Progetto Finanziato dal
Ministero dell'Ambiente e della Tutela del Territorio e del Mare
Direzione Generale Protezione della Natura

SOS Bocche di Bonifacio

SOS - Bocche di Bonifacio (2009-2010)

DEC/DPN 2291 del 19/12/2008

Cucco A.[1], Ribotti A.[1], Olita A.[1], Fazioli L.[1], Sorgente B.[1], Sinerchia M.[1], Satta A.[1], Perilli A.[1], Borghini M.[2], Schroeder K.[2] and Sorgente R[1]

[1] *Institute for Coastal Marine Environment (IAMC - CNR), Oristano, Italy*

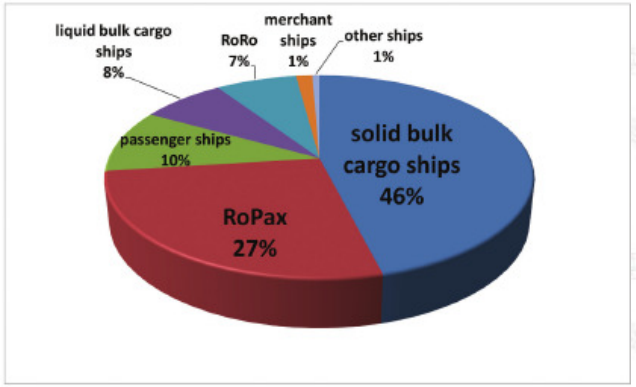
[2] *Marine Science Institute (ISMAR - CNR), La Spezia, Italy*

Type of vessel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Oil tanker	29	35	32	22	11	18	13	18	22	10	210
Chemical tanker	227	198	132	114	141	90	95	65	65	38	1165
Liquefied gas carrier	105	105	109	64	35	20	24	16	5	12	495
Supply ship	184	111	97	73	54	47	58	49	55	54	782
Generic cargo ship	1604	1614	1353	1314	1494	1262	1274	1266	1220	1016	13417
Cargo-freezer ship	58	82	89	59	25	22	5	12	18	28	398
Container ship	292	363	424	364	208	112	151	178	183	105	2380
Passenger ship	323	341	239	263	357	374	343	422	420	467	3549
Ro/Ro	261	175	108	222	113	279	190	87	156	111	1702
Ro/Ro - Car carrier	86	71	83	90	49	26	71	132	182	73	863
Passenger Ro/Ro	804	917	728	624	869	1012	1200	1157	1146	1033	9490
Depolluting vessel	47	69	13	6	4	2	2	2	1	0	146
Research vessel	3	9	10	5	9	2	3	10	6	11	68
Dredge ship	0	0	0	0	3	1	1	1	0	0	6
Cable ship	7	6	12	8	13	19	21	19	23	16	144
Pontoon-barge vessel	1	0	0	0	0	1	2	0	1	1	6
Tugboat	12	14	7	13	23	13	20	21	16	7	146
School vessel	0	0	2	5	1	0	3	0	1	0	12
MY Charter	1	0	0	11	190	5	0	2	0	0	209
Total	**4044**	**4110**	**3438**	**3257**	**3599**	**3305**	**3476**	**3457**	**3520**	**2982**	**35188**

The Strait of Bonifacio is a natural international reserve (FR & IT).

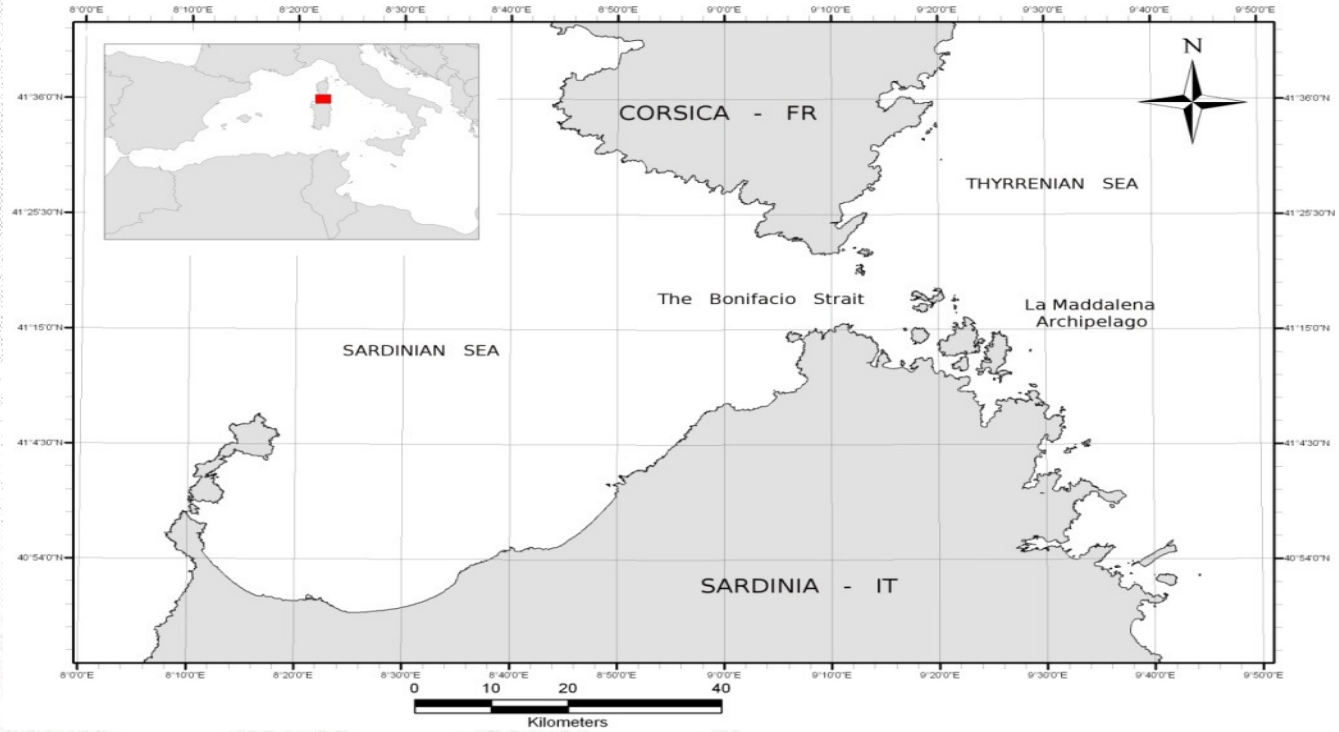
The Strait is crossed every year by more than 3500 vessels exceeding 300 tons GT (VTS data)

Yearly, about 1 oil-spill event occurs



THE BONIFACIO STRAIT (SOB) (PSSA)

Particularly Sensitive Seas Area



IMO INTERNATIONAL MARITIME ORGANIZATION

E

MARINE ENVIRONMENT PROTECTION COMMITTEE
61st session
Agenda item 9

MEPC61/INF.XX
XX August 2010
ENGLISH ONLY

IDENTIFICATION AND PROTECTION OF SPECIAL AREAS AND PARTICULARLY SENSITIVE SEA AREAS

Designation of the Strait of Bonifacio a Particularly Sensitive Sea Area

1. Introduction

The "Strait of Bonifacio" sea area appears to be a highly sensitive zone not only for the uniqueness, diversity and significance of its habitats and ecosystems, but also for its shipping traffic and its hydrographical and meteorological factors that considerably increase the probability of maritime accidents and consequently the risk of marine and coastal pollution.

The vulnerability of this marine strait linked to these two significant aspects was analyzed in the "SOS – Bocche di Bonifacio" project [1](funded by the Italian Ministry for the Environment, Land and Sea and carried out by IAM – *Instituto per l'Ambiente Marino e Costiero* – CNR *Consiglio Nazionale delle Ricerche* – UOS – *Gruppo di Oceanografia Operativa di Oristano*) aimed to implement an innovative system of forecasting and monitoring of marine circulation for the management of environmental emergencies caused by the huge maritime traffic through the strait.

Therefore, all the following data and analysis have been extrapolated from the above-mentioned project.

SOS - Bocche di Bonifacio (2009-2010)

funded by the Italian Ministry of Environment
DEC/DPN 2291 del 19/12/2008

..... IMPLEMENTATION OF INTEGRATED OPERATIONAL SYSTEM FOR MANAGING OIL-SPILL EMERGENCIES IN THE SOB ...

•.. by preventing and/or limiting the damages.

•.. by facilitating the local authorities to plan and coordinate the response operations.

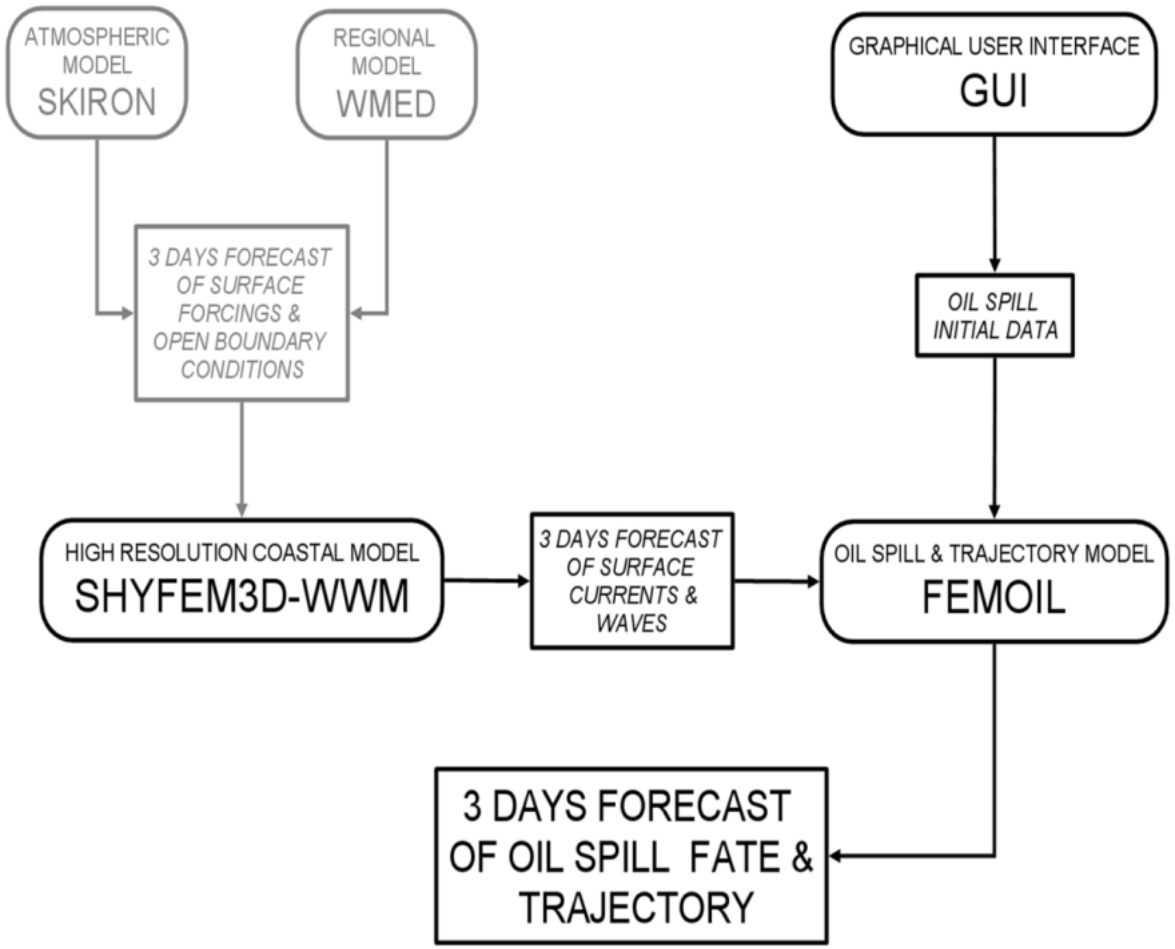
•.. by creating "scenarios and risk maps" used to quickly prepare appropriate intervention strategies

- Implementation of an operational forecasting system: Bonifacio Oil spill Operational Model (BOOM)

- Measurements and analysis of the surface transport paths and 3D water currents fields in the SOB area

- Calibration and validation of BOOM system throughout comparison with measured data.

