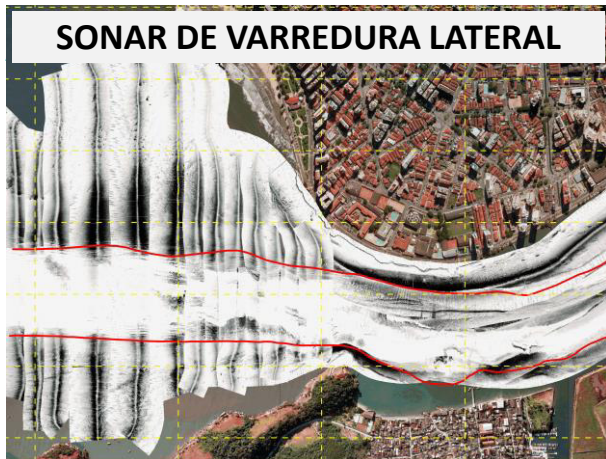


**Sonar de varredura lateral**

**Luiz Antonio Pereira de Souza**

*Curso apresentada no WORKSHOP DE HIDROGRAFIA PORTUÁRIA  
E PETROLÍFERA, 4., 2021, on-line. 100 slides.*

*A série “Comunicação Técnica” compreende trabalhos elaborados por técnicos do IPT, apresentados em eventos, publicados em revistas especializadas ou quando seu conteúdo apresentar relevância pública. **PROIBIDO REPRODUÇÃO, APENAS CONSULTA***



1

## SONAR DE VARREDURA LATERAL

Luiz Antonio Pereira de Souza (Laps)

Área de Cidades, Infraestrutura e Meio Ambiente - CIMA  
Instituto de Pesquisas Tecnológicas do Estado de São Paulo - IPT



2

### 1. Fundamentos da Sonografia

### 2. Exemplos de aplicação

### 3. Importância do uso do mapeamento de superfícies submersas

4. Por que Sonar de Varredura Lateral ?

### 5. Modelos de SSS no mercado

6. Uso simultâneo de várias frequências

7. Resolução x cobertura

### 8. Cobertura do Nadir (gap filler)

9. Ultra alta resolução

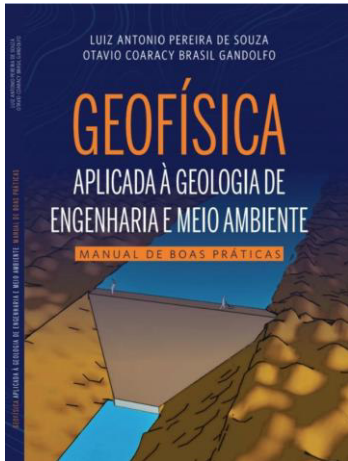
10. Aquisição de dados x interferências

### 11. avanços tecnológicos

3



4

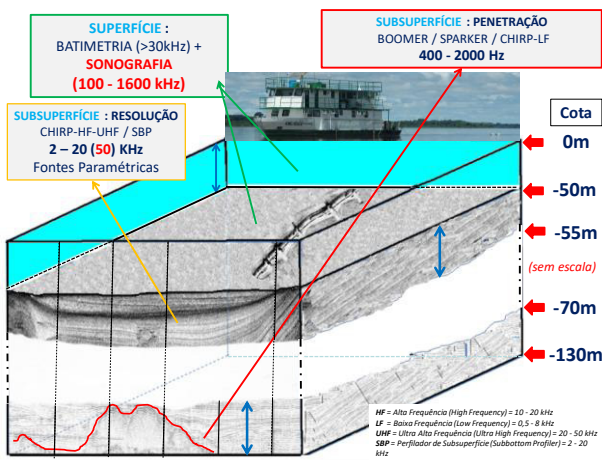


ipt

5

Meridata Edgetech R2SONIC Reson  
 Klein HMS Falmouth Scientific Benthos  
 Kongsberg  
 Applied Acoustics  
 Chesapeake - Sonarwiz  
 Echo81 Hypack  
 Golden Softwares  
 GlobalMapper GPS TrackMaker  
 Hydro International Outras Revistas  
**Oceanology International**  
 US Geological Survey Eventos Universidades  
 Marinha do Brasil IPT CPRM

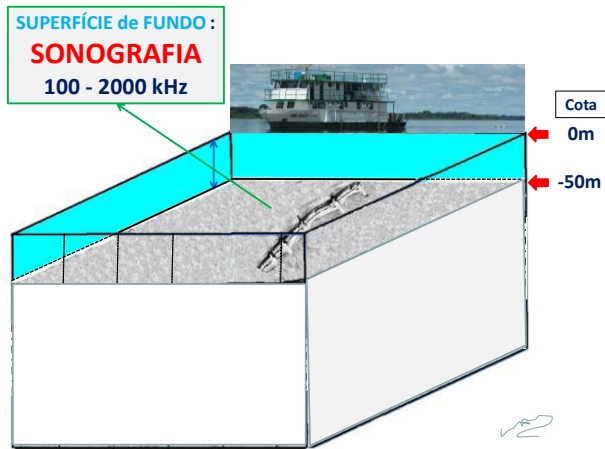
6



7



8



9

PRA QUE SERVE UM  
SONAR DE  
VARREDURA  
LATERAL?

10

- geologia (mapeamento: geológico, habitats...)
- construção ou redimensionamento de portos
- hidrovias (rios e áreas costeiras)
- operações de dragagem, áreas de bota-foras
- instalação de cabos, dutos e emissários submarinos
- molhes, marinas, 'wind farms', pontes e túneis
- assoreamento de rios e reservatórios
- construção de barragens
- regeneração de praias
- atividades pesqueiras (recifes artificiais)
- prospecção mineral
- arqueologia subaquática

11

INVESTIGAÇÃO de **SUPERFÍCIE**

**IMAGEAMENTO**

fontes acústicas: **sonar de  
varredura lateral**

> 100 kHz \*

12

INVESTIGAÇÃO ACÚSTICA DA SUPERFÍCIE DE FUNDO

IMAGEAMENTO

(6, 8, 12..)  
 100, 300, 400, 500, 700, 900, 1600 kHz  
**Sonar de Varredura Lateral**

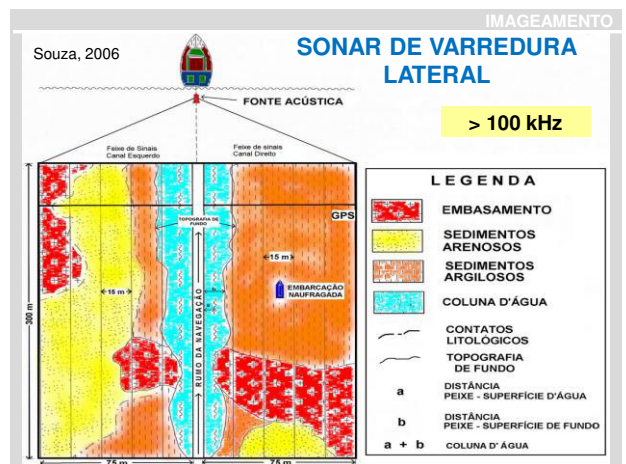
13

Objetivo principal da imageamento:  
**Mapear a superfície de fundo (apenas a superfície !!!)**

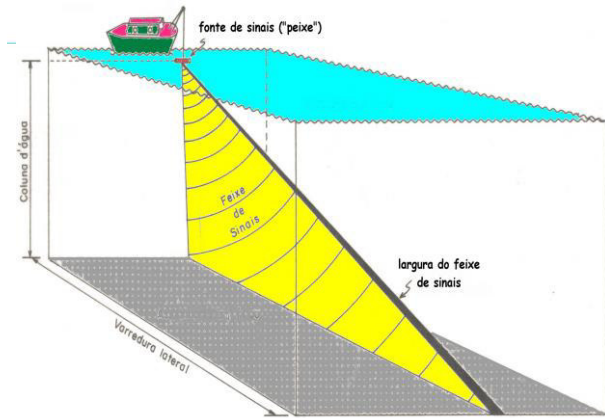
14



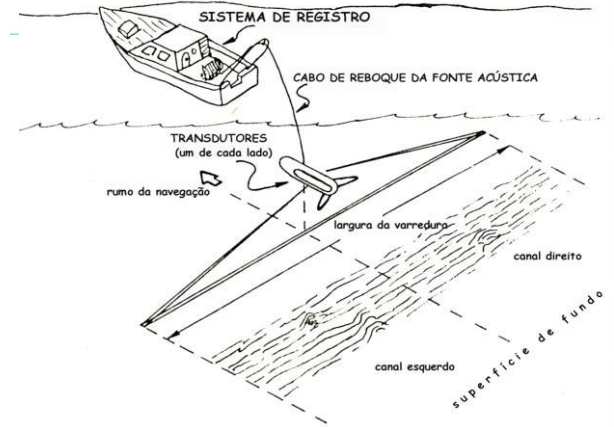
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16



17



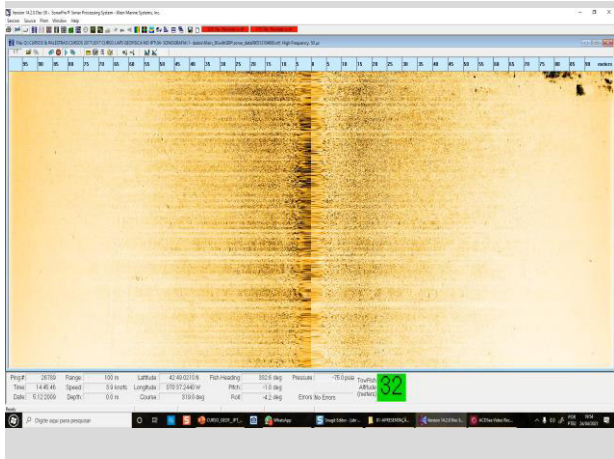
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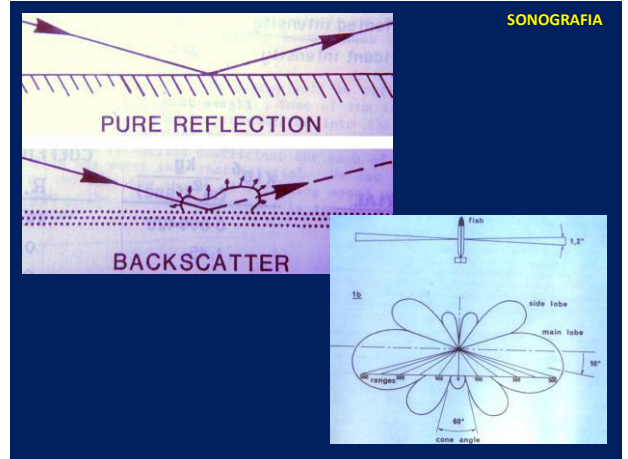
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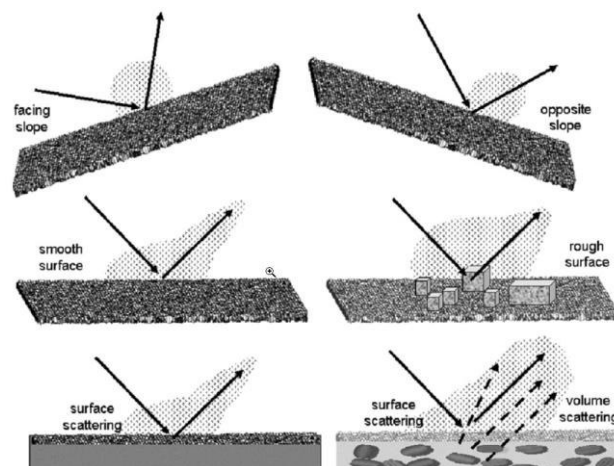
20



