Baltic Way: Towards using the potential of currents for the benefit of society

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The Baltic Sea: a major marine highway, extremely rapid increase of traffic density in its eastern part

Scandinavia:

Intense marine transport since the viking times

Tallinn-Helsinki city traffic

Russia:

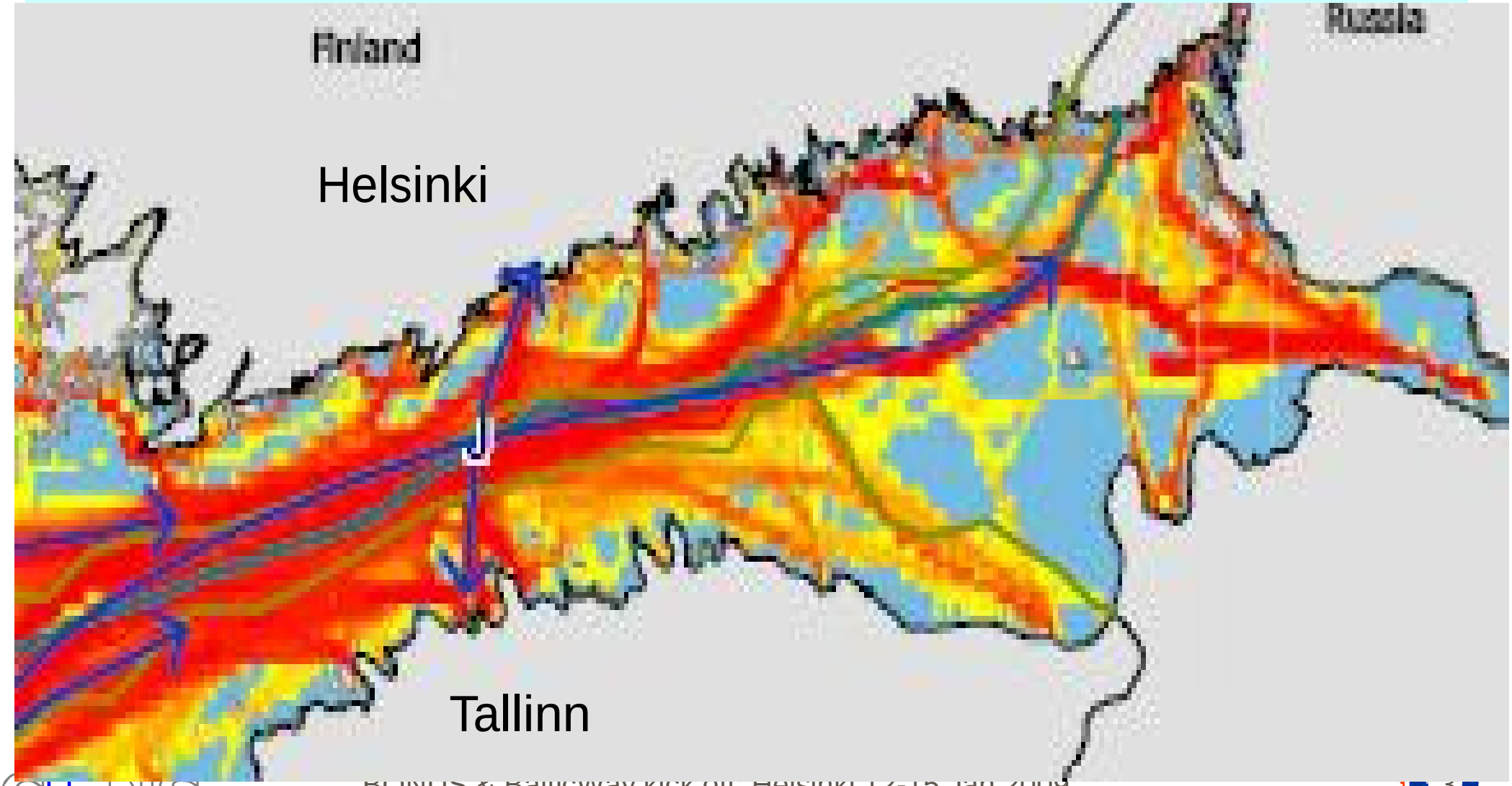
Raw materials
Oil products

Baltic states:

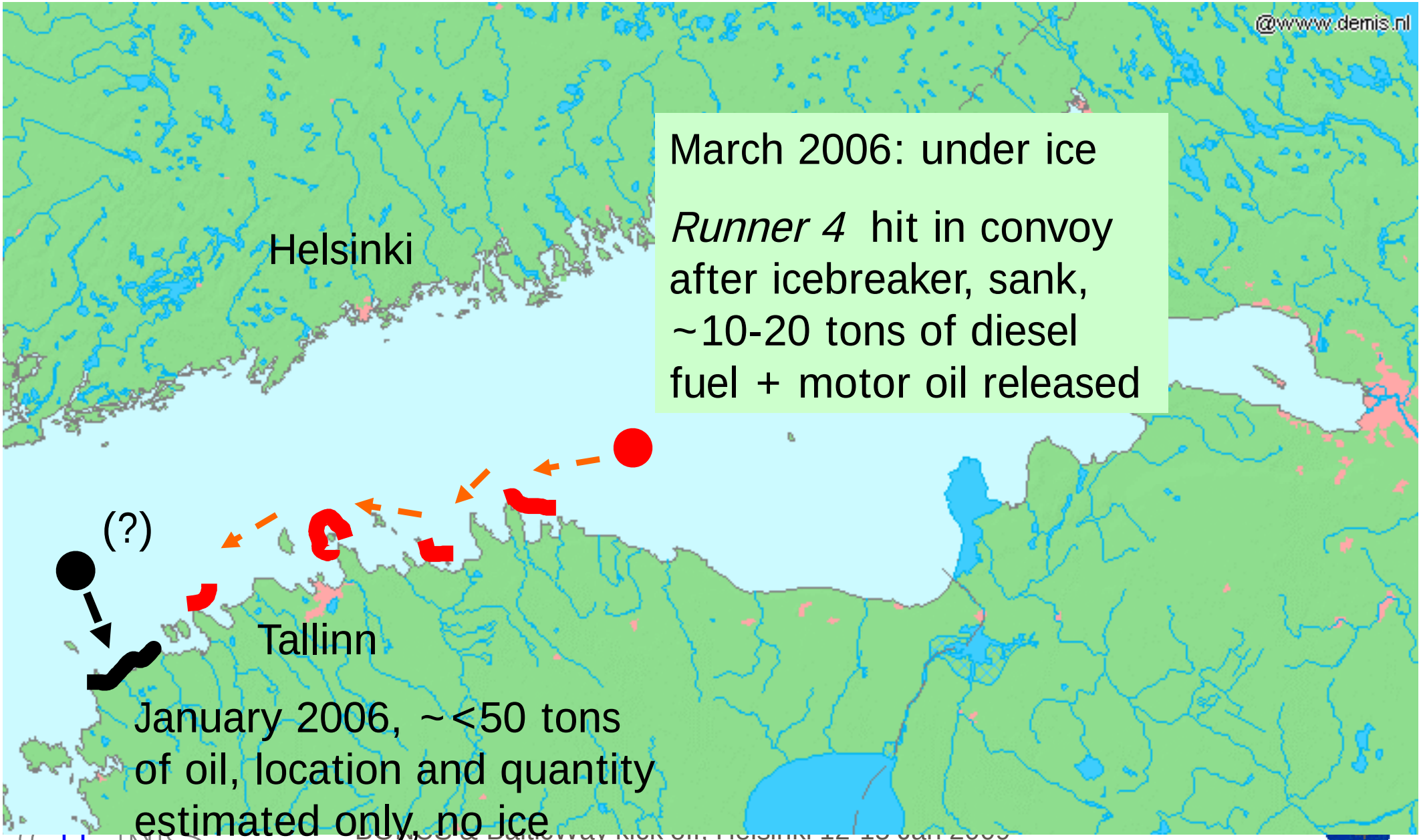
Fast developing economy + cargo flow

Trondheim
Oulu
Vaasa
FINLAND
Gulf of Bothnia
Turku
Helsinki
Åland Islands
Gulf of Finland
St. Petersburg
Stavanger
Stockholm
Tallinn
Hiiumaa
ESTONIA
RUSSIA
Skagerrak
Kattegat
Saaremaa
Gulf of Riga
Gotland
Baltic Sea
Riga
DENMARK
Öland
Copenhagen
Malmo
Funen
Zealand
Bornholm
LITHUANIA
Kiel
Rügen
Kaliningrad (RUSSIA)
Vilnius
Gdansk
Minsk
GERMANY

Ship routes in the Gulf of Finland -- a gateway to Russia



Two major (in local scale) oil pollutions in Estonia in 2006



The pollution fortunately hit small sections

Oil spill transport:

- wind
- waves

Properties relatively well understood & reliable forecasts exist

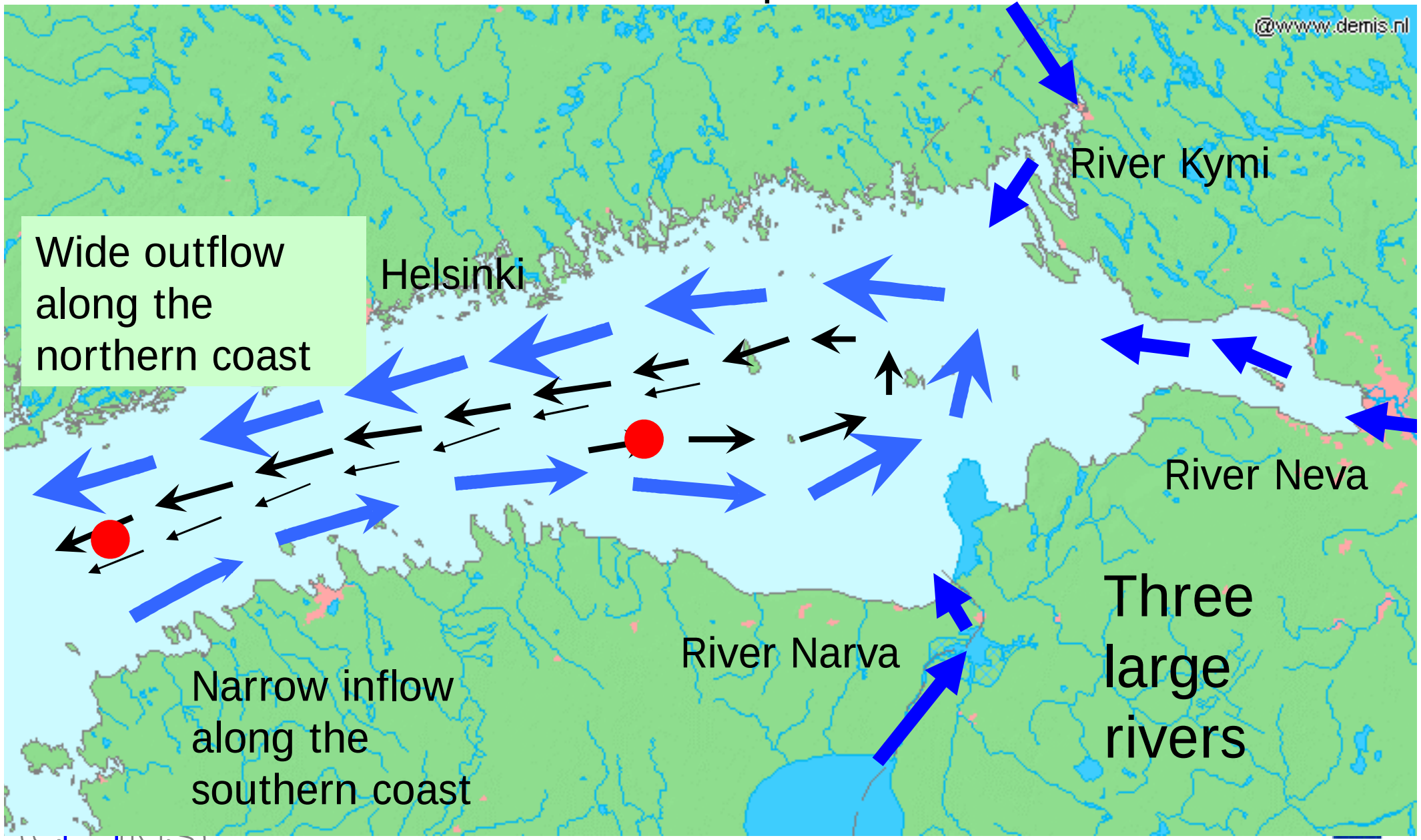
Transport basically downwinds / downstream

