UNCLASSIFIED

Mine Impact Burial Prediction

Dr. Peter Chu, LCDR Ashley Evan

LCDR Anthony Gilles

LCDR Timothy Smith, and LCDR Victoria Taber

Naval Postgraduate School

NDIA Joint Undersea Warfare Technology Spring Conference,

San Diego, March 28-31, 2005

UNCLASSIFIED

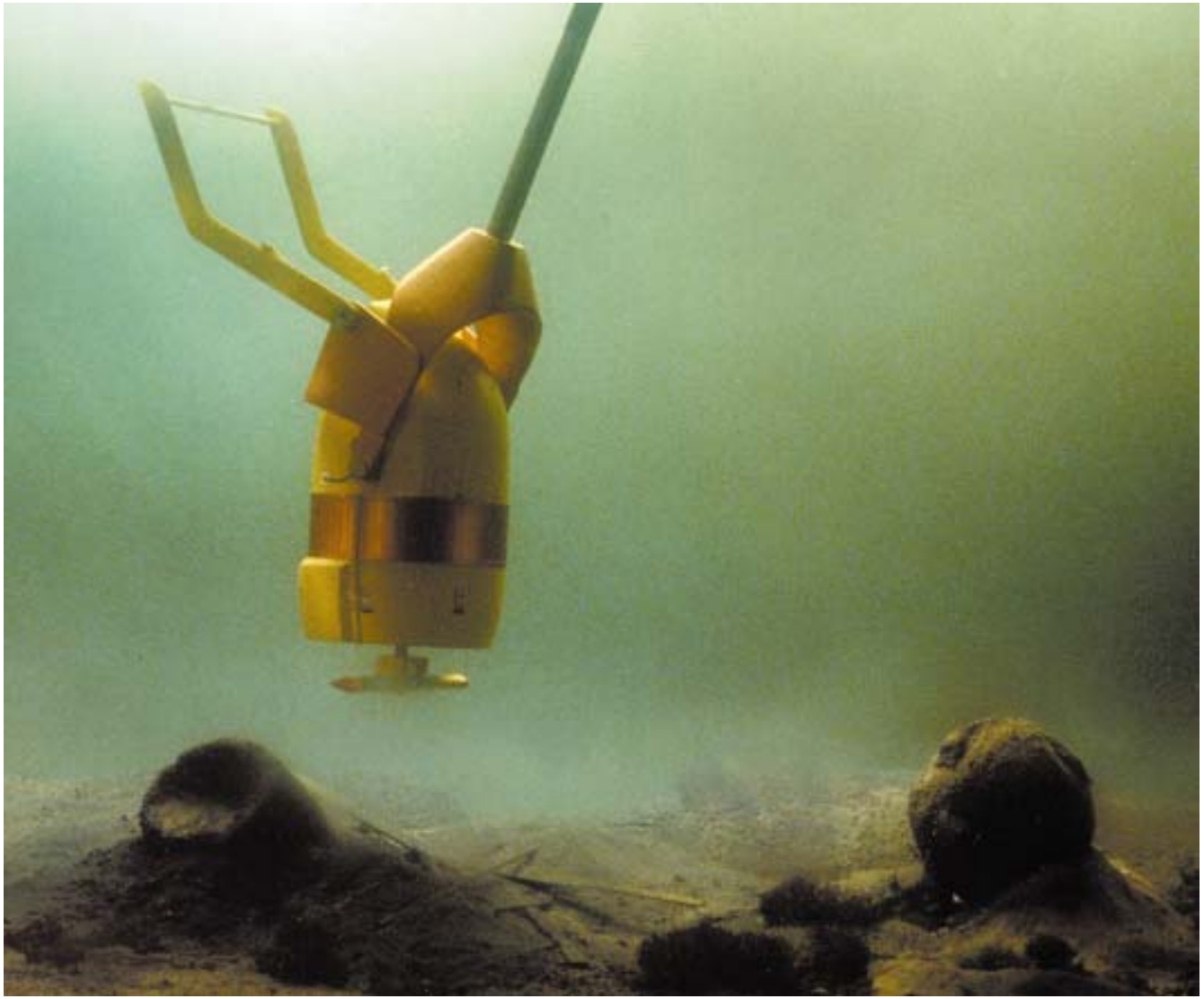
Collaborators

- Peter Fleischer, Steve Haeger, Mark Null (Naval Oceanographic Office)
- Phil Valent, Paul Elmore, Mike Richardson, Andre Abelev (Naval Research Laboratory)
- Alan Brandt, Sarah Rennie (APL, John Hopkins University)
- Thomas Weaver (German Federal Armed Forces Underwater Acoustic and Marine Geophysics Research Institute)

Mine – Threat to Naval Operations

Picture obtained from Dr. Heidi Vosbein, NRL-SSC Code 7180

Mine Burial



Challenges to Buried Mine Hunting

Miner Burial Prediction (Now)

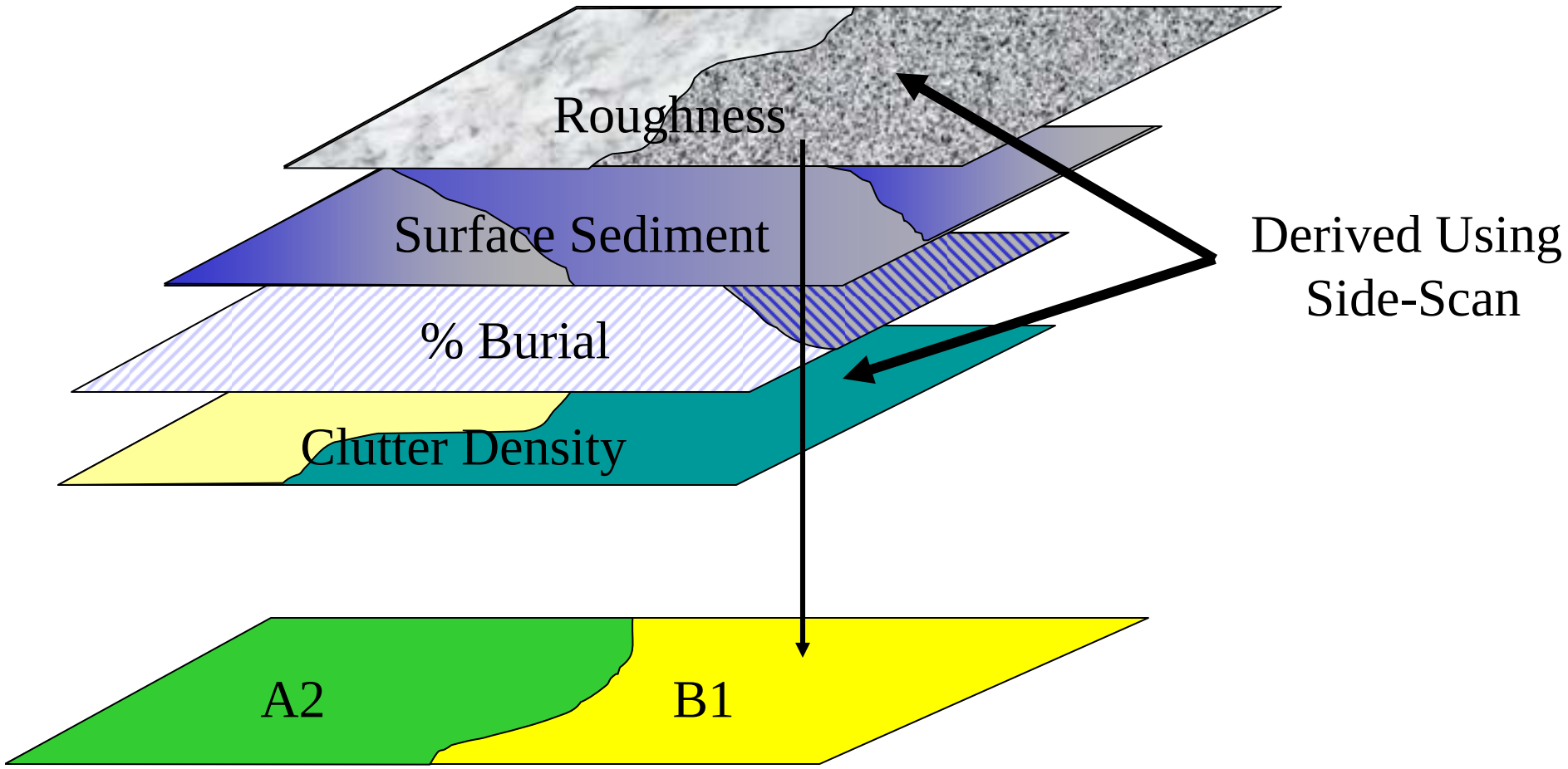
Semi-Empirical

SEDIMENT
DATA BASE
(~ 240 categories)

% BURIAL

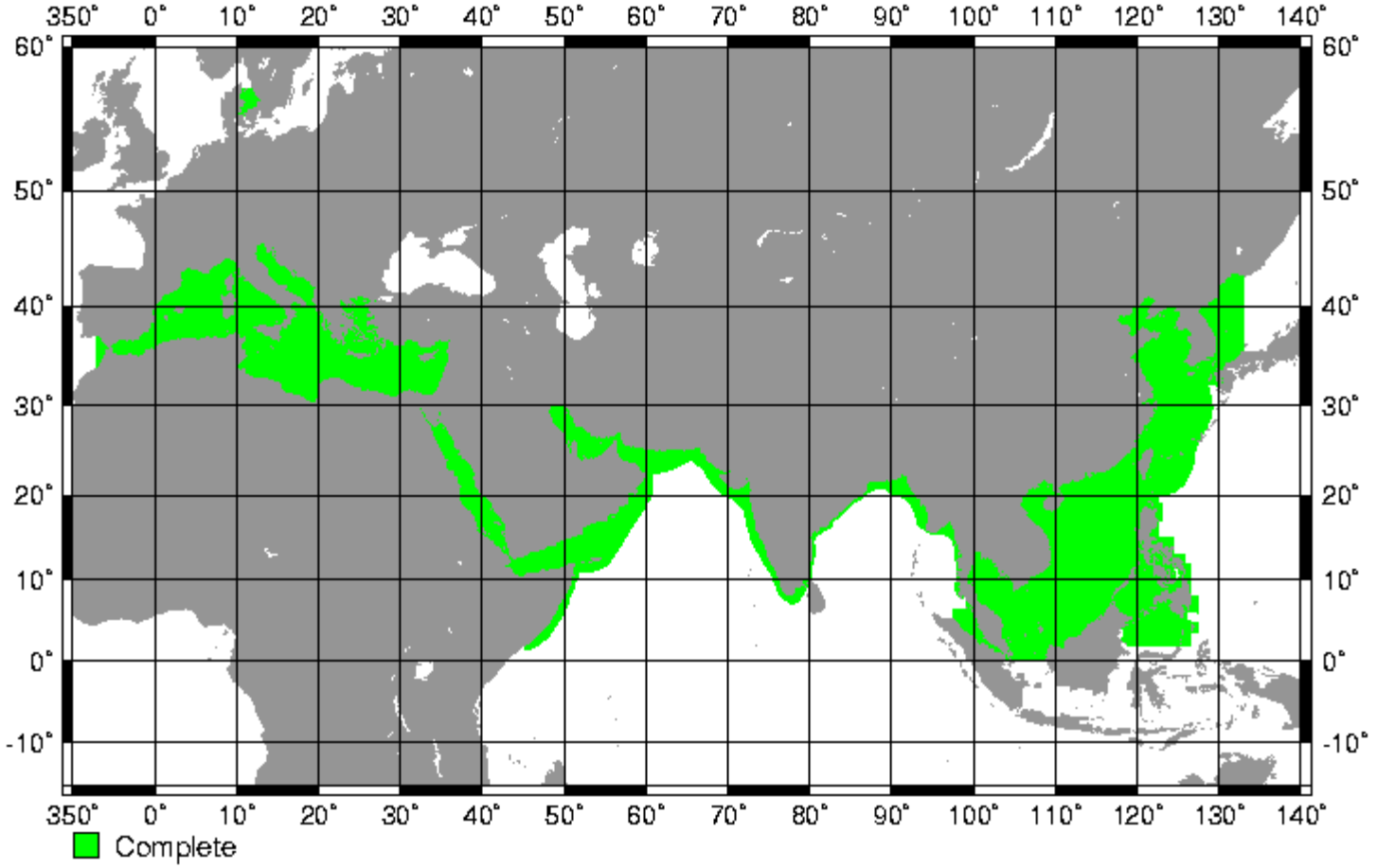
(5 Doctrine Categories)