21



22



23



24



25



26



27



28





Klein 3000 100/500 kHz do IPT

29



30



Rio Araguaia – Conceição do Araguaia

31



Rio Araguaia –Araunã

32



33



34



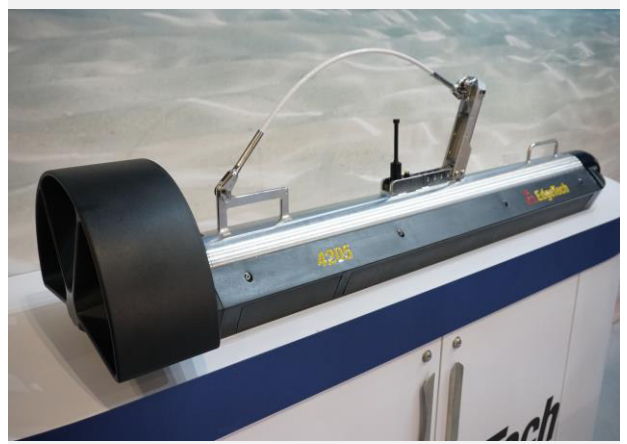
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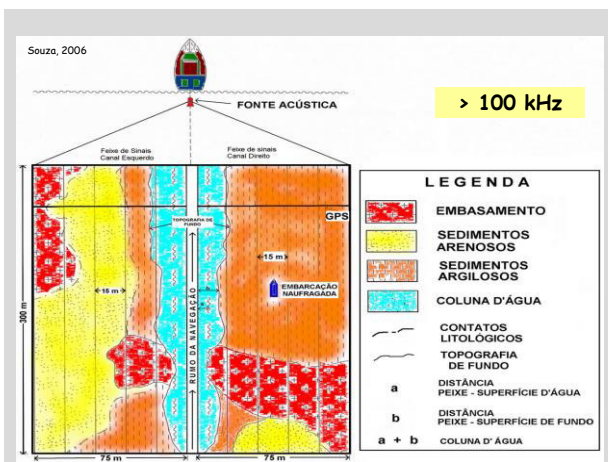
36



37



38



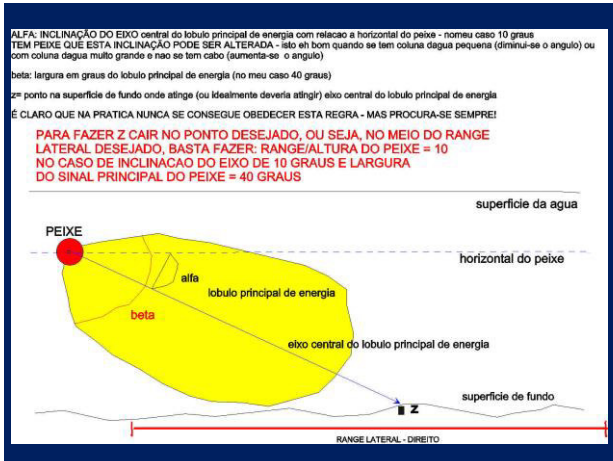
39

### AQUISIÇÃO DE DADOS

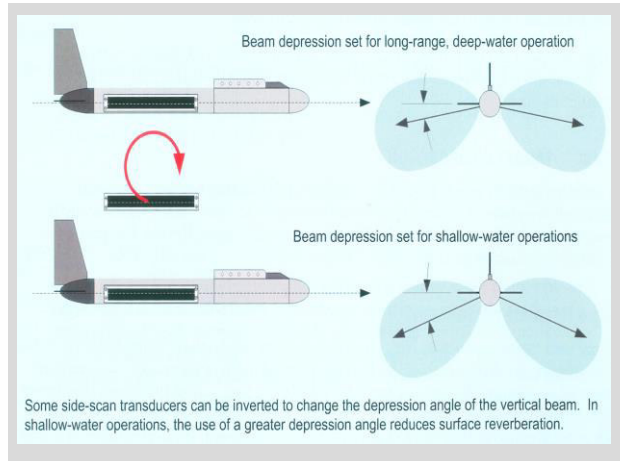
In = Out

- **Objetivo do projeto:** resolução / cobertura
- **Seleção do equipamento:** frequência/energia/calibração
- **Operação:** programação das linhas / velocidade da embarcação / altitude do peixe (SSS)
- **Ambiente:** estado do mar / tipo de fundo / interferências

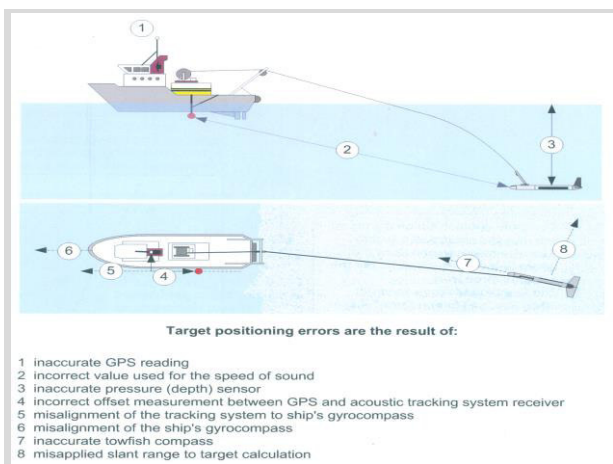
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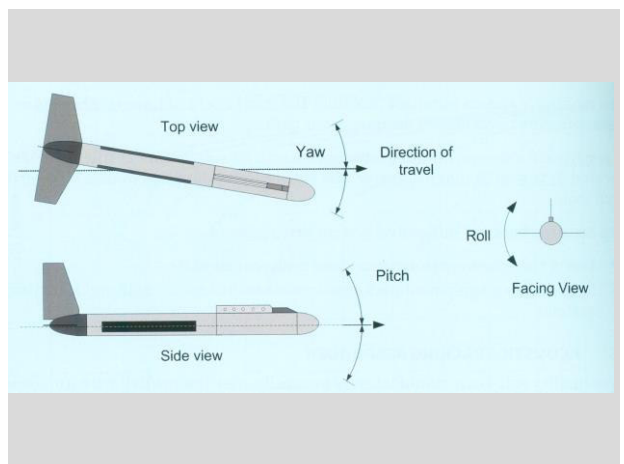
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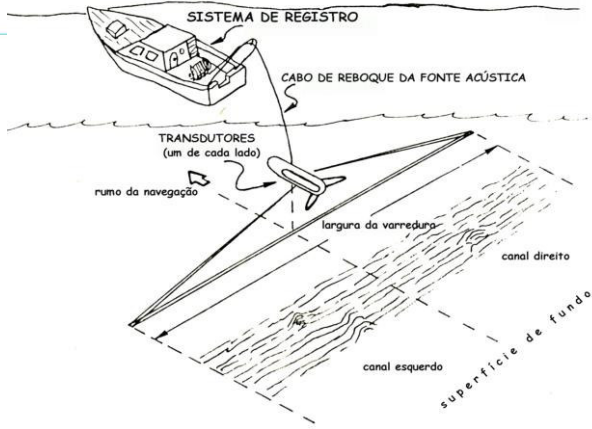
42



43



44



45

**A IMPORTÂNCIA DA CORREÇÃO DA VELOCIDADE DA EMBARCAÇÃO**

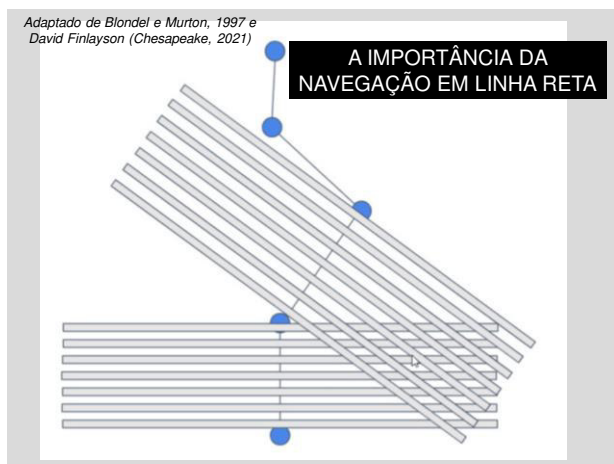
Varições da distância entre os 'pings' ao longo da linha

**OBJETIVO: GARANTIR IMAGEM 1:1**

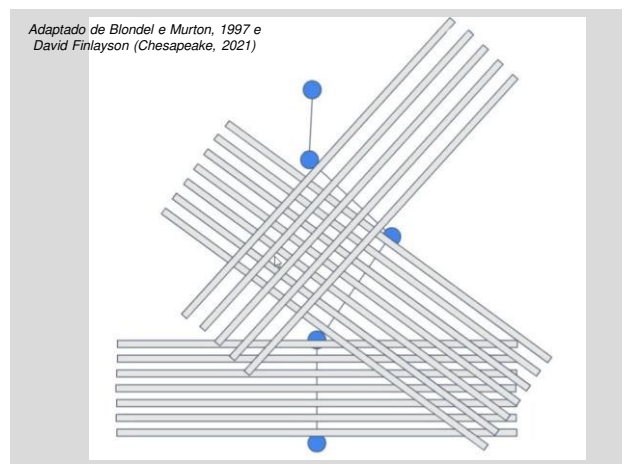
Perfil da velocidade da embarcação

Adaptado de Blondel e Murton, 1997 e David Finlayson (Chesapeake, 2021)