- currents

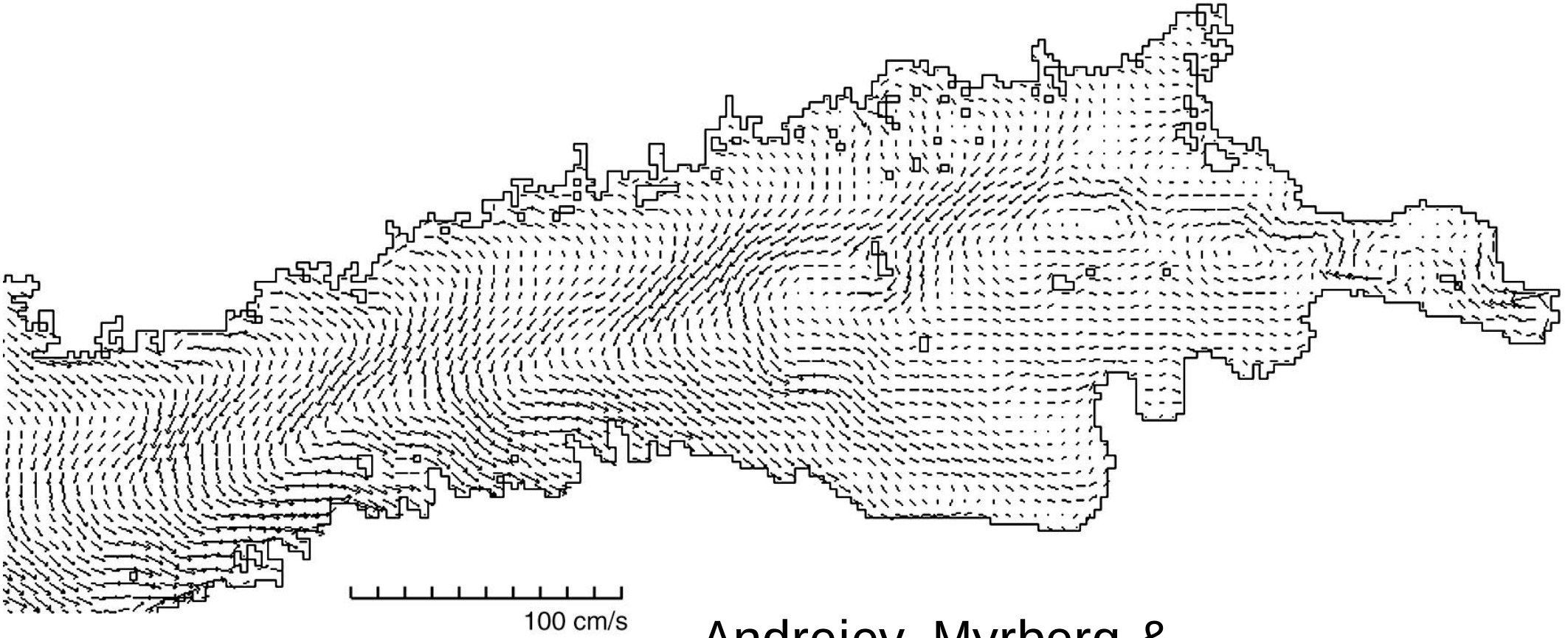
Created as an integral reaction of water masses to a number of factors

Exact transport direction nearly impossible to forecast

Classical circulation pattern: the above oil spills had little chance to hit the southern coast since northern winds & waves were not present