- Implementation of graphical user interface (GUI) to guarantee the accessibility, usability and the interaction with the BOOM



THE BOOM CORE

a coupled 3D hydrodynamic and wave model **(SHYFEM3D-WWM),** a Lagrangian trajectory module and a weathering module **(FEMOIL)** based on finite elements method (www.seaforecast.cnr.it).

nested to a regional open ocean forecasting system based on a finite difference hydrodynamic model **(WMED)** (www.seaforecast.cnr.it).

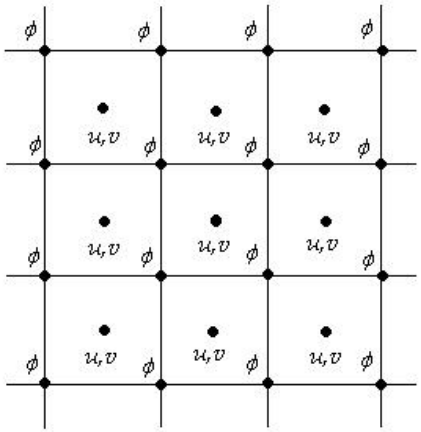
surface boundary conditions provided by **SKIRON** meteorological forecasting system (http://forecast.uoa.gr)

GUI to predict oil spill fate within 72 hours time lag both in the past (**backward simulation**) or in the future (**forward simulation**).

THE MODEL FRAMEWORK

[1] 3D **HYDRODYNAMIC** MODEL

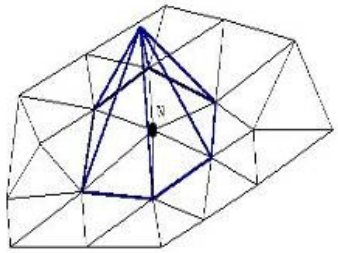
[2] **WIND WAVE** MODEL – WWM



[3] **TURBULENCE CLOSURE MODEL**– GOTM

[4] 3D **EULERIAN TRANSPORT & DIFFUSION** MODEL

[5] 3D **LAGRANGIAN TRANSPORT & DIFFUSION** MODEL

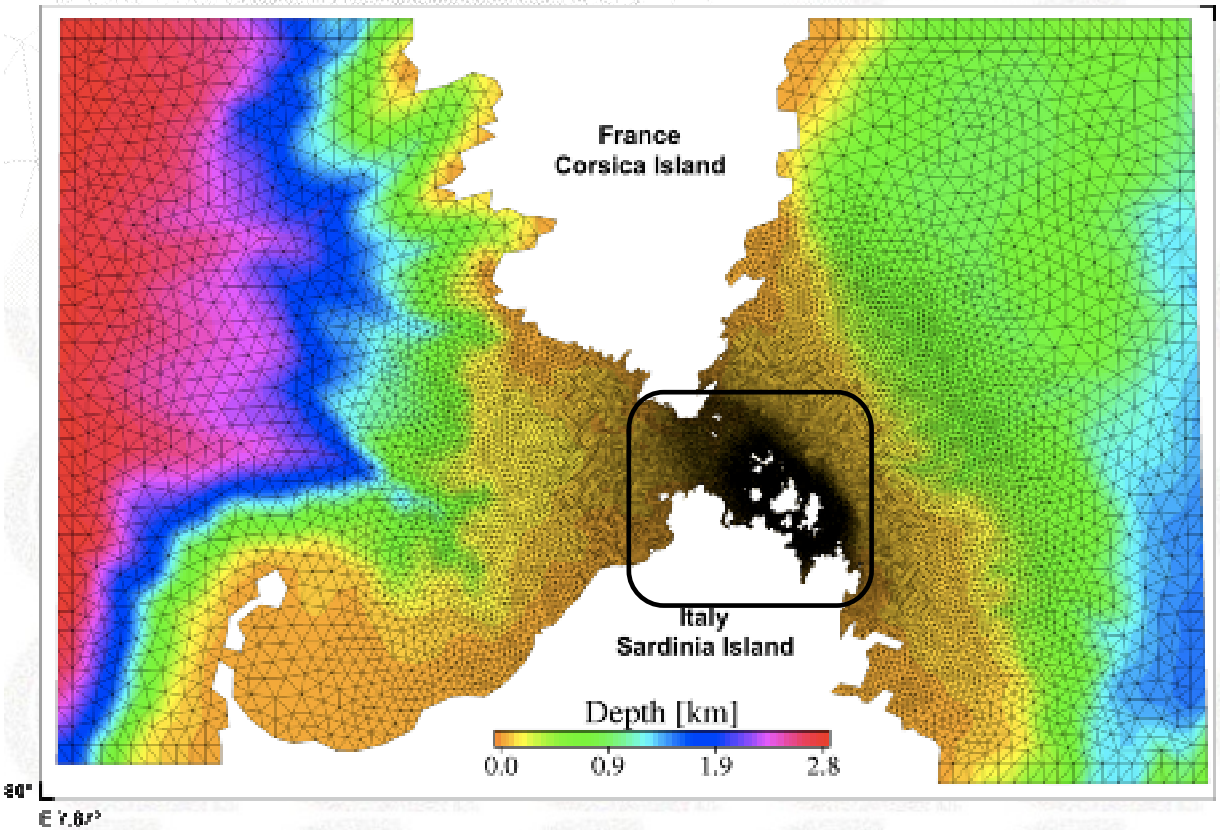


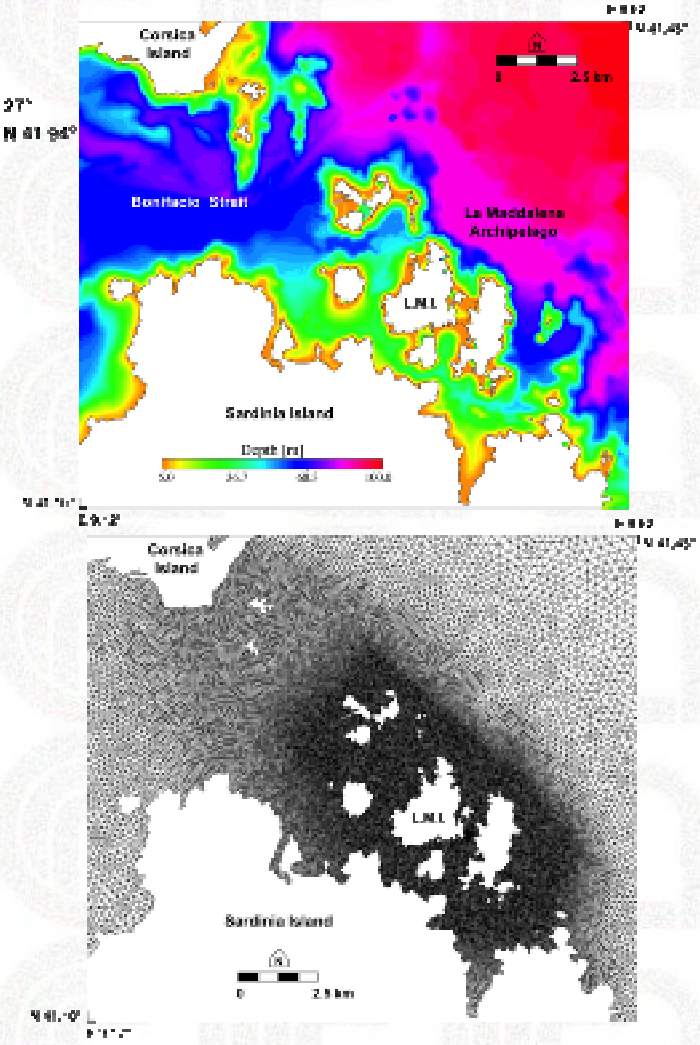
[6] 3D **SEDIMENT TRANSPORT** MODEL – SEDTRANS05

[7] 3D **WATER QUALITY** MODEL – BFM

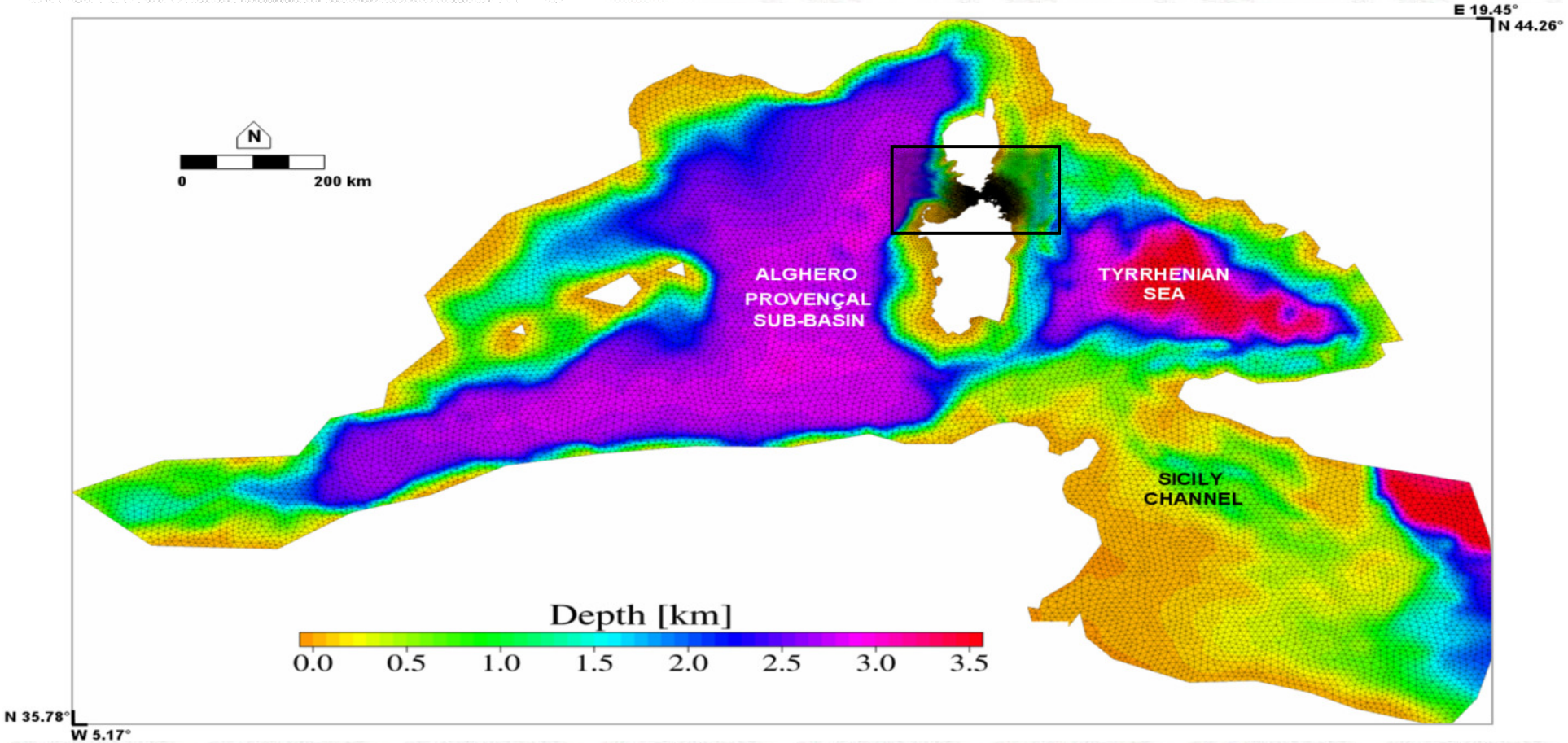
PROCESS	METHOD
Advection	Eulerian velocity+ wind & wave Stokes Drift
Diffusion	Fick Law
Dynamical Spreading	Fay (1976)
Emulsification	Mackay et al. (1982)
Evaporation	Stiver and Mackay (1984)
Type of spilling	Istantaneous or continuos spilling
Oil-land interaction	Total Entrapment

THE HYDRODYNAMIC MODEL DOMAIN IS REPRODUCED BY MEANS OF UNSTRCTURED FE MESH WITH SPAT. RES. VARYING BETWEEN 50 TO 500 m OF THE SOB AND LA MADDALENA ARCHIPELAGO





THE WAVE MODEL DOMAIN IS REPRODUCED BY MEANS OF UNSTRCTURED FE MESH WITH SPAT. RES. VARYING BETWEEN 50 TO 15000 m OF THE WHOLE WESTERN & CENTRAL MED. INCLUDING THE HIGH RESOLUTION HYDRO MESH