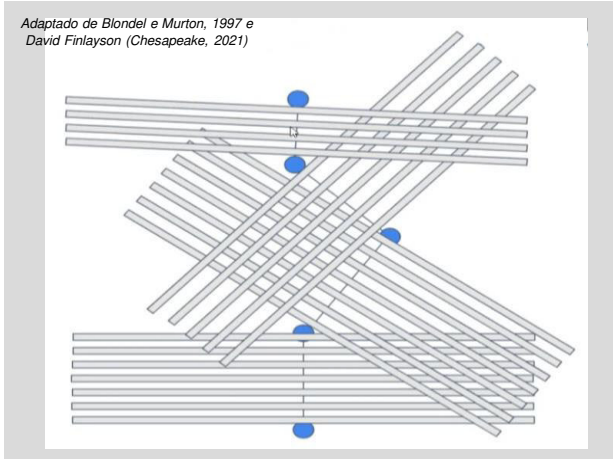
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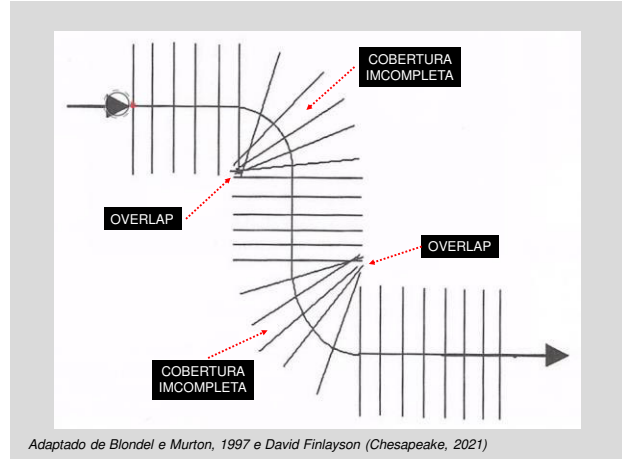
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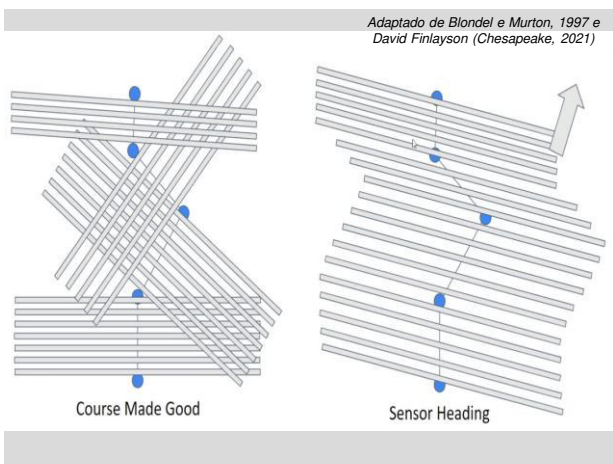
48



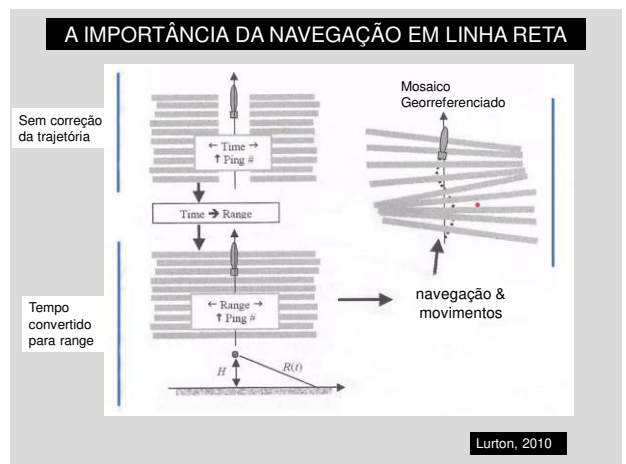
49



50



51

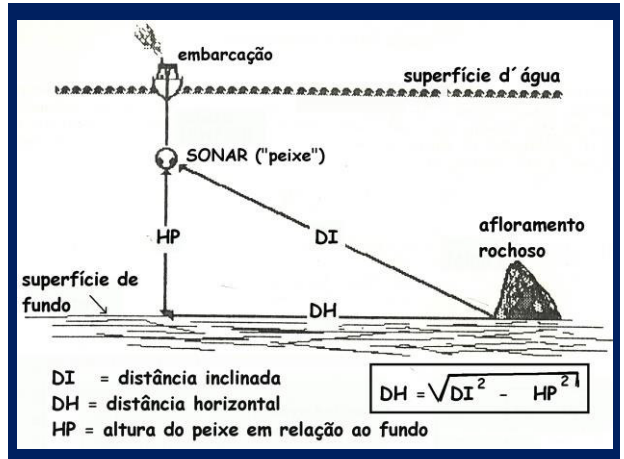


52

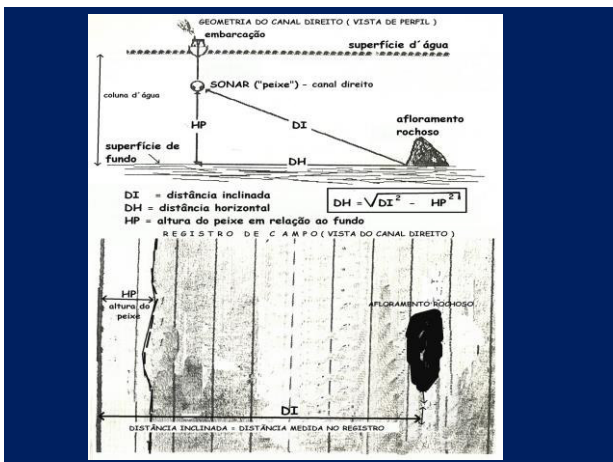
O que é processar dados de sonar de varredura lateral?



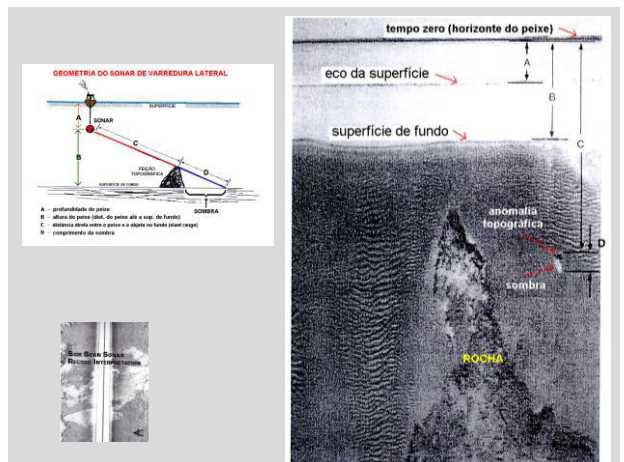
53



54



55



56

### CÁLCULO DA ALTURA DO OBJETO

**ALTURA DO OBJETO (ANOMALIA TOPOGRAFICA)**

$$H_t = \frac{L_s \times H_f}{R_s + L_s}$$

$$= \frac{28 \times 15}{56}$$

$$= 7.5$$

57

Lat: 23.37.0842 S  
Lon: 045.20.9323 W

Length: 10.2 m  
Width: 30.1 m  
Height1: 3.0 m  
Height2:  
Outline:  
Name: Target0045

Classification: [0] None

Notes: The operator places target notes here. Multiple lines [Grow]

Prog#: 127476 Range: 76 m Latitude: 23.37.1200 S Fish Heading: 138.3 deg Pressure: 0.3 psia TyeFish: 4  
Time: 11.08.03 Speed: 3.8 knots Longitude: 045.20.9602 W Pitch: 0.8 deg Tilt: 0.0 deg  
Date: 18.02.09 Depth: 0.0 m Course: 125.6 deg Roll: 3.1 deg Errors: No Errors  
Head: Range: 53 meters Lat: 23.37.0842 S Lon: 045.20.9323 W

58

### INTERPRETAÇÃO DA IMAGEM DO SONAR DE VARREDURA LATERAL

- Forma
- Textura

59

forma

10 m

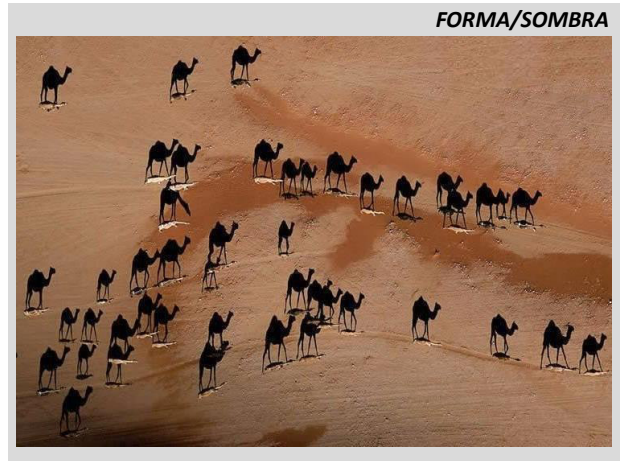
Fonte: Marine Sonic

60

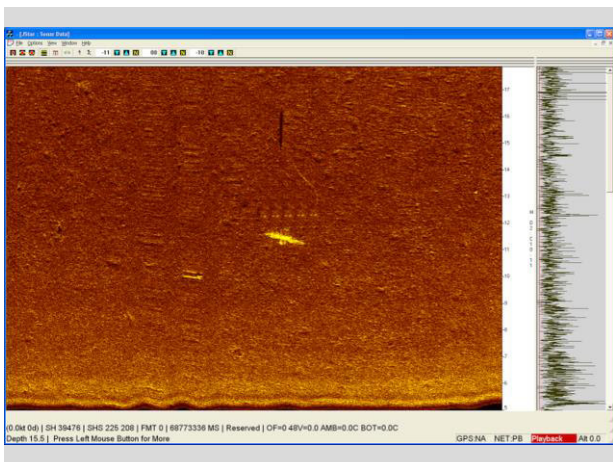




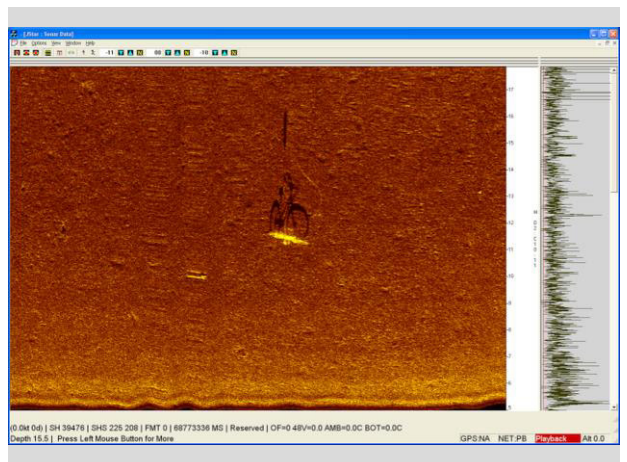
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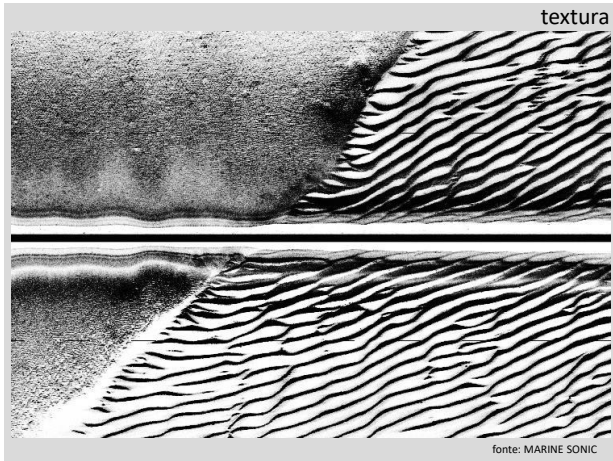
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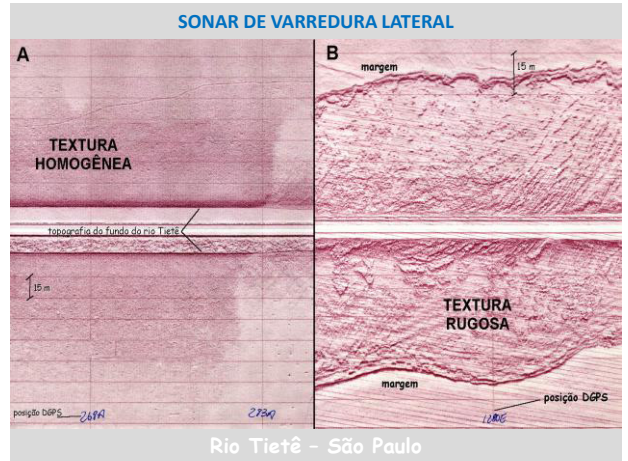
63