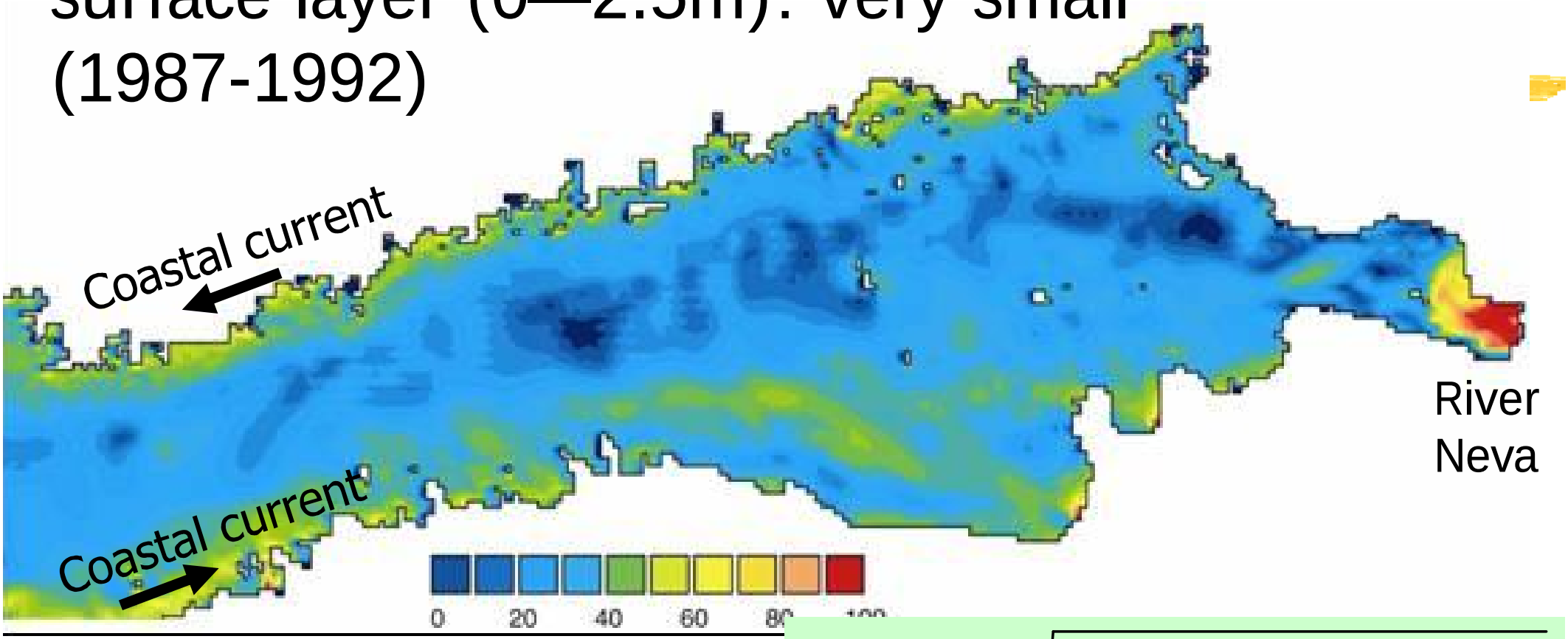


Circulation patterns: extremely complex at any time instant



Andrejev, Myrberg & Lundberg, *Tellus A* 2004

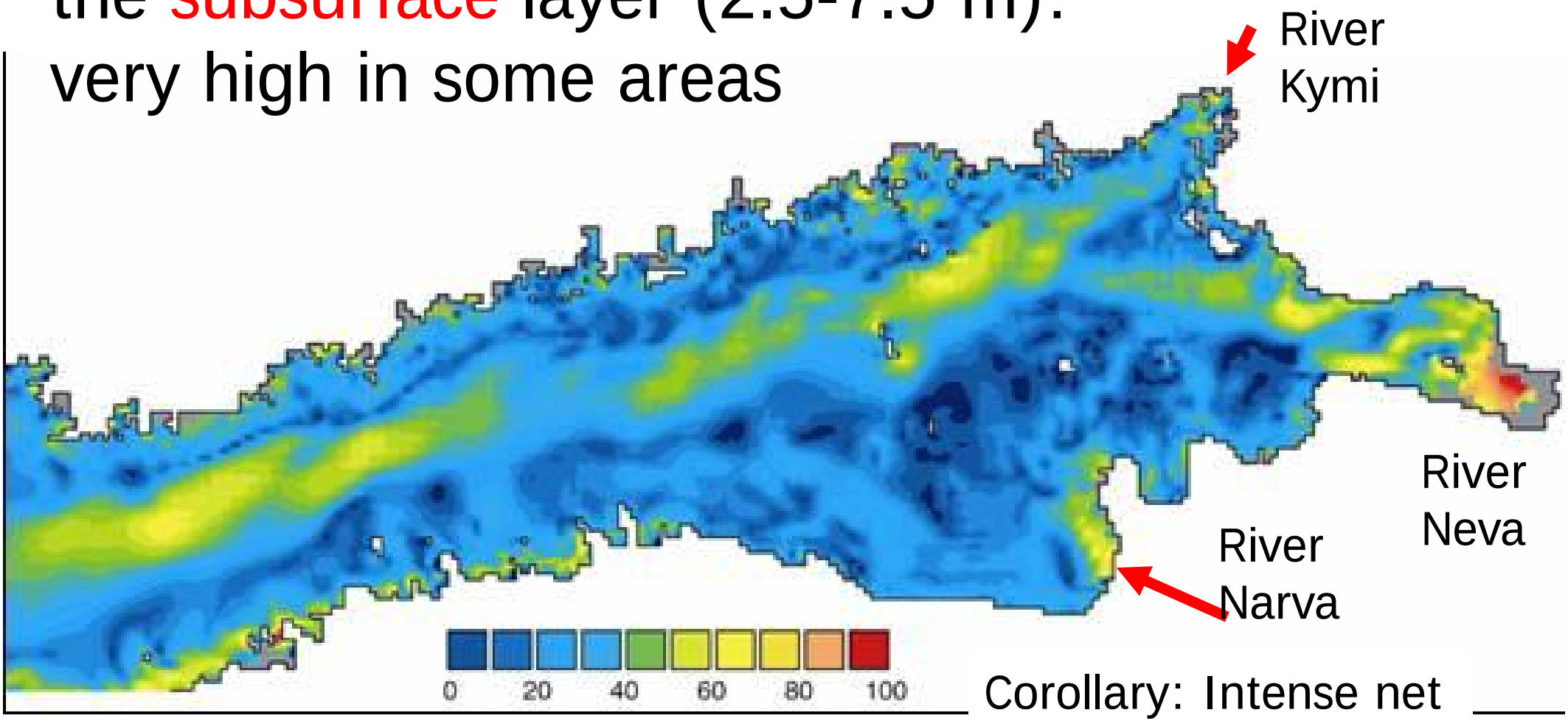
Mean persistency of motions of the surface layer (0—2.5m): very small (1987-1992)



Andrejev et al. *Boreal Environment Research* **9**, 1-16, 2004.

$$PERS = \frac{\sqrt{\left(\sum_n u_n\right)^2 + \left(\sum_n v_n\right)^2}}{\sum_n \sqrt{u_n^2 + v_n^2}}$$

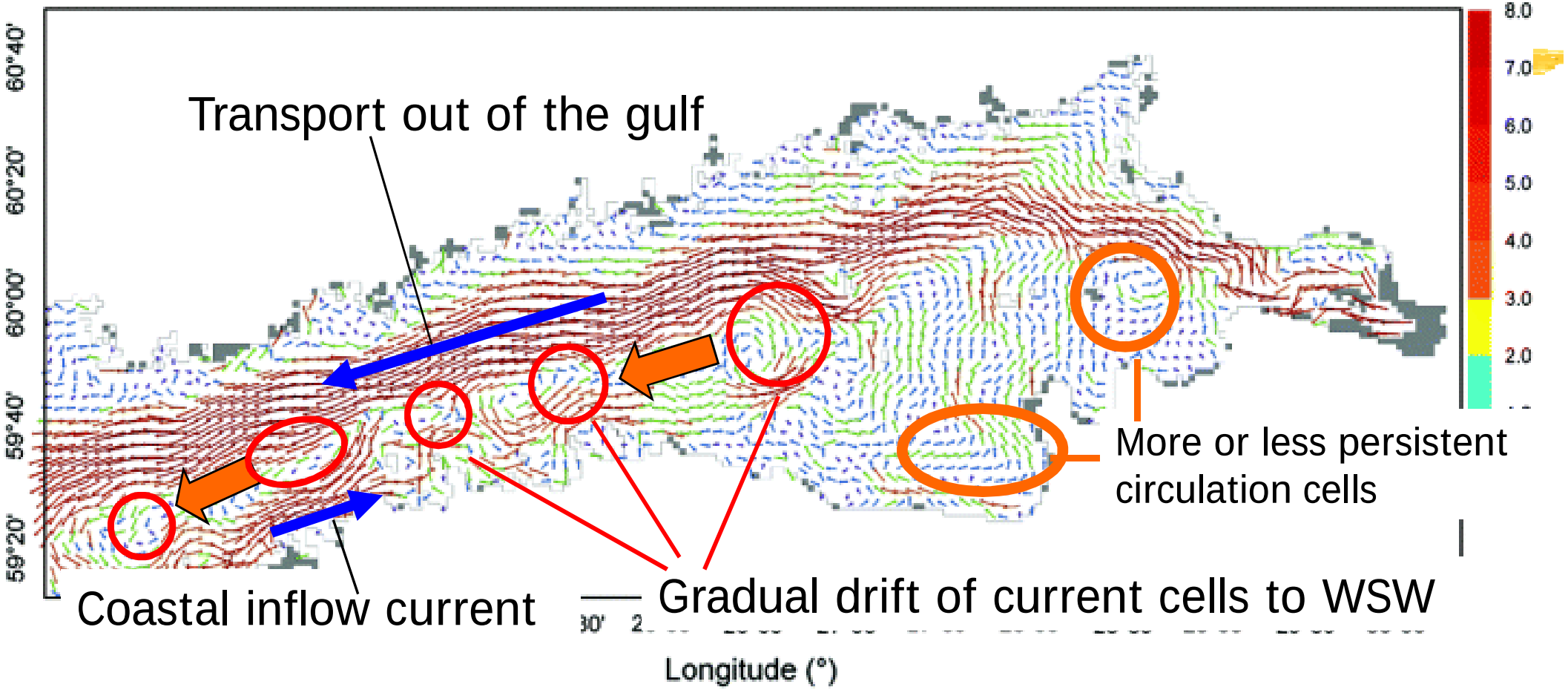
Mean persistency of motions of the subsurface layer (2.5-7.5 m): very high in some areas