Environmental Inputs to Doctrine for Minehunting



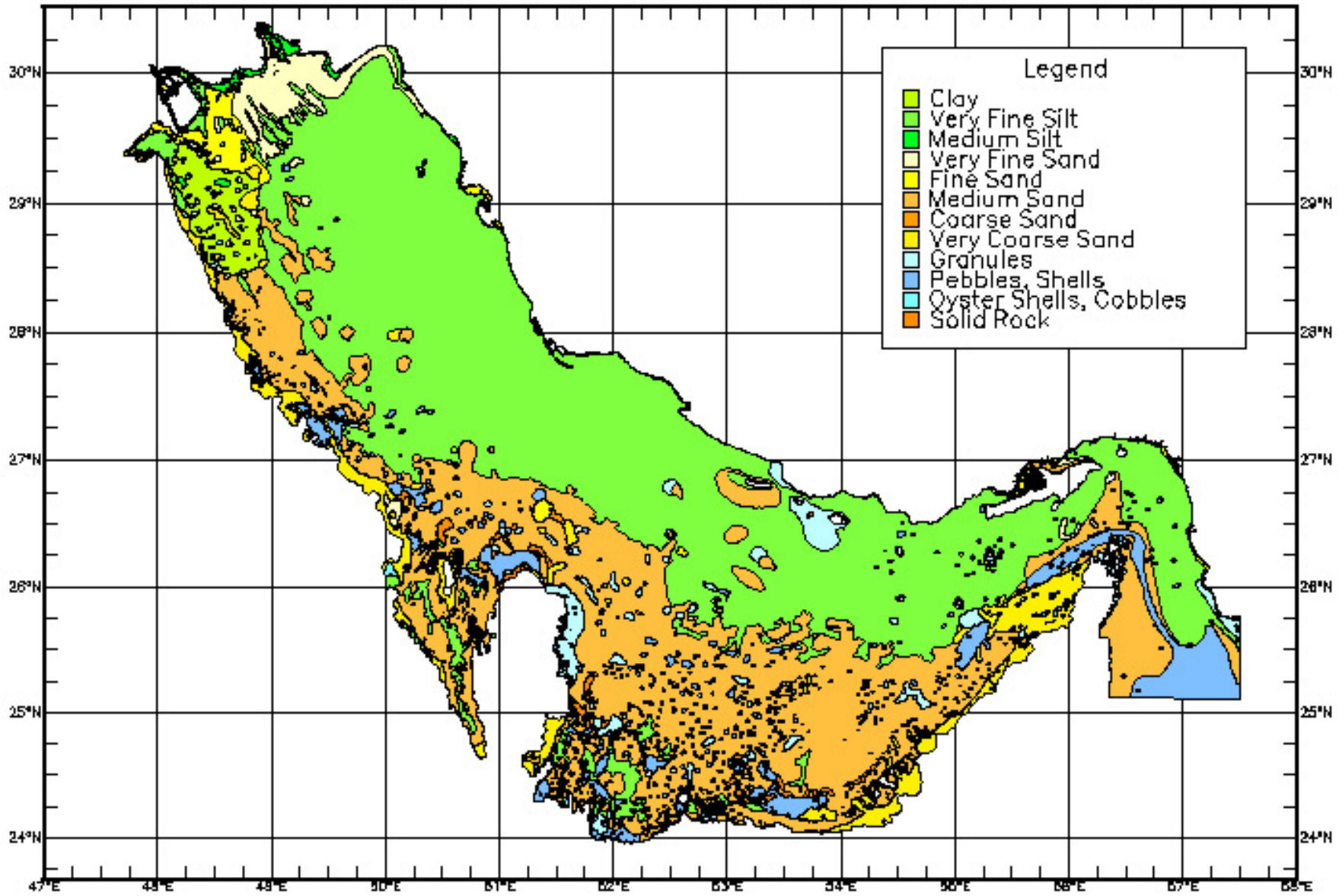
Naval Oceanographic Office

Status of MIW Sediments Database



Aug 00

ARABIAN GULF BOTTOM TYPES



Approved For Public Release Distribution Unlimited

WHY BURIAL PREDICTION?

NAVOCEANO MIW Databases:

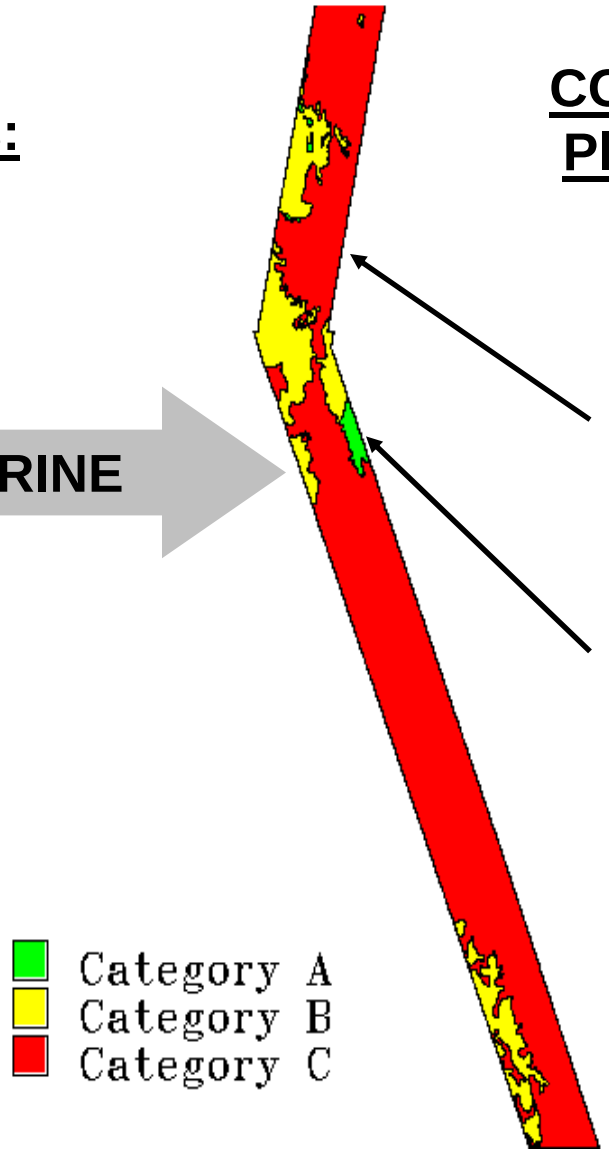
SEDIMENT TYPE

MINE CASE BURIAL

ROUGHNESS

CLUTTER DENSITY

DOCTRINE



COMINEWARCOM Planning, Tactics

(MEDAL)

A track in the red area takes 3.5 times (per unit area) longer to clear than a track in the green area.

Mine Burial Prediction
Sediment Categories to MEDAL

NAVAL OCEANOGRAPHIC OFFICE

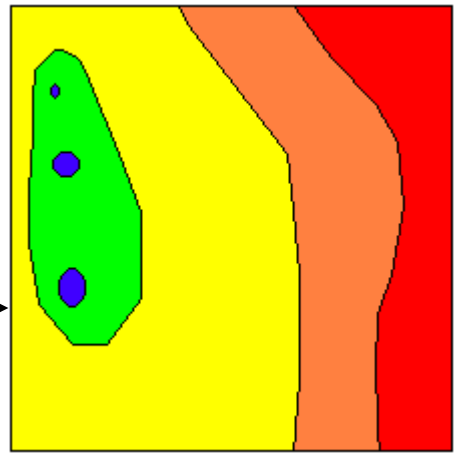
MIW and SPECOPS Master Sediment Tables
Version 6.2.0, 05 Oct 2004

MASTER SEDIMENT RECLASSIFICATION TABLE

Type	Enhanced Categories Description	Enhanced	Mine Burial (5) (1-2-3-4-5)	Mine Burial (4) (2-3-4-5)
T	Rock	**1101**	1	2
T	Sand	**1102**	3	3
T	Silty Sand	**1103**	3	3
T	Sandy Silt	**1104**	4	4
T	Silt	**1105**	4	4
T	Clayey Silt	**1106**	4	4
T	Silty Clay	**1107**	5	5
T	Clay	**1108**	5	5
T	Sand - Silt - Clay	**1109**	4	4
T	Gravel	**1112**	2	2
T	Sandy Gravel	**1113**	2	2

Mine Burial (5) Category	% Burial	RGB
1	0	
2	>0 to <=10	
3	>10 to <=20	
4	>20 to <=75	
5	>75 to <=100	

GIS MAP:
to CEAS for Bottom Typology and into MEDAL



DOCTRINAL MINE BURIAL CATEGORIES AND MEDAL

NAVOCEANO

"200" **Enhanced** Category Sediments

SPECOPS Category

"70" **Standard** Category

15 **Reduced** Category

Doctrinal Burial

Acoustic Model (**CASTAR**)

Acoustic Model: CASS/GRAB 32/23 **HFEVA** Category

R&D Community

MEDAL V. 7

(Mine Warfare Environmental Decision Aid Library)

"70" Category (internal)

15 Category

'4' Category

Acoustic Model (CASTAR)

