Short Course on

Remote Sensing of Potential Fishing Zones & Ocean State Forecast

Organized
by
International Training Centre for
Operational Oceanography (ITCOocean),
ESSO-INCOIS, Hyderabad.
March 24-29, 2014

OIL SPILL TRAJECTORY PREDICTION IN INDIAN WATERS USING GNOME

SJ PRASAD

INFORMATION SERVICES & OCEAN SCIENCES GROUP(ISG)

MoES, GOVT OF INDIA HYDERABAD, ANDHRA PRADESH ,INDIA

Email : prasadsj@incois.gov.in

Date : 29.03.2014

OUTLINE

- OIL SPILL AND ITS TYPES
- OIL SPILL PRONE ZONES
- SOURCES OF OIL SPILLS AND ICG STATISTICS
- OIL WEATHERING PROCESS
- ENVIRONMENTAL IMPACTS OF OIL SPILLS
- NEED FOR OIL SPILL TRAJECTORY PREDICTION SYSTEM
- OIL SPILL MODELING AND TRAJECTORY FORECASTING SYSTEM AT INCOIS WITH CASE STUDY

OIL SPILL AND ITS TYPES

WHAT IS AN OIL SPILL

- Release of liquid petroleum hydrocarbon into land /water body
- Form of water pollution

TYPES OF SPILL

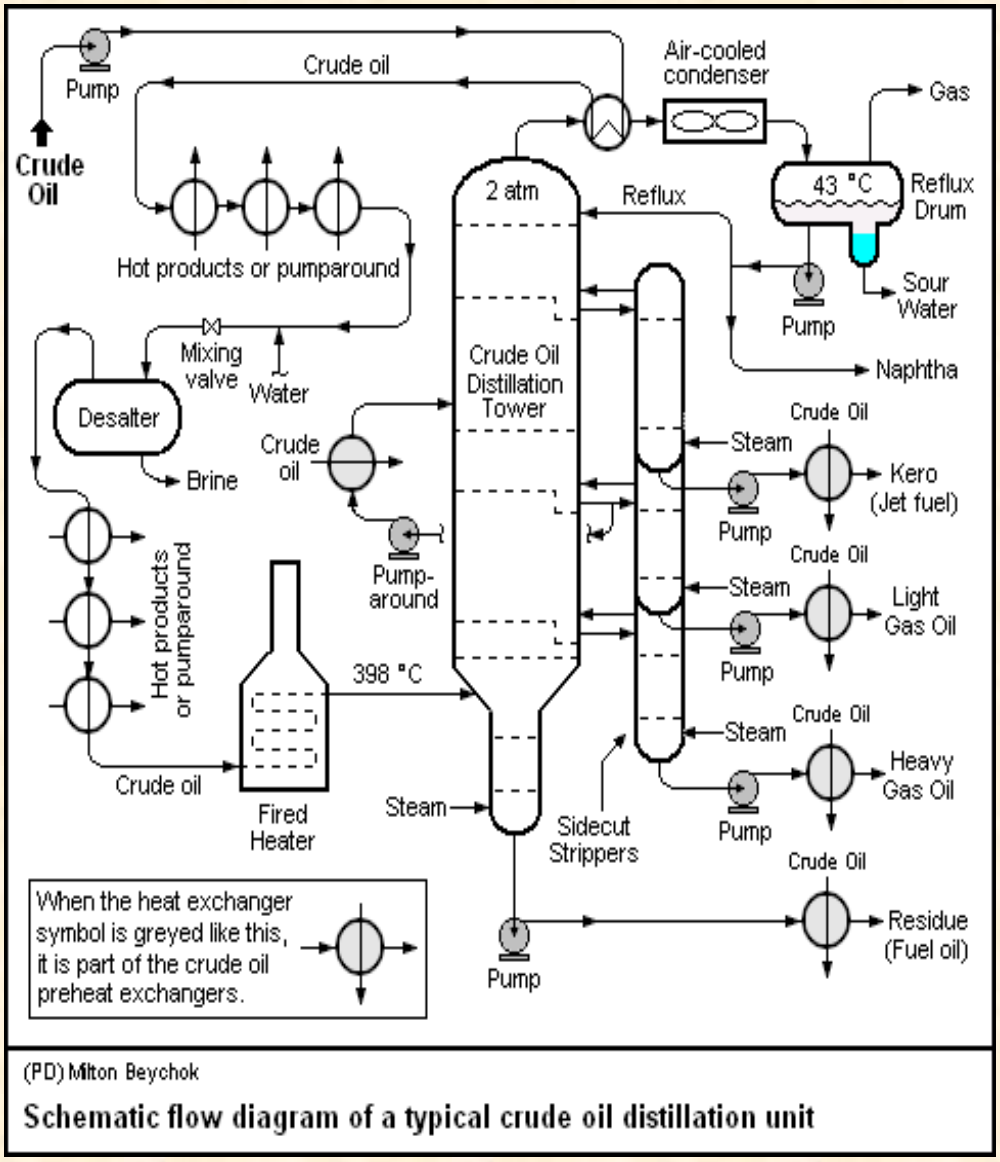
Tier -1 < 7 Tonnes

Tier -2 >7 <700 Tonnes

Tier - 3 > 700 Tonnes

CRUDE OIL AND ITS PRODUCTS

Crude oil, is a naturally occurring, flammable and usually dark brown or greenish colored liquid found primarily in underground geological formations. Crude oil consists of a complex mixture of hydrocarbons of various molecular weights plus other chemical compounds.



(PD) Milton Beychok

Schematic flow diagram of a typical crude oil distillation unit

OIL SPILL PRONE ZONES

OIL SPILL PRONE ZONES

SHIP ROUTES

PORTS AND HARBOURS

COASTAL ZONES

OFFSHORE OIL PLATFORMS

SOURCES OF OIL SPILLS AND ICG STATISTICS

SOURCES OF OIL SPILLS

Natural seepage from seabed

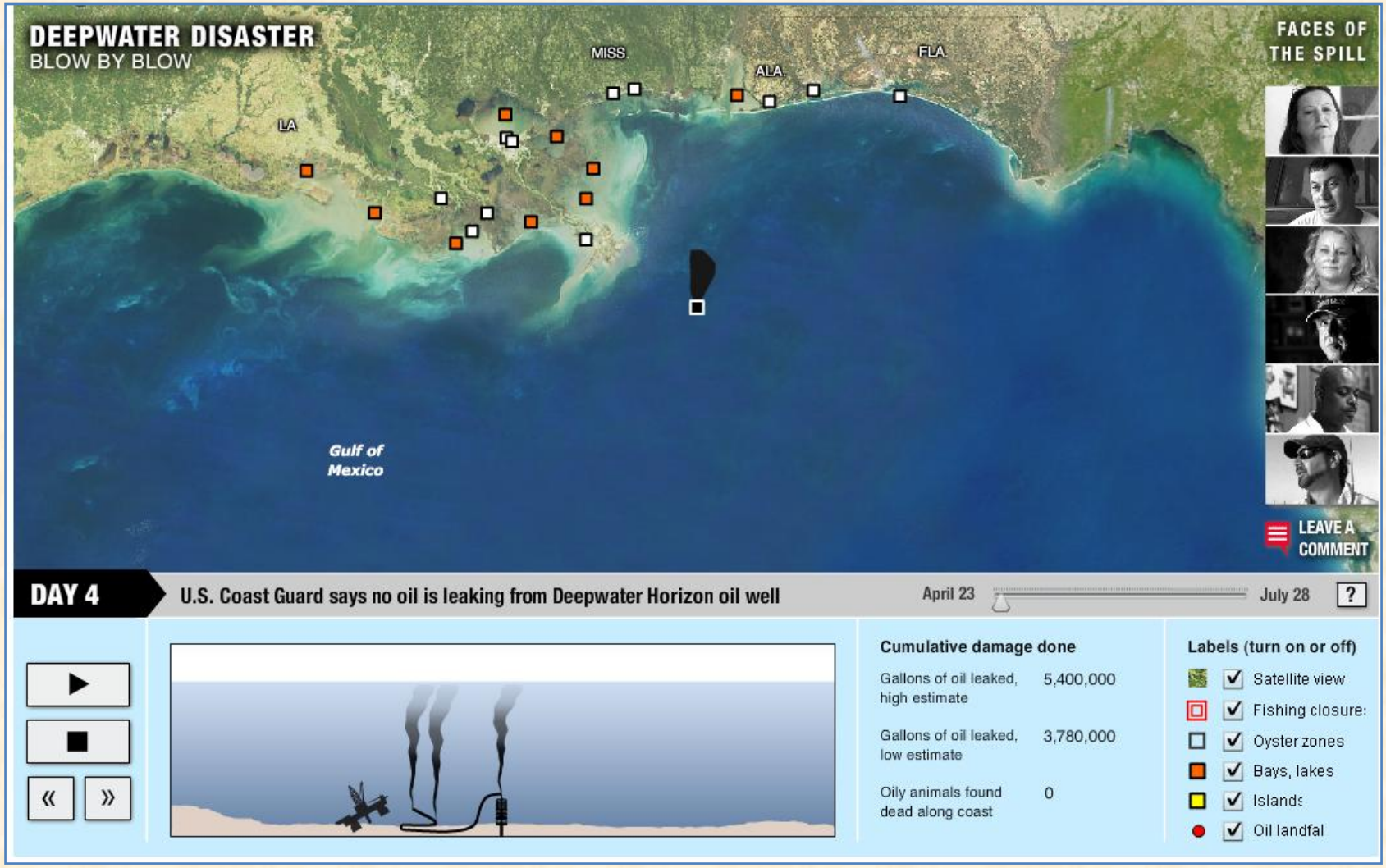
Ship-borne

Upstream Exploration and Production

Transfer to Downstream

BP DEEPWATER HORIZON ACCIDENT INVESTIGATION REPORT

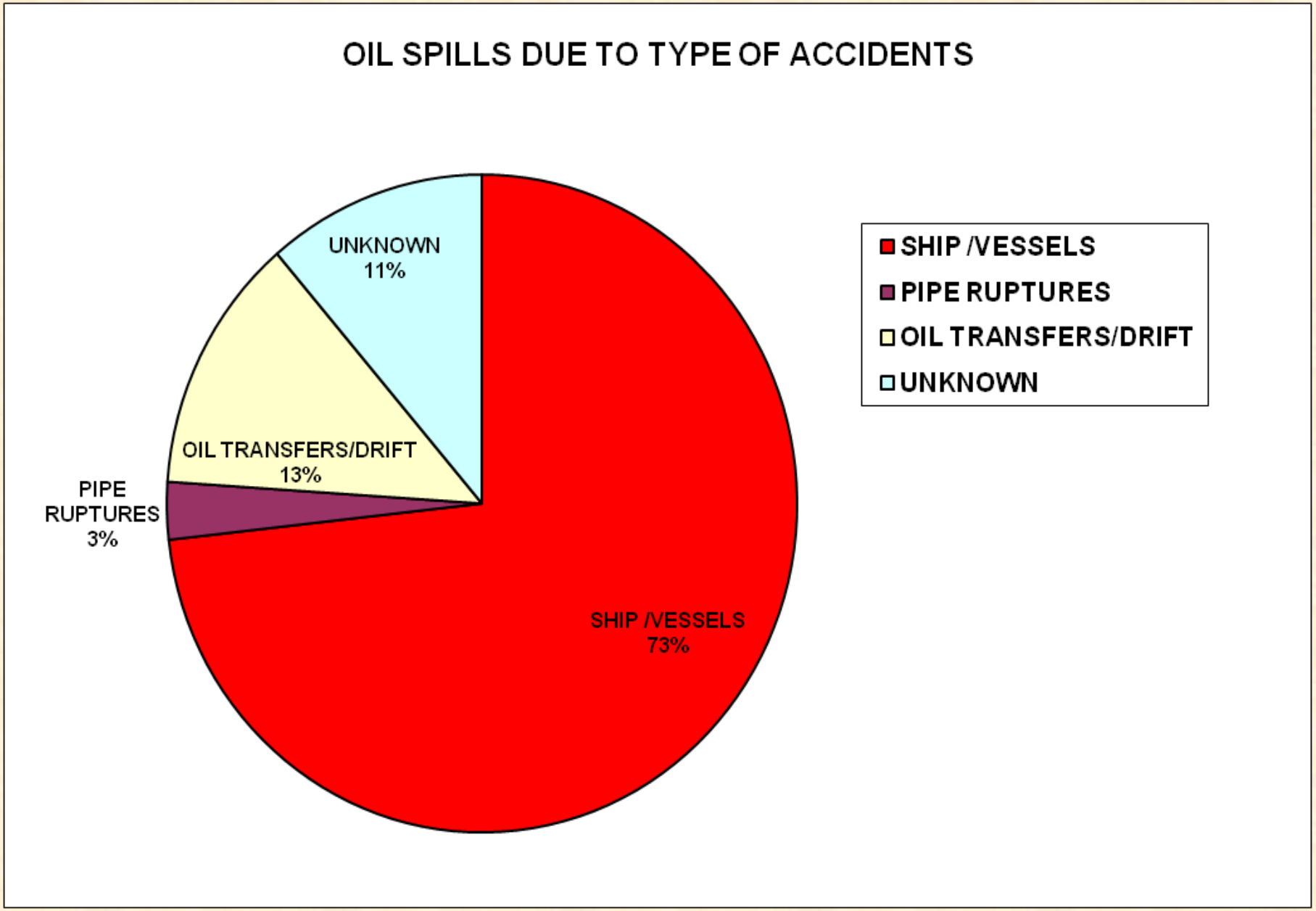
http://www.nola.com/news/gulf-oil-spill/deepwater-disaster/index.ssf



