

# Environmental Sensor Networks & Data Assimilation

*National Oceanography Centre, Southampton, 14<sup>th</sup> March 2007*



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# Introduction

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## BMT Cordah Limited

- **Wholly owned subsidiary of BMT Group Limited**
- **BMT Group Divisions: Energy and Environment, Defence, Transport, Ports and Logistics, Marine and Insurance**
- **Part of BMT Energy and Environment Division**
- **BMT Group: 27 subsidiary companies totalling ~1200 specialist consultants, scientists and engineers**
- **BMT Group offices: Based in Europe, SE-Asia, USA, Canada, South-Africa and Australia**
- **BMT Cordah Group Offices: Based in the UK(4), Poland(1), Hong-Kong(1), Norway(1) & USA(2)**

# Business Activities

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## Market Sectors

- **Energy and Environment: Oil and Gas industries, Renewables, Government Authorities and Departments, National and Regional Agencies, EU Commission, European Space Agency...**
- **Defence: UK Navy, MOD....**
- **Transport: Mainly Shipping and Rail industries worldwide....**
- **Ports and Logistics: Port and Harbours Authorities, Shipping Industries....**
- **Marine and Insurance: Shipping industries insurers, International Tankers Owners ...**

# Environmental Sensor Networks & Data Assimilation

*Environmental Data Measurement, Modelling and Generic Fusion*

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# Data Modelling based on Environmental Measurement

## ICREW project with the Environment Agency

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- **Sensor measurement of key environmental parameters over time: Rainfall, Cloud cover, Wind field etc...**
- **Development of data-driven models for risk of exceedence prediction**
- **12 years (1992-2004) of microbial contamination sampling data at 54 beaches within 7 bathing zones in England and Wales**
- **Correlated with 12 years (1992-2004) environmental paramters**
- **Discovery of contextual information as important influence on choice of dataset**
- **Models were validated against unseen 2005 data**

# Data Modelling based on Environmental Measurement

## ICREW project with the Environment Agency

- Model Validation against 2005 measurement data
- Water treatment infrastructure improvement post-1996
- Contextual information with post-1996 data was used for better performance

