  - the polycyclic aromatic hydrocarbons (**PAH**);
  - the asphaltic components (**AC**): the resins and the asphaltenes.

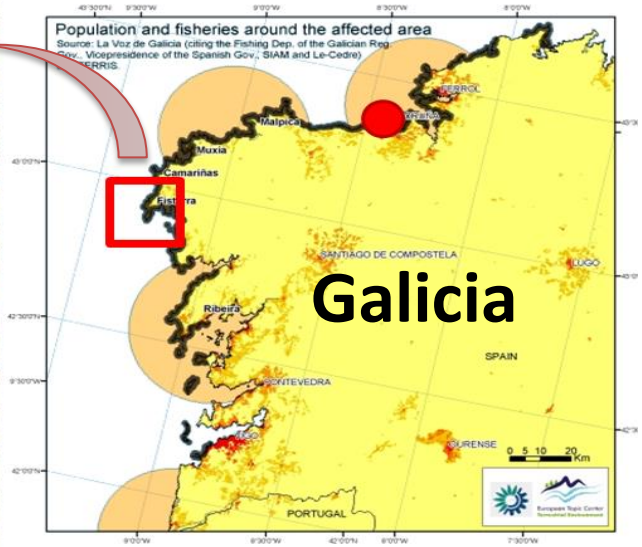
Field study on the Atlantic coast of France and in the Loire River estuary, 1999 to 2014



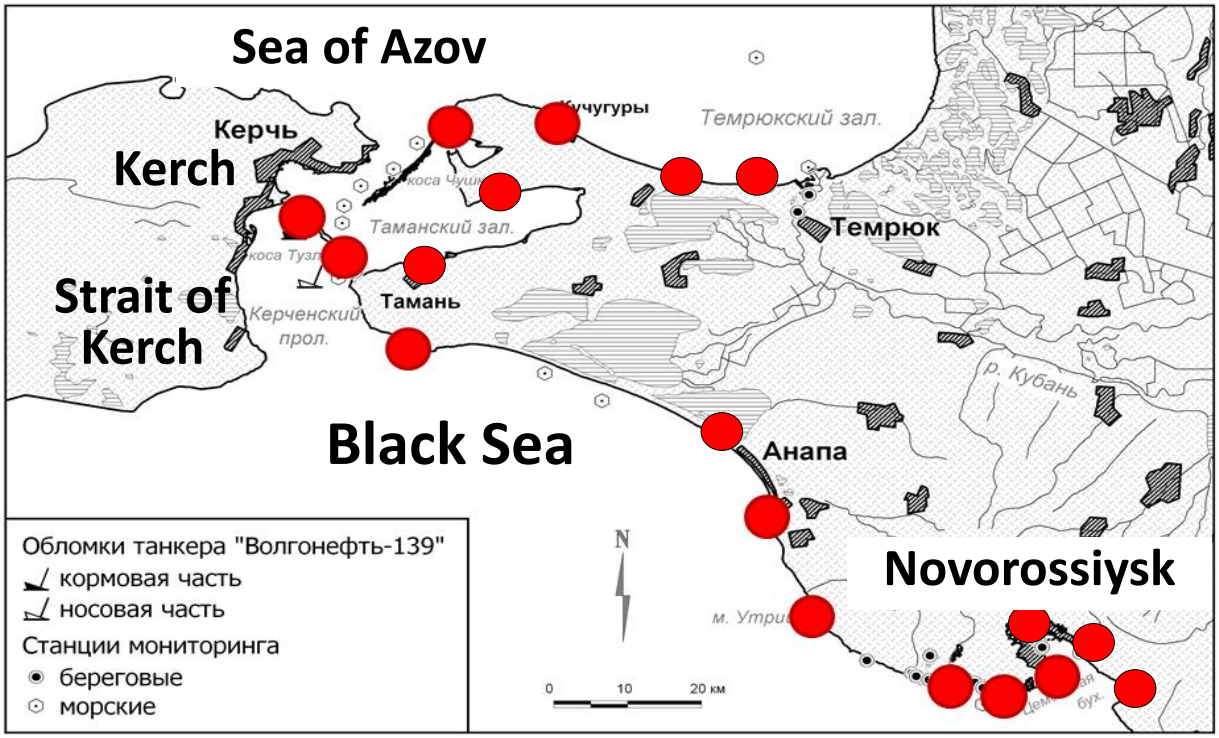
Field study on the Atlantic coast of Spain, 2011, 2012, 2014