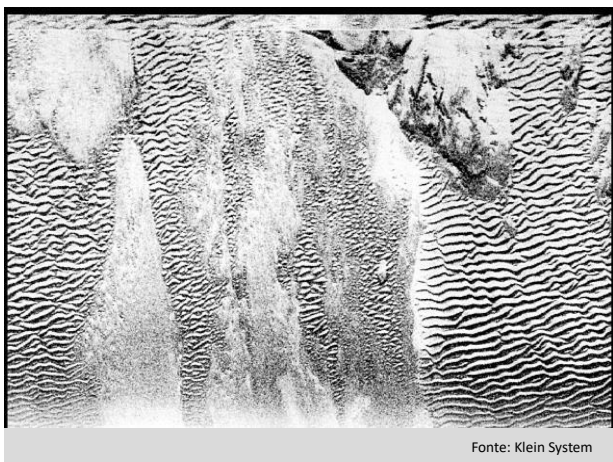
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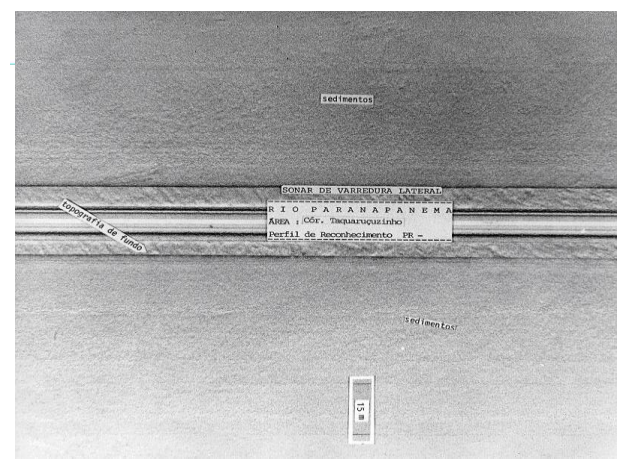
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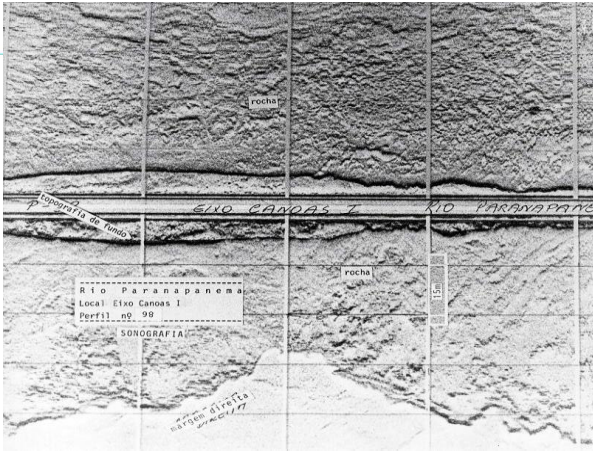
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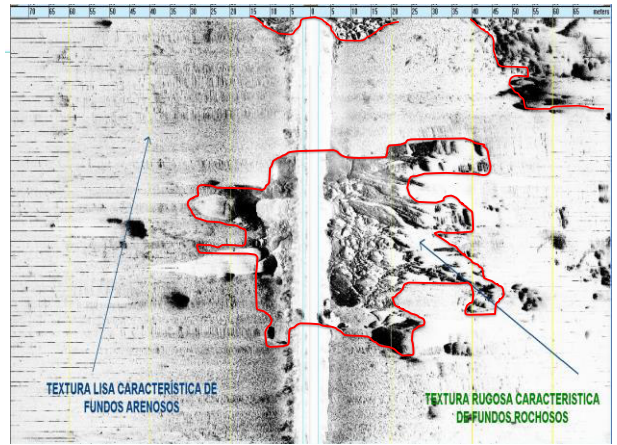
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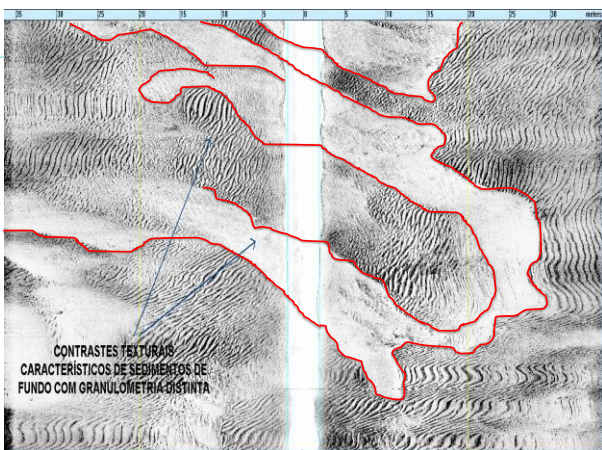
68



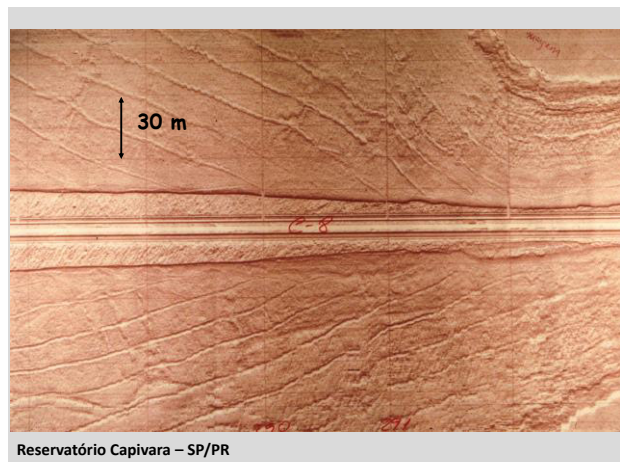
69



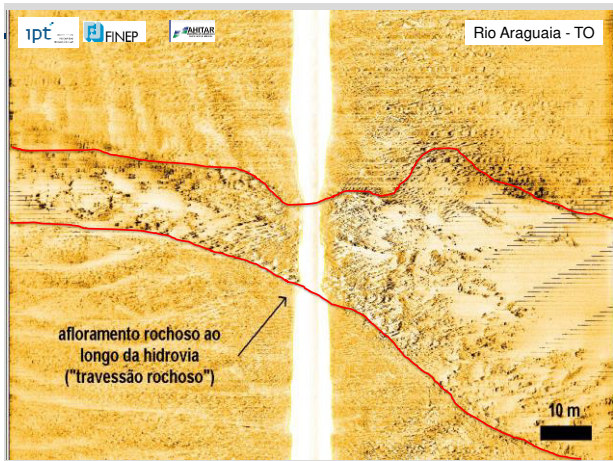
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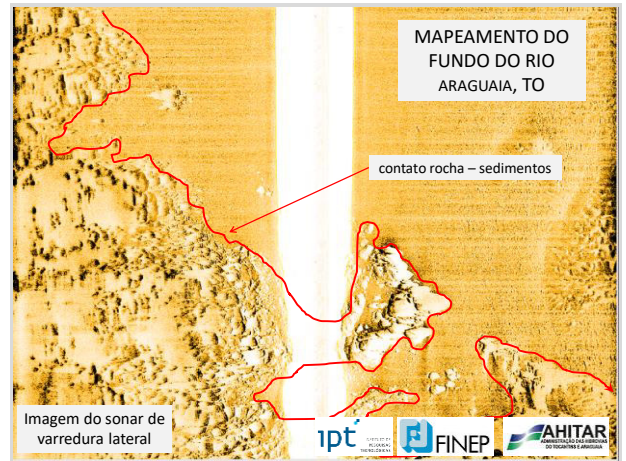
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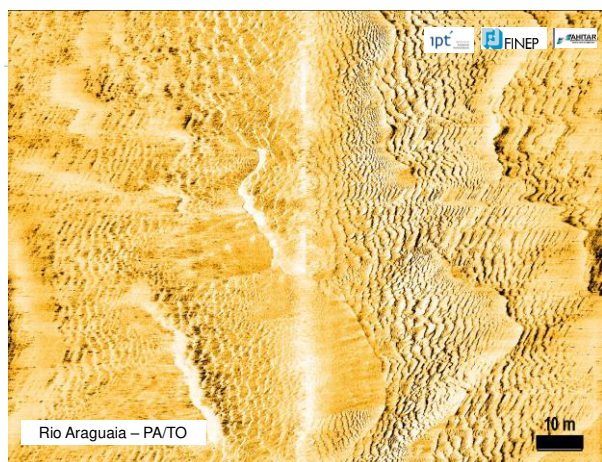
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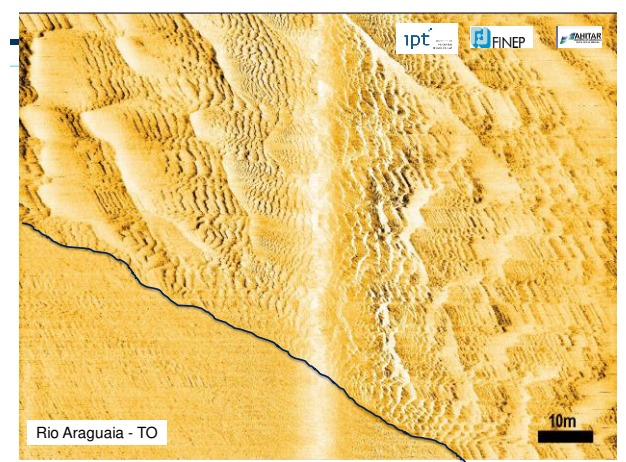
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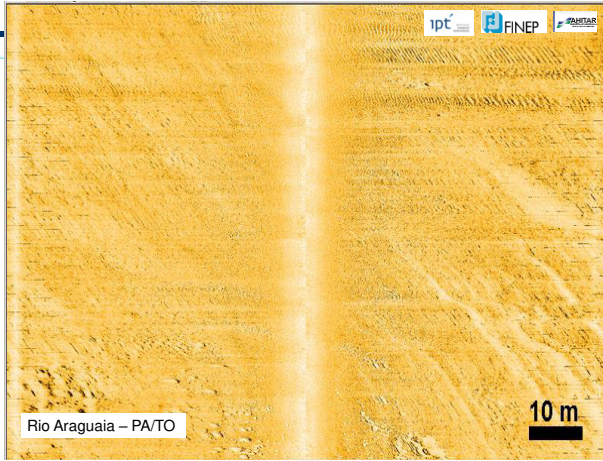
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75