DEEPWATER HORIZON BLOWOUT/CLEAN UP METHODS

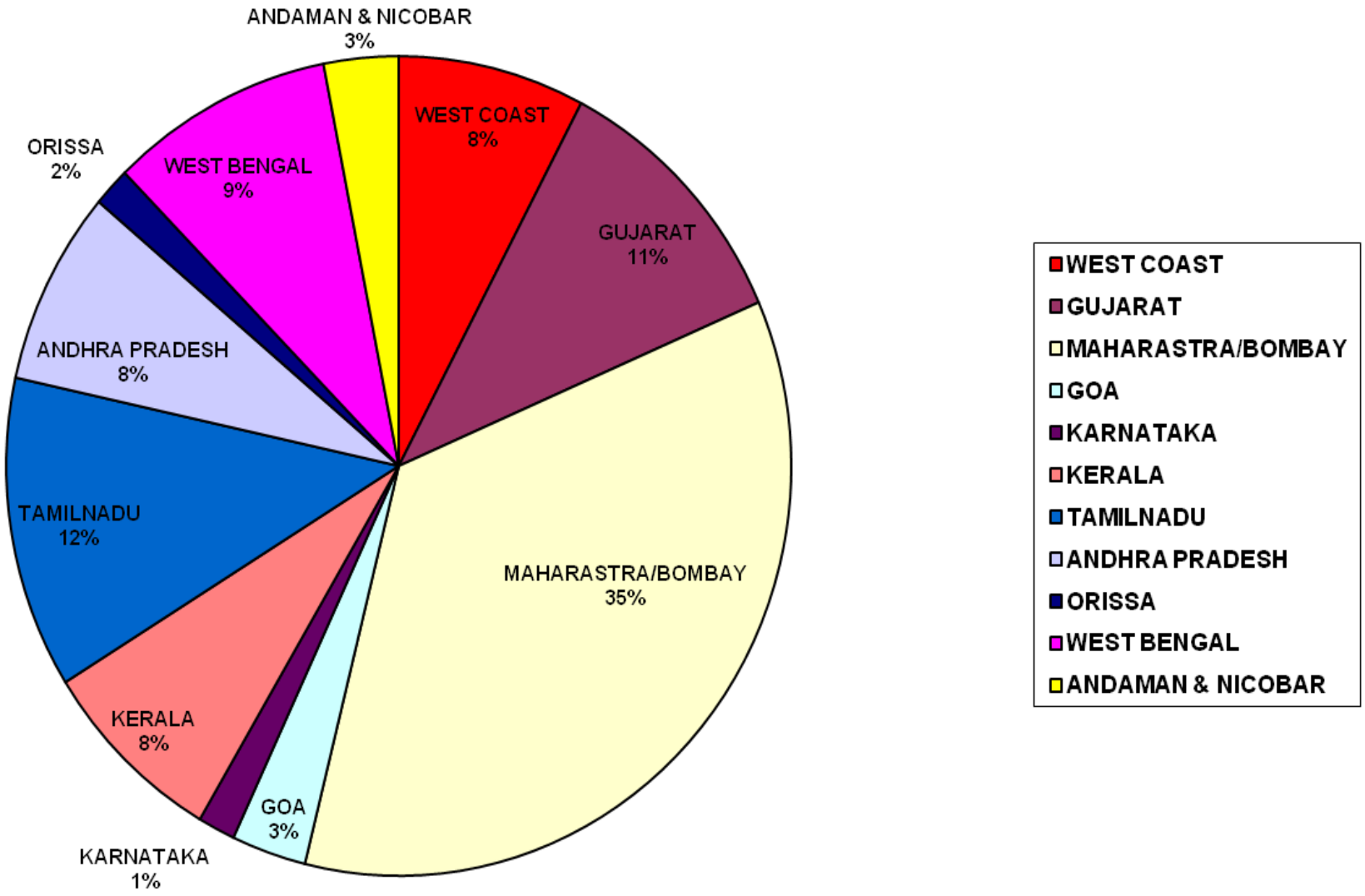
- Between April 20, 2010 and July 15, 2010 approximately 20,58,00,000 gallons of oil leaked into the Gulf of Mexico.
- The blowout is at a depth of 5,000ft (one mile below the surface of the ocean). Most of the oil rises to the surface because oil is less dense than water.
- Some of the oil gets trapped in underwater currents and can travel throughout the ocean.
- Dispersants (Corexit) to improve the separation of particles and to prevent settling or clumping,
- Booms are the temporary floating barrier used to contain an oil spill
- *Ab*sorbents are materials that pick up and retain liquid causing the material to swell (saw dust, straw) sorbents need to be both oleophilic (oil-attracting) and hydrophobic (water-repellent).

ICG STATISTICS ON INDIAN SCENARIO



Source : Indian coast Guard,2012

OIL SPILLS ALONG THE COASTAL ZONES



Source : Indian coast Guard,2012

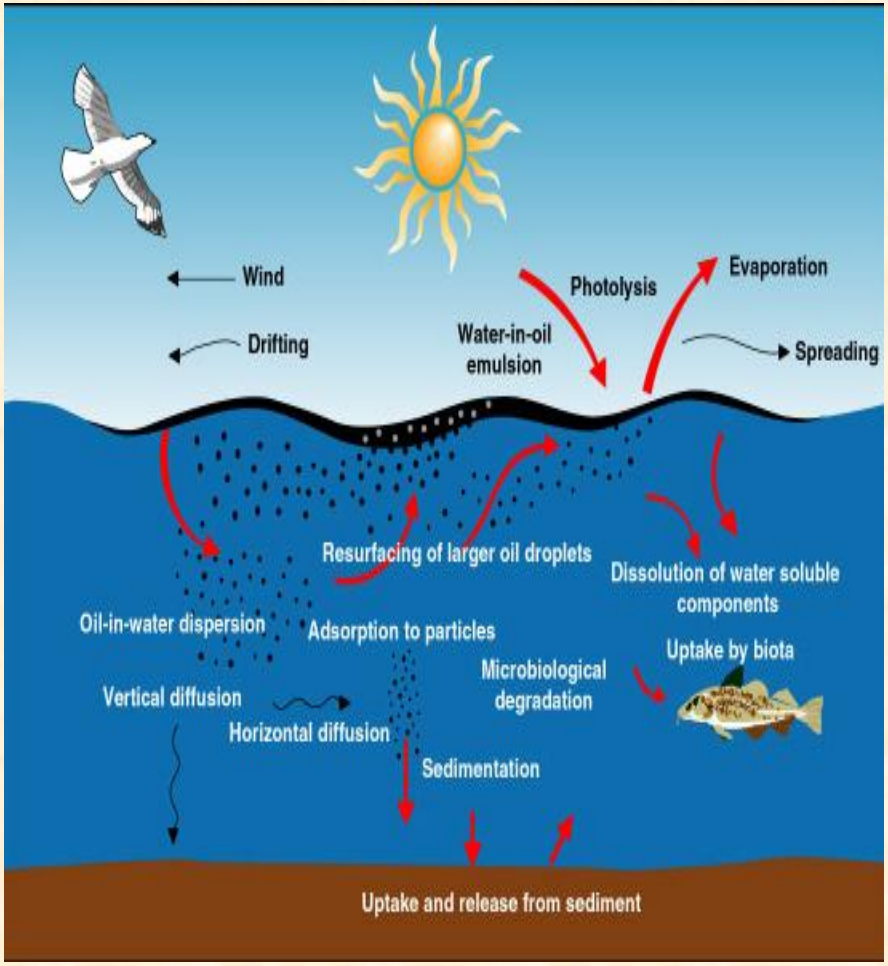
OIL WEATHERING PROCESS

OIL WEATHERING

Oil weathering is defined as the process that makes changes in chemical composition and physical characteristics over time.

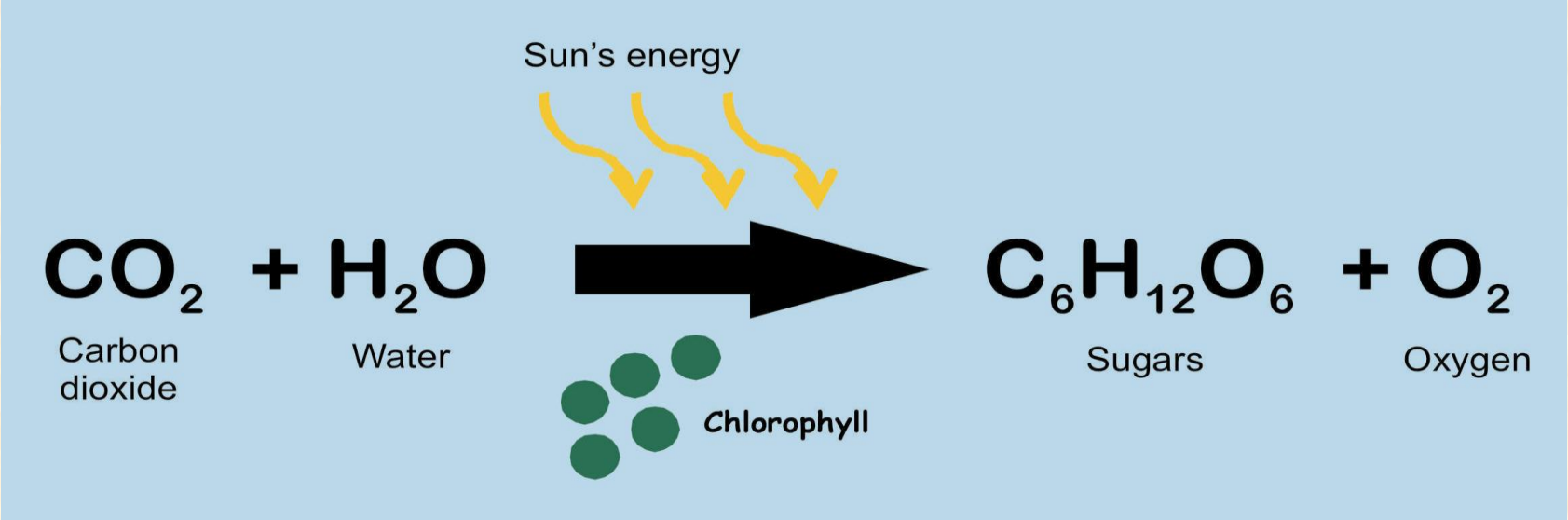
Soon after an oil spill incident, the following process will happen

- **Emulsion (water in oil)**
- **Dispersion (Oil in water)**
- **Evaporation**
- **Spreading**
- **Adsorption**
- **Drifting**



ENVIRONMENTAL IMPACTS OF OIL SPILLS

IMPACT ON PHOTOSYNTHESIS IN THE MARINE ENVIRONMENT



Phytoplankton can only carry out this process where there is sufficient light intensity penetrating the sea water. This area is called the ***photic zone*** and is often the top 100 metres of the ocean.