Andrejev et al. *Boreal Environment Research* **9**, 1-16, 2004.

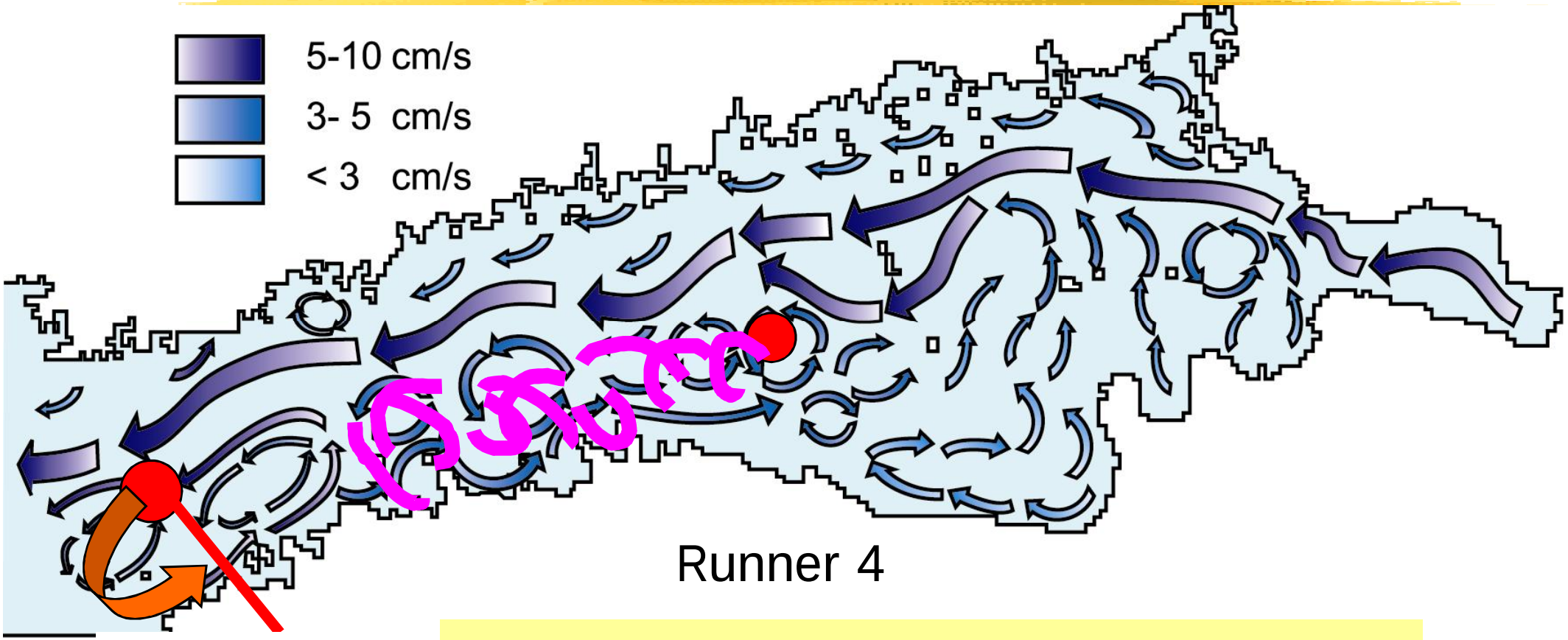
Corollary: Intense net directional transport in areas of high persistency

Patterns: more clear structure in the subsurface layer (average 1987-1992)



The simulated mean circulation in the subsurface layer between 2.5--7.5 m from 31 August 1987 to 31 August 31 1992. O. Andrejev, K. Myrberg, P.A.Lundberg, Age and renewal time of water masses in a semi-enclosed basin -- application to the Gulf of Finland. - *Tellus A* **56** (5), 548-558, 2004.