Graphics

MIW Doctrine

A,B,C,D

MEDAL V. 9

32/23 HFEVA Category

'4' Category

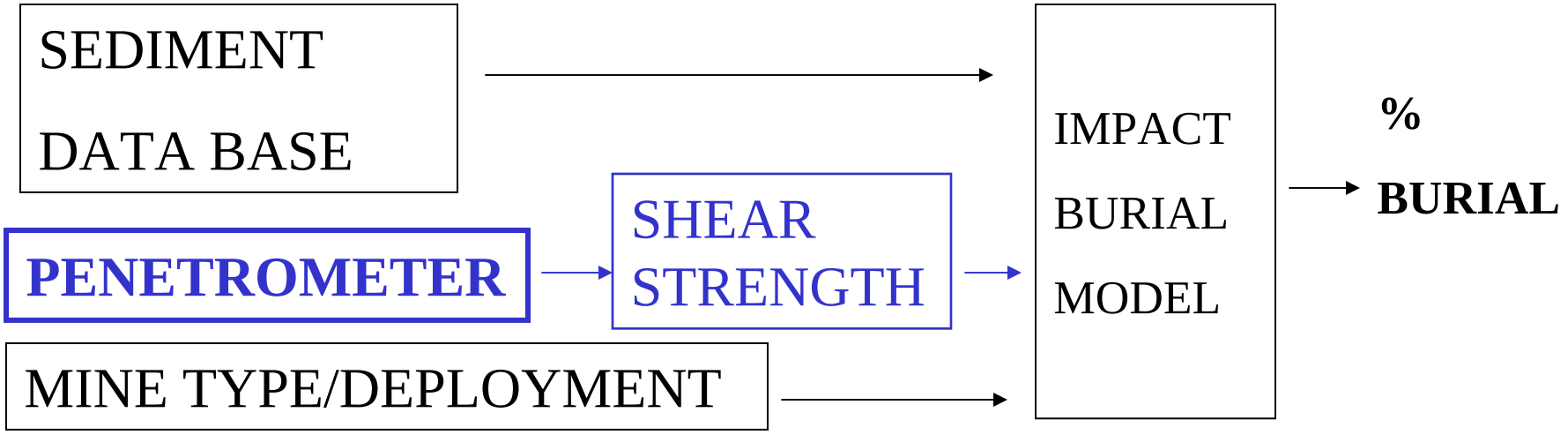
Acoustic Model - 23 (CASS/GRAB)

Graphics - 32

MIW Doctrine

A,B,C,D

Mine Burial Prediction
(Physically Based Modeling)



UNCLASSIFIED

Mine Burial Expert System Model (MBESM) by Rennie and Brandt

DATA SOURCES:
NAVO Databases
& Operational Models
On-site Surveys
Classification

USER INTERFACE
Mission Planning

Navy
Intelligence

NAVY TDA
(MEDAL)

MINE TYPE &
DEPLOYMENT ANALYSIS

ENVIRONMENTAL
CHARACTERIZATION

NAVO Warfare Support
NRL Liaison

MBESM

Model Input Distributions

IMPACT BURIAL
MODEL

SUBSEQUENT
BURIAL MODEL

OUTPUT
INTERPRETER

Predictions of %Burial
Probability Distributions

UNCLASSIFIED

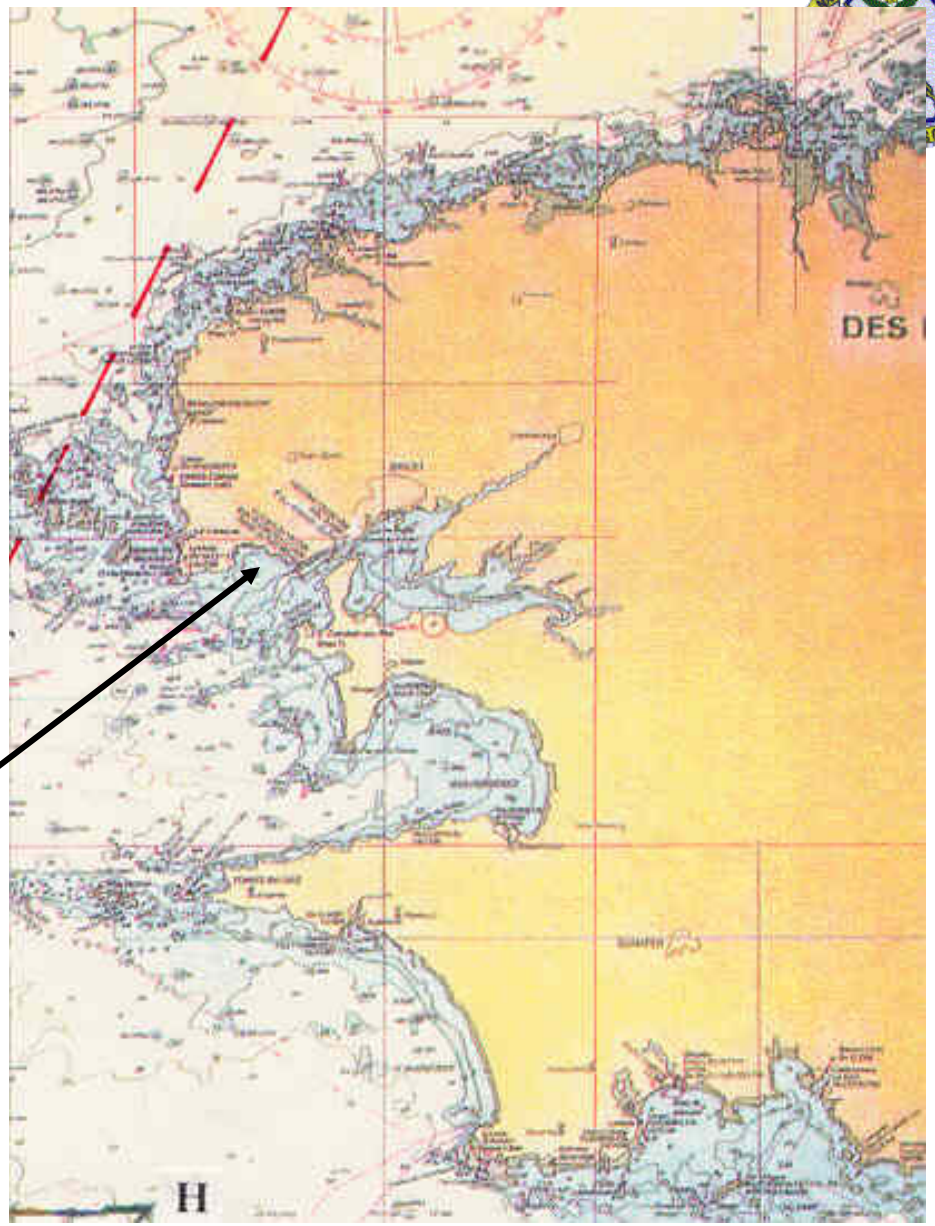
Mine Impact Burial Experiments

- NPS Mine Impact Burial Experiments (1/12-th Size)
- NSWC-Carderock Mine Impact Burial Experiment (1/3 Size)
- German Baltic Sea Experiment (Full Size)
- French/German Nearshore Experiment (Full Size)