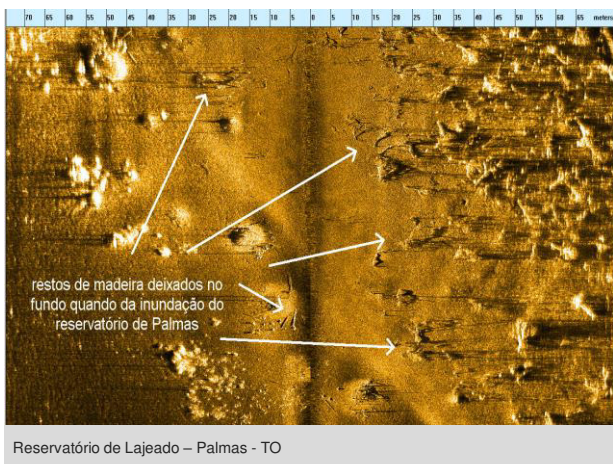
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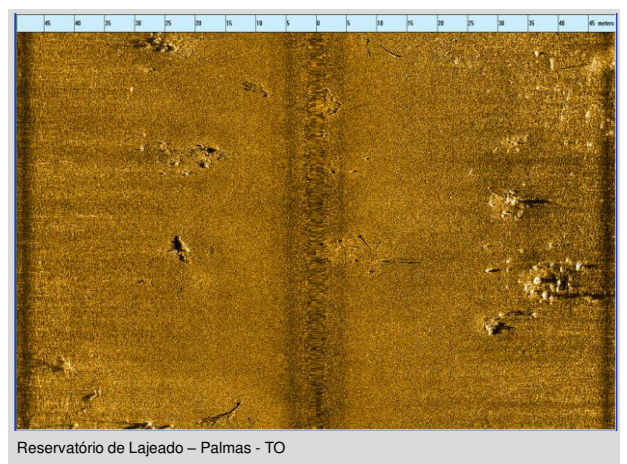
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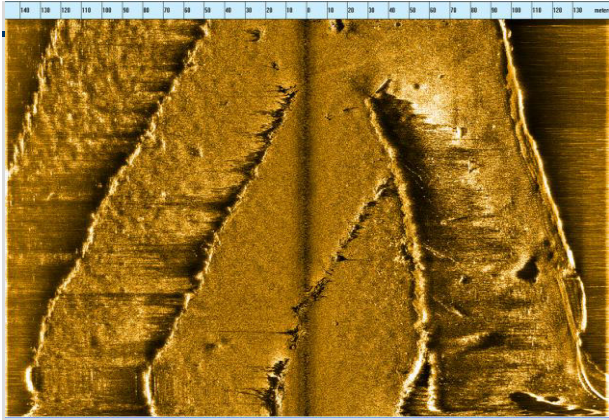
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79

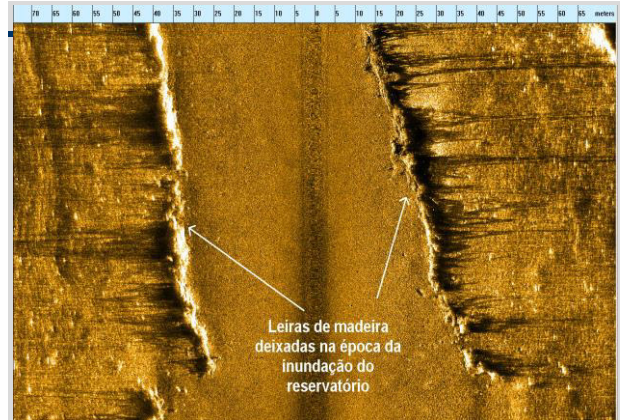


80



Reservatório de Lajeado – Palmas - TO

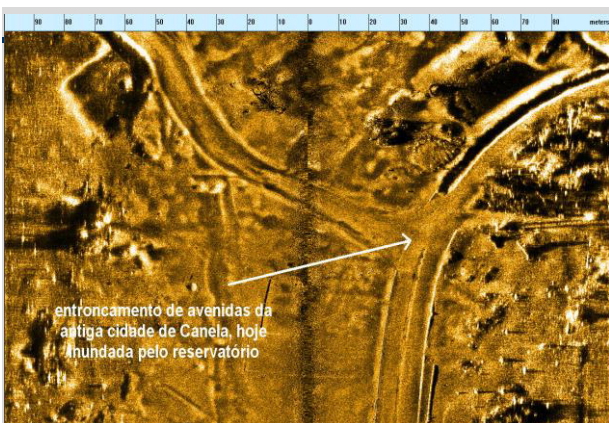
81



Leiras de madeira deixadas na época da inundação do reservatório

Reservatório de Lajeado – Palmas - TO

82



entroncamento de avenidas da antiga cidade de Canela, hoje inundada pelo reservatório

Reservatório de Lajeado – Palmas - TO

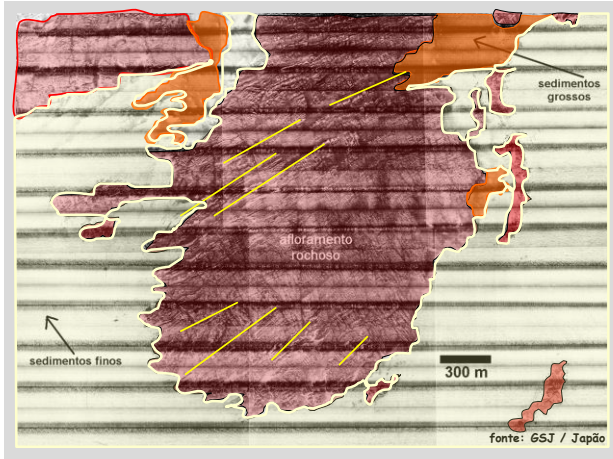


83

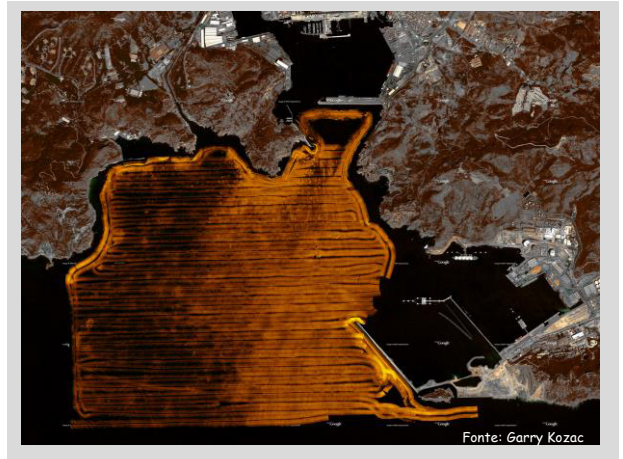


# MOSAICOS

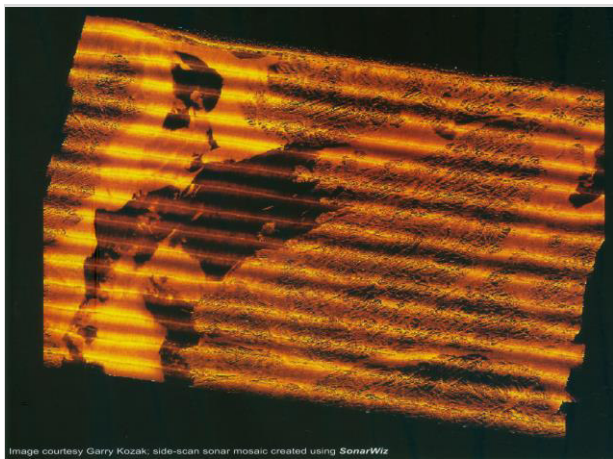
84



85



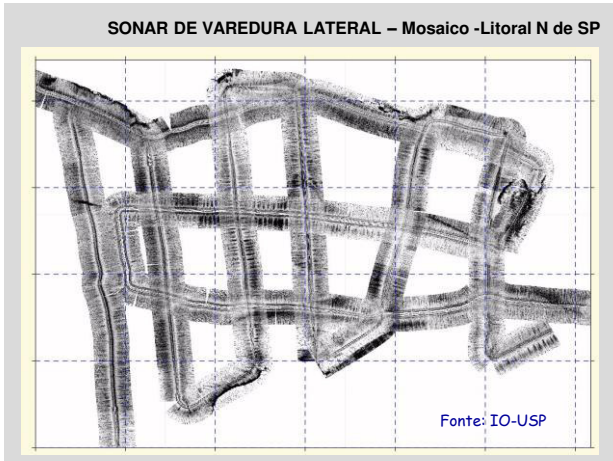
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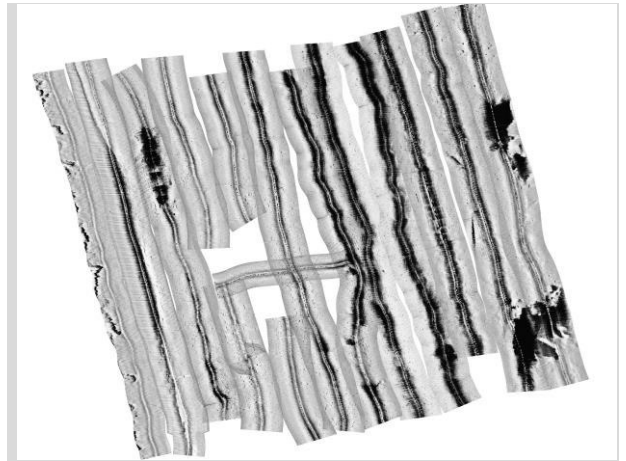
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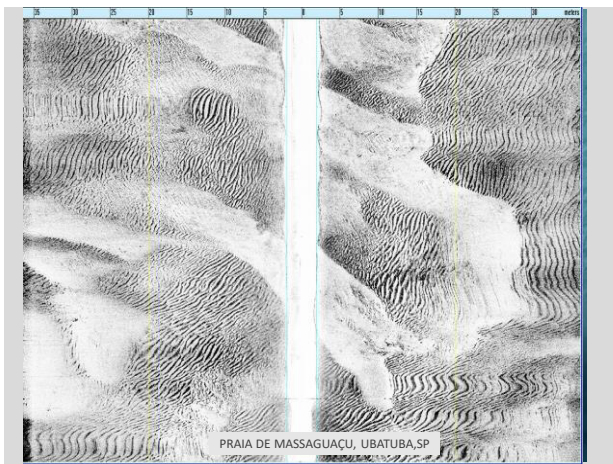
88