Heavier oils will cover the surface, thereby not allowing the sunlight to penetrate.

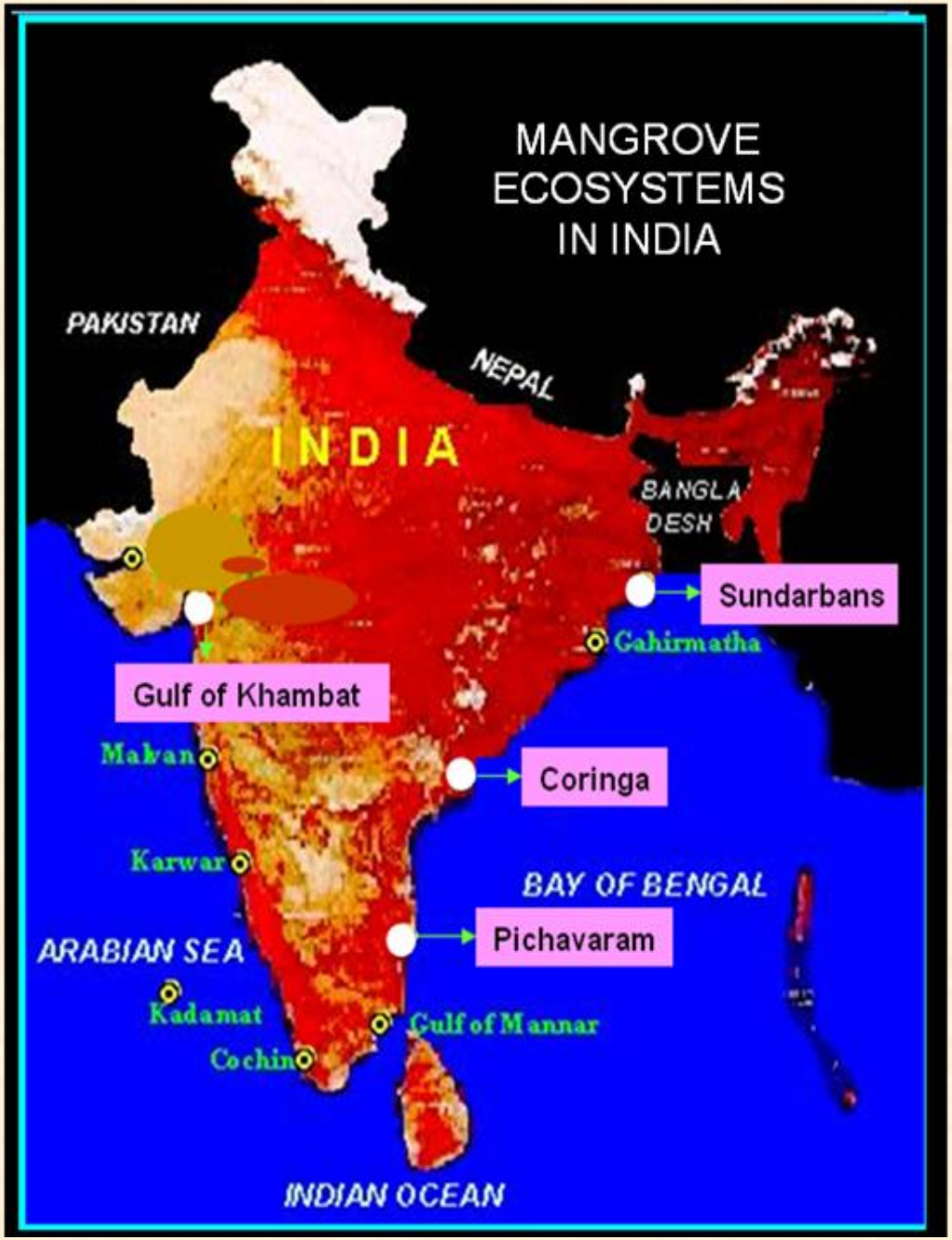
IMPACT OF OIL ON FAUNA

Birds

- **Loss of insulating properties**
- **Loss of immunity**
- **Inhalation of toxic volatile hydrocarbons**

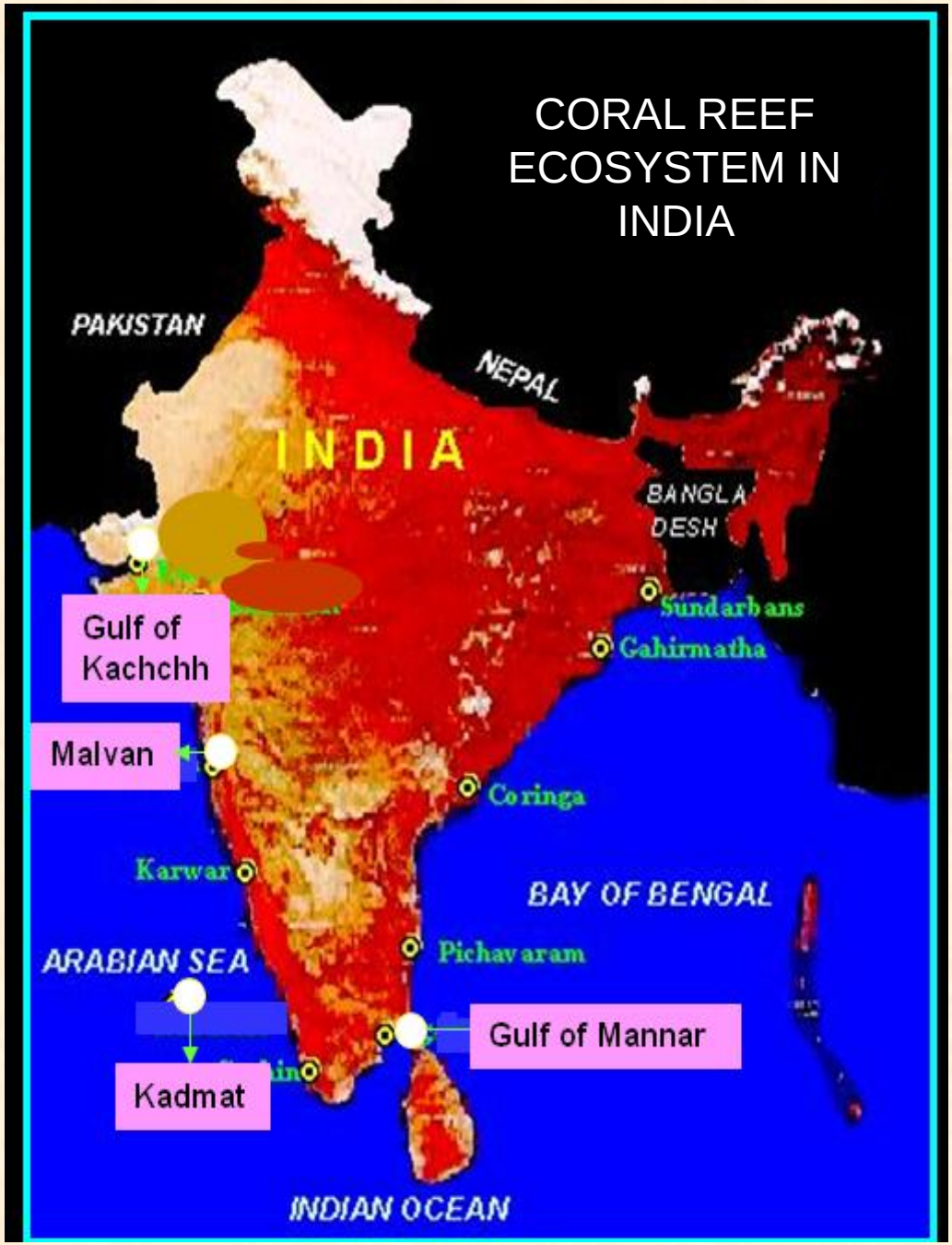
IMPACT OF OIL ON FISHERIES

- Loss of breeding habitats
- Accumulation of toxins
- Poor taste



IMPACTOF OIL IN MANGROVES

- Light fuels oils can cause mortality in 24-48 hours in red mangroves and black mangroves.
- Crude oils – coat the prop roots and reduce the ability to exchange gases.
- Long term persistence – cause leaf loss and to death.



SIGNIFICANCE OF CORAL REEFS

- Coral reefs - natural barriers that protect nearby shorelines from the eroding forces of the sea,
- Coral reefs cover less than 1% of the Earth's surface, they are home to 25% of all marine fish species.

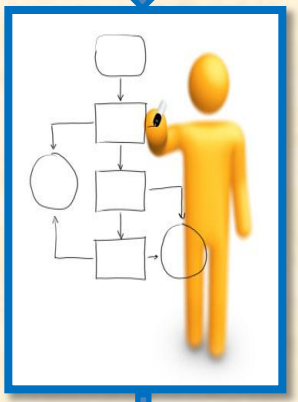
IMPACT OF OIL IN CORAL REEFS

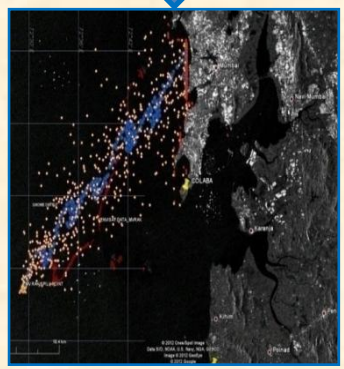
- Effect the health of the larger reef community
- Some of the more territorial fish will even remain in the area until death.

NEED FOR OIL SPILL TRAJECTORY PREDICTION SYSTEM

INCOIS AID IN OIL SPILL PREPAREDNESS AND RESPONSE

DISSEMINATION OF OIL SPILL ADVISORY TO THE USERS

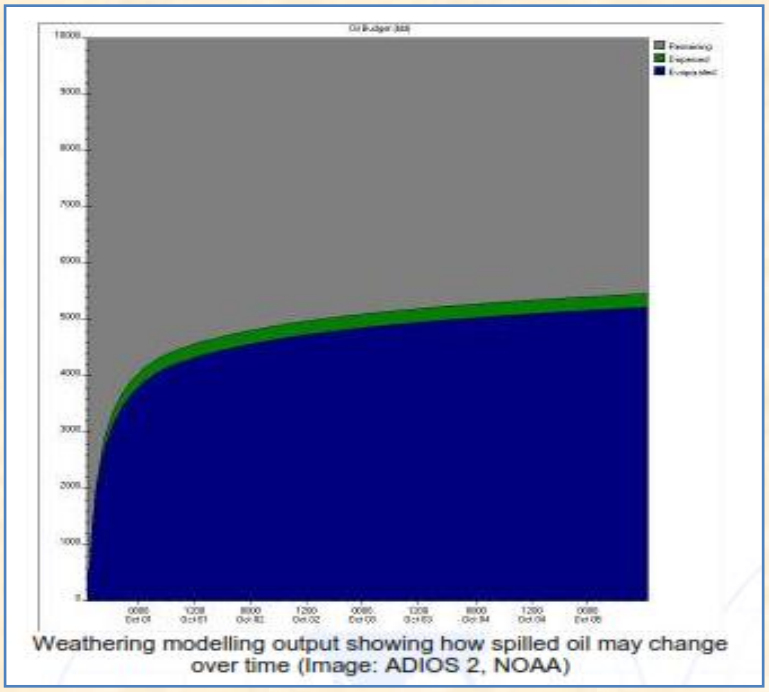




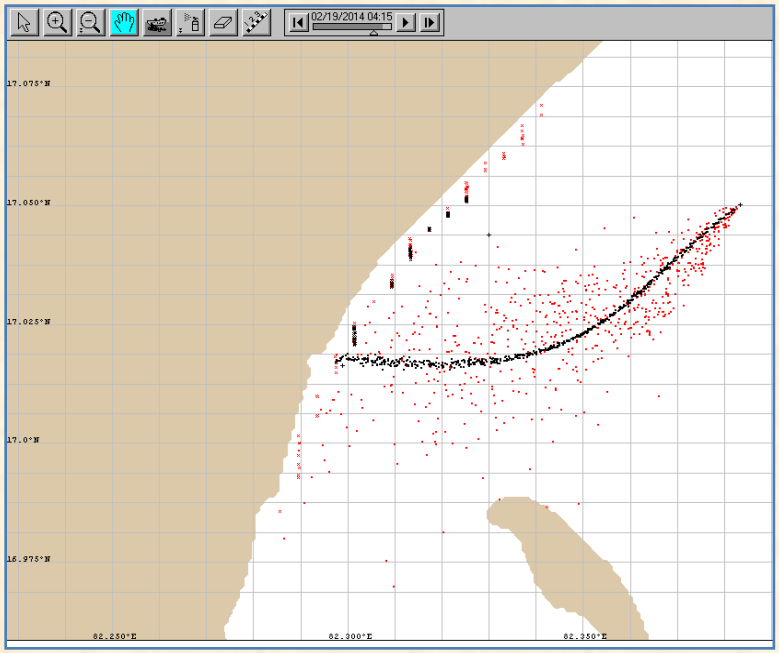
SIGNIFICANCE OF OIL SPILL TRAJECTORY PREDICTION