Site of Experimentation

- 15 meters water depth
- sandy bottom
- STRONG WAVE EFFECT

BERTHEAUME



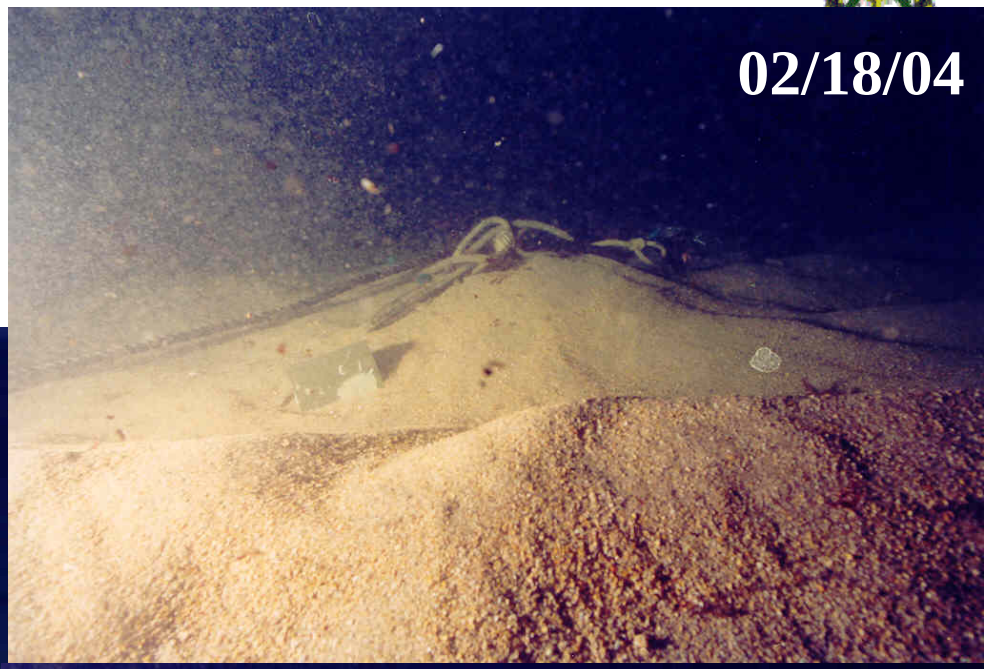
Example: Mine Burial Experiment

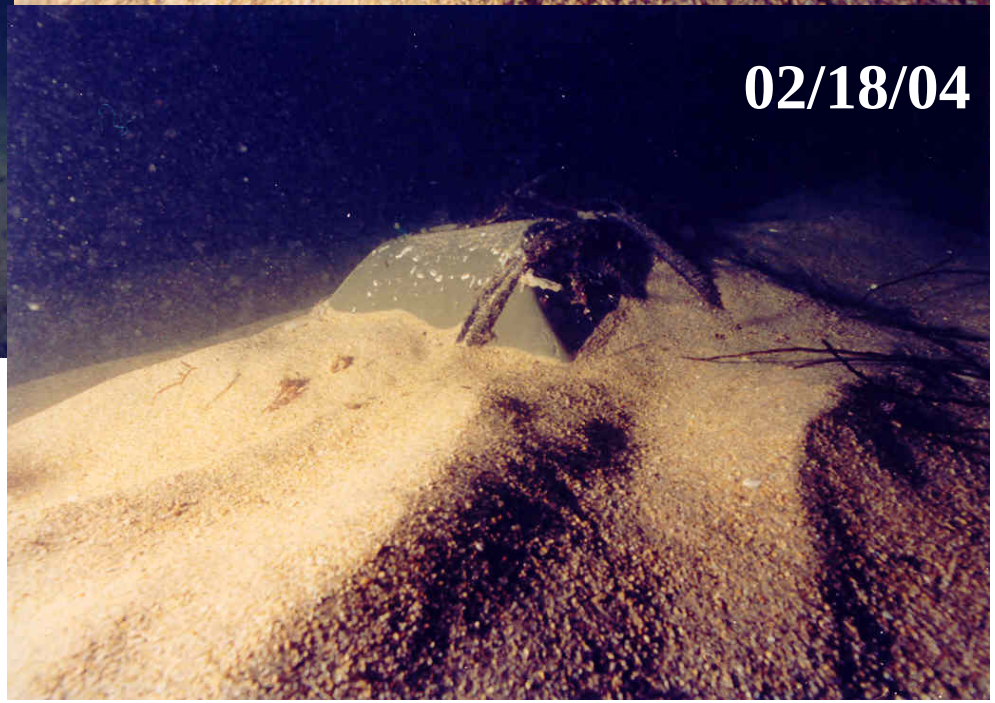
January 2004

FWG Burial Recording Mine

MANTA Minelike Target

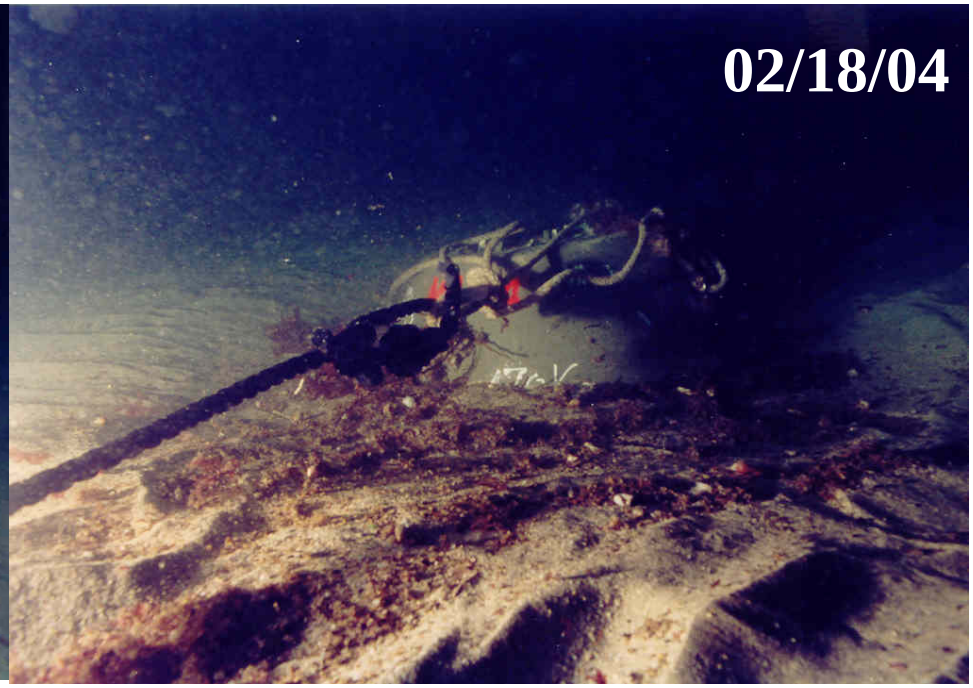
MINELIKE TARGET (ROCKAN)





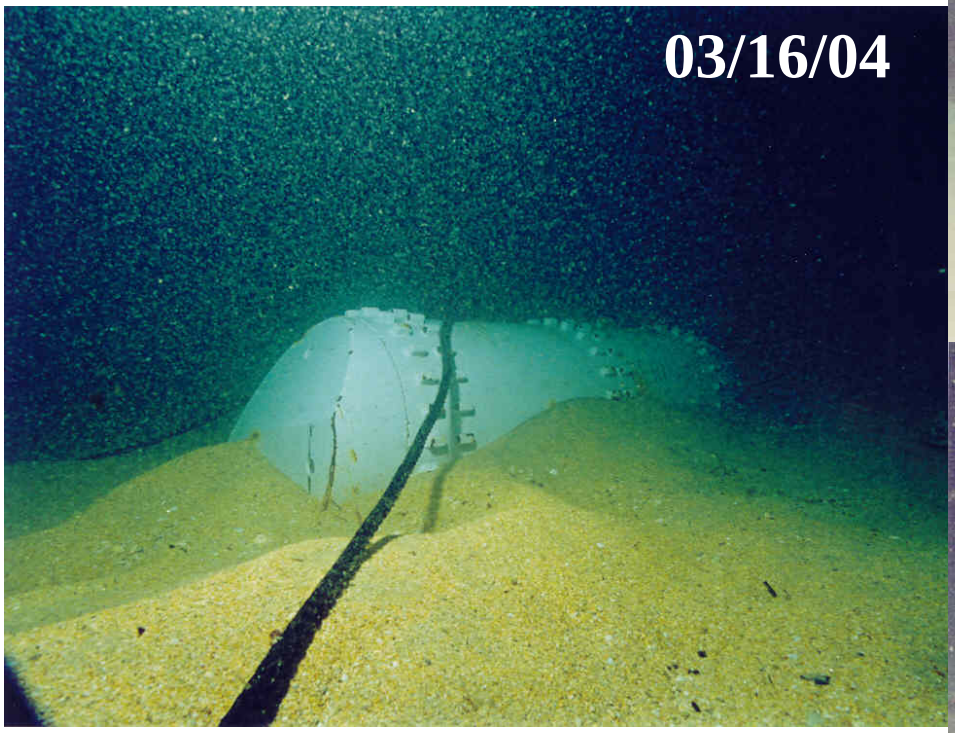
Burial observations
January 28 - February 18

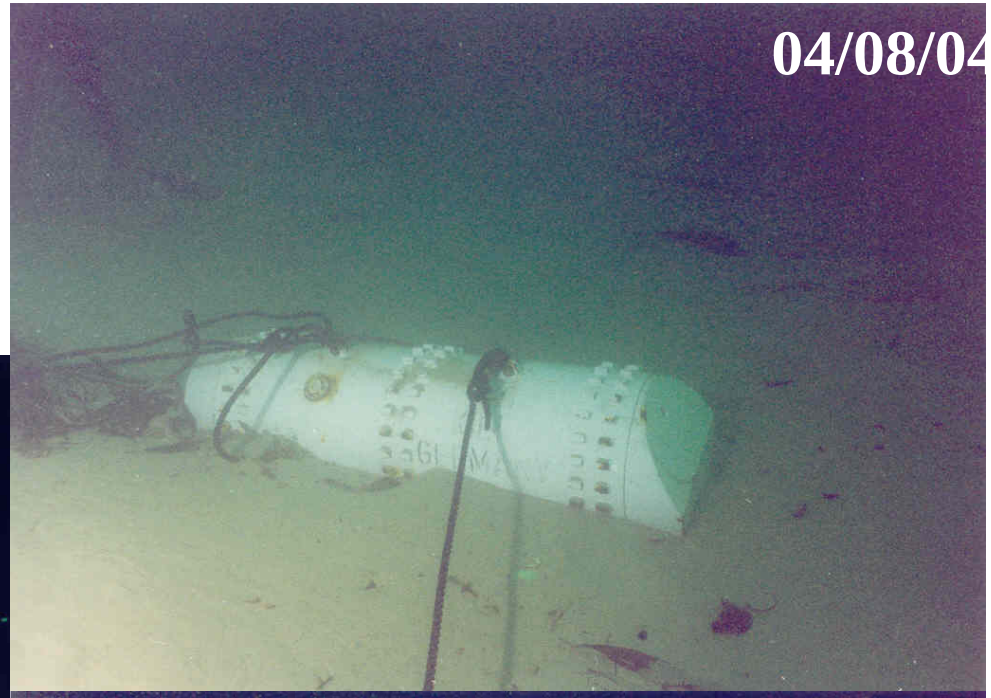
MINELIKE TARGET (MANTA)