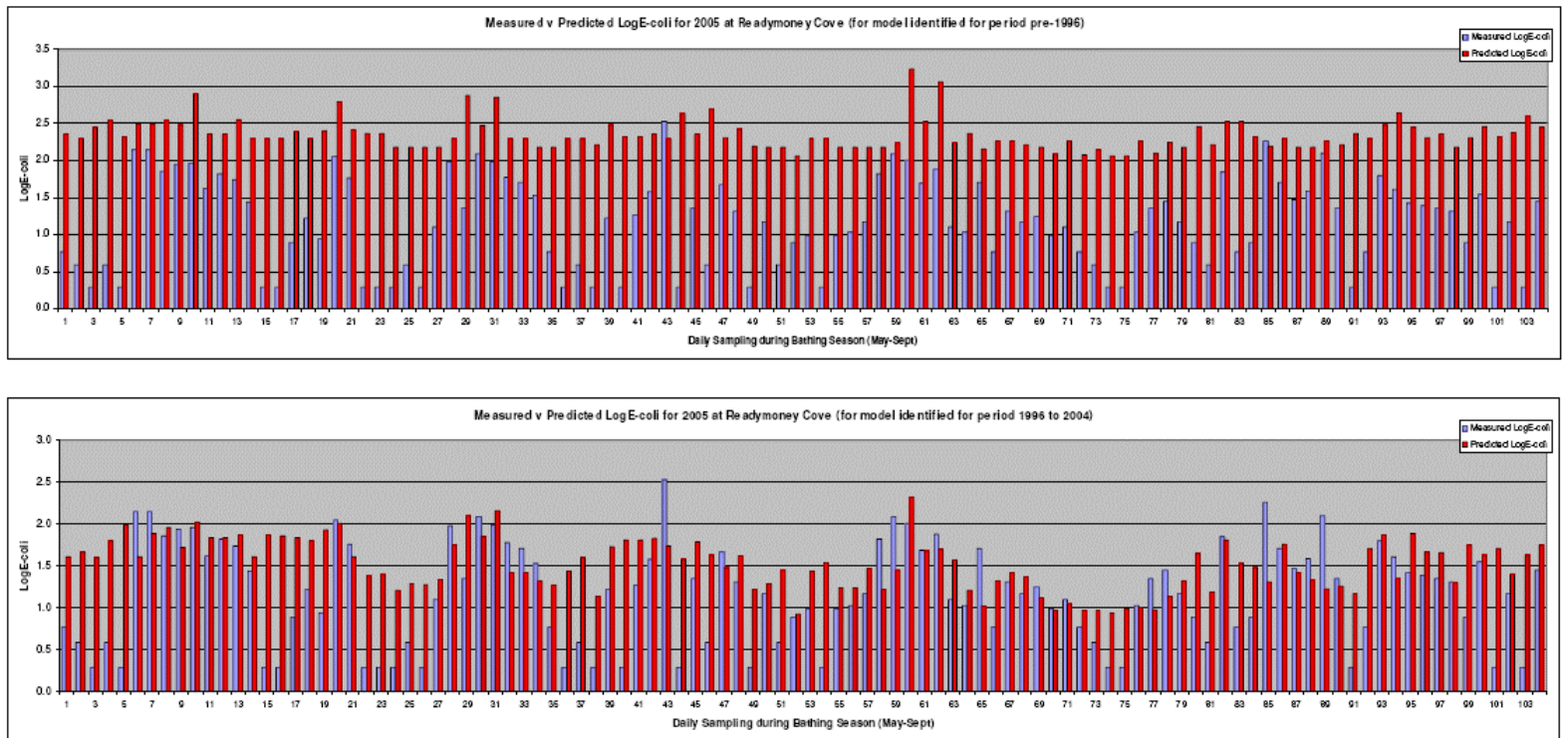


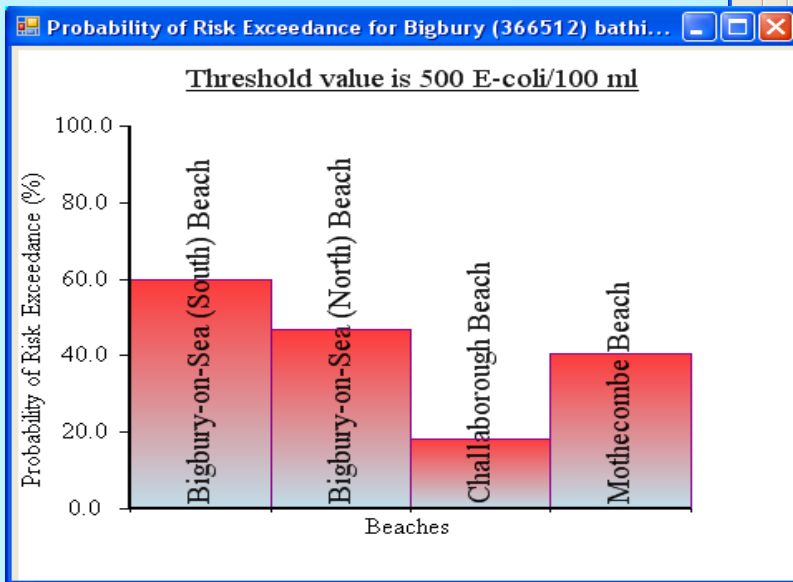
Figure 27. Validation of models at Readymoney Cove Beach against 2005 data identified for period 1990-1995 (upper diagram) and identified for period 1996-2004 (lower diagram).

# Data Modelling based on Environmental Measurement

## ICREW project with the Environment Agency

- Data-driven decision-support tool was cosequently developed
- Used in context with EA compliance for monitoring water quality under the EU 22<sup>nd</sup> December 2000, Water Framework Directives
- Minimised the EA cost for water quality sampling statutory obligation

### Predicted WQ risk of exceedence



#### Model Run Details

Environmental Setup

Sea Water

Beaches for Bathing Zone Bigbury [366512]			
Name	Temperature (°C)	Sunshine (h)	Num. Bathers
▶ Bigbury-on-Sea (South) Beach	13	6	4
Bigbury-on-Sea (North) Beach	6	7	0
Challaborough Beach	5	4	1
Mothecombe Beach	14	2	3

Precipitation (mm)

0 to 24 Hours: 12

25 to 48 Hours: 25

49 to 72 Hours: 0

Weather: Wind 4.30m/s 35.54°, Cloud Cover (%) 20.