India possessing sensitive ecosystems and aquatic organisms along its coastline comprising estuaries, lagoons, mangroves, backwaters, salt marshes, mudflats, rocky shores, sandy structures and known for its coastal and Marine biodiversity. The marine habitats are being affected due to the oil spills caused due to vessel collisions and illegal discharges. In order to prevent the impact of oil spills on the marine environment an oil spill trajectory prediction system is required, to provide the trajectory of an oil spill thereby protecting the Marine habitats.

In the event of oil spill, the direction and movement of the oil will be predicted in advance in our system and will be disseminated to the Regulatory Authority. The clean up and control measures will be planned and carried out accordingly.



Weathering modelling output showing how spilled oil may change over time (Image: ADIOS 2, NOAA)



OIL WEATHERING AND TRAJECTORY MODELING

WEATHERING MODELS – Predicts the changes in the oil characteristics with respect to the time.

TRAJECTORY MODELS - Predicts the path of the spilled oil with respect to the time

USES OF OIL SPILL MODELS

1. **Contingency planning - to protect the marine organisms**
2. **Mock drills/ exercise - conducted by various offshore industries as a part of regulations**
3. **Oil spill response operations - to issue the advisory in the event of oil spills.**

OIL SPILL MODELING AND TRAJECTORY

FORECASTING SYSTEM AT INCOIS

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(An Autonomous Body under the Ministry of Earth Sciences, Government of India)

ONLINE OIL SPILL ADVISORY (OOSA)

INCOIS Home | OSF Home | Service Description & User Manual | Contact Us

WELCOME TO OIL SPILL TRAJECTORY PREDICTION

USER INFORMATION

Name:

Organisation:

Email:

Contact no:

SPILL INFORMATION

Region of Spill:* INDIAN OCEAN

Start Date:* 03/26/2014 16:07:00 End Date:* 03/26/2014 16:07:00

Start Position* Lon: 84.1417 Lat: 17.8545 DMS-DD

Pollutants:* SELECT

Quantity Released:* 500 Units: SELECT

submit

http://172.16.1.15:8080/OilSpill/index.html

OIL SPILL TRAJECTORY PREDICTION SYSTEM

Oil Spill Information	
Start Date:	01/21/2014 15:20:00
End Date	01/23/2014 15:23:00
Start Longitude	84.1417
Start Latitude	17.8545
Pollutants	CONSERVATIVE
Quantity Released	500 BARRELS
Trajectory Prediction for	48 Hours

Your process is completed successfully and the output will be sent to your Email

Download Output

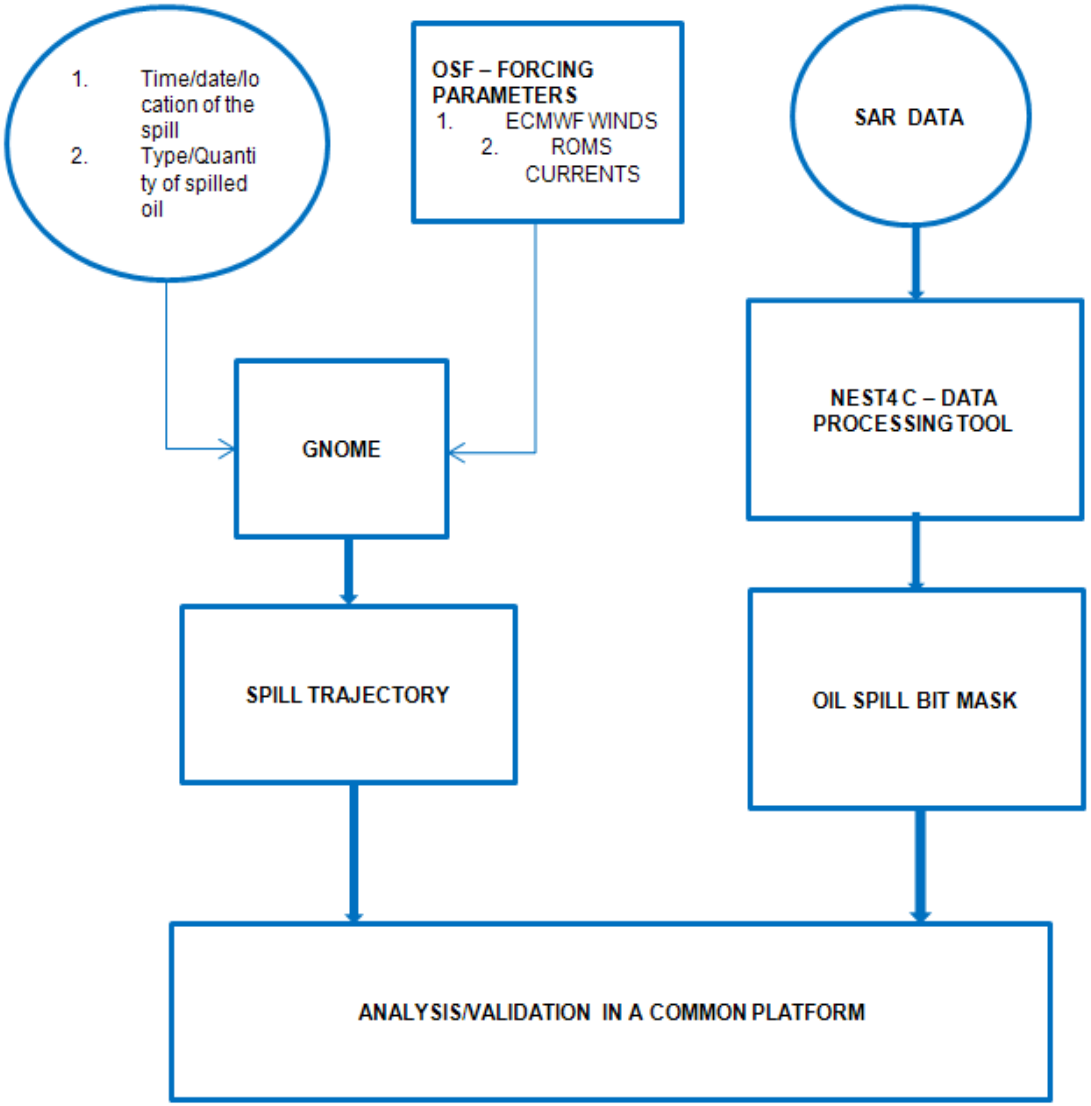
BACK to HOME

SALIENT FEATURES OF THIS SYSTEM

1. INCOIS being the first organization in India to intiate/issue Online Oil Spill Advisory to their users.
2. Users can submit their request online
3. Moreover they themselves can trigger the model and get the output.
4. The predicted trajectory will be generated immediately and will be disseminated to their emails.
5. The trajectory will sent in a Movie(.mov) format, so that the users by playing the movie, will come to know the respective places of oil drift.
6. This system will also eliminate the telephonic and fax traffic during emergency situations.

OIL SPILL TRAJECTORY PREDICTION- METHODOLOGY

METHODOLOGY



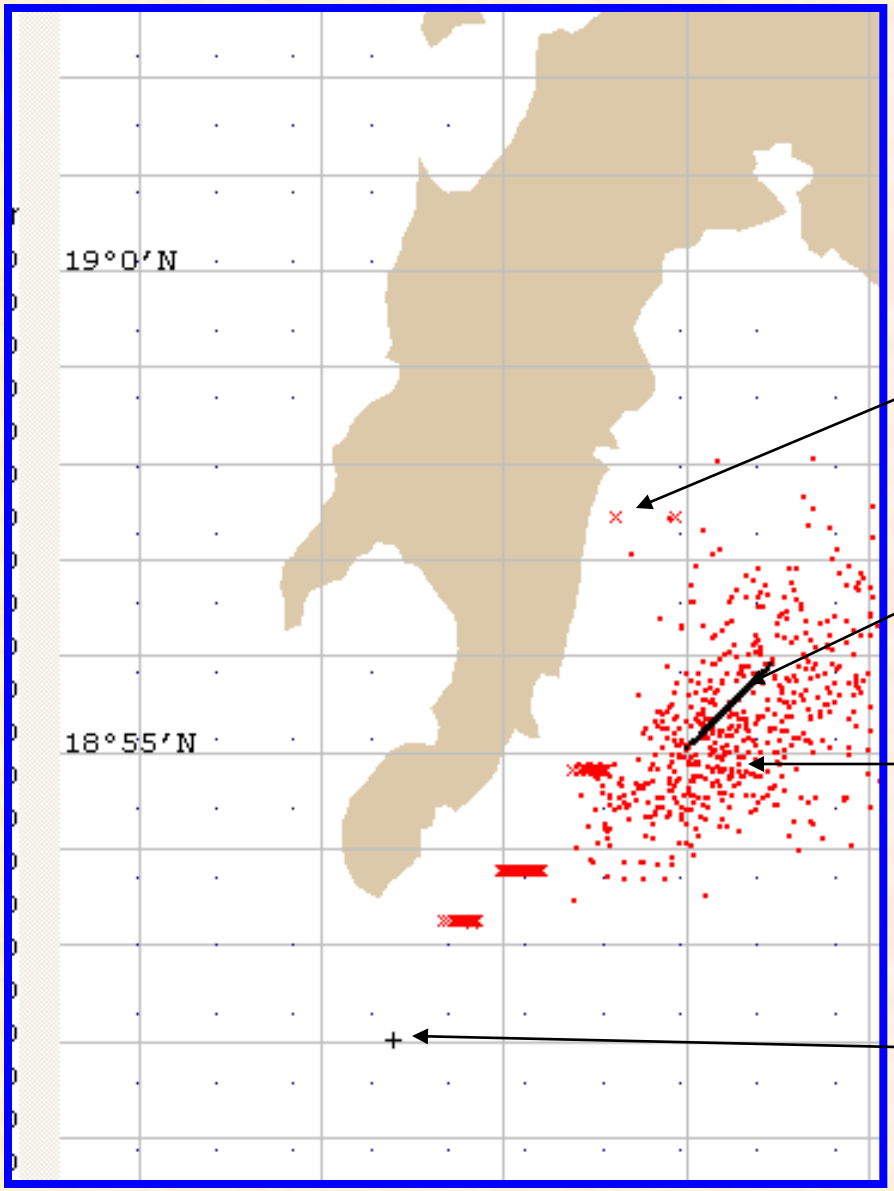
DESCRIPTION

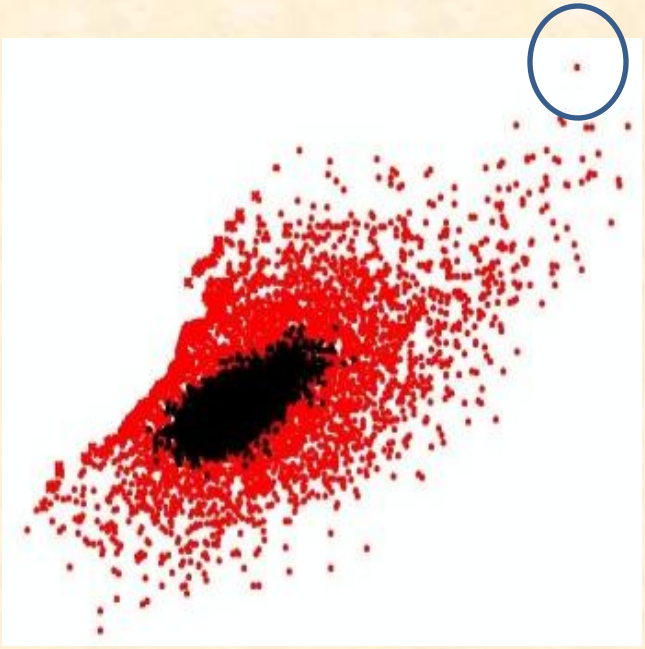
- GNOME, an oil spill trajectory model developed by NOAA is used in this prediction system.
- The details such as time, date, location, type and quantity of the oil spilled will be obtained the Regulatory authority / users. The major forcings like ECMWF winds and ROMS currents are the driving parameters.
- The predicted trajectory will be disseminated to the users in movie, image and text formats.
- The available SAR data will be subjected to oil spill detection
- Both the observed and the predicted trajectory will be compared in a common platform.