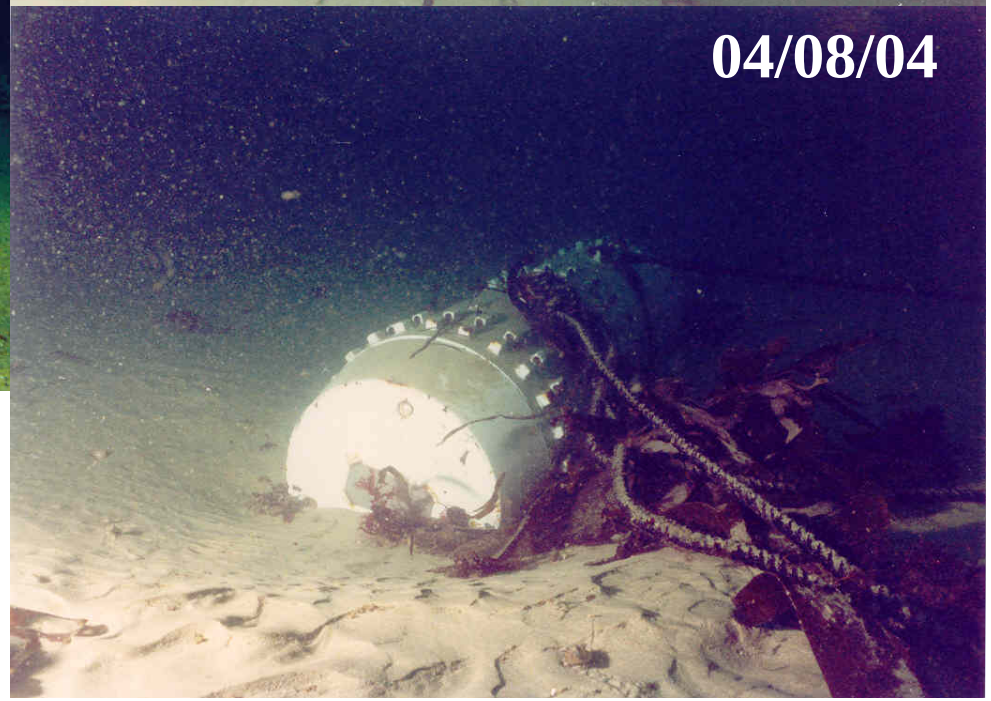


Burial observations
January 28 - February 18

BRM - FWG

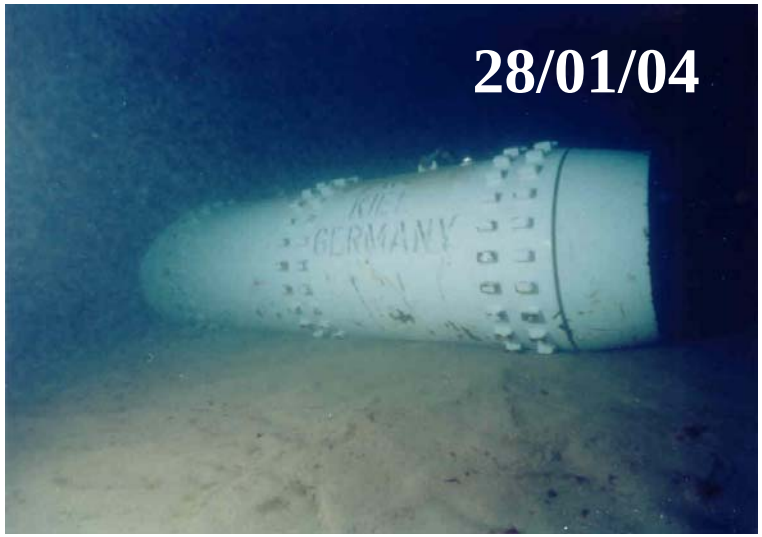


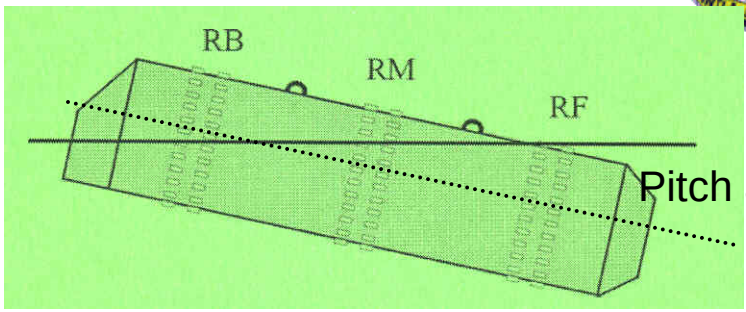




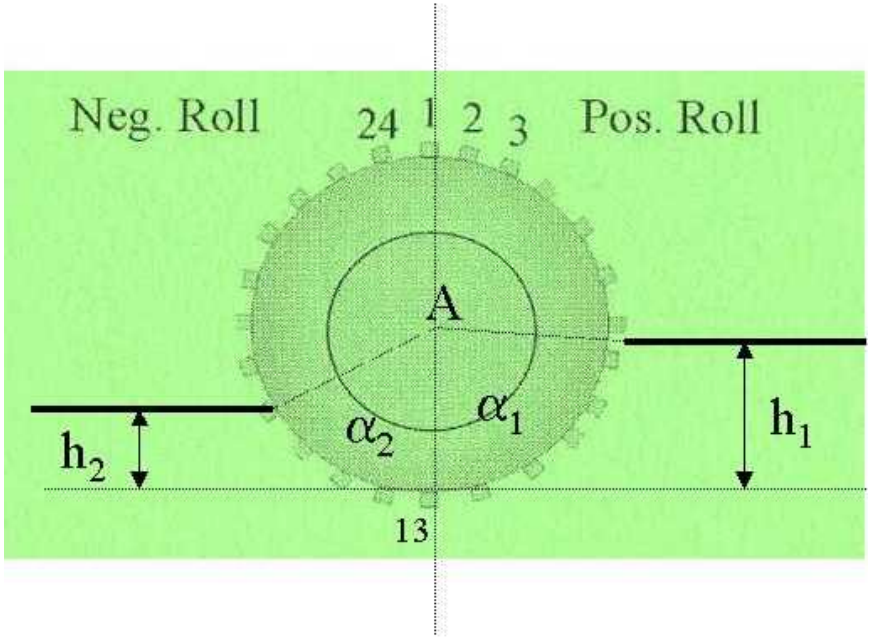
Burial observations
March 16 - April 8

FWG Burial Recording Mine - Procedure





N : number of buried sensors



Burial estimates

$$\frac{h_m}{D} = 0.5 - 0.5\cos\left(\frac{\alpha_1 + \alpha_2}{2}\right) = 0.5 - 0.5\cos\left(\frac{\pi N}{12}\right)$$

$$\frac{h_1}{D} = 0.5 - 0.5\cos(\alpha_1 - \alpha_r)$$

IMPACT BURIAL MODELING

New Development of 3D Model

IMPACT35

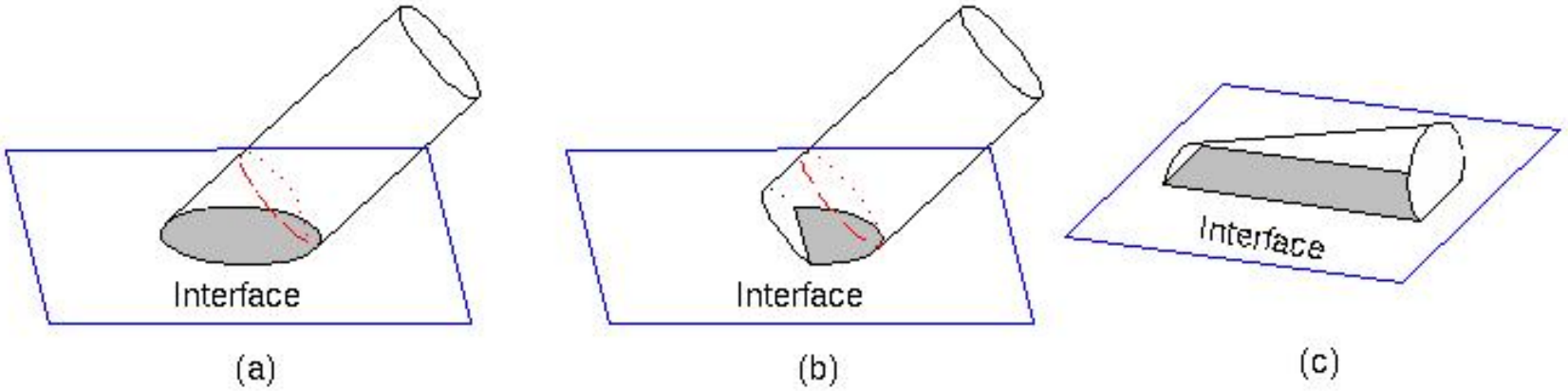
Momentum Equation in E-Coordinate System

$$\frac{d}{dt}\begin{bmatrix} u \\ v \\ w \end{bmatrix} = -\begin{bmatrix} 0 \\ 0 \\ \left(1-\rho_w/\bar{\rho}\right)g \end{bmatrix} + \frac{1}{\bar{\rho}\Pi}\begin{bmatrix} F_x \\ F_y \\ F_z \end{bmatrix},$$

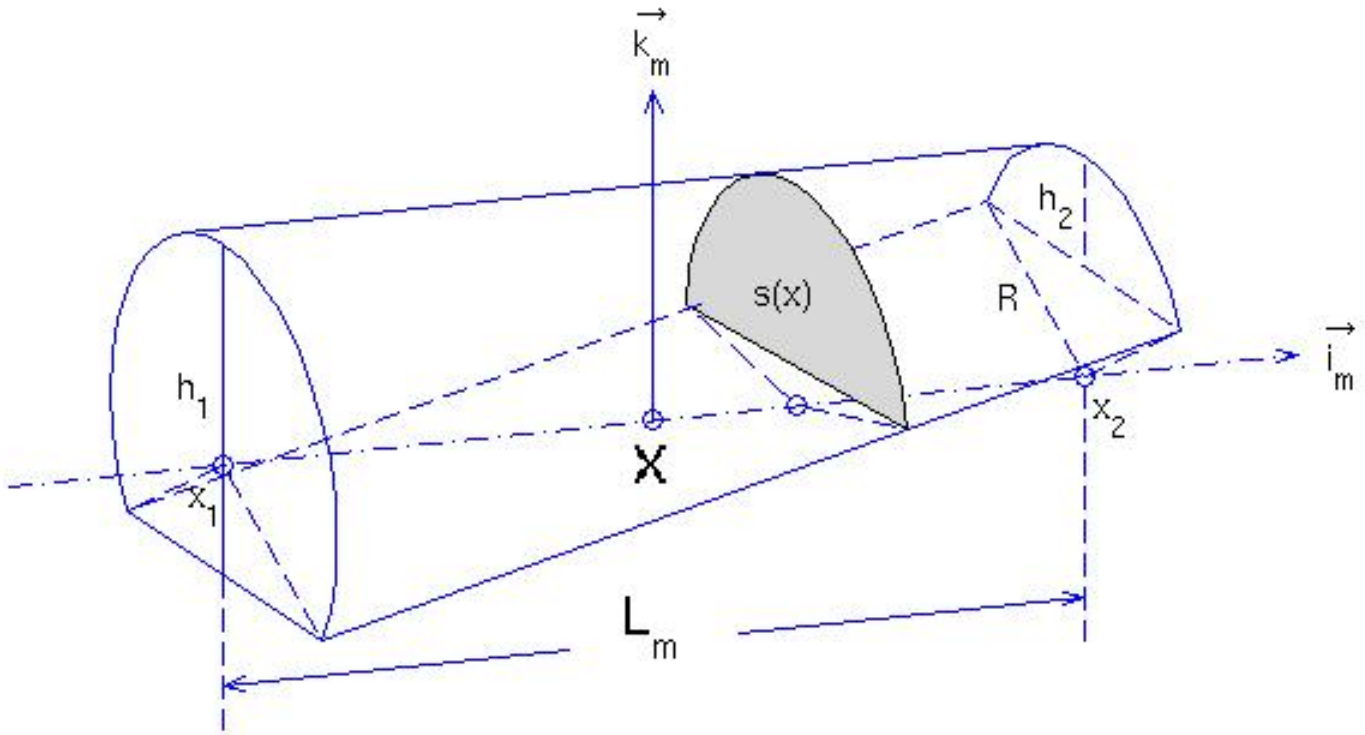
Moment of Momentum Equation in M-Coordinate System

$$\mathbf{J} \cdot \frac{d\boldsymbol{\omega}}{dt} = \mathbf{M}_b + \mathbf{M}_h \,,$$