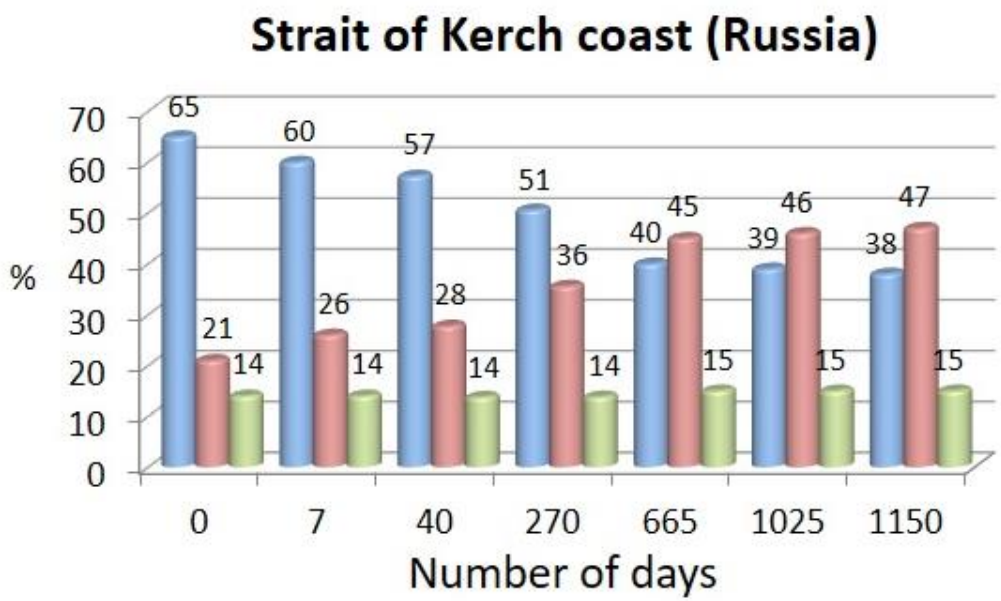


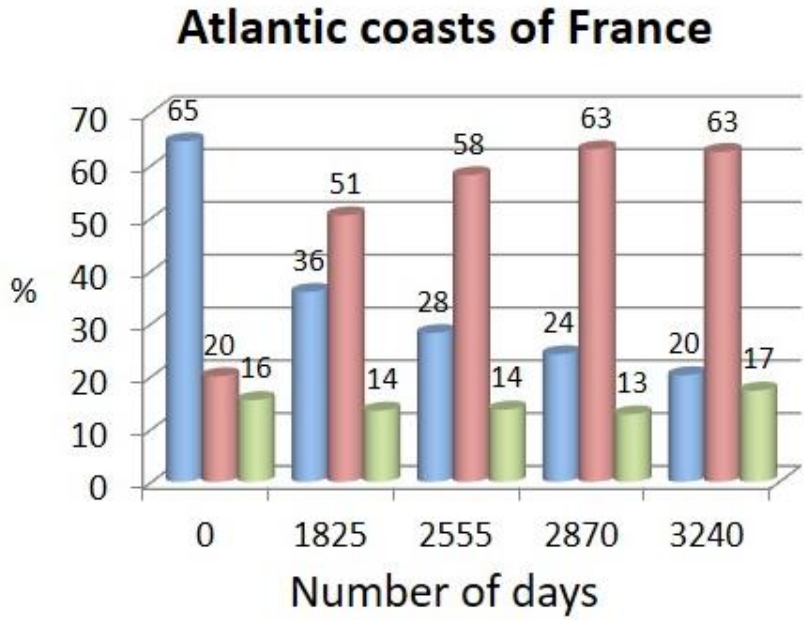


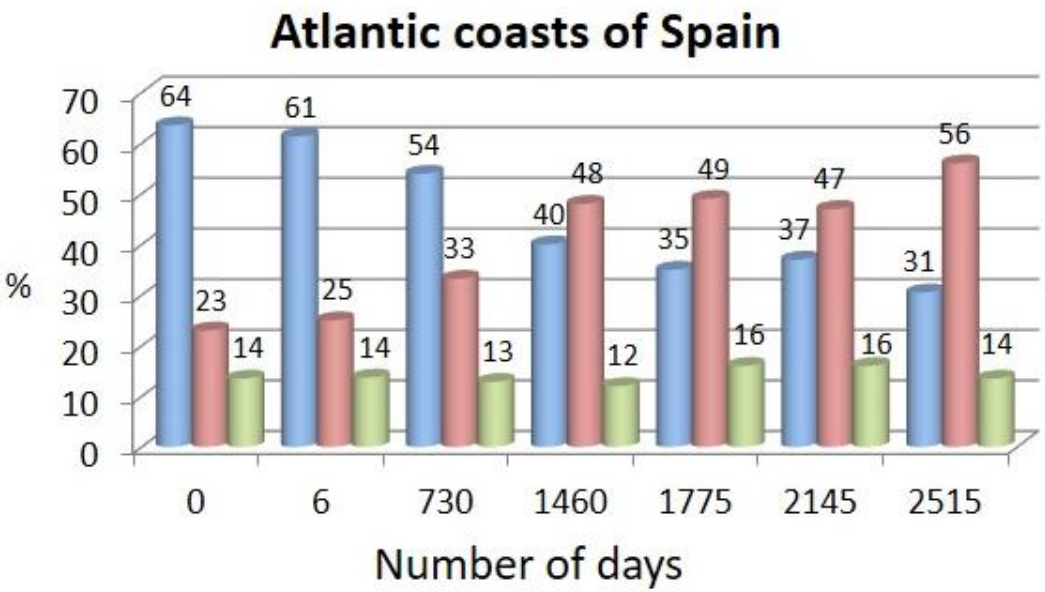
Field study in the Strait of Kerch and in the area of Novorossiysk, 2007 to 2016



Natural transformation of composition of spilled fuel oil