GNOME- (General NOAA Operational Modeling Environment)

- GNOME was developed by the Emergency Response Division of NOAA's Office of Response and Restoration.
- First release - March, 1999 ,Recent version - GNOME 1.3.8 - Jan 2014
- Predict how wind, currents, and other processes might move and spread oil spilled on the water.
- It gives the best estimate (black color) and Minimum regret estimates (red color) of spill trajectories.

MAGNIFICATION OF THE OUTPUT IMAGE





Every LE/spill dots indicates

- Position in Lon, ,lat (degrees)
- Time of release (seconds)
- Status of the particle with time.
- Pollutant type
- Mass of the pollutant(grams)
- Age – time since release (seconds)

Types of release

- One time/ instantaneous
- Continuous

CASE STUDY

OIL SPILLS IN INDIAN WATERS

MV RAK SPILL_ 06.08.2011 AT BOMBAY HIGH

MSC CHITRA SPILL_07.08.2010 AT BOMBAY HIGH

MV BLACK ROSE SPILL _ 09.09.2009 AT PARADIP

MV ASIAN FOREST _19.07.2009 AT MANGALORE

MSC CHITRA SPILL DETAILS

TYPE OF OIL : FUEL OIL #6

QUANTITY : 700 TONS

LOCATION : 18°51’59”N,72°48’48”E

MODEL RUN : 07.08.2010 09.00 hrs

to 16.08.2010,09.00 hrs

MSC CHITRA SPILL ANALYSIS

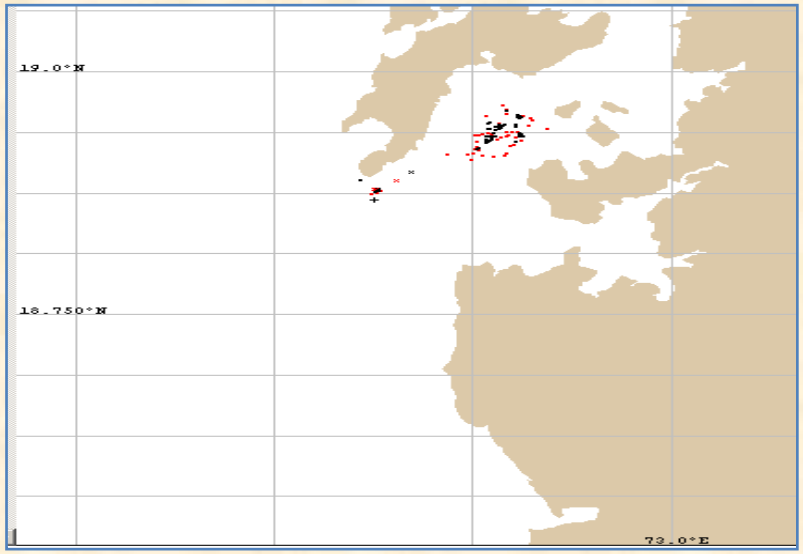


Figure 6. Spill trajectory on 08.08.2010,10.00hrs

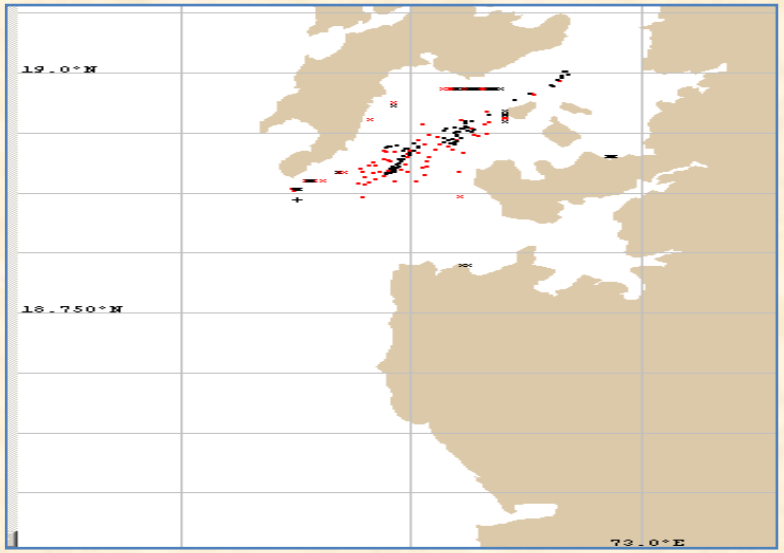


Figure 7.Spill trajectory on 10.08.2010,10.00hrs

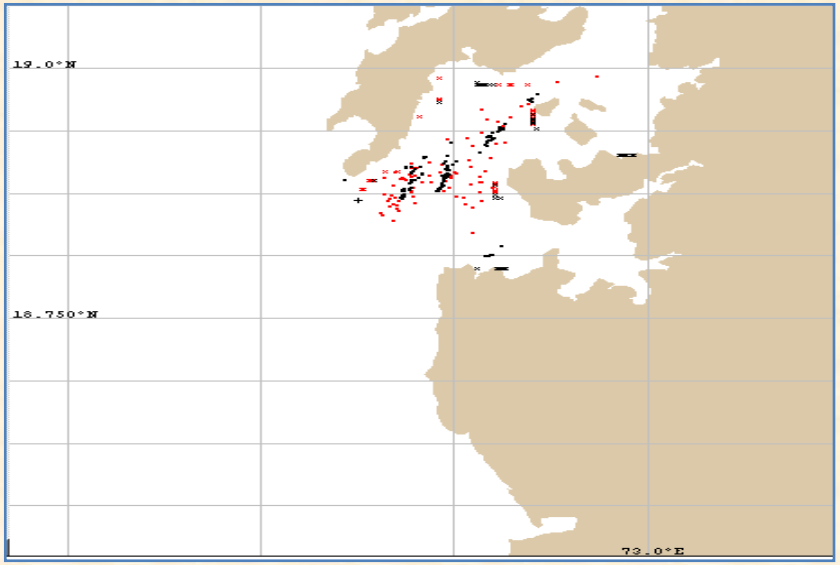


Figure 8.Spill trajectory on 12.08.2010,10.00hrs

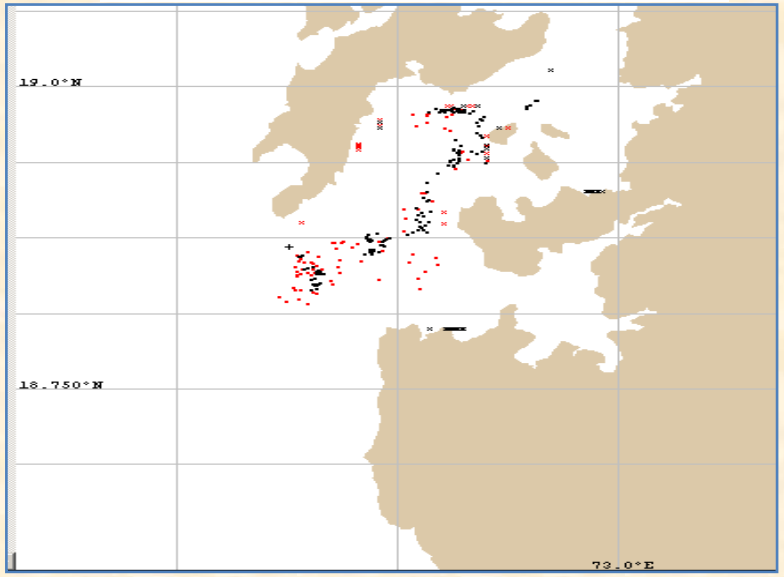
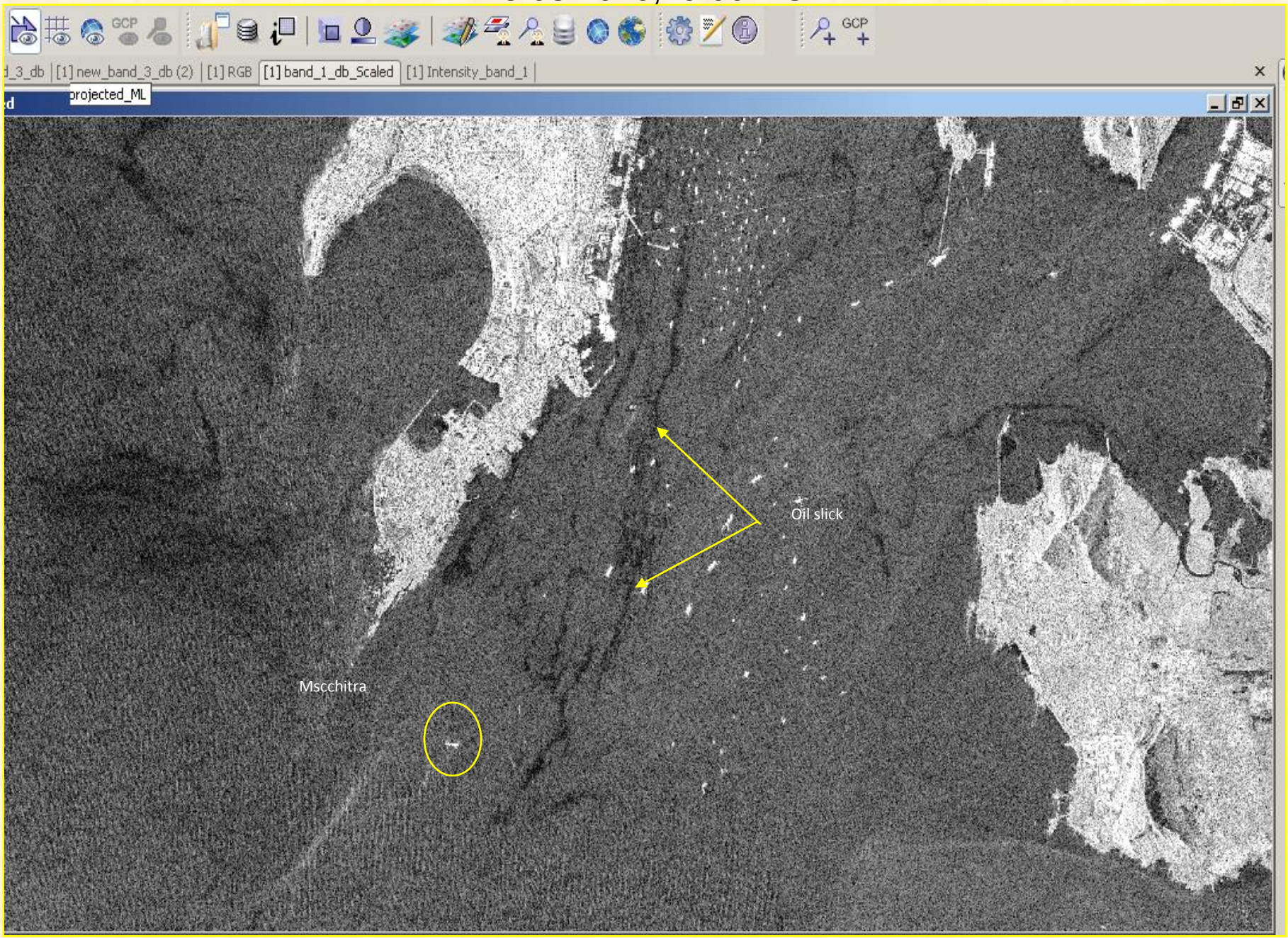
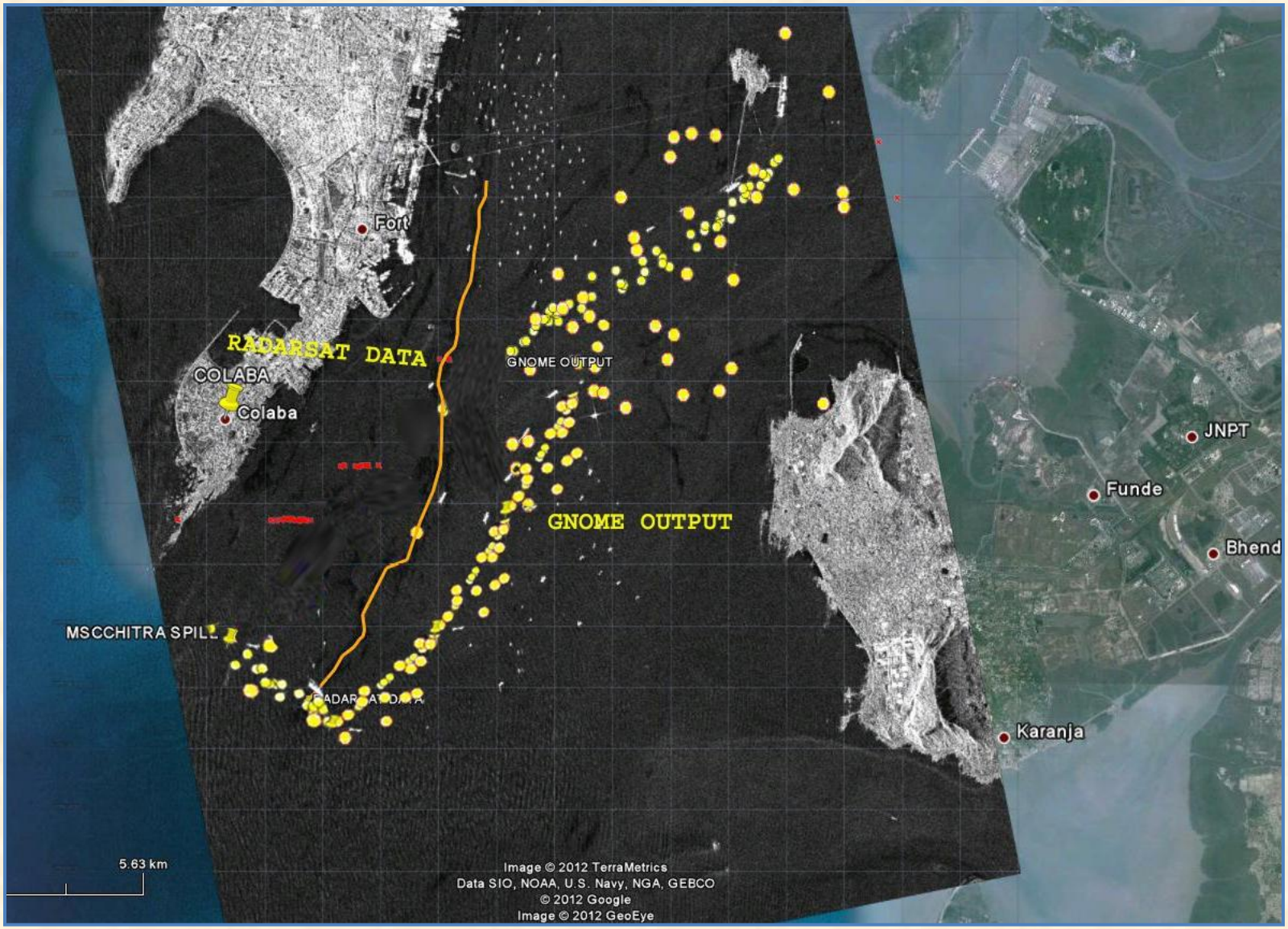


Figure 9.Spill trajectory on 15.08.2010,19.00hrs

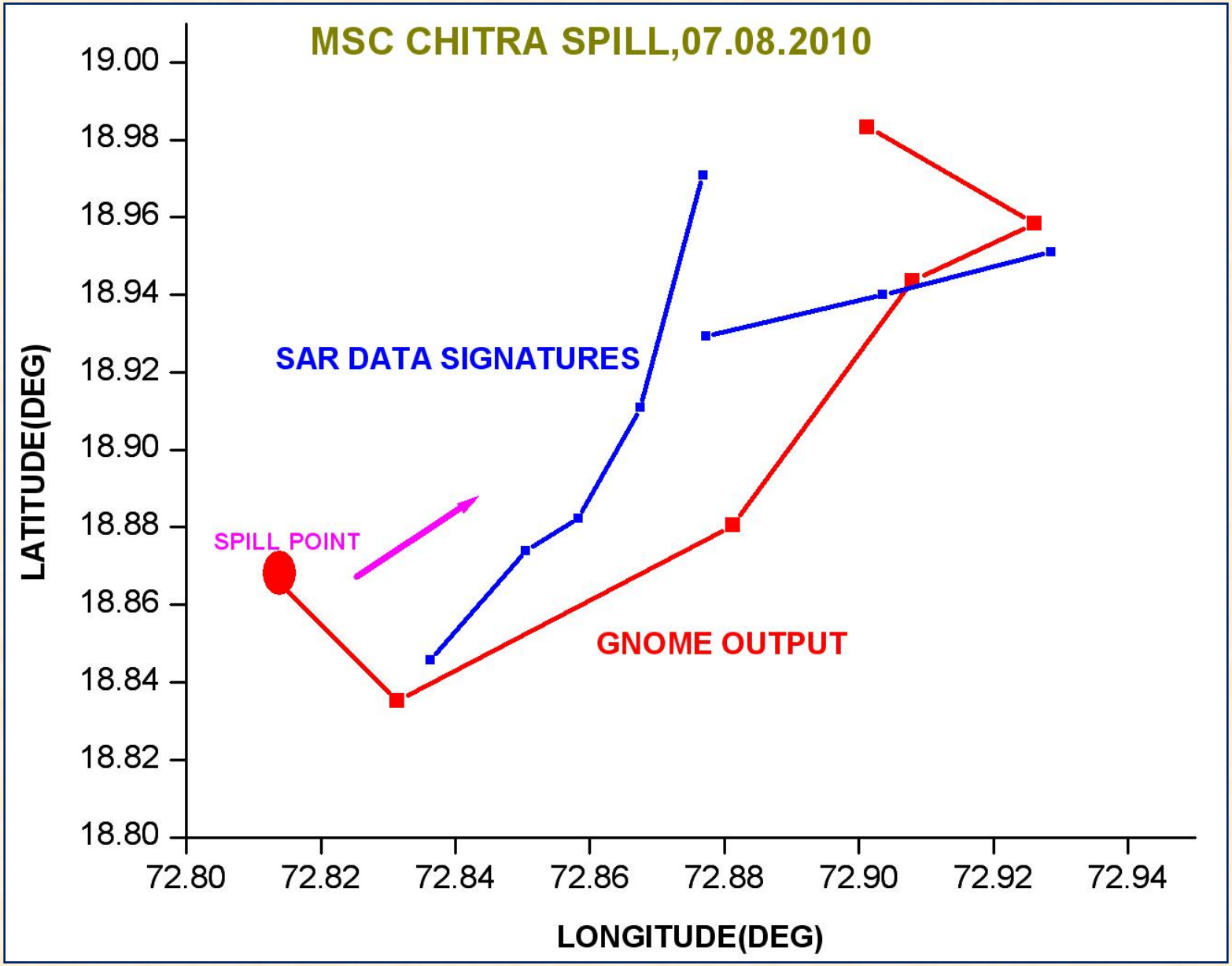
15.08.2010,19.00 hrs



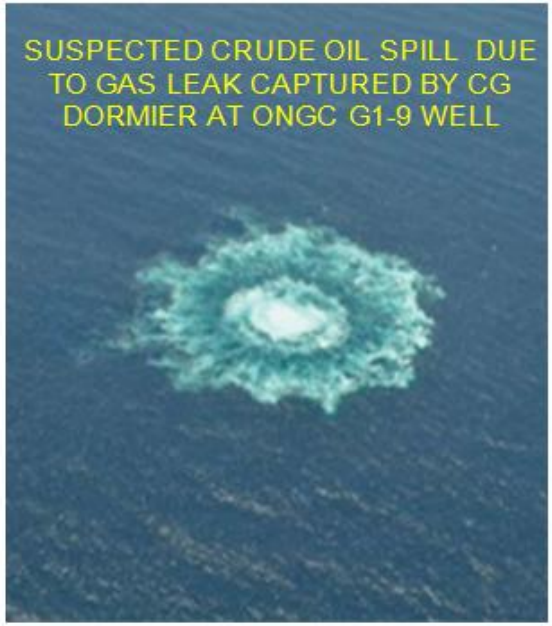
SUPERIMPOSITION OF MODEL OUTPUT AND OBSERVATION IN GOOGLE EARTH



GRAPHICAL COMPARISON OF MODEL OUTPUT AND OBSERVATION



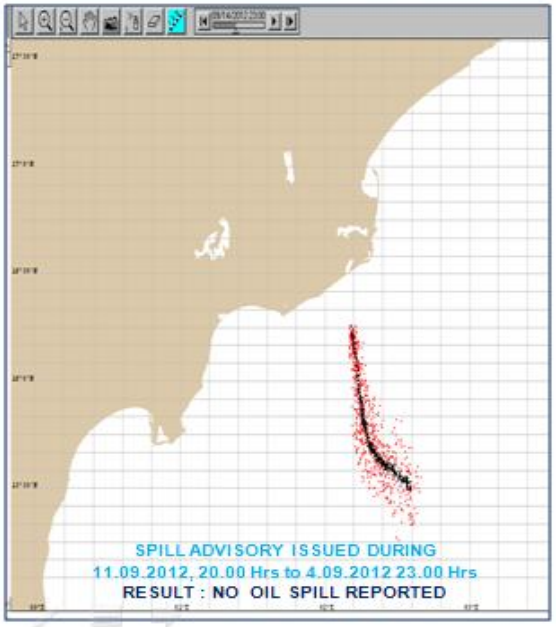
OIL SPILL ADVISORIES – ISSUED DURING SEP 2012 TO JUNE 2013