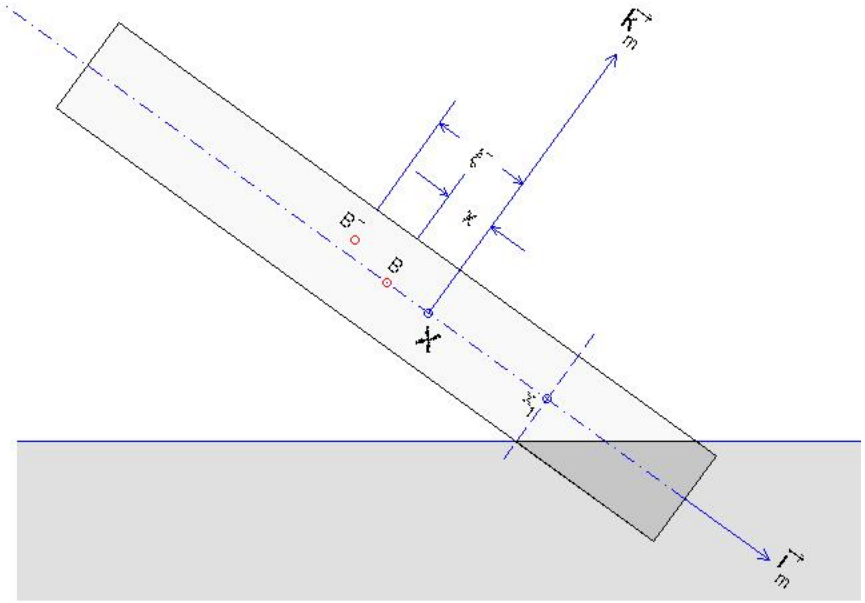
Interfacial Penetration Modeling



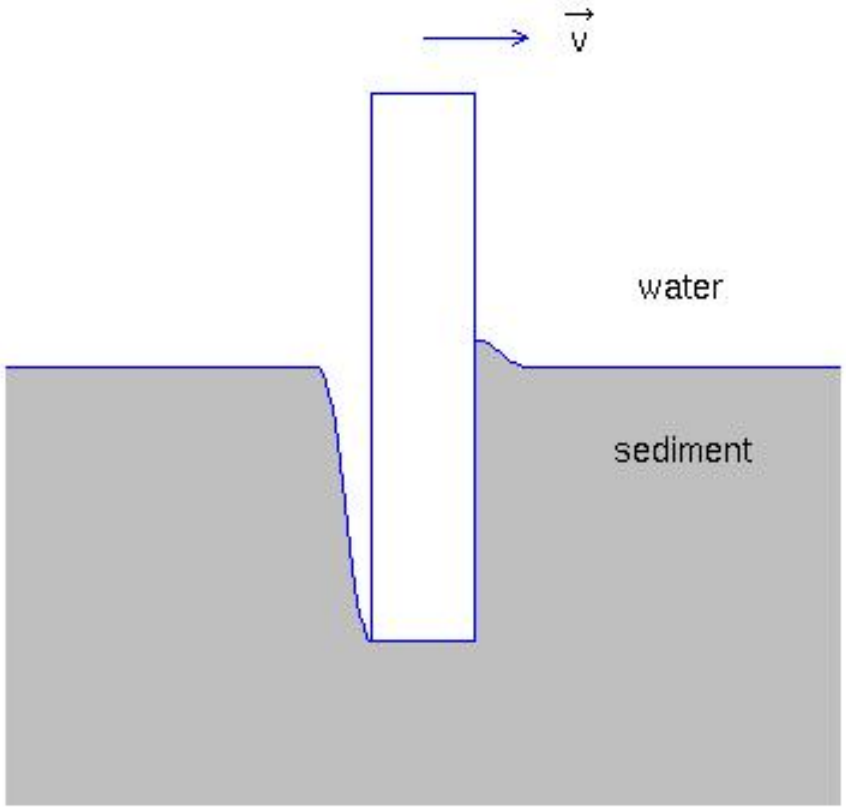
M-Coordinate System



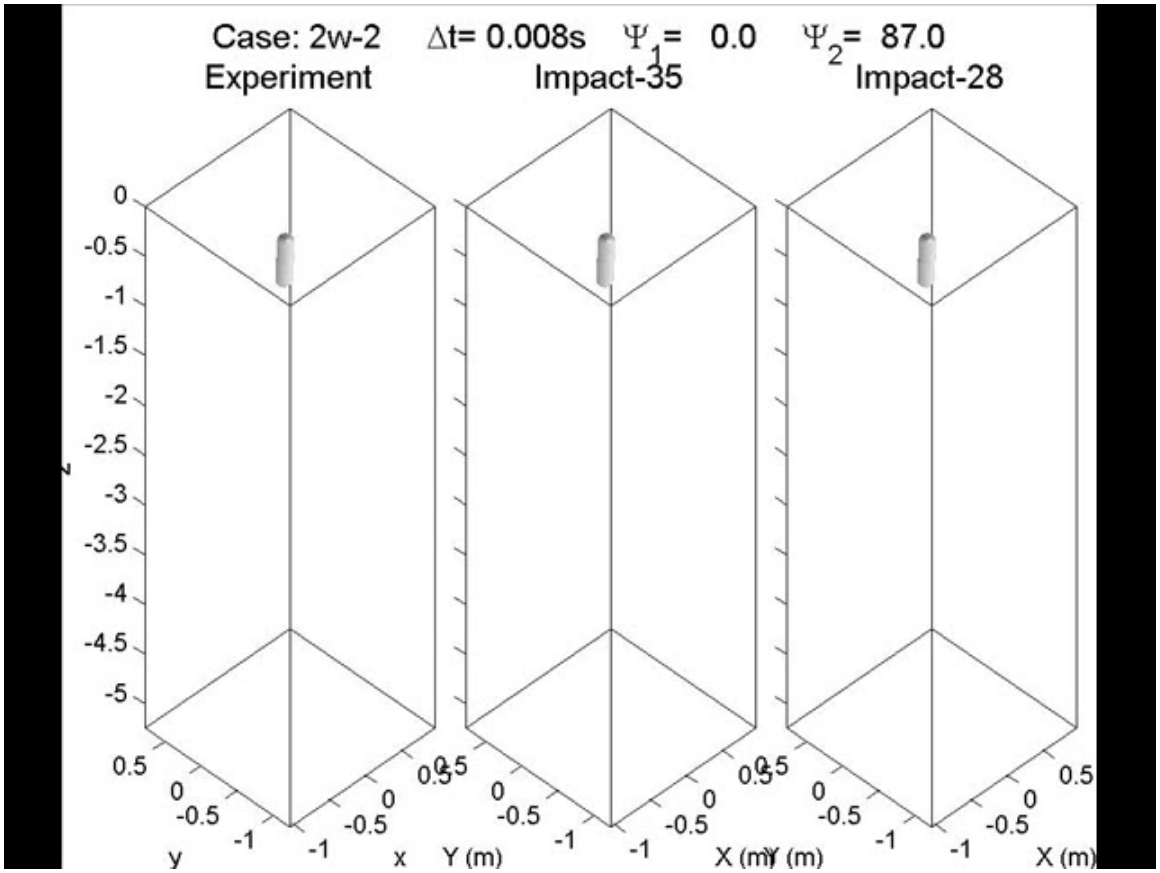
Equivalent Cylinder



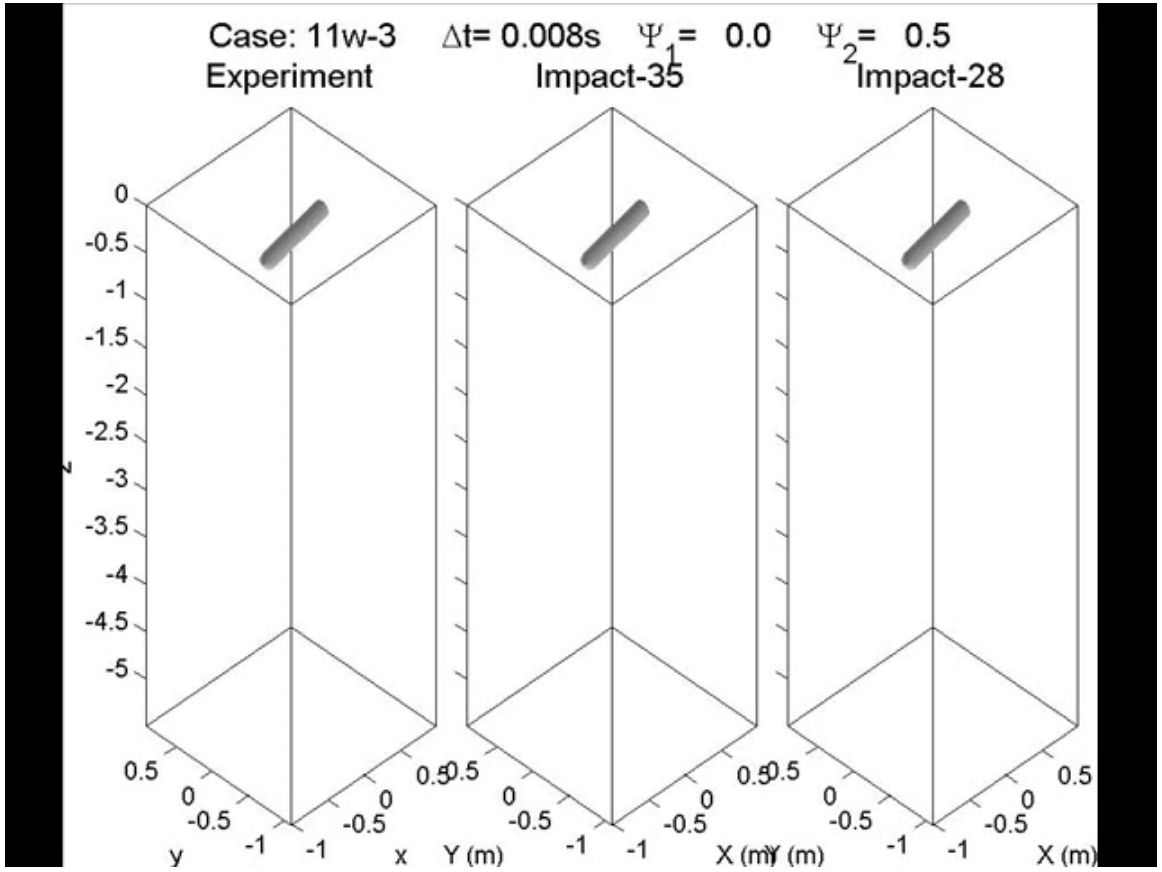
Penetration into Sediment



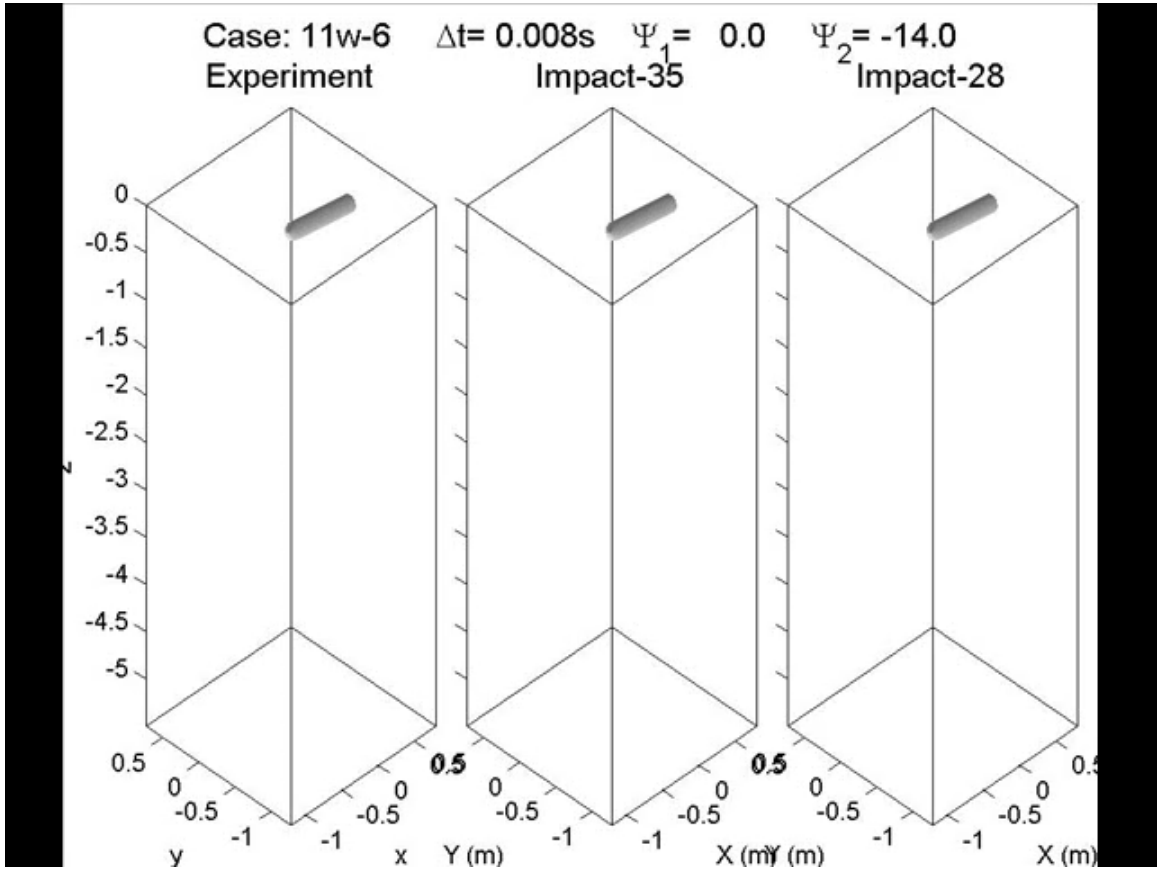
Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data