Tides: Tidal Range (m) 2.5, Time with respect to High Water (h) -2

Location: Bigbury (366512)

Buttons: Back, Cancel, Finish

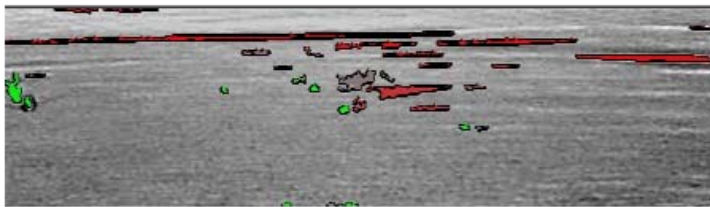
### Environmental Input data

# Pollution Detection based on Vision Data Training

## Blue Water Project with the European Commission FPV



Training the CM Neural Network



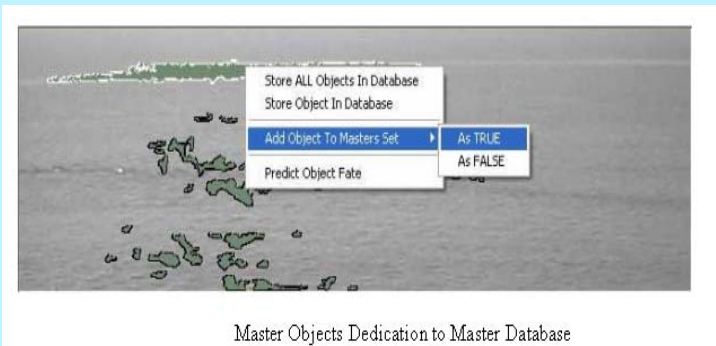
CM Testing Programme (green: non slick (boat), red: slick, brown: unknown)

- *Image Data Analysis, refinement and features extraction*
- *Neural Networks Data training*
- *Use of Environmental parameters and contextual information*
- *Oil slick identification and fate*

### Current interest

- *Volume of pollution predictions from Vision Data*

- *Oil type identification using Vision Data*



Master Objects Dedication to Master Database

# The Generic Fusion Approach

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## Issues

- Lack of a unified and generic data fusion methodology in environmental sciences
- Lack for generic development and re-use of fusion technologies
- Lack of engineering standards related to data fusion services implementations
- Lack for generic and formalised information fusion framework

# The Generic Fusion Approach

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## *The Great Challenge*

- Achieve more realistic assessment of the state of the environment
- Achieve state variable forecast with error estimation → crucial for decision-making
- Potentially obtain new undiscovered information about the state of the environment
- Achieve timely assessments on potential threats and deterioration of the state of the environment
- Achieve tactical (potentially real time) decision-making capability in environmental management

# The Generic Fusion Approach

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## *Joint Director of Laboratories Model (JDL)*

### *Sensor measurement and model data put in level services*

- Level 0: Data Pre-processing
- Level 1: Object(s) Refinement
- Level 2: Situation(s) Refinement
- Level 3: Impact(s) Refinement

# The Generic Fusion Approach

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## *JDL Level 0: Data Pre-processing*

- Blending of data from different sources with different time and space referencing (example: geographical referencing and time zones etc..)
- Blending of data from different sources with different measurement frequencies (example: Images at different wavelength)

## *JDL Level 1: Object(s) Refinement*

- Discovery of patterns in data (example: seasonality, periodicity, background levels in time series...etc..)
- Features extractions (example: high level image analyses using Principal Component Analyses etc....)
- Identification of objects in spatial data (example: techniques for contouring of objects from image data...etc...)

# The Generic Fusion Approach

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## *JDL Level 2: Situation Refinement*

- Identification of relationships between objects and surrounding environment (example: is the oil a natural or man made oil???)
- Use of statistical correlation techniques in observation data for identifying cause and effect processes between identified objects or patterns and other processes.

## *JDL Level 3: Impact Refinement*

- Use data and models to infer details about the data in the future and in spaces where observation cannot be achieved → spatial and temporal forecasting
- Model and data integration through common stochastic frameworks
- Best estimation of data with error control
- Risk estimation and probability of exceedence.

# The Generic Fusion Approach

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## *Generic Fusion Services in SANY*

- Use of Generic composite services of fusion levels
- The fusion level servicing applies to three domain applications
- It includes the Marine Risk, Atmospheric Risk and GeoHazard Risk