NESTING WITH WMED OPERATIONAL SYSTEM

• 3D SHYFEM VERSION

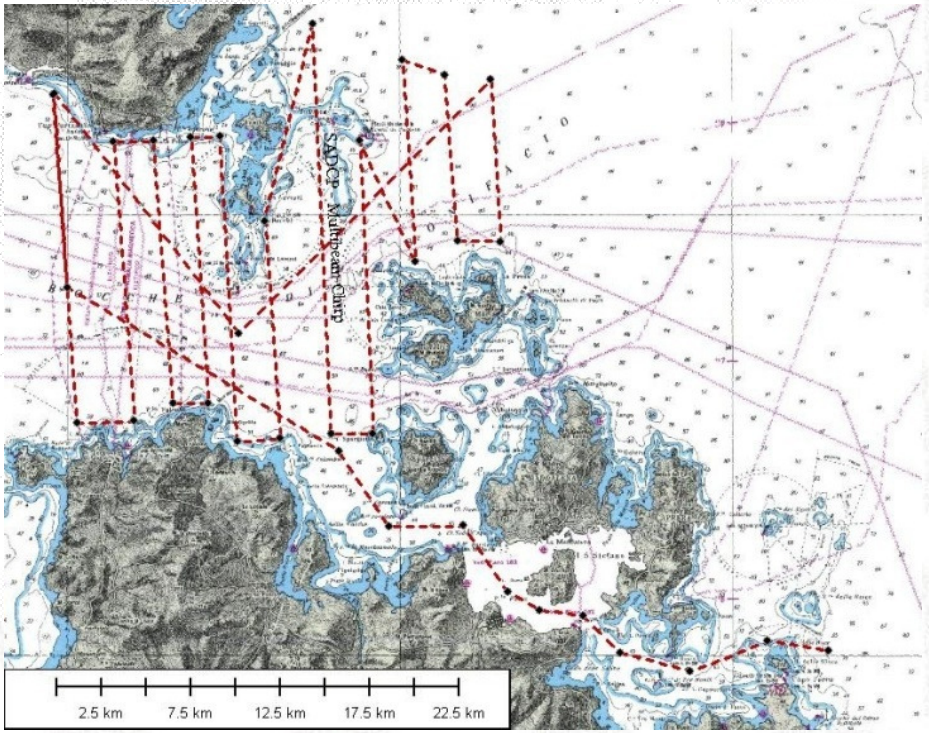
• NESTING WITH STRUCTURED GRID OPERATIONAL OCEANOGRAPHIC MODEL – MFSTEP OPERATIONAL SYSTEM

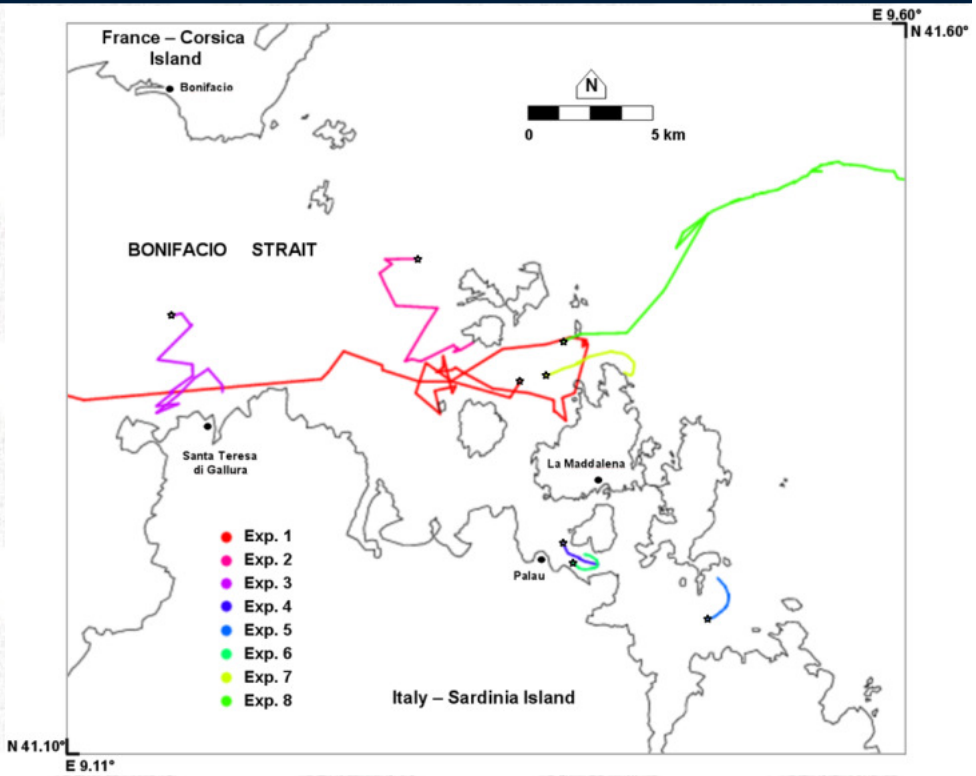
FROM
Free Surface
Finite differences
Arakawa C grid
Structured Grid
s layers

1 way nesting

TO
Free Surface
Finite Elements
Arakawa B grid
Unstructured Grid
Z layers

EXPERIMENTAL DATA





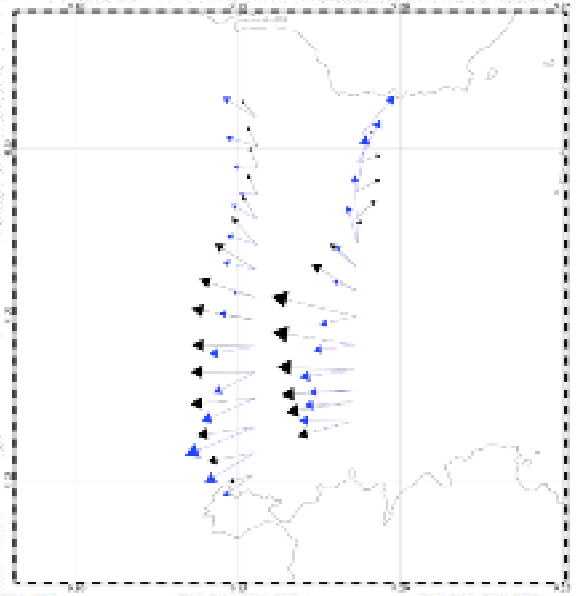
CURRENT PROFILES

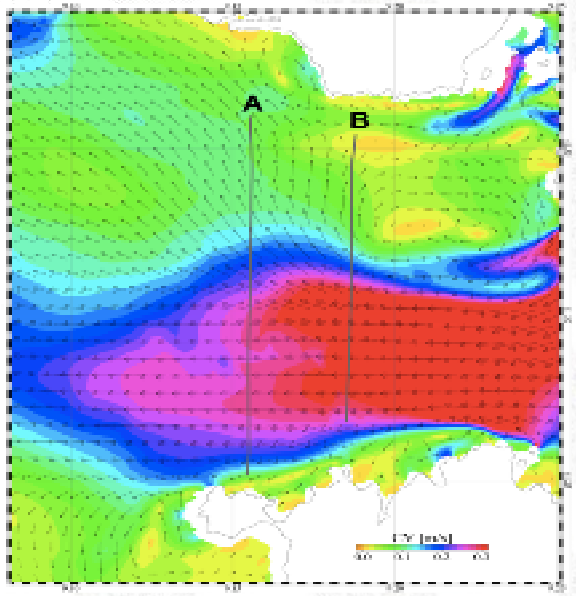
Two field campaigns (2008- 2009) ADCP measurements inside the Strait area and La Maddalena Archipelago.

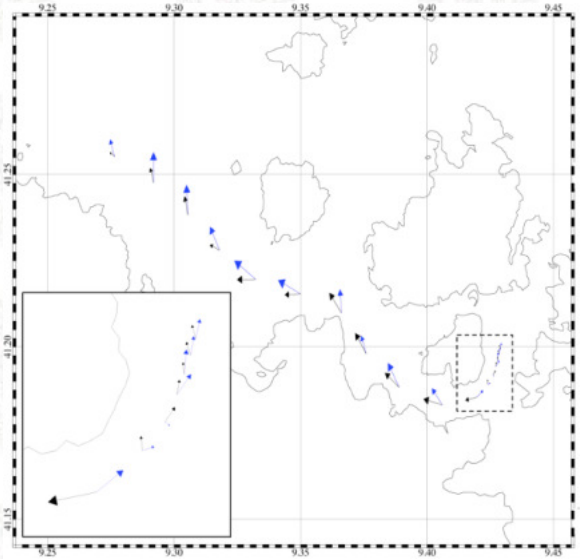
SURFACE TRANSPORT

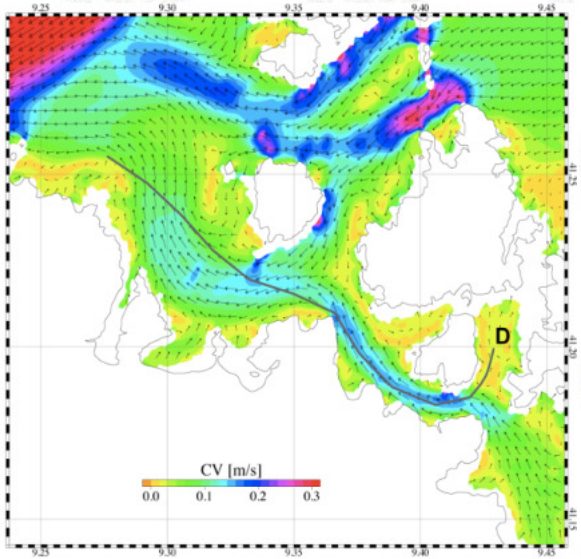
11 GSP and satellite Lagrangian buoys released in different weather conditions and locations in the Strait area and in the La Maddalena Archipelago (2009-2010)

COMPARISON WITH ADCP DATA









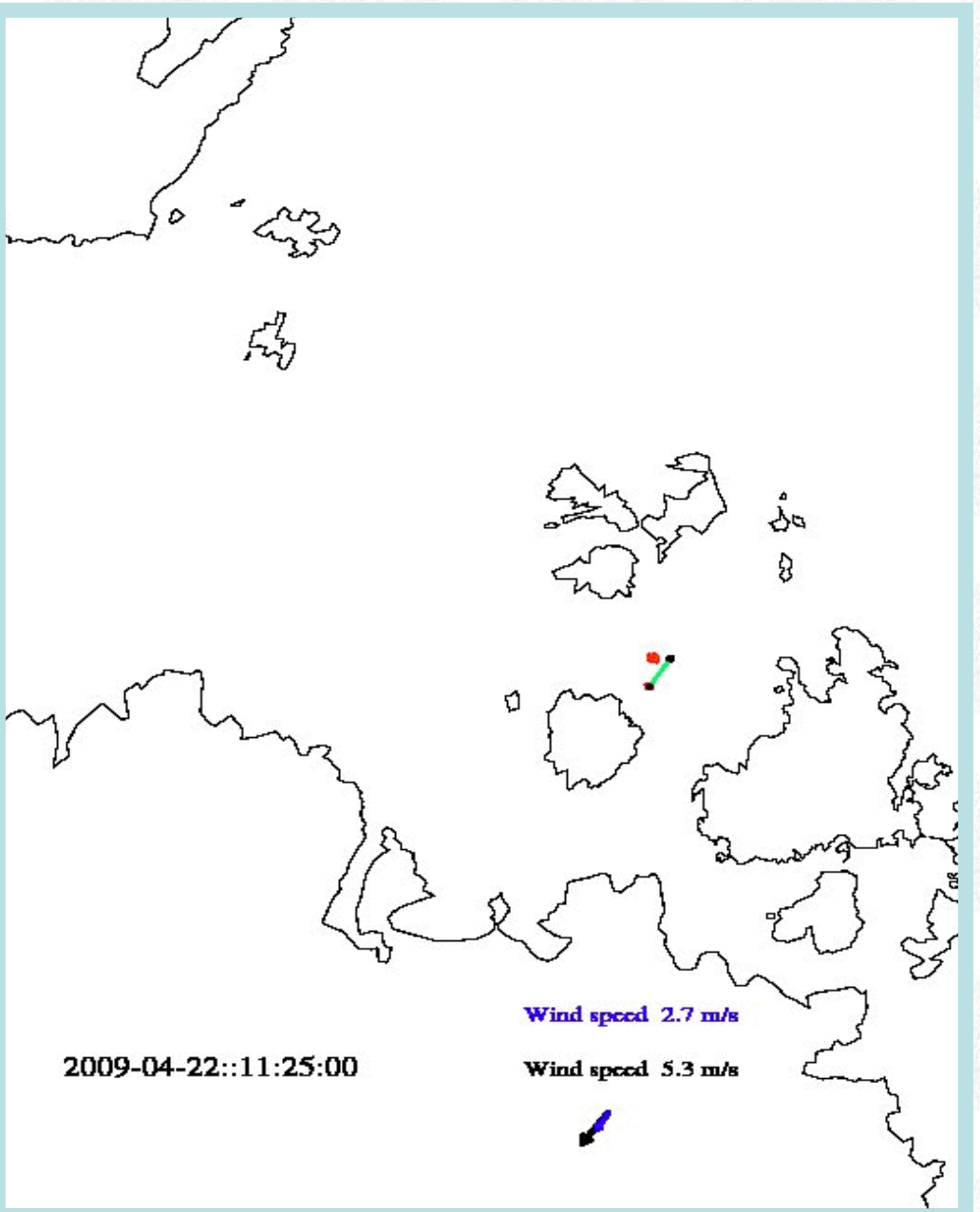
MODEL RESULTS WERE COMPARED WITH CURRENT VELOCITIES MEASURED BY ADCP DATA WITHIN SURFACE LAYERS