89



90



91



92





93



94



95

Porto Primavera  
SP/MS

Erosão de margens de reservatórios

96

**AMBIENTES SUBMERSOS : RIOS e RESERVATÓRIOS**



97

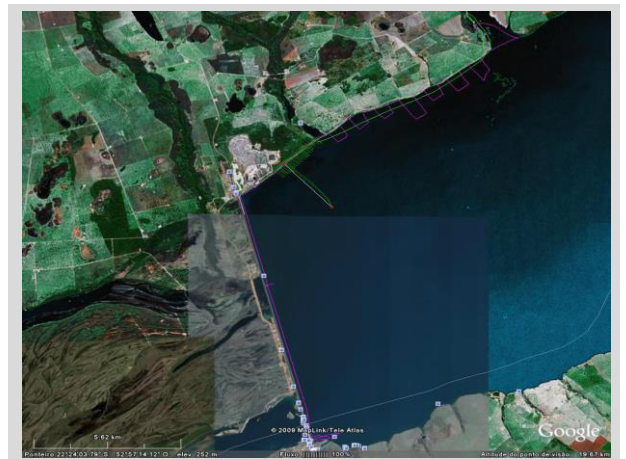
**Reservatório Porto Primavera SP/MS**



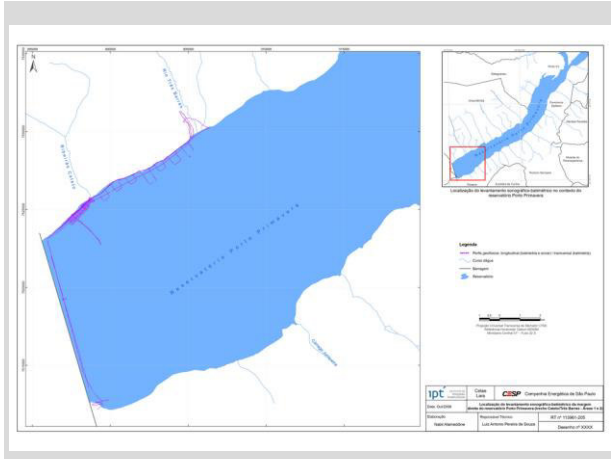
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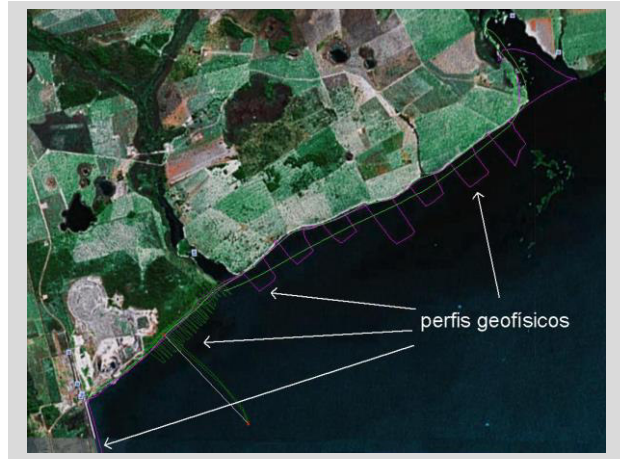
99



100



101



102



103



104



105



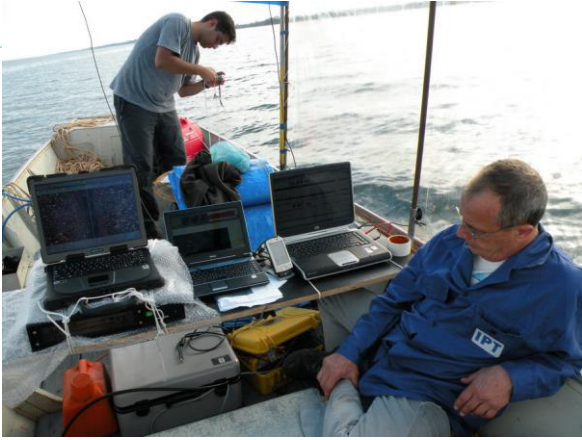
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107



108



109



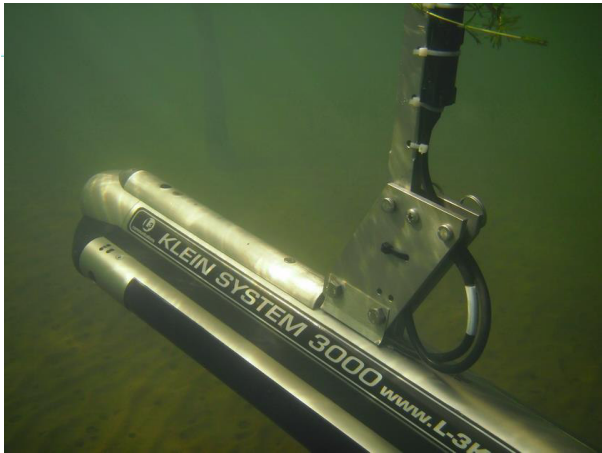
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111



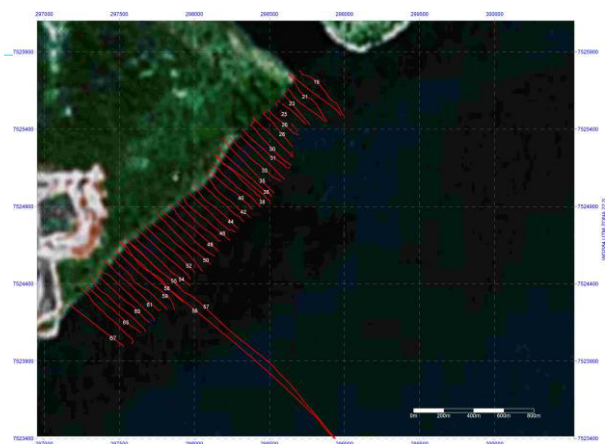
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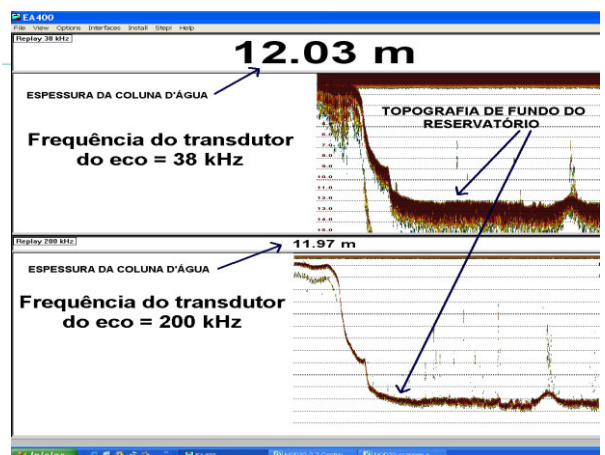
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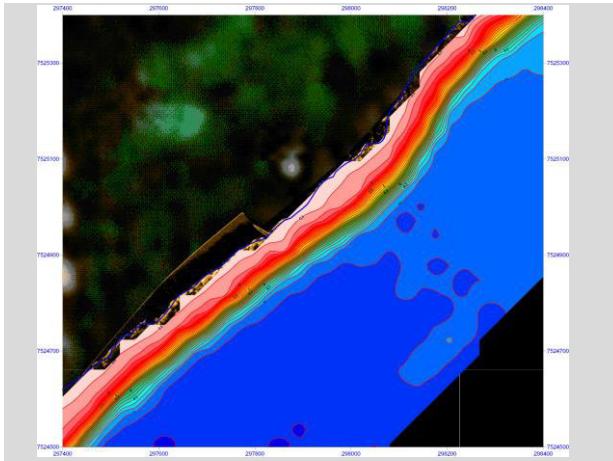
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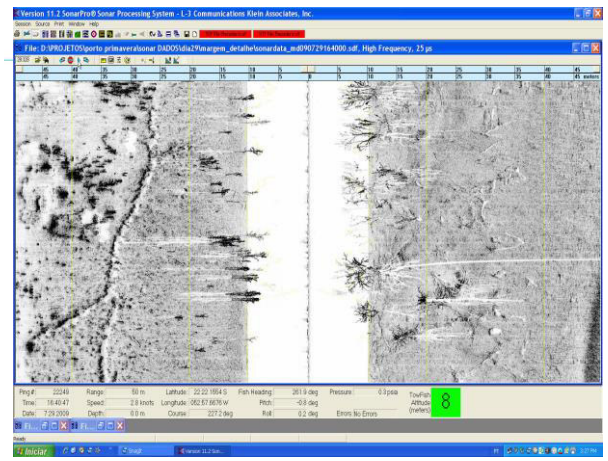
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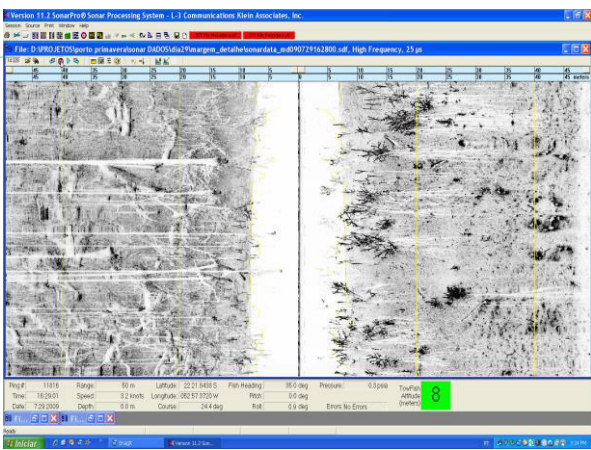
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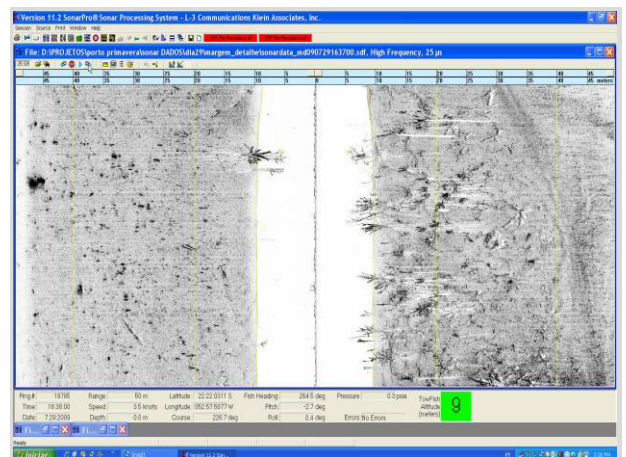
117