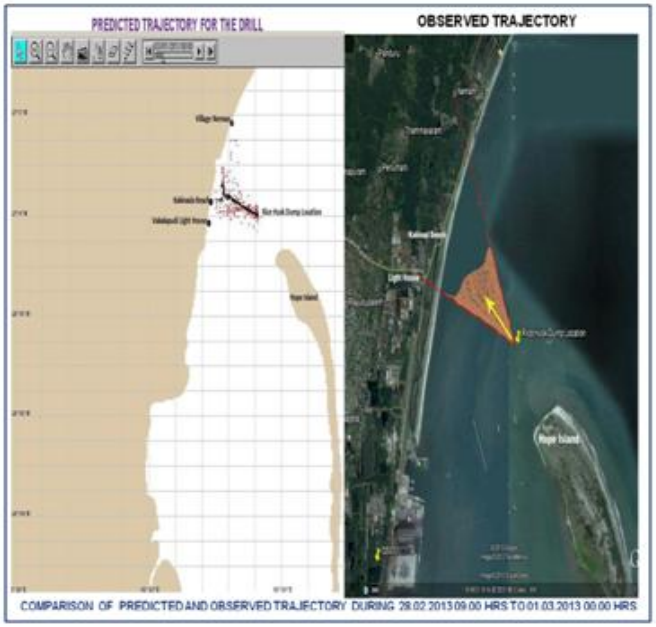


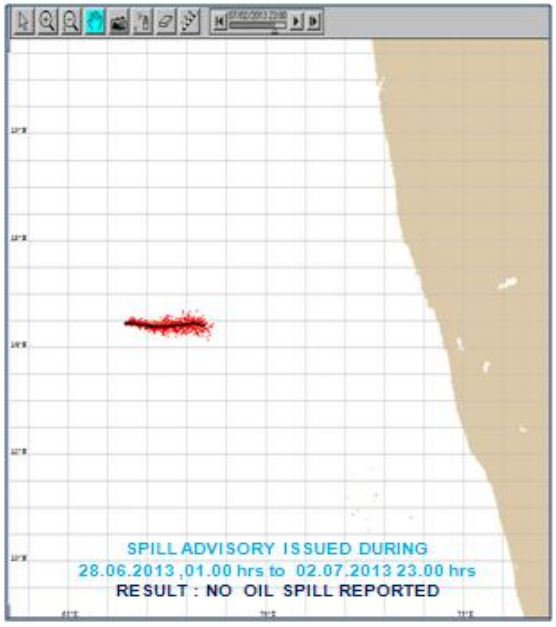
Oil Spill Response Exercise was carried out on 28th Feb-2013 at Inner Anchorage Area, Kakinada Sea Port form 09.00 to 13:10 hrs.

Following Executive Involved from RIL:

Shri Nanduri Rao
Shri Priyabrath Rath
Shri Shuvonkar Pyne
Shri Yeleswarapu Murthy
Shri Raman Sunderesan
Shri Sambhu Kodukulla
Shri Ramesh Chandr Das
Shri Aravind Jayaprakash
Shri Ramesh Puri G
Shri Srimanta Panda
Shri Dinesh Shura
Shri Sandeep Kumar
Shri Vineet Kumar
Shri Mohammed Ali Sha
Shri P V V S Murthy
Shri V Sudeer
Shri Kumar Ajay
Shri Rajasheaker Reddy
Shri N V Vardan Kumar
Shri Harish Chandra P
Shri Mohammad Yaseen







INCOIS aid for Search And Rescue (SAR) Operations during Oct 2013

Model is forced with forecasted wind and current.

Black dots indicate best estimate and red dots estimate with 10 % uncertainty.

18 crew members found on 14.10.2013,06:45 hrs, Near swarnarekha river mouth, 21°33'48"N,87°24'0"E Deviation of 14.5 km from prediction

Life raft found on 13.10.2013,16.38 hrs Near Digga Mohan, 21°38'20.1"N,87°31'8.5"E, Deviation of 3.5 km from prediction.

Location of MV BINGO sunk on 12.10.2013,13.30 hrs : 21° 13.49'N,88°13.27'E

Forecasted path for the search and rescue of life raft missing from MV Bingo sank off Sagar Islands on 12 October 2013

21°20'N

21°0'N

87°0'E 87°20'E 87°40'E 88°0'E

INCOIS

Oil Spill Response – Mock Drill

18th February-2014

(Level - I)

Oil Spill Response – Vessels deployed

Oil Spill Response Exercise was carried out on 18th Feb-2014 at Outer Anchorage Area, Kakinada Sea Port form 08:25 to 14:30 hrs.

Following Vessel Involved in Exercise:

- **Lewek Harrier - AHTS (RIL Charter Hire Vessel)**
- **Jala Hamsa– TUG (KSPL Vessel)**
- **SMS Able – Security Vessel**

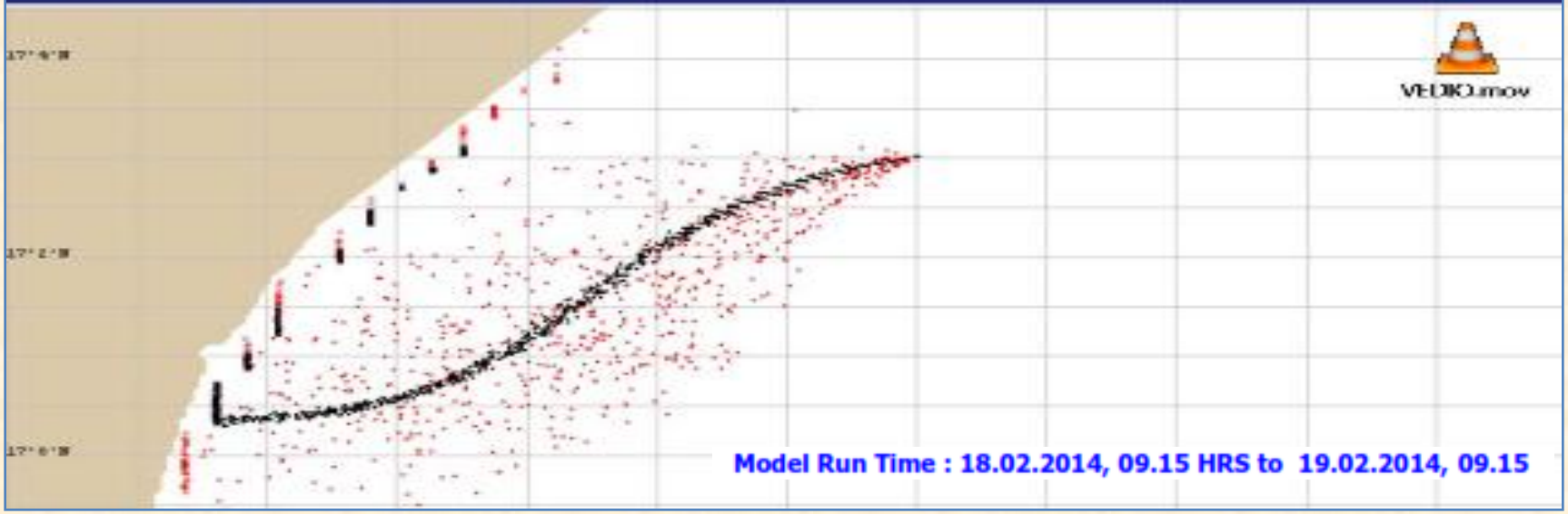
Oil Spill Response Team - Onshore

Oil Spill trajectory modeling

Oil Spill trajectory modeling was carried out with the support from Indian National Centre for Ocean Information Services (INCOIS).

- **INCOIS provided direction of the spill based on the weather conditions from the spilled locations. Following details were provided to INCOIS:**
- **Location of Spill:** **Lat. 17 degrees 03 min North, Long 82 degrees 23 min East**

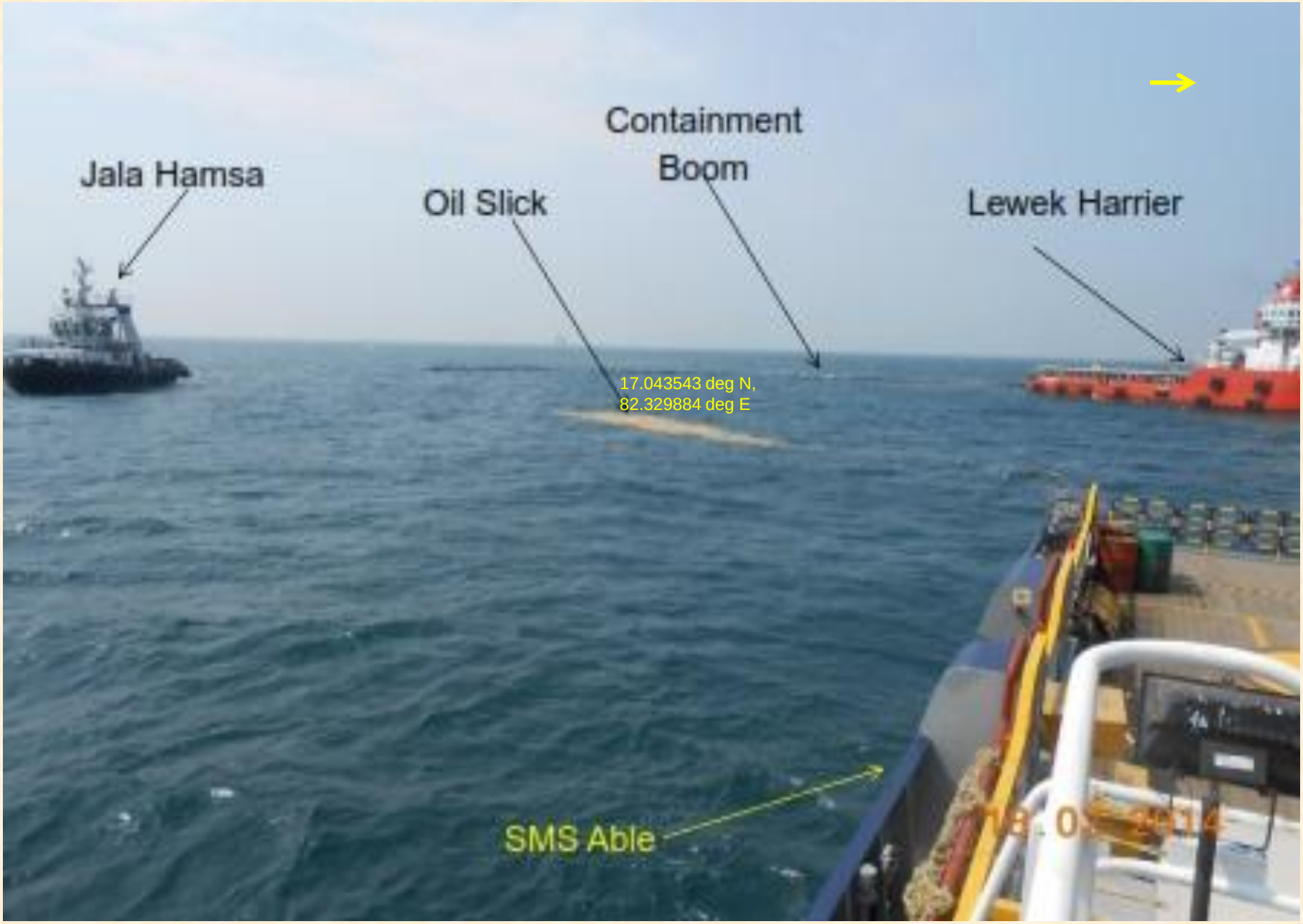
Oil Spill Trajectory predicted by INCOIS