Transects	Avg. Obs. Vel.	Avg. Mod. Vel.
A-B	0.1771	0.1973
C	0.1401	0.1323
D	0.1059	0.0842
Tot.	0.1427	0.1486

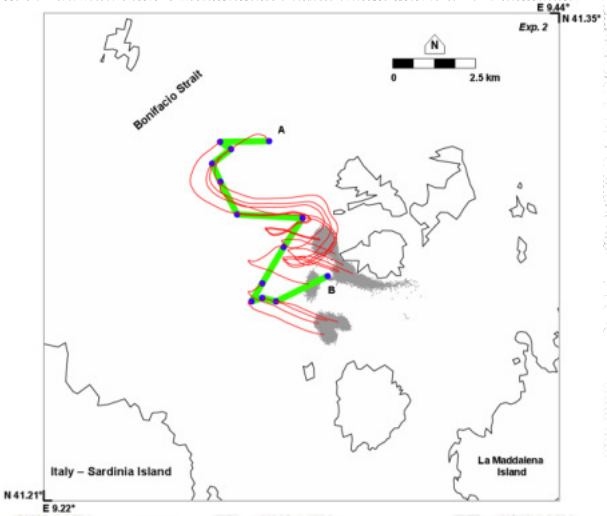
Transects	Mod. – Obs.	Vect. Diff.
A-B	0.0202	0.1116
C	-0.0078	0.0987
D	-0.0217	0.0678
Tot.	0.0059	0.0935

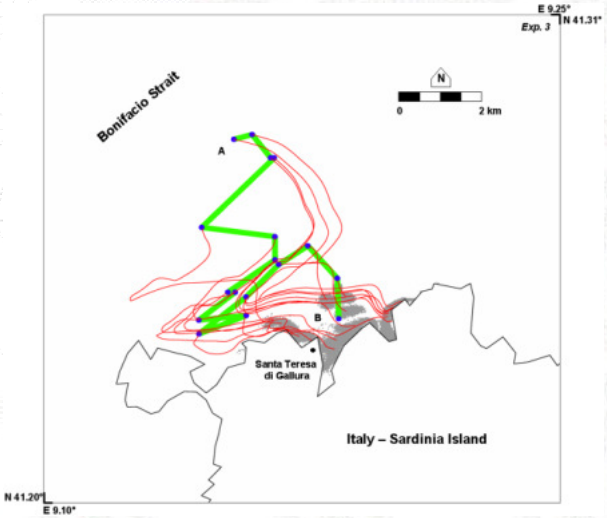
CALIBRATION PROCEDURE:

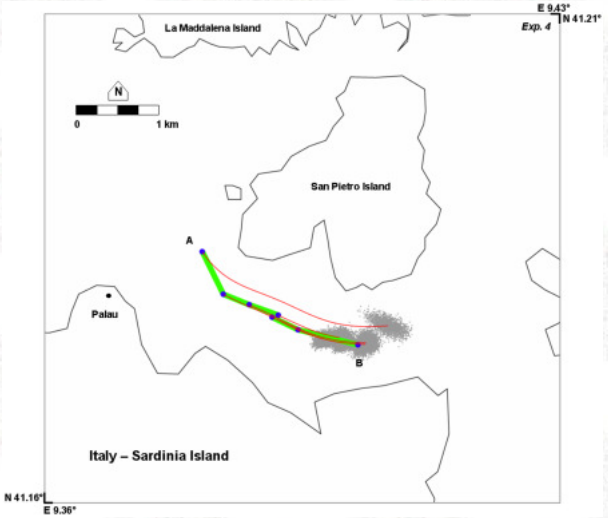
- Releasing particles at each drifter position
- Computing the average distance between particles & drifter position
- Changing a, b and c values (Transport parameters)
- Trial & error method

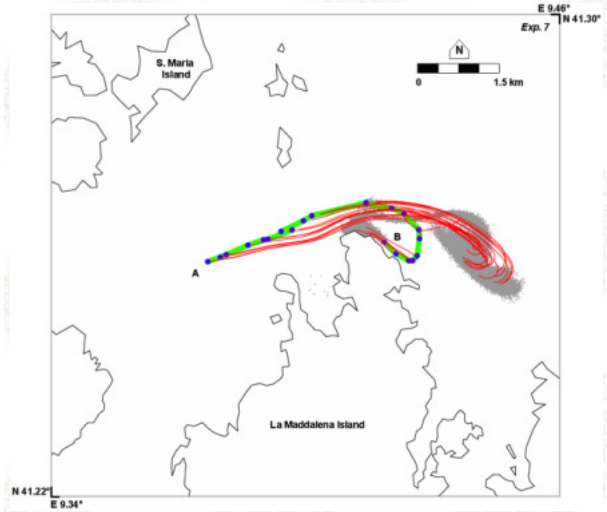


F O R W A R D M O D E





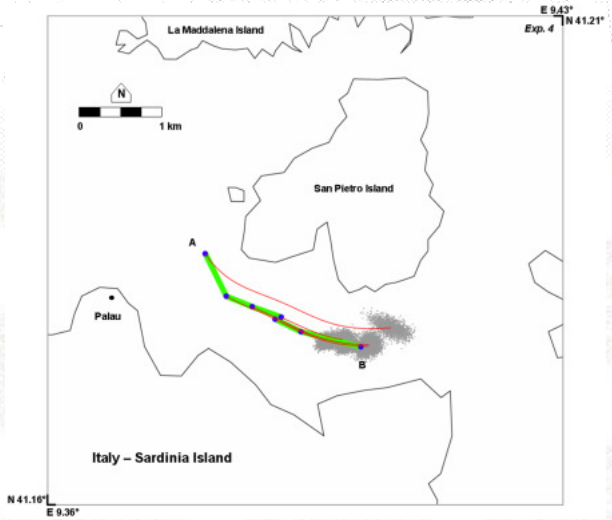


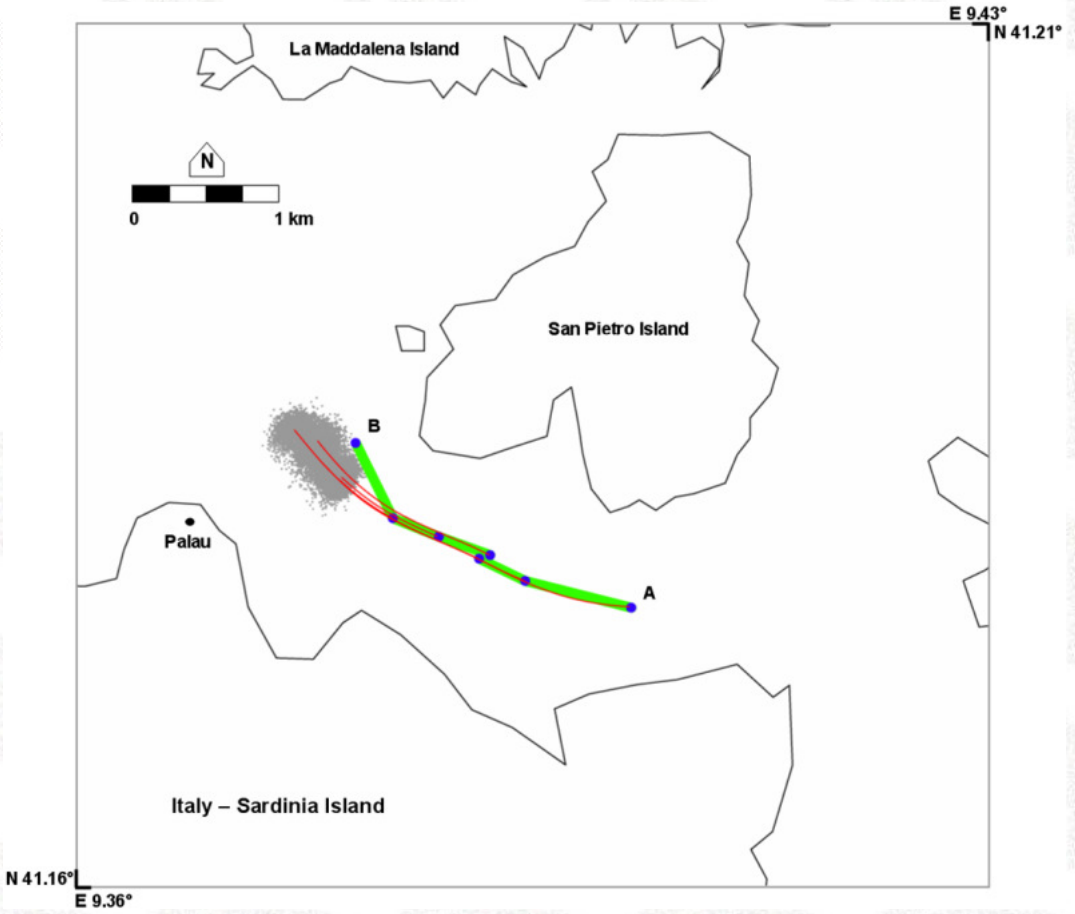


OBSERVED (GREEN LINES) AND SIMULATED TRAJECTORIES (RED LINES) IN FORWARD MODE. BLUE CIRCLES CORRESPOND TO THE OBSERVED DRIFTER POSITIONS. GREY DOTS REPRESENT THE FINAL POSITIONS OF ALL THE RELEASED PARTICLES. A AND B LABEL THE INITIAL AND FINAL POSITION.

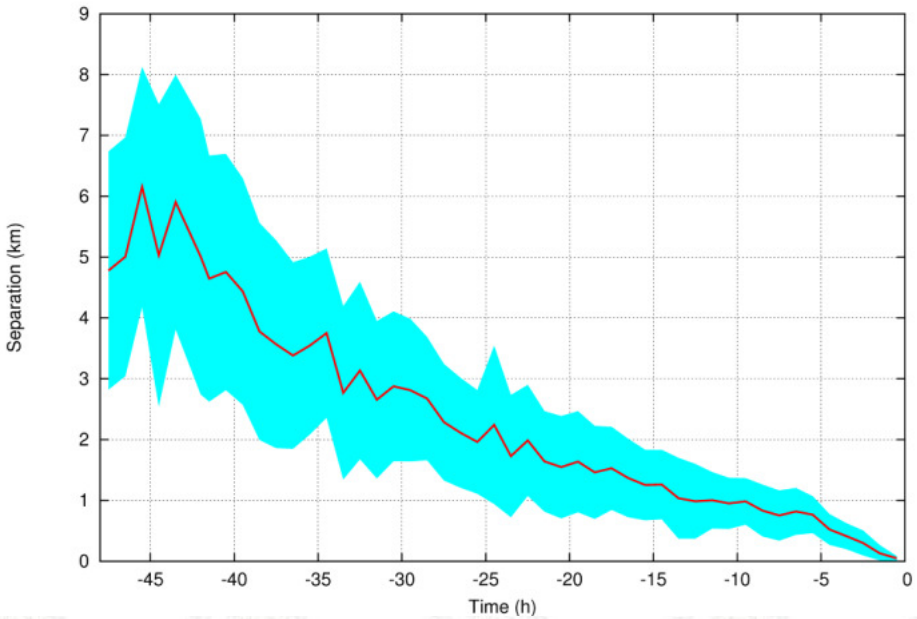
B A C K W A R D M O D E

FROM FORWARD TO …..