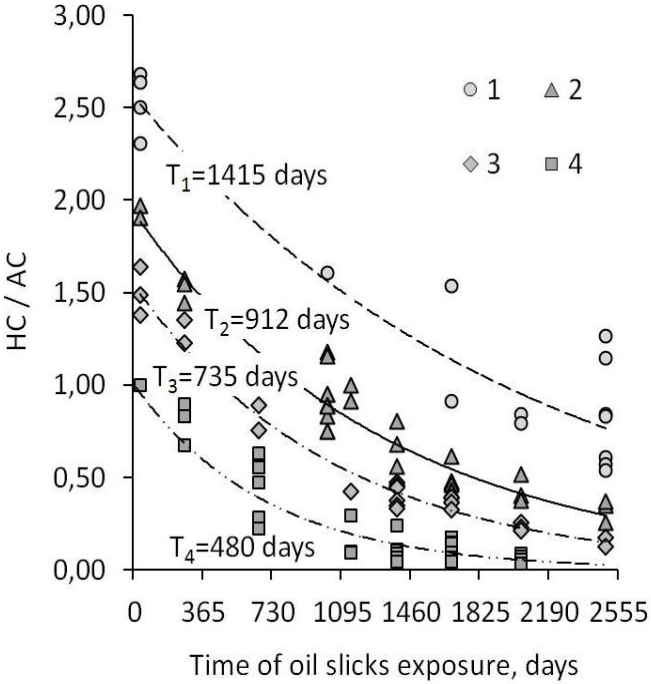


- the sum of saturated, mono- and di-aromatic hydrocarbons;
- the sum of asphaltic components (resins and asphaltenes);
- the sum of polycyclic aromatic hydrocarbons (PAH).