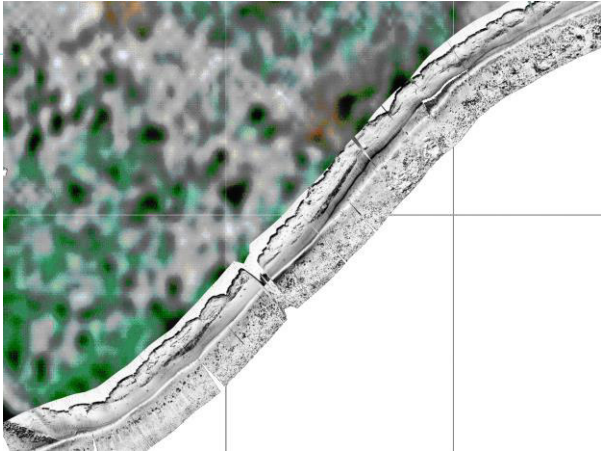
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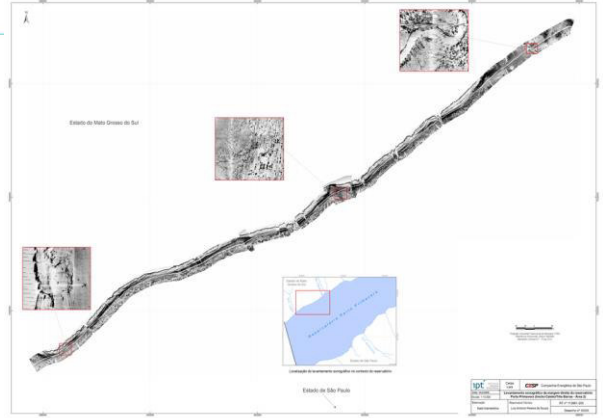
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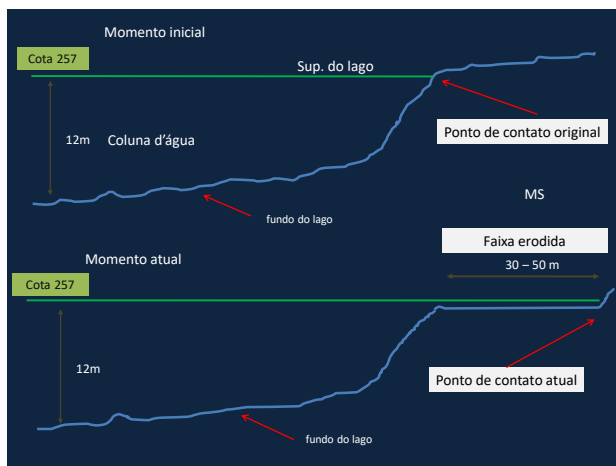
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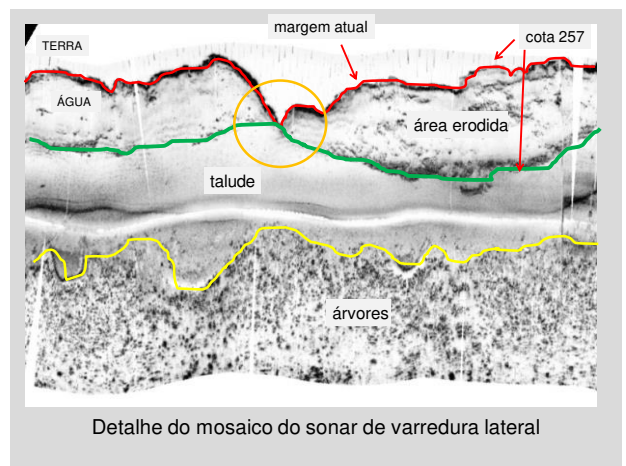
121



122



123



124

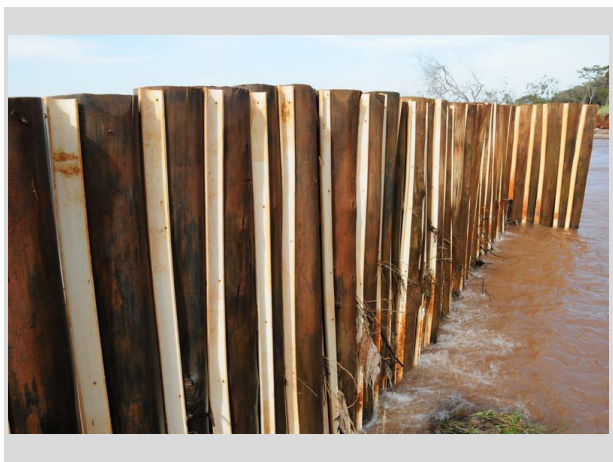




125



126



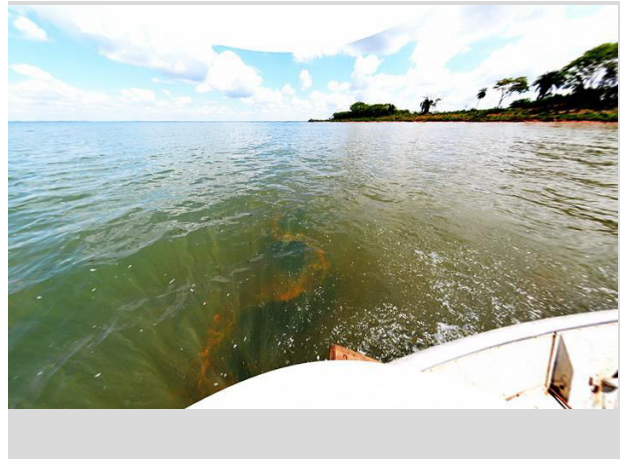
127



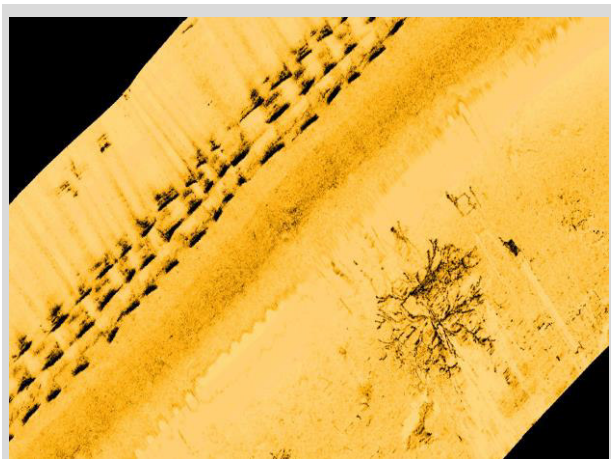
128



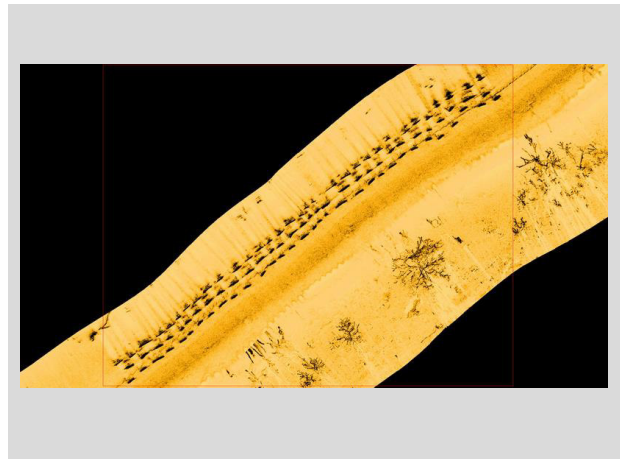
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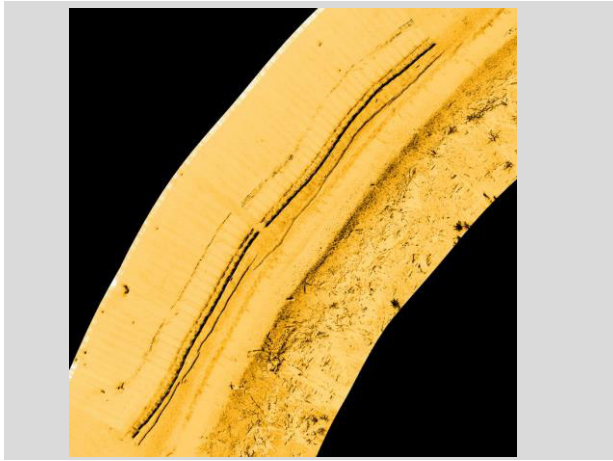
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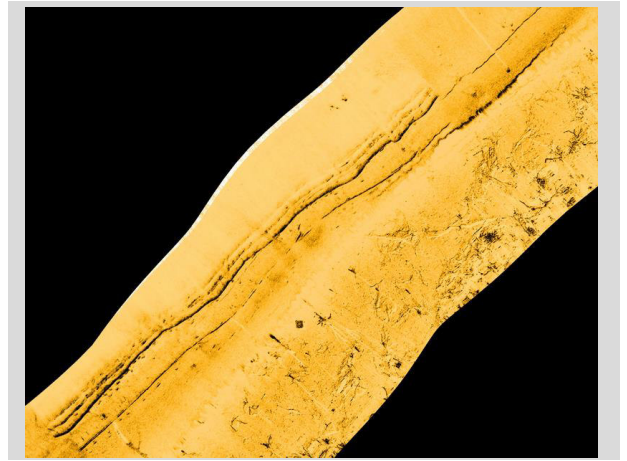
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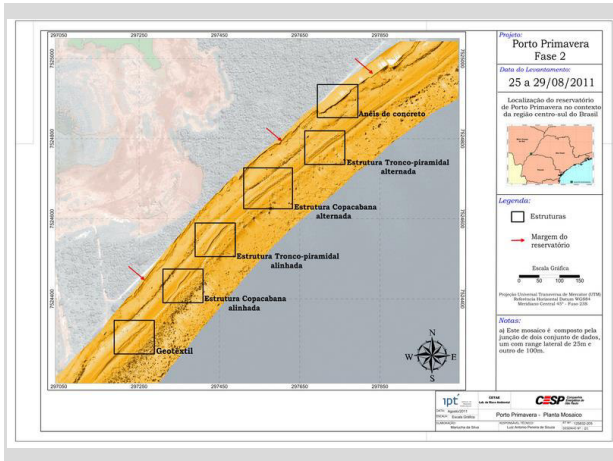
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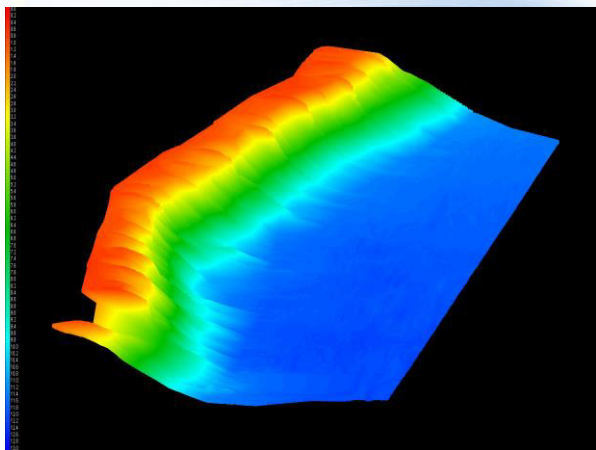
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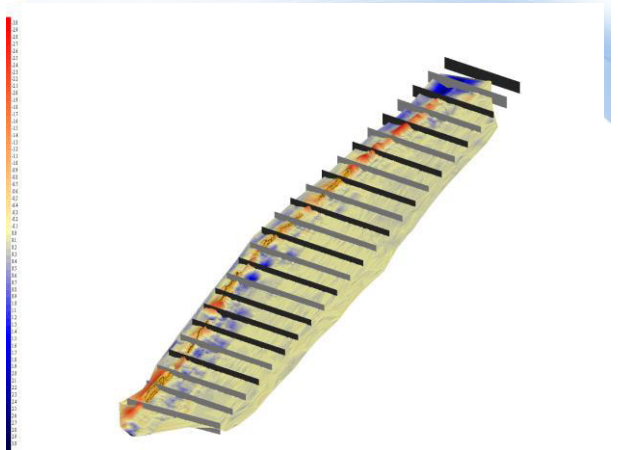
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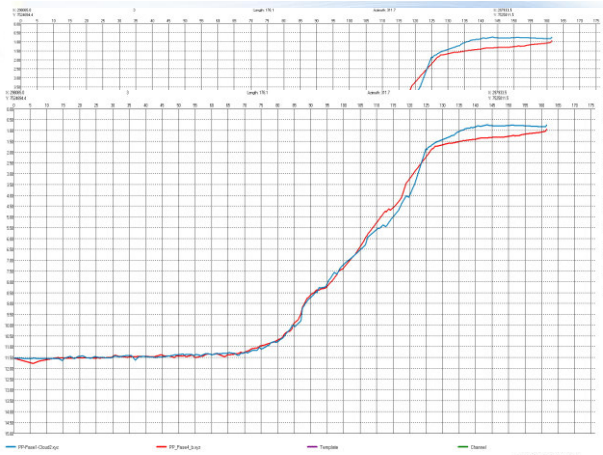
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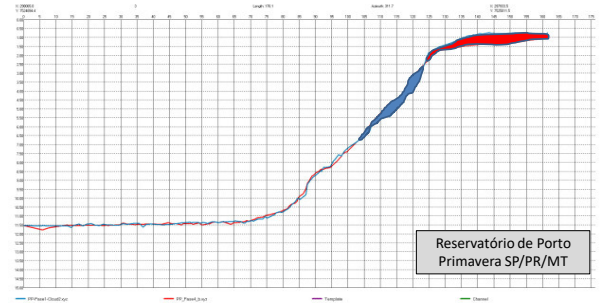