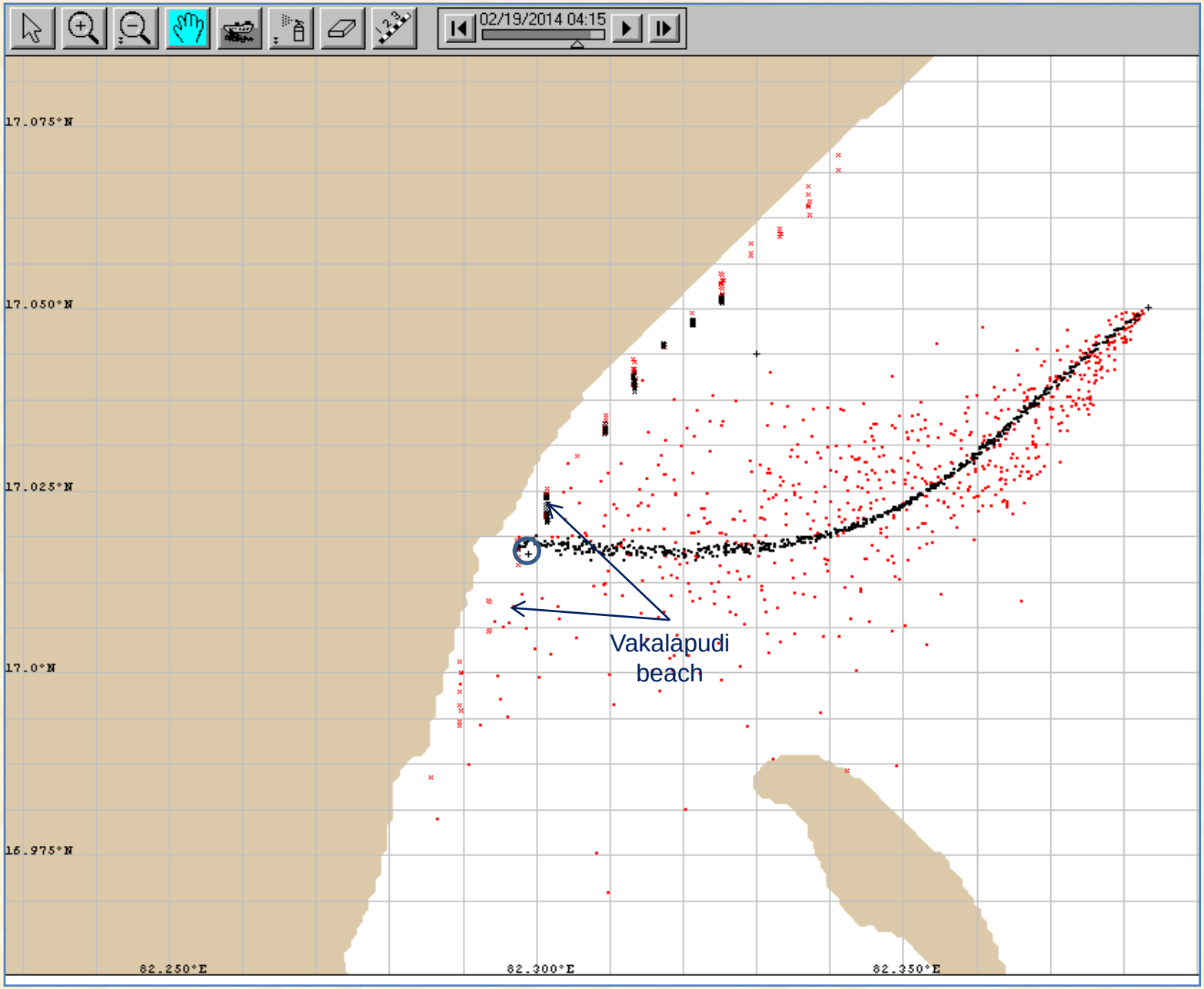
Boom Inflation and Boom Towing operation in progress

J-Shape formation to contain Oil Spill from SMS Able

POSITION OF THE HUSK ON PHOTO BY 11.15 HRS, 18022014



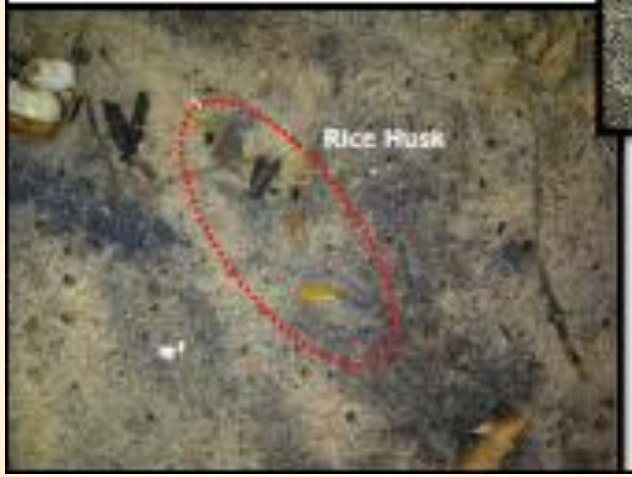
PREDICTED POSITION OF THE HUSK BY 04.15 HRS, 19022014



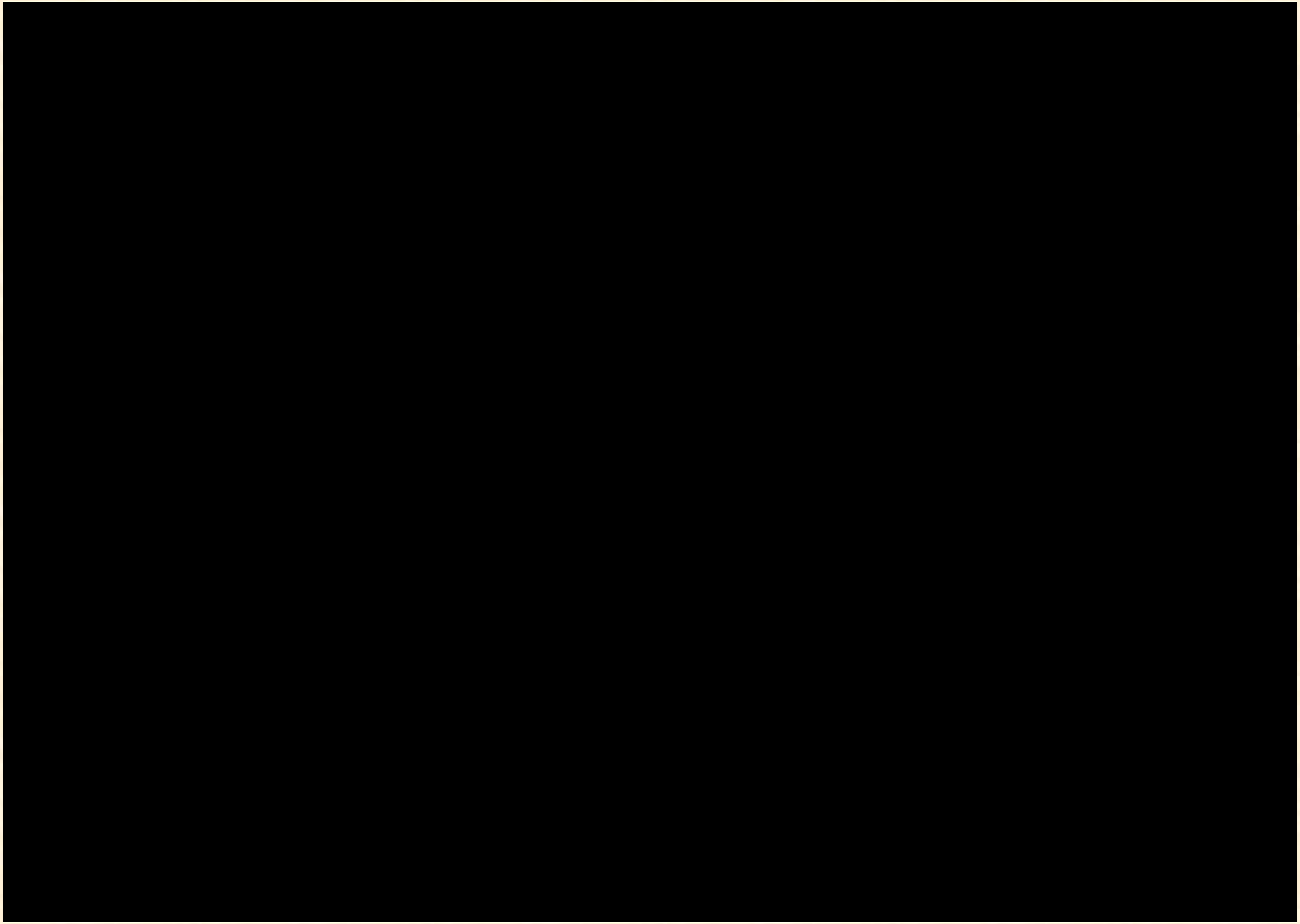
Traces of rice husk sighted on Vakalapudi beach – 19 Feb 14

KG D6
Exploration & Production

(After 06.00 am)

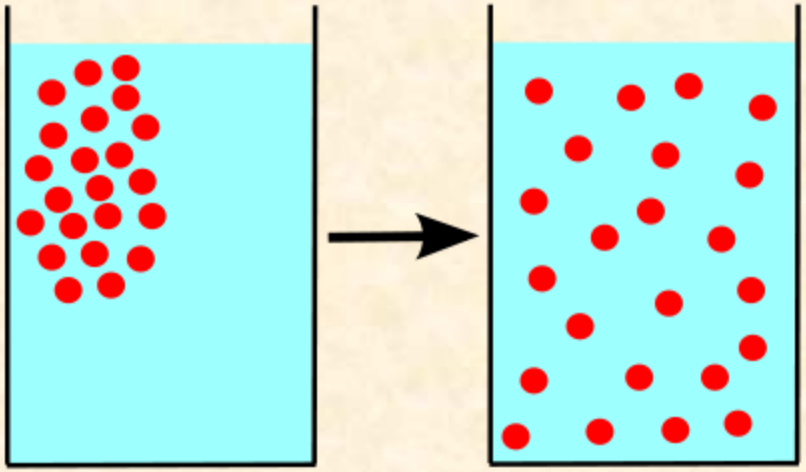


SAMPLE OUTPUT OF GNOME

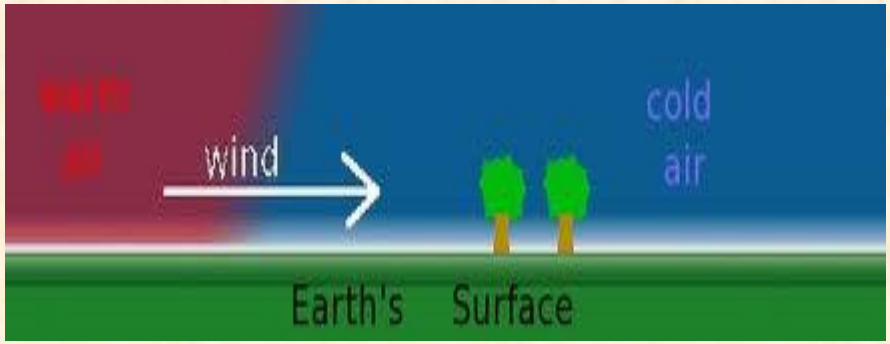


THANK YOU

The ***Deepwater Horizon*** **oil spill** (also referred to as the **BP oil spill**, the **BP oil disaster**, the **Gulf of Mexico oil spill**, and the**Macondo blowout**) began on 20 April 2010 in the Gulf of Mexico on the BP-operated Macondo Prospect. It claimed eleven lives[6][7][8][9] and is considered the largest accidental marine oil spill in the history of the petroleum industry, an estimated 8% to 31% larger in volume than the previously largest, the Ixtoc I oil spill. Following the explosion and sinking of the *Deepwater Horizon* oil rig, a sea-floor oil gusher flowed for 87 days, until it was capped on 15 July 2010.[8][10] The US Government estimated the total discharge at 4.9 million barrels (210 million US gal; 780,000 m^3).[3] After several failed efforts to contain the flow, the well was declared sealed on 19 September 2010.[11] Some reports indicate the well site continues to leak.[12][13



Diffusion refers to the process by which molecules intermingle as a result of their kinetic energy of random motion



advection is a transport mechanism of a substance or conserved property by a fluid

NEST – PROCESSING STAGES

- The data processing includes the major steps like preprocessing, land sea masking, dark spot detection and finally clustering & determination.
- The dark spots are detected using an adaptive thresholding method which involves the detection of the pixels that has lower values than the threshold shift set.
- Pixels detected as part of the dark spot are clustered and then eliminated based on the dimension of the cluster and user selected minimum cluster size.
- The obtained oil spill signatures are taken for the comparison. The spill trajectory and the oil spill signatures are exported to a common platform for the ease of comparison.

CRITERIA FOR OIL SPILL SIGNATURE

The probability of oil spill is increased

- if the surrounding areas are homogeneous
- if the contrast between the slick and the neighboring region is high
- when the dissimilarity between the dark slick and the surrounding area is high

the probability of look-alikes is increased

- if the surrounding areas are heterogeneous.
- if the contrast between the slick and the neighboring region is low
- when the dissimilarity between the dark slick and the surrounding area is low.