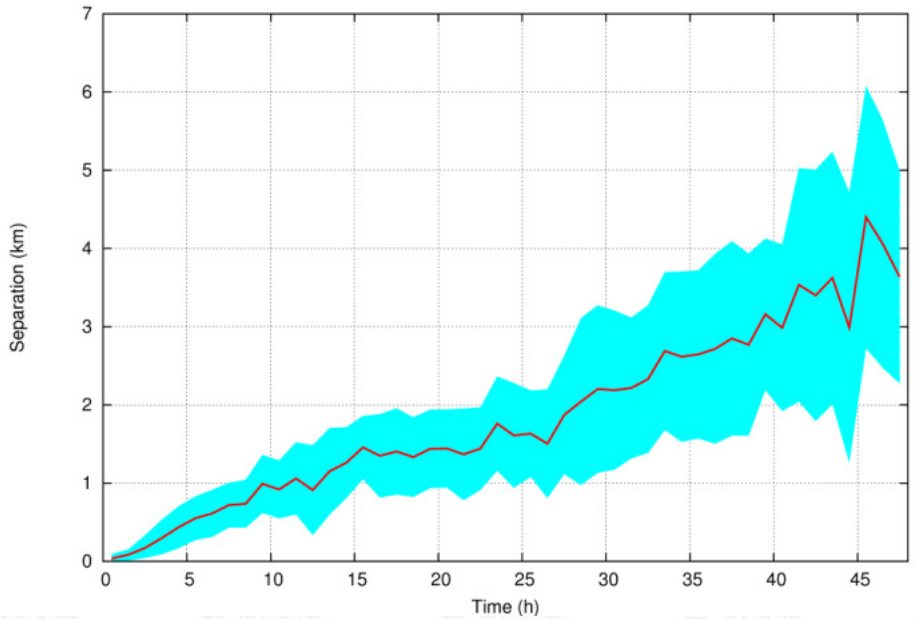




BACKWARD MODE



FORWARD MODE



DISTANCE BETWEEN OBSERVED AND SIMULATED TRAJECTORIES AS A FUNCTION OF THE BACKWARD (LEFT) AND FORWARD (RIGHT) PREDICTION TIME. MEAN VALUE (LINE) AND STANDARD DEVIATION (SHADED AREA) ARE REPORTED.

OPERATIONAL PRODUCTS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Progetto coordinato dal CNR-IAMC di Oristano
in collaborazione con la Guardia Costiera Capitaneria di Porto di La Maddalena
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SOS BOCCHE DI BONIFACIO
Lo Stretto delle Bocche di Bonifacio è il braccio di mare tra la Sardegna (capo Testa e Punta Falcone) e la Corsica (capo Pertusato) di alta valenza ambientale per l'eccezionale rilievo paesaggistico e per la notevole varietà di habitat presenti.
Per il suo status giuridico di stretto internazionale, è attraversato ogni anno da migliaia di navi, in particolare da navi che trasportano carichi pericolosi ed inquinanti (petroliere, chimichiere e gasiere) spesso non dotate del doppio scafo.
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Il Sistema di Previsione
Partecipanti
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Rassegna Stampa
In Primo Piano
http://www.sos-bocchedibonifacio.eu/index.php
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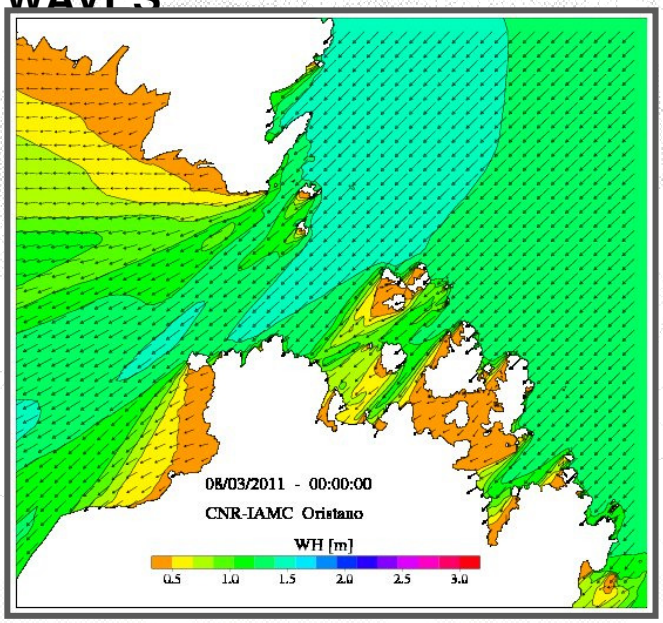
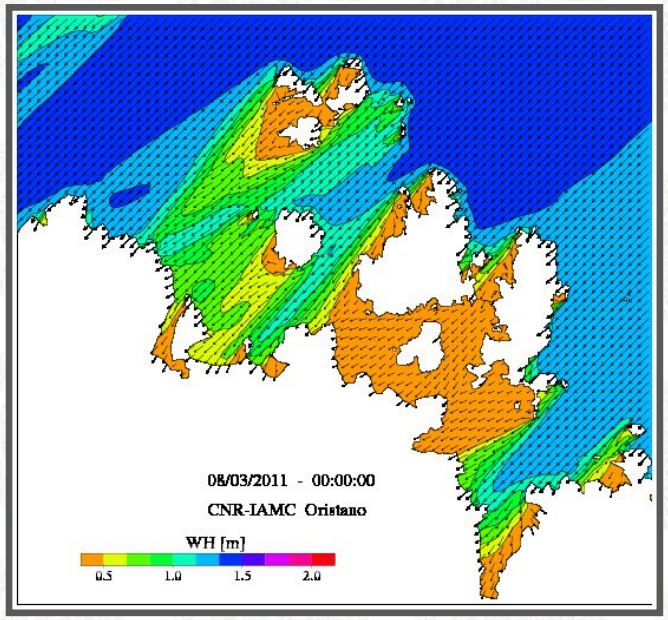
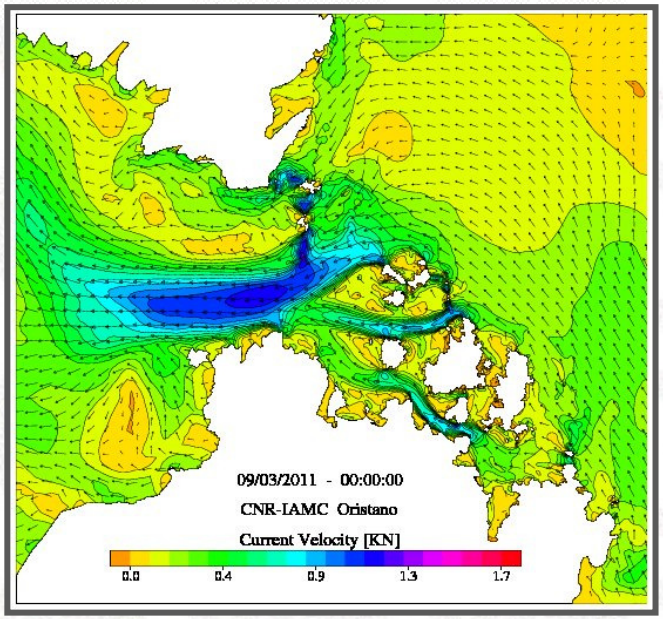


DAILY A 3 DAYS FORECAST OF ….

WAVE SWH & DIRECTION OF PROPAGATION IN THE SOB AND IN THE LA MADDALENA ARCHIPELAGOS

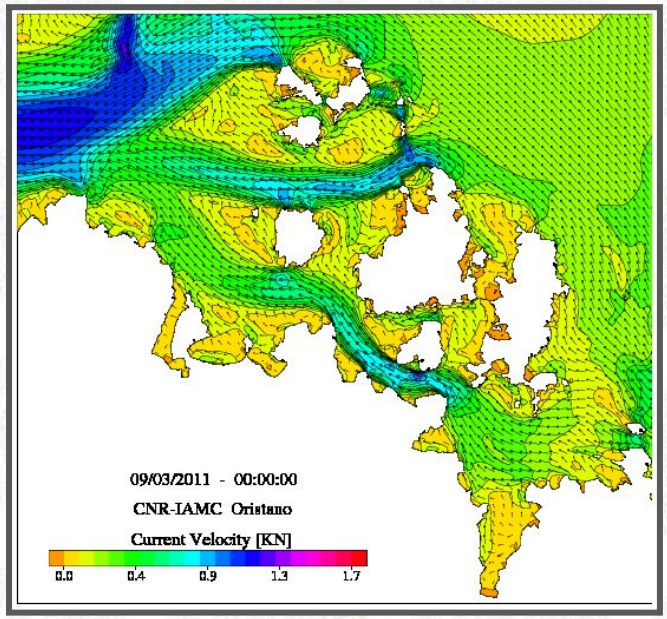




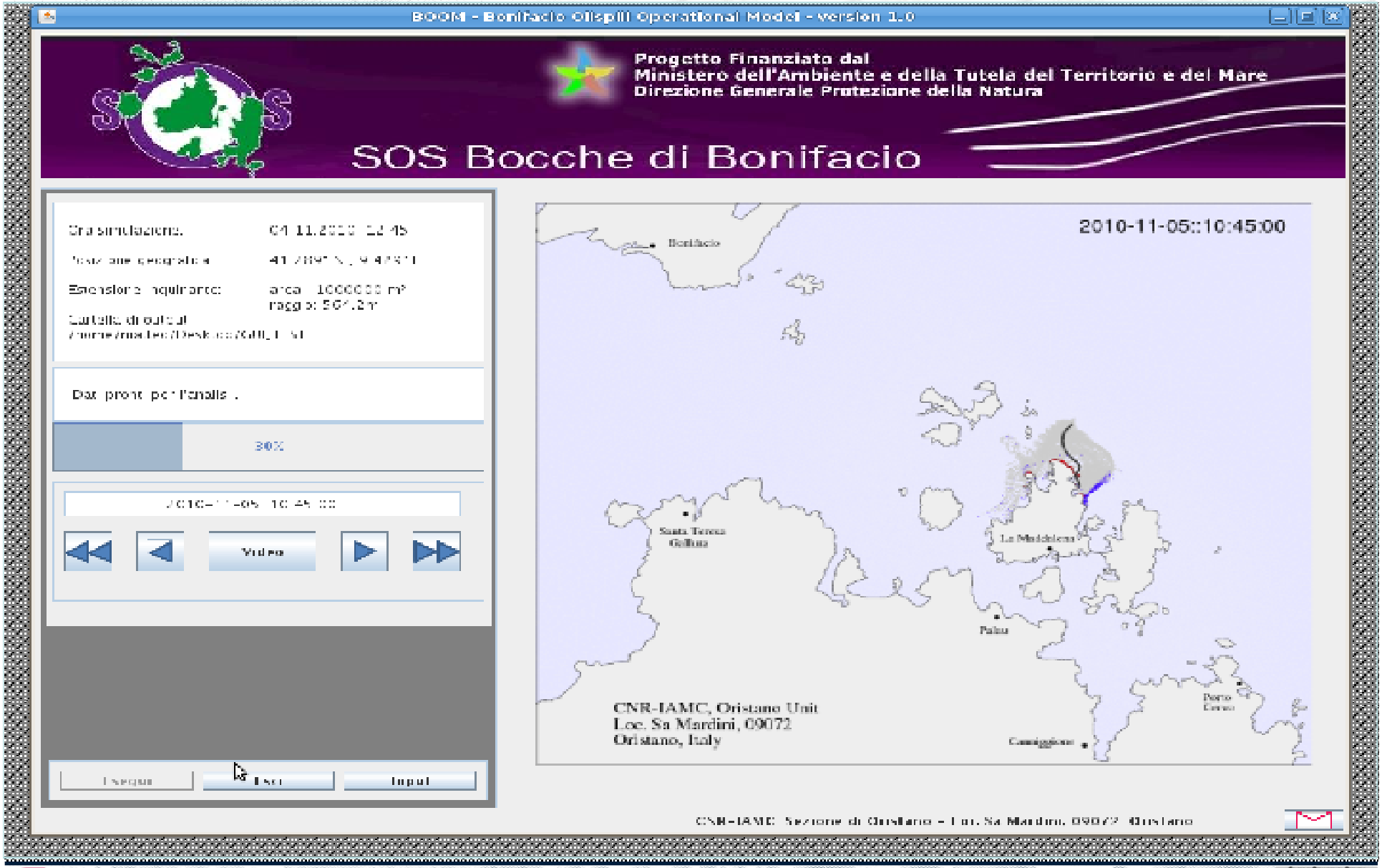
SURFACE WATER CURRENT IN THE SOB AND IN THE LA MADDALENA ARCHIPELAGOS

AT

http://www.seaforecast.cnr.it



OIL SPILL FORECASTING BY MEANS OF GRAPHICAL USER INTERFACE



SOS Bocche di Bonifacio

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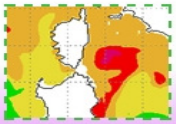
- Area di Studio
- Motivi
- Fasi e Attività
- Staff

Le Osservazioni

Le Previsioni



Progetto coordinato dal CNR-IAMC di Oristano

in collaborazione con la Guardia Costiera Capitaneria di Porto di La Maddalena

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Simulazioni numeriche di ipotetici scenari locali di inquinamento marino da idrocarburi

Scenario 1
Collisione tra una nave passeggeri, in servizio tra S. Teresa Gallura (I) e Bonifacio (F), e una nave cisterna-petroliera che attraversa le Bocche di Bonifacio in direzione est-ovest.