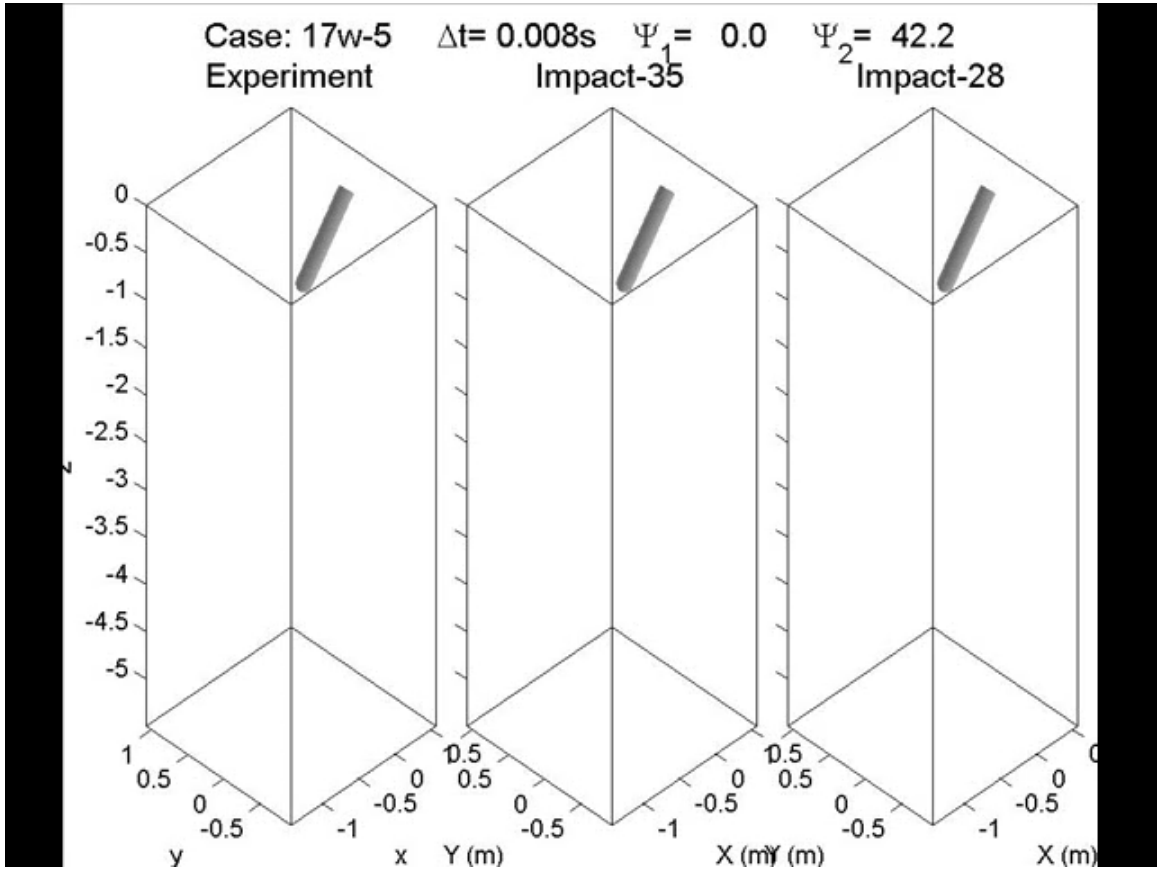
Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data



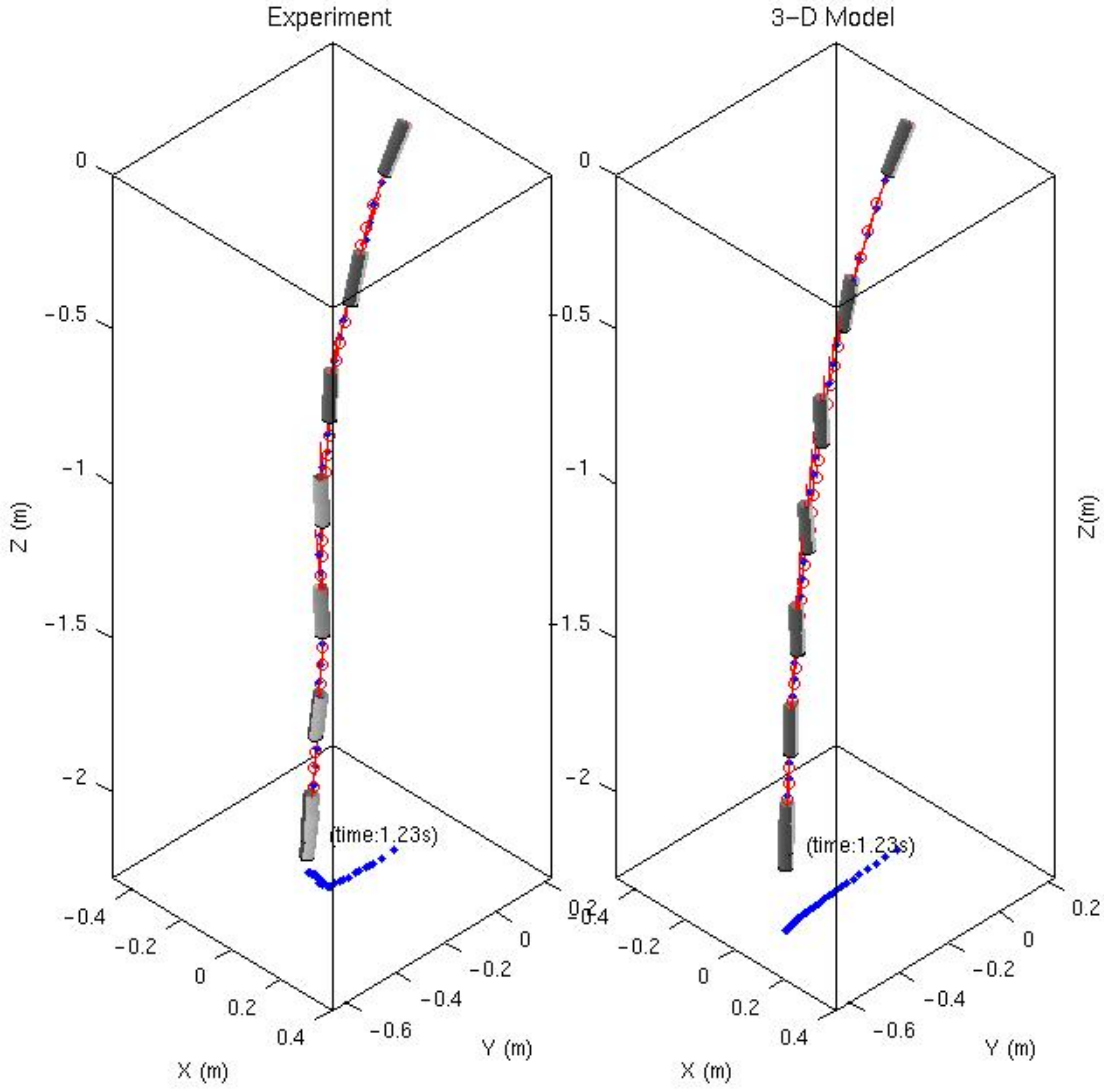
Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data



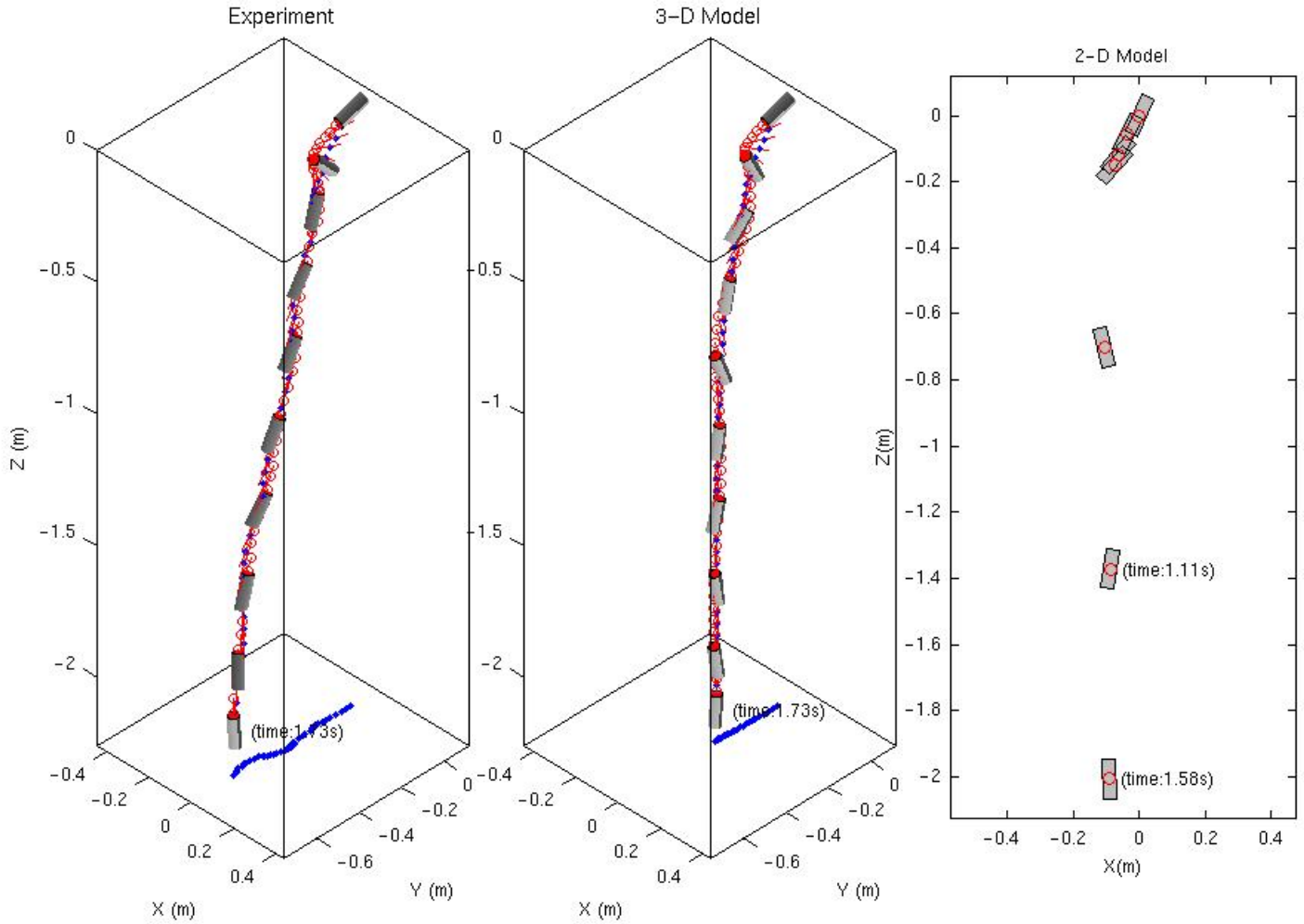
Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data