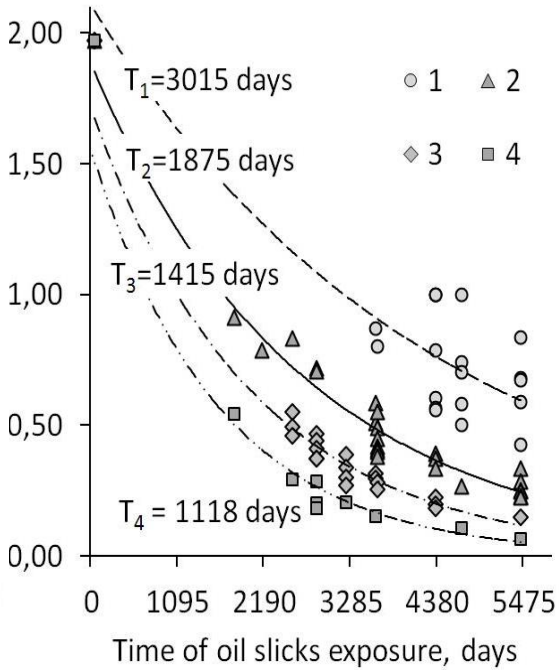
Temporal changes in the ratio of hydrocarbons content to asphaltic components content (HC/AC) in the fuel oil slicks found on the sea coasts

$$(HC/AC)_t = (HC/AC)_0 \cdot e^{-kt} \qquad T = \ln 2 \mid k$$

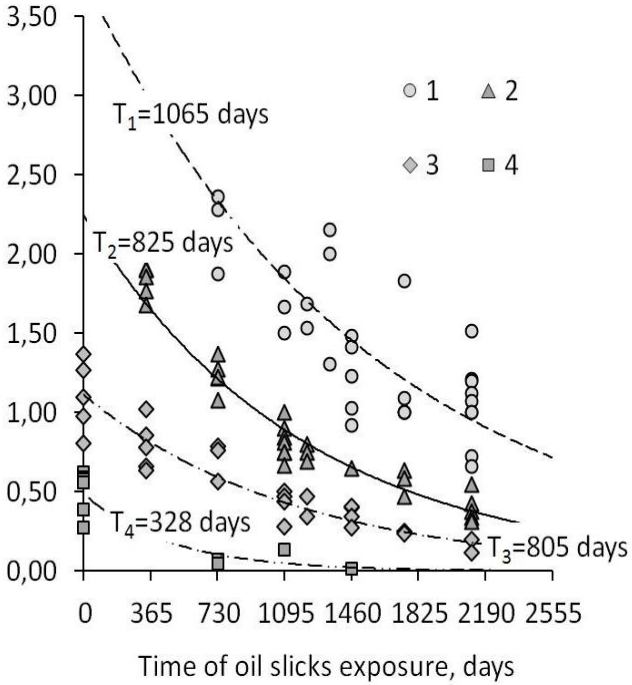
Atlantic coasts of France and Spain



Strait of Kerch coast (Russia)



Black Sea coast in the area of Novorossiysk



1 - large accumulations; **2** - weathered crusts 2 to 5 cm thick; **3** - weathered crusts 5 to 10 cm thick; **4** - weathered films; T – average half-periods of oil pollution natural transformation (the indexes correspond to the numbers in the legend).