Scenario 2
Incaglio di una nave da carico, partita dal porto di Livorno (I) e diretta a Barcellona (E), in corrispondenza degli scogli di Barrettini (Arcipelago di La Maddalena, Italia).

Scenario 3
Incaglio di uno Yacht, in trasferimento da Porto Cervo (I) a Marsiglia (F), in corrispondenza degli scogli dell'Isola Piana (Arcipelago di La Maddalena).

Scenario 4
Collisione tra un mototraghetto impiegato sulla tratta di linea Palau–La Maddalena e un Motor Yacht proveniente da Porto Cervo (I) e diretto a Bonifacio (F).

Scenario 5
Collisione tra un'imbarcazione da pesca e una unità da diporto a vela nelle vicinanze del Golfo di Cannigione (Arzachena, Italia).

Scenario 6
Scontro di un mototraghetto in trasferimento verso il porto di La Maddalena (I) con gli scogli dell'Isola delle Bisce (Parco Nazionale dell'Arcipelago di La Maddalena, Italia).

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In Primo Piano

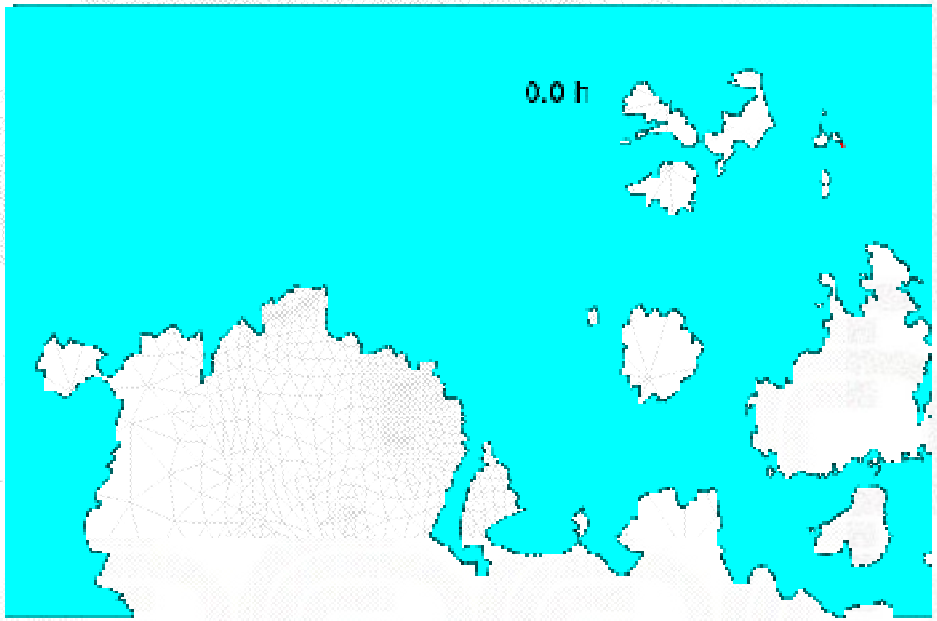
Sfiorato il danno ambientale alle secche di Punta Galera
Mercoledì, 02 Settembre 2009

II Meeting del Progetto
Martedì, 01 Settembre 2009

I Esperimento "ADCP nelle Bocche"
Martedì, 01 Settembre 2009

V Esperimento "GIUSTINIANO"
Lunedì, 24 Agosto 2009

IV Esperimento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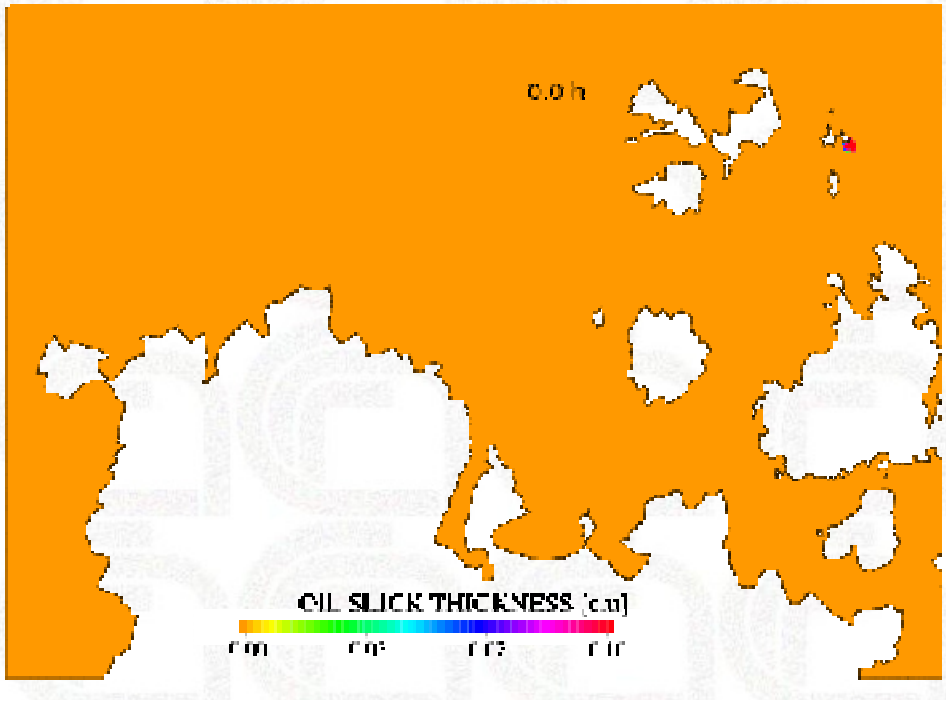
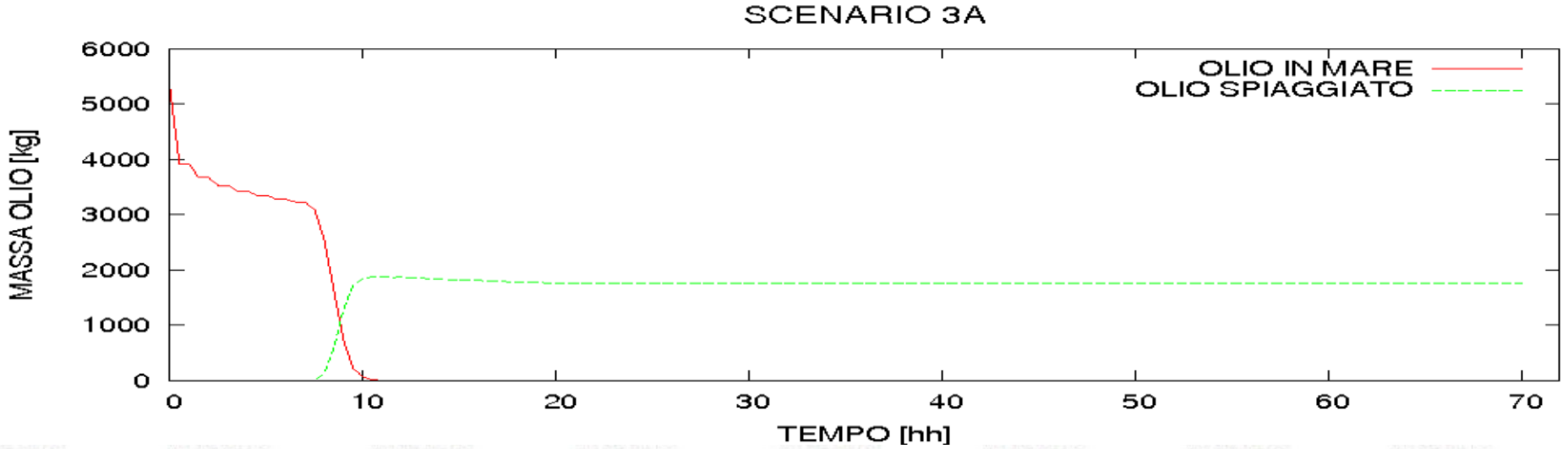
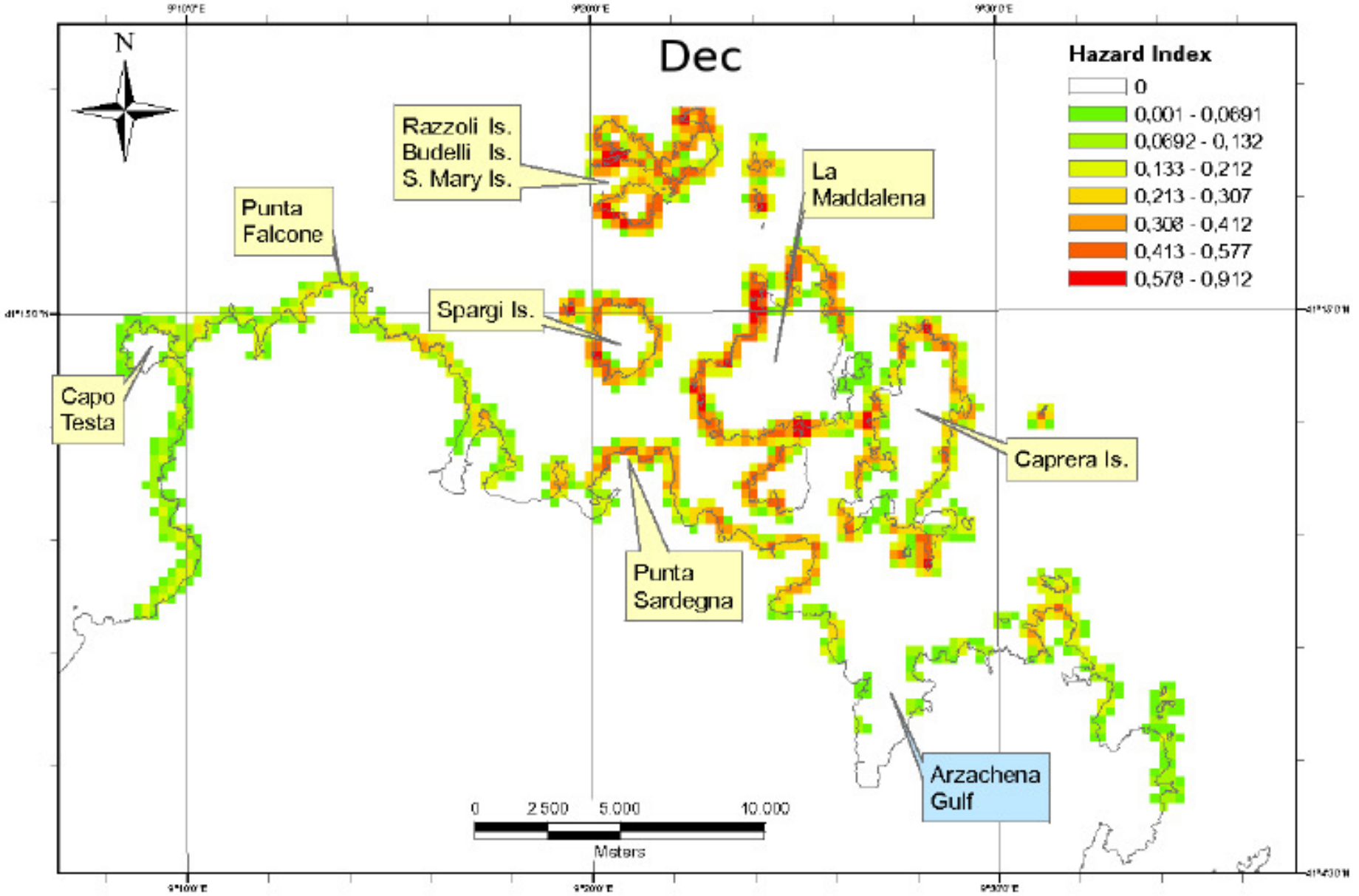
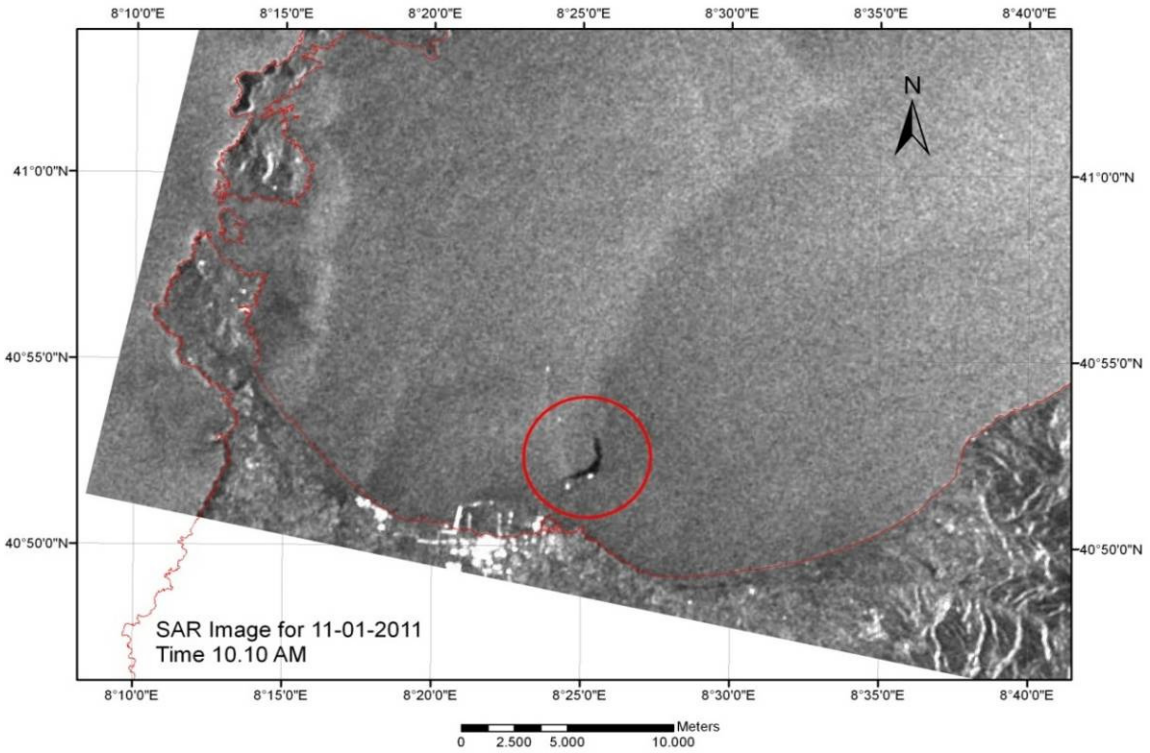