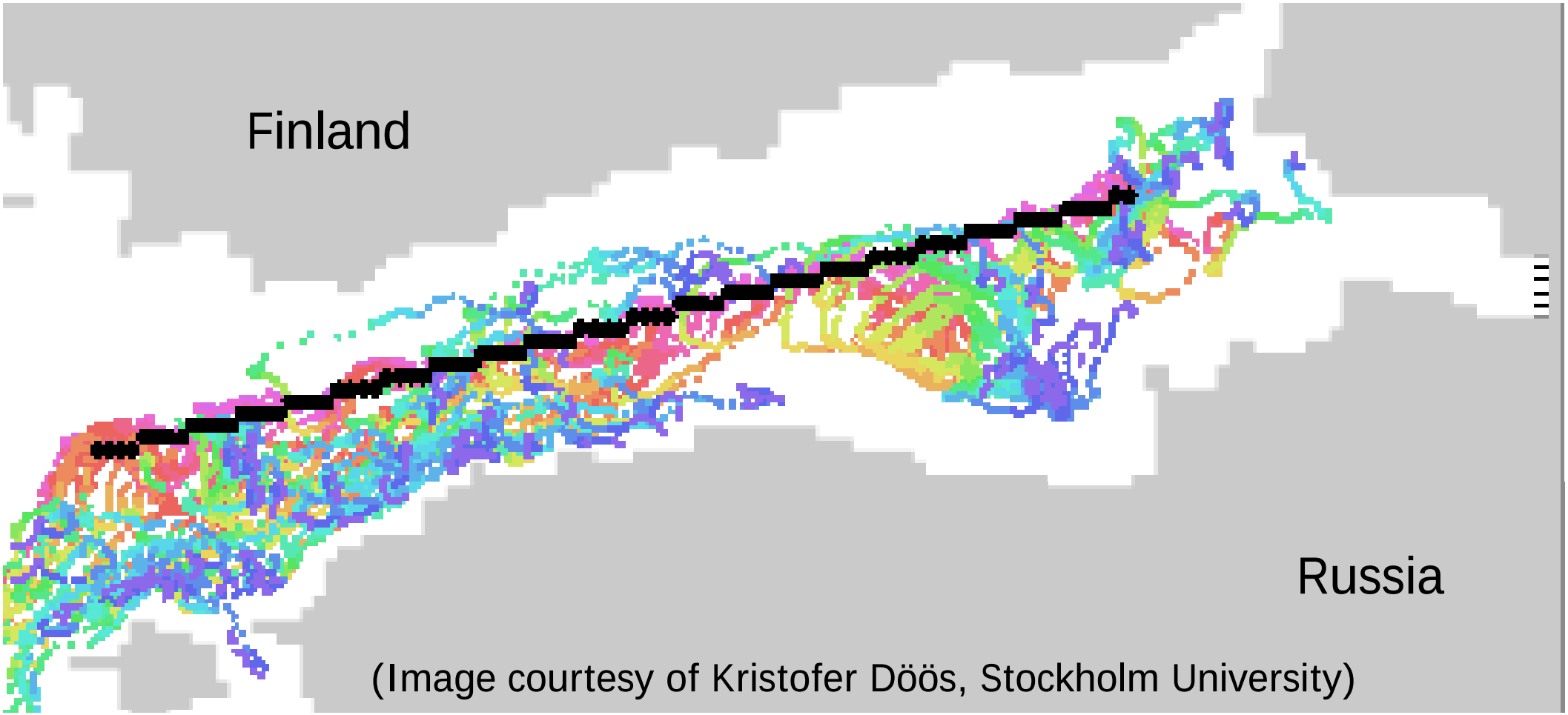
The pattern: well explains why oil pollution hit the southern coast



The question: does the knowledge of this pattern help us?

- The potential of the current pattern can be used for reduction of ‘costs’ of oil pollution

Anisotropic transport patterns



(Image courtesy of Kristofer Döös, Stockholm University)

The question:

Can we do something to “handle” oil pollution?

Two options:

(i) Reducing of probability of pollution (double hulls, warning systems, navigation devices etc.)

(ii) Reducing the consequences of disasters

Existing hints:

- unexpected ways of pollution propagation
- nontrivial patterns of subsurface flows
- anisotropic transport properties
  - ⇒ technology for coastal protection (?)

Handling consequences

If we could organize human activities so:

that the probability of transport of the (potential) oil pollution to the high-value regions (e.g. coasts) will be smaller (than today),

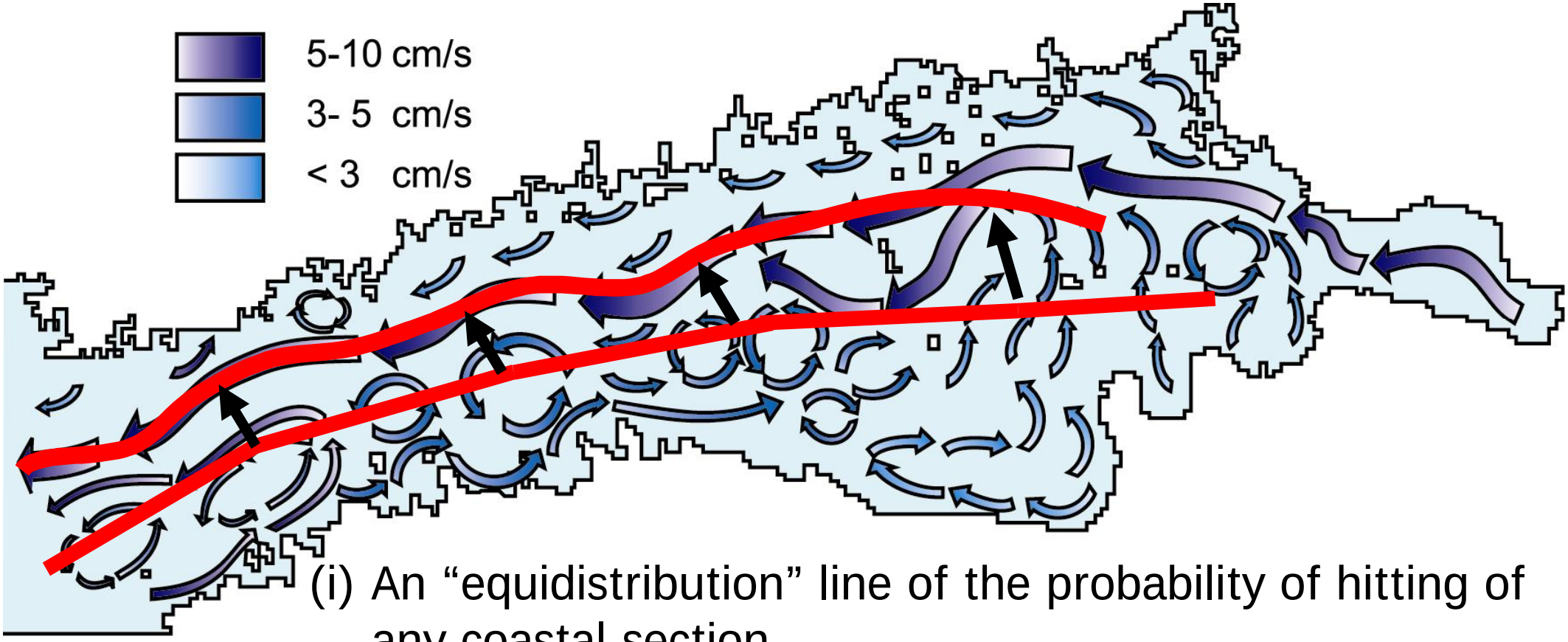
the consequences of (potential) disasters would be smaller.

(i) the pollution apparently will remain in less vulnerable areas (e.g. open sea) longer time

(ii) probably will be carried out of the Gulf of Finland within reasonable time (3-4 weeks (?))

This would be possible if the potential pollution will occur (=ships sail) only in the “stream” area ...