Half-periods of fuel oil natural transformation on the sea coasts in different geographical conditions

Polluted sites	Part of littoral zone	Forms of fuel oil traces			
		Films	Crusts 2 to 5 mm thick	Crusts 5 to 10 mm thick	Large accumulations
Western coast of France, Croisic Peninsula and Noirmoutier Island, large granitic tidal flat passing into low granitic cliffs and dunes	upper	**1073** (5)	1368 (7)	1910 (6)	**3309** (7)
	middle	1137 (4)	1440 (7)	1898 (7)	2739 (4)
Loire River estuary, muddy coast with reeds and protection embankment	upper	**426** (4)	759 (2)	**891** (2)	-
	middle	-	838 (2)	-	-
North-Western coast of Spain, Cape Finisterre, high granitic cliffs surrounding a bay with sand beach and dune	above high tide level	-	-	1961 (2)	2598 (1)
	upper	-	**1421** (3)	1901 (2)	**3187** (3)
	middle	-	1428 (2)	1670 (6)	3178 (4)
Strait of Kerch, the Black Sea side, Tuzla dam made of limestone blocks with narrow sand beaches	upper	**440** (3)	733 (2)	896 (4)	1374 (2)
	middle	659 (14)	834 (7)	896 (9)	**2198** (5)
	lower	612 (2)	782 (5)	1016 (3)	1534 (1)
Strait of Kerch, the Sea of Azov side, low clay cliff with protection embankment, large sand beach, rock groynes	upper	**504** (5)	-	961 (7)	-
	middle	551 (3)	723 (2)	-	1103 (1)
	lower	567 (4)	739 (2)	944 (6)	**1199** (3)
Area of Novorossiysk seaport, the Black Sea coast, high flysh cliffs with pebbly and gravel beaches and spits	upper	-	-	899 (5)	707 (1)
	middle	291 (2)	846 (20)	821 (20)	**1151** (26)
	lower	**259** (3)	-	794 (4)	990 (3)

Dependence of the rate of an oil slick natural transformation on its thickness

The results of regression analysis of the set of data on 162 samples of oil slicks taken on the Russian, French and Spanish coasts show that the half-period of a fuel oil slick transformation (***T***) significantly (r = 0,86) depends on its thickness (***h*, mm**) according to the equation:

$$T_i = T_1 \cdot h^{0.408},$$

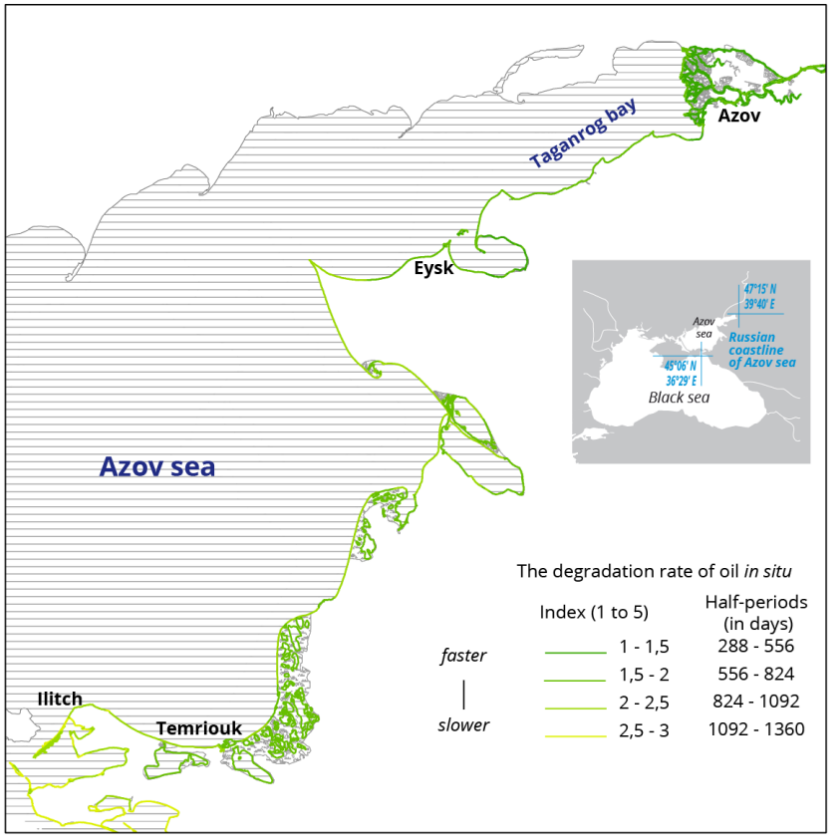
where T_i is the half-period of transformation of an oil slick ***i*** mm thick, T_1 is the half-period of transformation of an oil slick of 1 mm thick. The exponent of h is statistically significant.