0.0 h
OIL SLICK THICKNESS [cm]

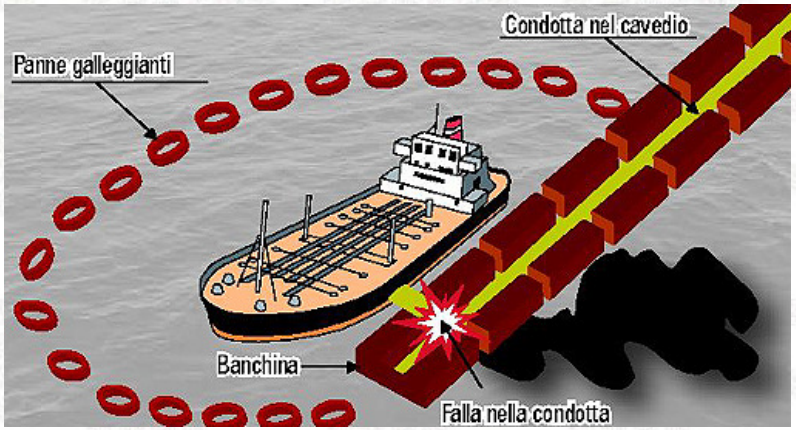

SCENARIO 3A
OLIO IN MARE
OLIO SPIAGGIATO
MASSA OLIO [kg]
TEMPO [hh]
0
1000
2000
3000
4000
5000
6000
0
10
20
30
40
50
60
70


Dec
N
Hazard Index
0
0,001 - 0,0691
0,0692 - 0,132
0,133 - 0,212
0,213 - 0,307
0,308 - 0,412
0,413 - 0,577
0,578 - 0,912
Razzoli Is.
Budelli Is.
S. Mary Is.
La Maddalena
Punta Falcone
Spargi Is.
Capo Testa
Caprera Is.
Punta Sardegna
Arzachena Gulf
0
2.500
5.000
10.000
Meters

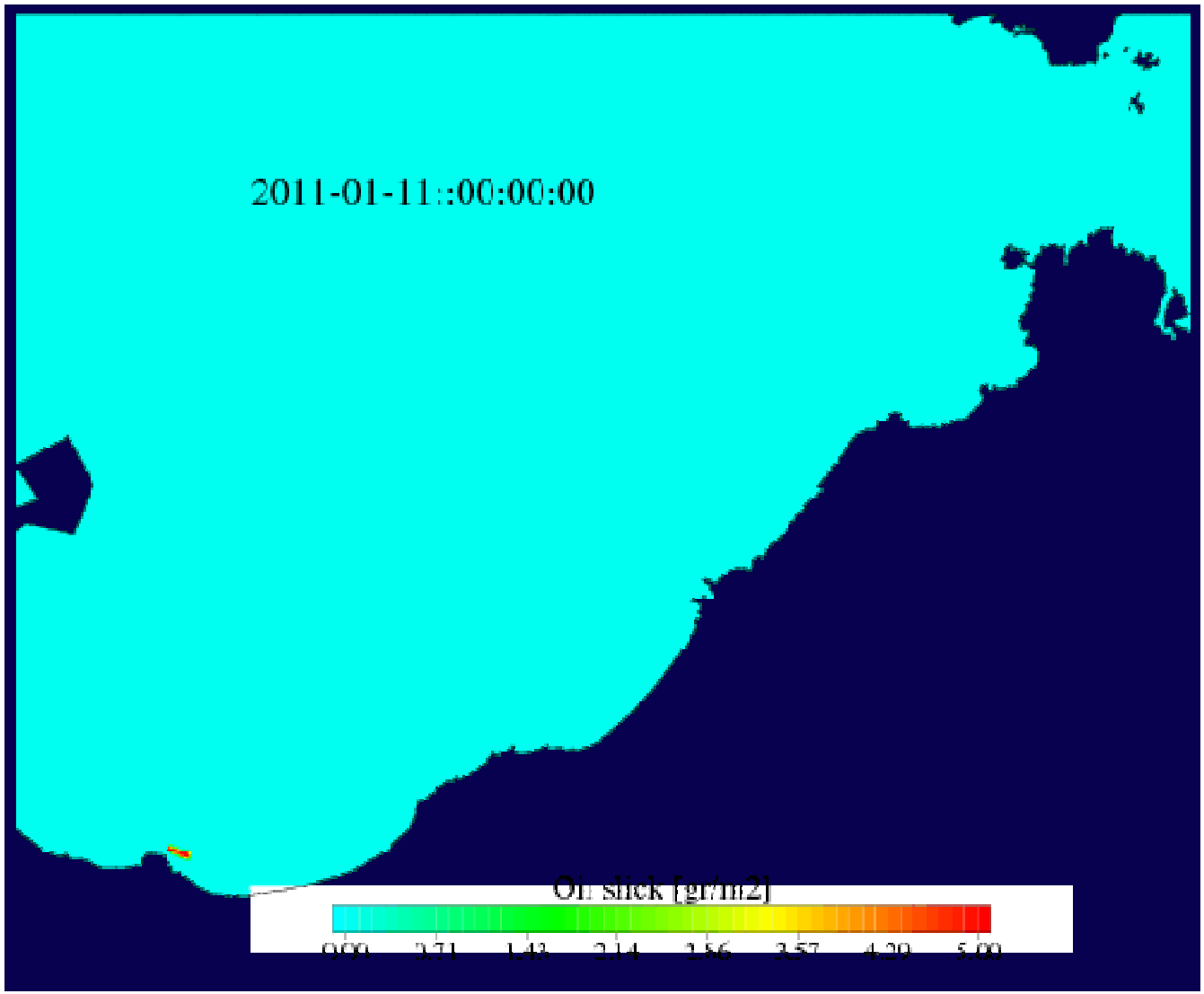


PORTO TORRES
OIL SPILL EVENT
10 - 01 - 11

High density oil spilled during transfering operation from oil tank to P.Torres harbour bunker



RAPID RESPONSE TO THE EMERGENCY:
THE BOOM MODEL DOMAIN WAS EXTENDED TO COVER THE INTERESTED AREA AND OIL SPILL PREDICTIONS WERE MADE DURING ABOUT THE 10 DAYS OF EMERGENCIES PROVIDING SUPPORT TO THE COAST GUARD



P.TORRES OIL SPILL EVENT SIM. RESULTS

- Continuous release of high density hydrocarbons.
- Started the 10-01-11 at 10:18 PM
- Ended 11-01-11 at 4:06 PM.
- About 20 hours of spilling.
- Total oil spilled estimated about 40 m^3

P.TORRES OIL SPILL EVENT SIM. RESULTS: COMPARISON WITH OBSERVATIONS

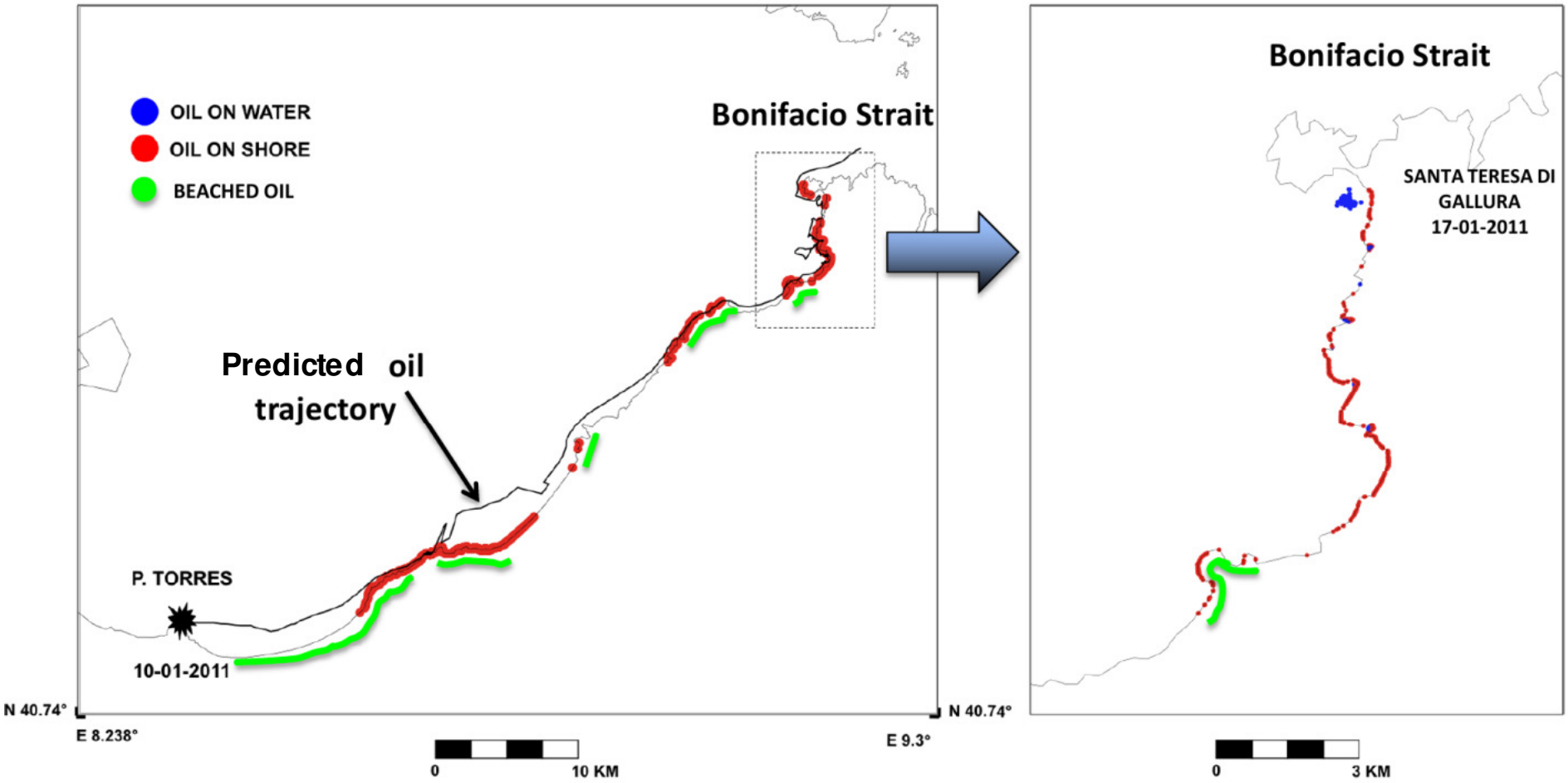


Figure 8

Cucco A., Sinerchia M., Ribotti A., Olita A., Fazioli L., Sorgente B., Perilli A., Borghini M., Schroeder K. Sorgente R., A high resolution real time forecasting system for predicting the fate of oil spills in the Strait of Bonifacio (western Mediterranean), (2012), *Marine Pollution Bulletin. In press.*