KOOL NOLOGY



(i) An “equidistribution” line of the probability of hitting of any coastal section

(ii) Fastest transport of oil spill to less vulnerable regions

T.Soomere, E.Quak, *Journal of Coastal Research, SI 50,* 2006

This is not a new idea – has been used, for example, in Portugal after the *Prestige* accident: safety corridor shifted more offshore

The subsurface current patterns apparently dominate:

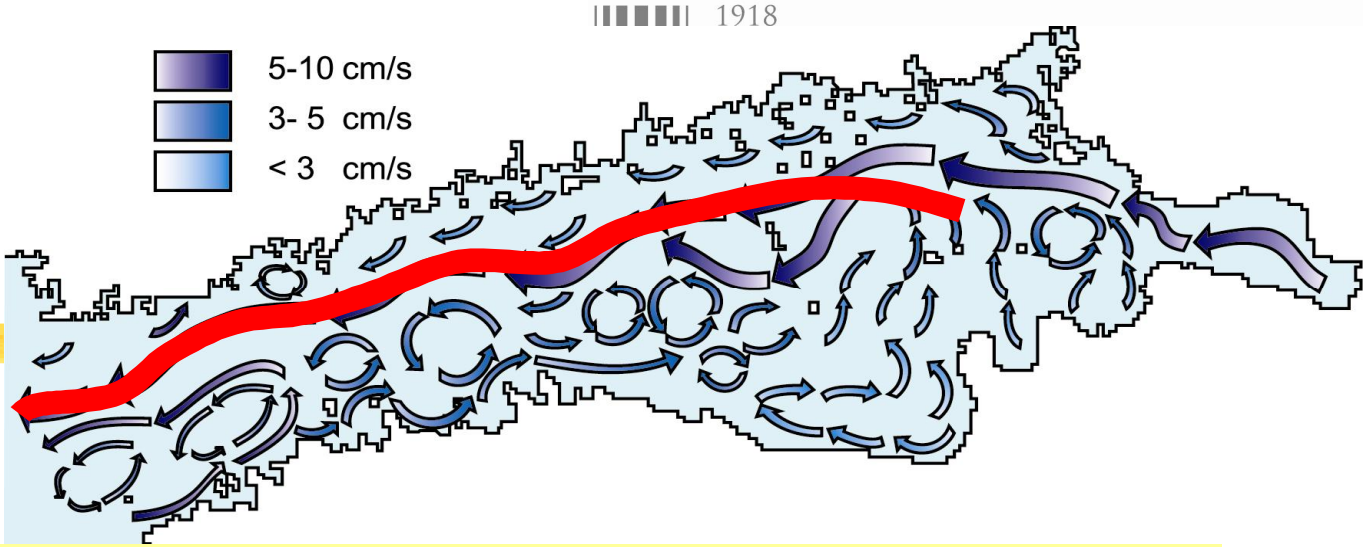
(i) During ice cover (3-4 months/year)

(ii) During calm conditions (April-June: mean significant wave height <40 cm, usually very weak winds)

A number of questions to answer

- does the fortunate pattern – e.g., subsurface stream – exist at all?
- where is it actually located? how stable it is?
- how & when the pattern affects the drift of oil pollution (that often is governed by wind and surface currents)
- the new fairway may enter territorial waters
- the probability of ship collisions may increase
- a large pool of mathematical questions have to be solved since this is essentially an inverse problem

General formulation



- an inverse problem compared with estimates of risk of pollution for specific sites
- search for areas, from which pollution does not propagate to vulnerable sections (coasts, sea farms, fishing areas etc.);
- at least, not within a reasonable time – that is, the problem involves a specific time scale & is site-dependent
- they may be called ‘islands’ / ‘corridors’ of reduced risk
- usually the problem is unsteady: the islands/corridors are time-dependent

BalticWay: an opportunity to develop foundations of a technology for reduction of consequences of disasters

BalticWay Objectives

- *Smart use of* the existence of semi-persistent *current patterns*
- for *protecting of vulnerable regions* (such as coastal spawning, nursing, tourist areas)
- through *identification of areas of reduced risks*

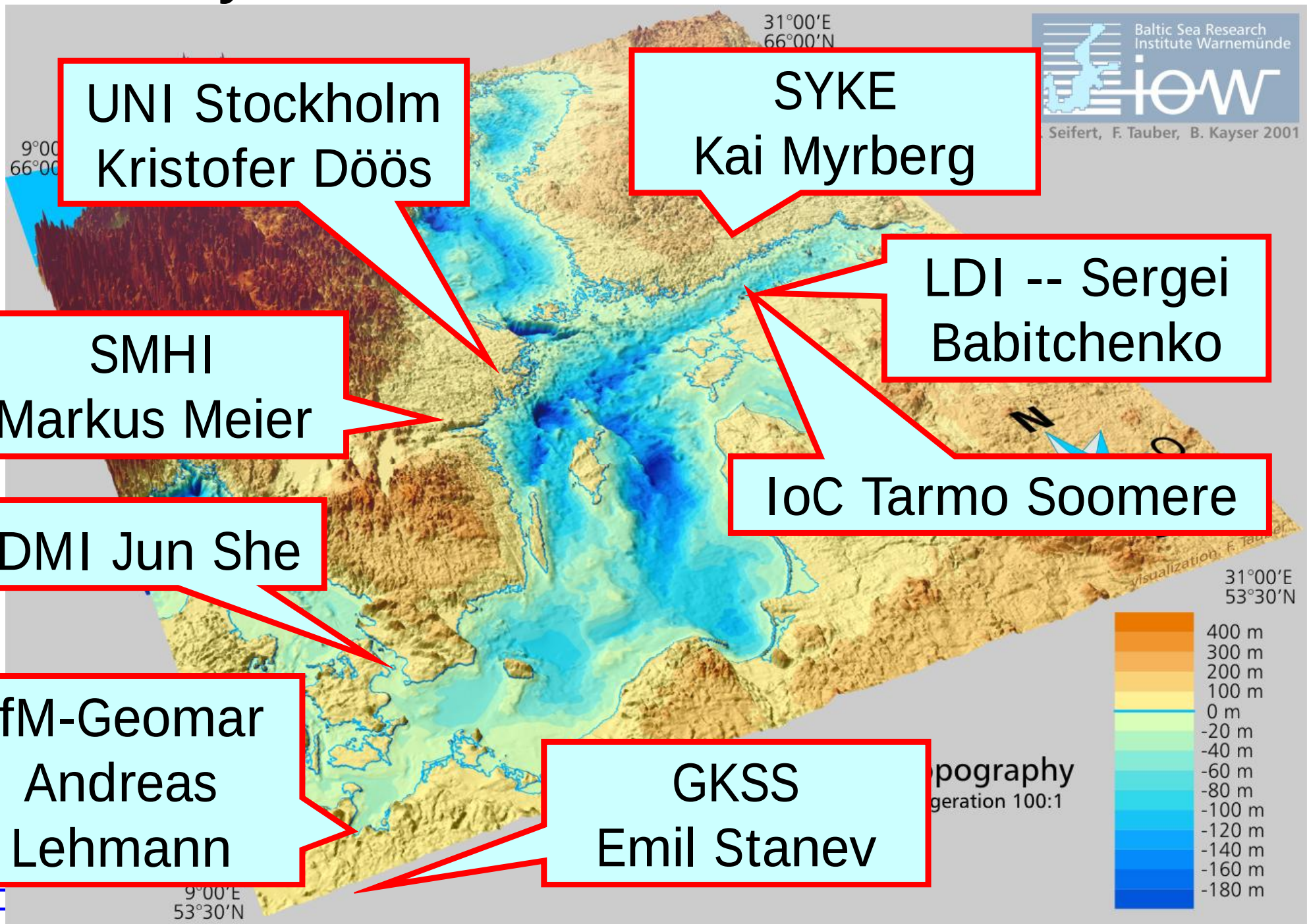
(where ship traffic should be directed or high-risk offshore structures be located)