Results of regression analysis of the of the influence of geographical factors on the rates of spilled oil transformation

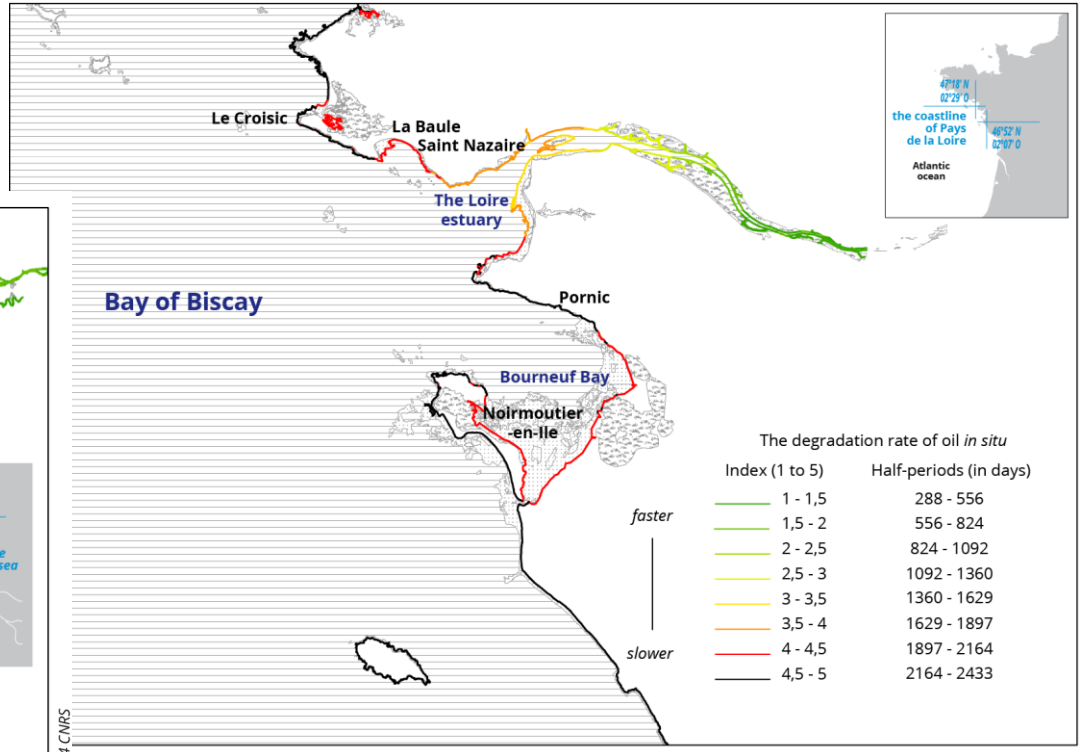
	Quantitative parameters of geographical factors of oil pollution transformation expressed in points of 5-point scale			
	I	***ESI***	***W***	***S, t***
Partial correlation coefficients	-0,47	-0,13	-0,71	-0,96
Multiple regression coefficients	**-0,05**	**0,17**	**0,09**	**-1,04**
Standard deviation of the multiple regression coefficients	0,07	0,07	0,10	0,11

$$k = 4{,}96 - 1{,}04S + 0{,}17ESI - 0{,}05I + 0{,}09W$$

Mapping of sea coasts by their capacity to destruct the spilled oil



Ebner©LETG-Nantes Geolittomer UMR 6554 CNRS



Ebner©LETG-Nantes Geolittomer UMR 6554 CNRS

We are very grateful for financial support of our scientific and academic cooperation to RFBR, the CNRS and the Ambasy of France in Russia

Thank you
for your attention !!!