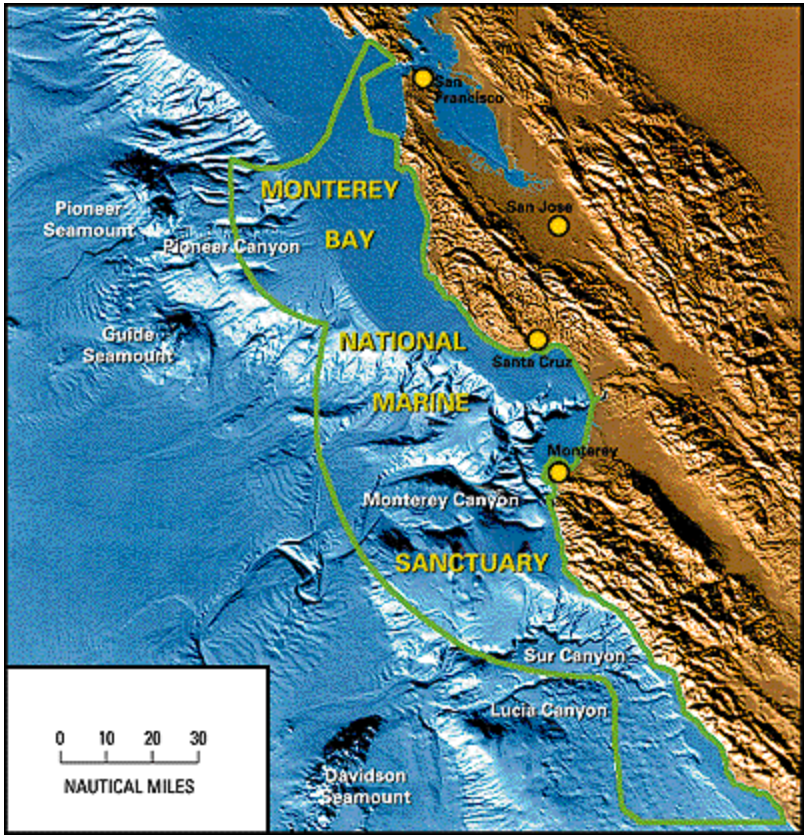
Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data

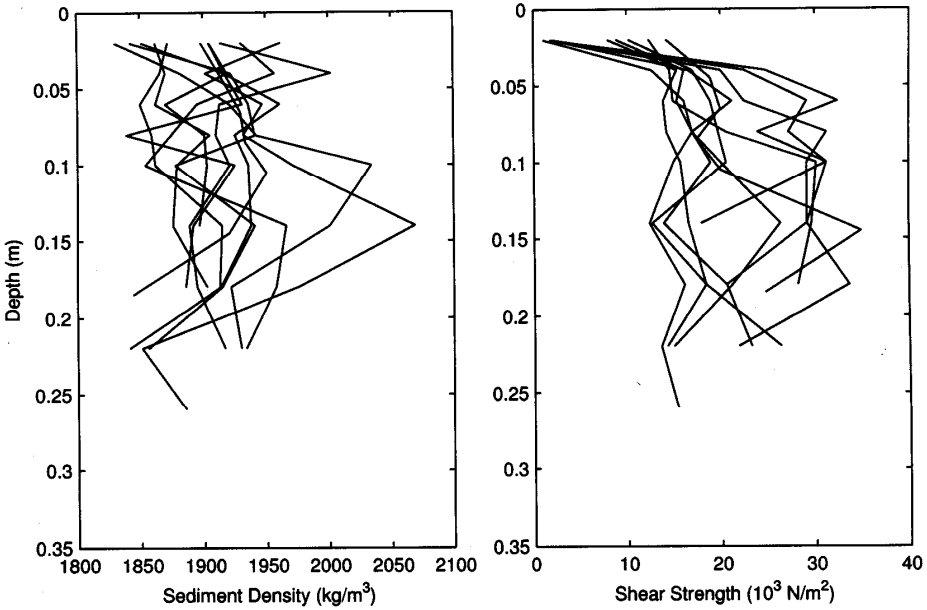


Comparison Between IMPACT28 (2D) and IMPACT35 (3D) Using Carderock Data

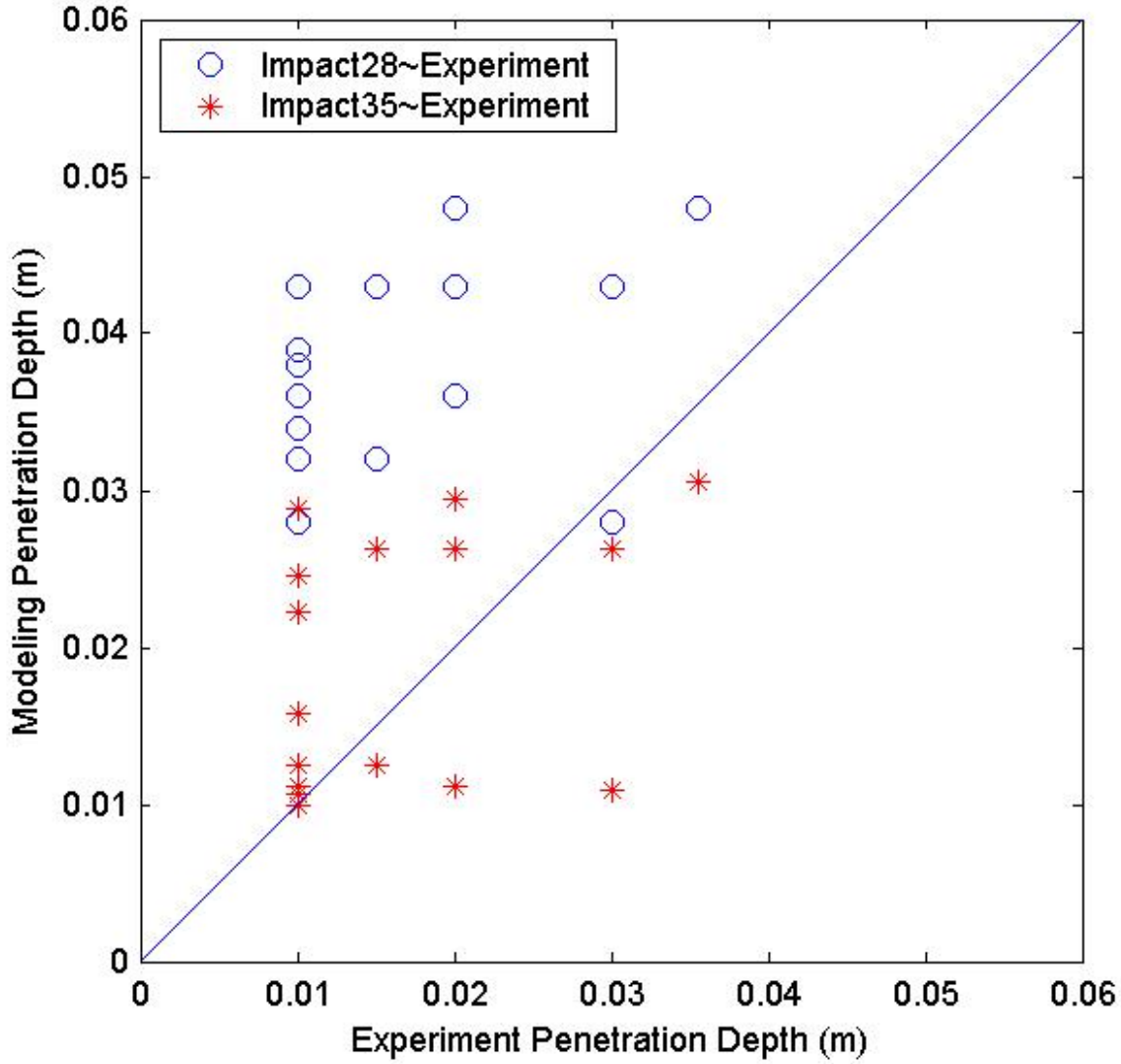


Gravity Cores During Mine Impact Burial Experiment (5/21/2000)

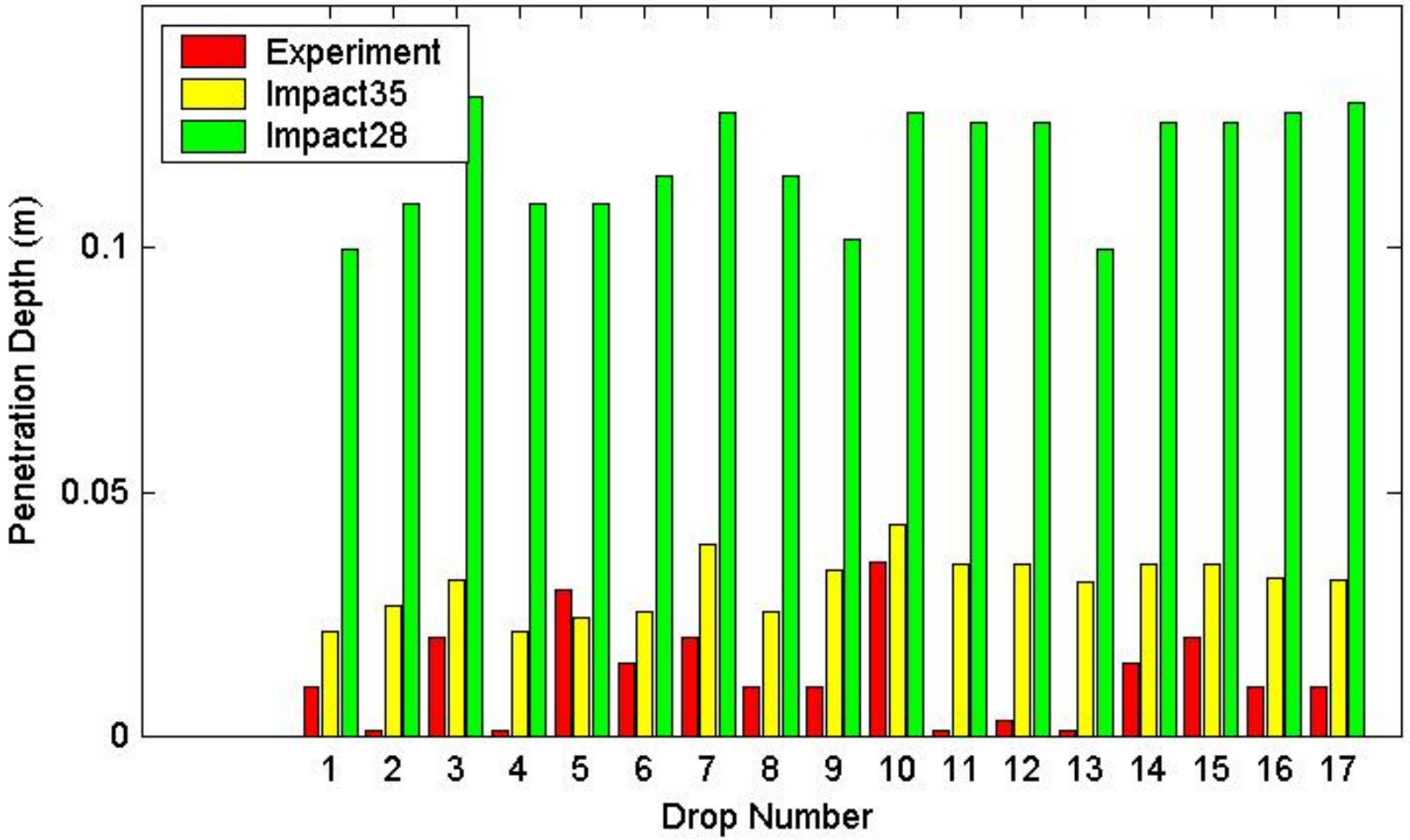




Model-Data Comparison



Predicted Burial Depth Comparison Using MIBEX Data



Conclusions

- IMPACT35 has capability to predict the COM position and mine orientation in the water column.
- The sediment part of IMPACT35 needs improvement