Limits set for the project

- Two target regions: Gulf of Finland and Western Baltic
- One generic example of a “high-value” region: coastal areas
- One single adverse effect: drift of oil pollution
- One activity to manage: ship routing, i.e. advantageous fairway design
- One platform for a technology prototype for environmentally friendly management of shipping and offshore activities to be developed

1918
TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

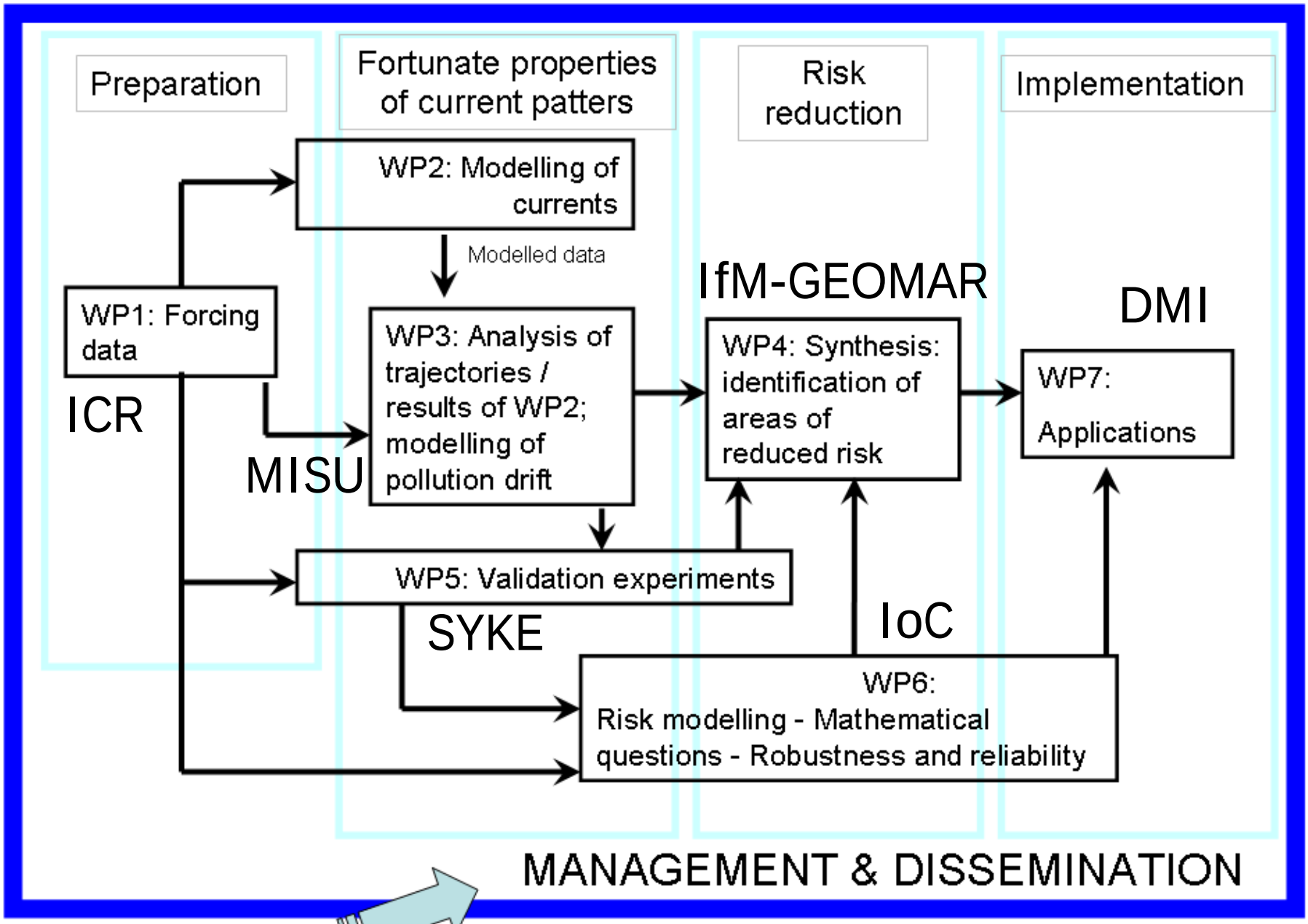
BalticWay Consortium



Scientific constituents

- Massive, high-resolution numerical simulation of Baltic Sea circulation;
- Analysis of direct and inverse transport problems for various tracers,
- including experimental validation;
- Use of specific properties of surfaces overlaying complex three-dimensional flows to analyze effects on the sea surface (= mathematics)

Work Plan


Preparation
Fortunate properties of current patters
Risk reduction
Implementation
WP2: Modelling of currents
Modelled data
WP1: Forcing data
ICR
MISU
WP3: Analysis of trajectories / results of WP2; modelling of pollution drift
IfM-GEOMAR
WP4: Synthesis: identification of areas of reduced risk
DMI
WP7: Applications
WP5: Validation experiments
SYKE
IoC
WP6: Risk modelling - Mathematical questions - Robustness and reliability
MANAGEMENT & DISSEMINATION
ADVISORY BOARD