Olita, A., Cucco, A., Simeone, S., Ribotti, A., Fazioli, L., Sorgente, B. and R. Sorgente (2012). Oil spill hazard and risk assessment for the shorelines of a mediterranean archipelago, *Ocean and Coastal Managment, 57, pp. 44-52*

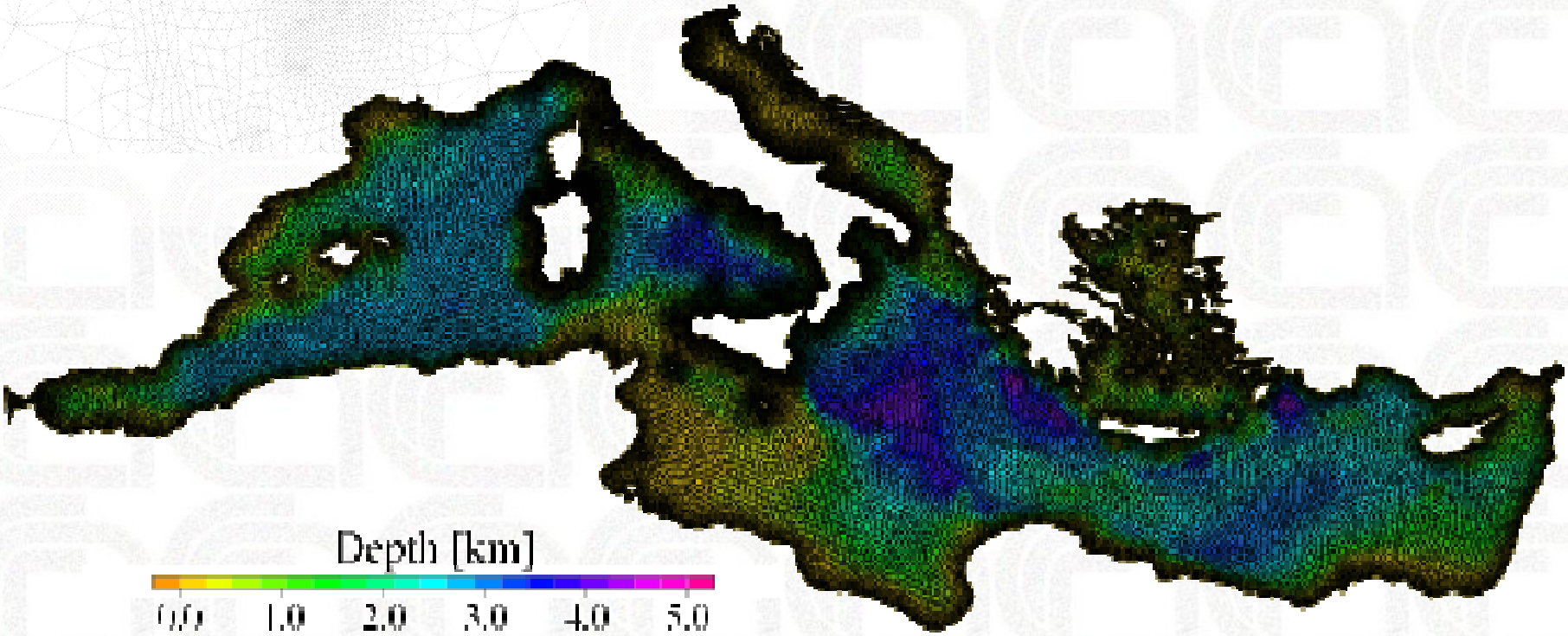
Sorgente, B., Sorgente, R., Olita, A., Fazioli, L., Cucco, A., Perilli, A., Sinerchia, M. and A. Ribotti (2012). Effect of protection rules and measures in a important International strait area: the Bonifacio Strait. *Journal of Operational Oceanography, Volume 5 No I, pp. 35-44.*

Cucco, A., M., Ribotti A., Olita A., Fazioli L., Sorgente B., Perilli A., Borghini M., Sinerchia ,M., Schroeder K. Sorgente R , Oil spills prediction in the Bonifacio strait area, western Mediterranean. *Under review in Ocean Science*

THANKS FOR YOUR ATTENTION

3. MODELLISTICA CORRENTE BAROTROPICA BOCCHE DI BONIFACIO

MODELLO IDRODINAMICO BAROTROPICO 3D CON GRIGLIA DI CALCOLO ESTESA A TUTTO IL SOTTOBACINOCON ELEVATA RISOLUZIONE PER L'AREA DI INDAGINE



$$\frac{\partial U}{\partial t} - fV + gH\frac{\partial \zeta}{\partial x} + \frac{1}{\rho_0}\frac{\partial p_{atm}}{\partial x} + \frac{\tau_{xb}}{\rho_0} - \frac{\tau_{xw}}{\rho_0} = \frac{F_x}{\rho_0 H}$$

$$\frac{\partial V}{\partial t} + fU + gH\frac{\partial \zeta}{\partial y} + \frac{1}{\rho_0}\frac{\partial p_{atm}}{\partial y} + \frac{\tau_{yb}}{\rho_0} - \frac{\tau_{yw}}{\rho_0} = \frac{F_y}{\rho_0 H}$$

$$\frac{\partial \zeta}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

2D Barotropic

$$\begin{cases} U = \int_{-h}^{\zeta} u \, \partial z \\ V = \int_{-h}^{\zeta} v \, \partial z \end{cases}$$

OPERATIONAL SET-UP

WHERE .....

τ_b = bottom stress

τ_w = wind stress

ρ_0 = water density

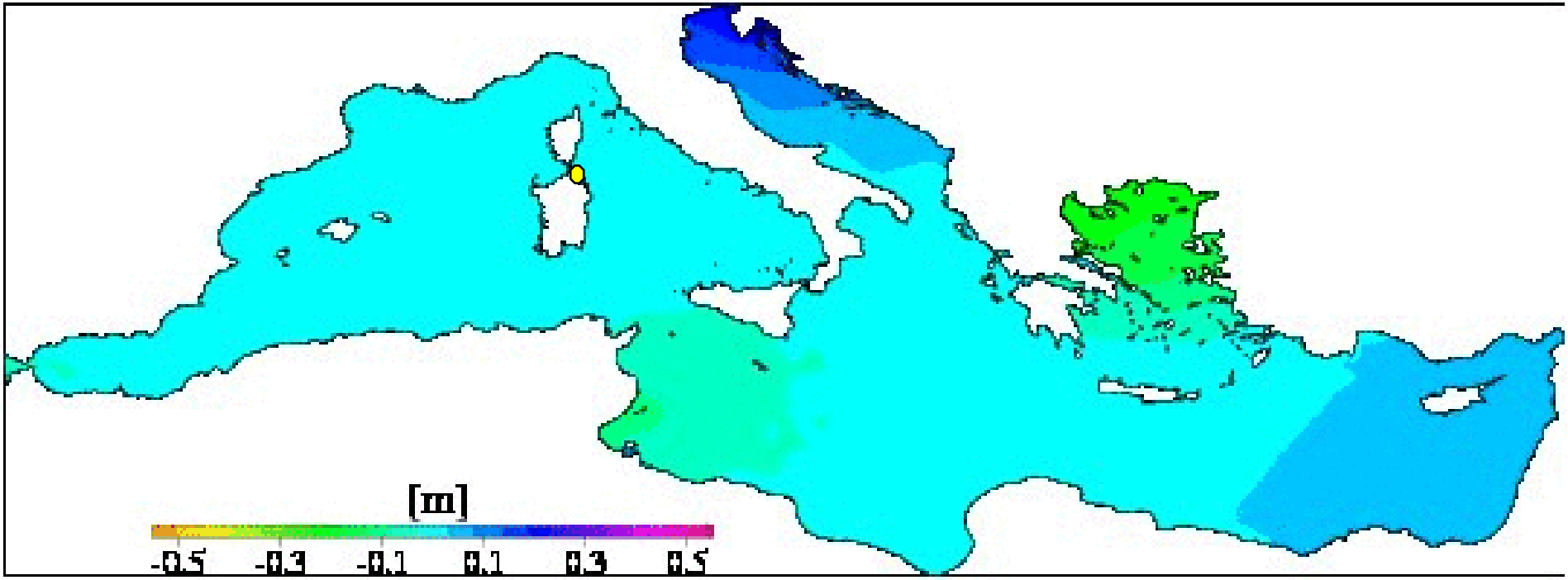
$H = \zeta + h$ (total level)

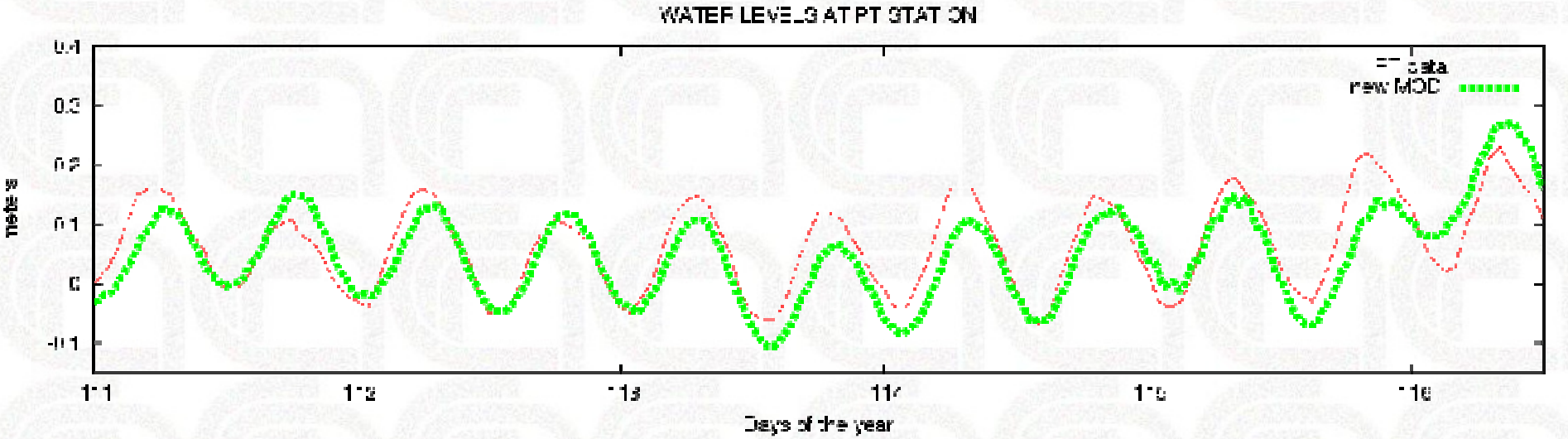
ζ = surge

HYDRODYNAMIC:
Time step: 300 s (adaptive)

FORCING:
- Meteorological data
- Tide at Gibraltar Strait
- Body + earth + load tides
  - 4 diurnal (K1, O1, P1, Q1)
  - 4 semidiurnal (M2, S2, N2, K2)
  - 3 long term (Mf, Mm, Ssa)

3. MODELLISTICA CORRENTE BAROTROPICA STRETTO DI BONIFACIO





3. MODELLISTICA CORRENTE BAROTROPICA BOCCHE DI BONIFACIO