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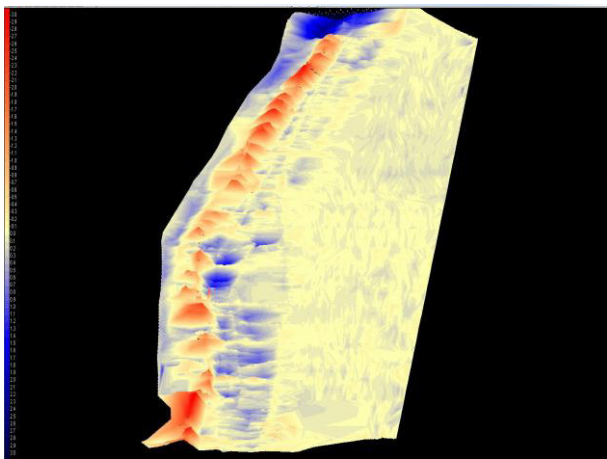


141

**Comparação entre perfis batimétricos realizados em períodos distintos**



142



143



144

# Porto Primavera SP/MS

Erosão de margens de  
reservatórios  
**JUSANTE**

145



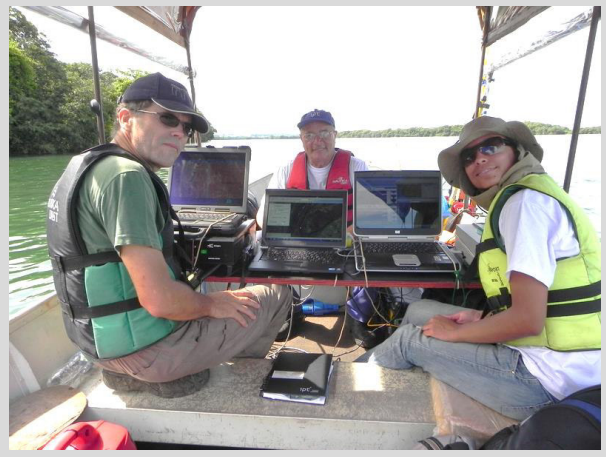
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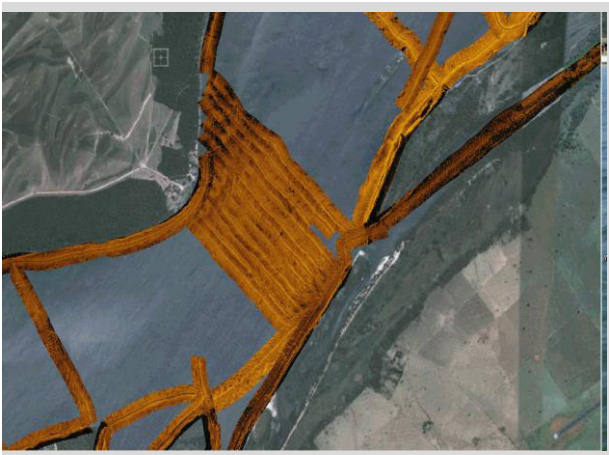
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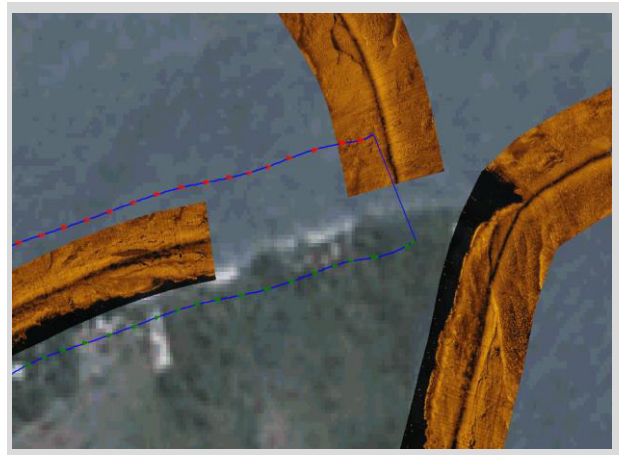
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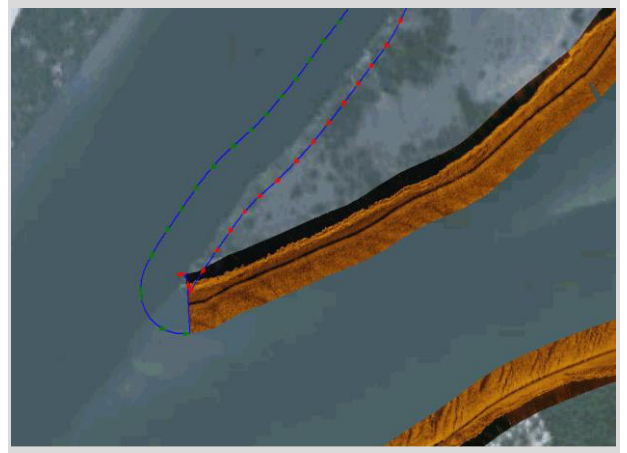
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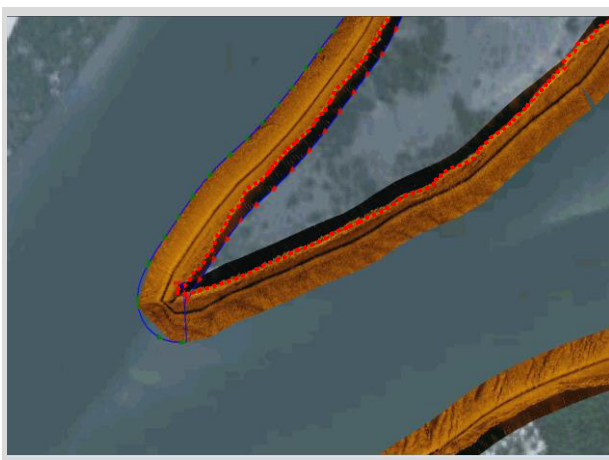
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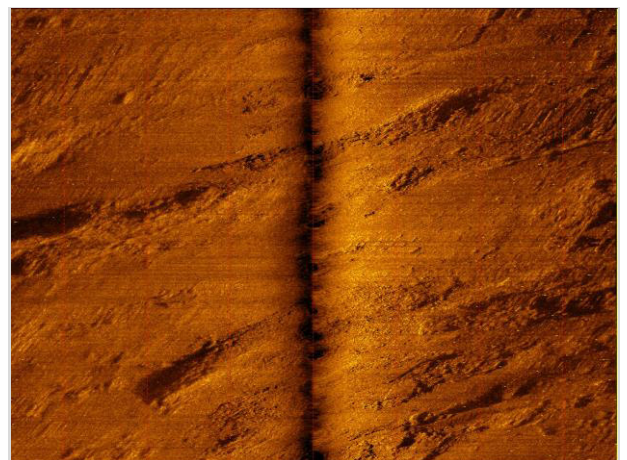
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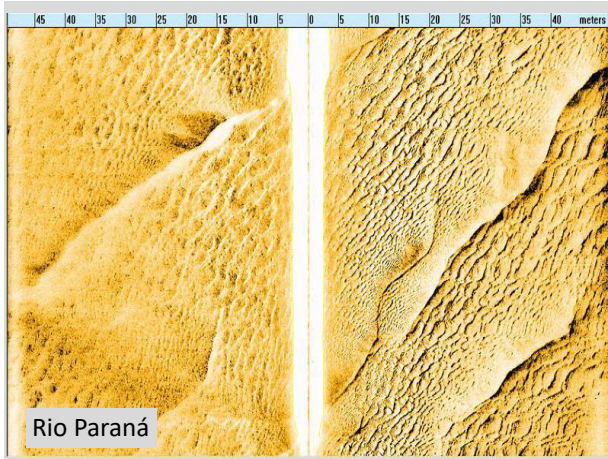


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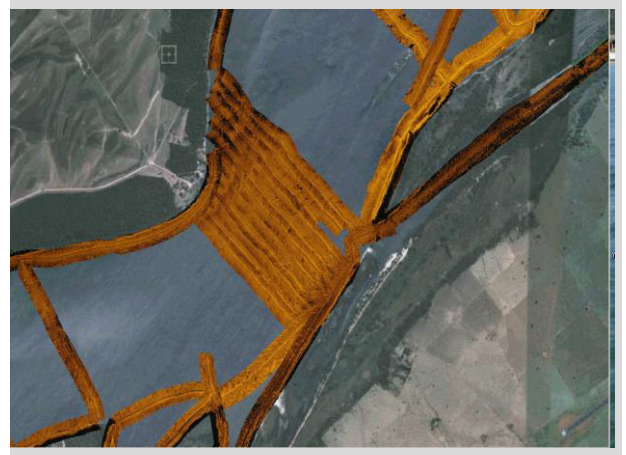


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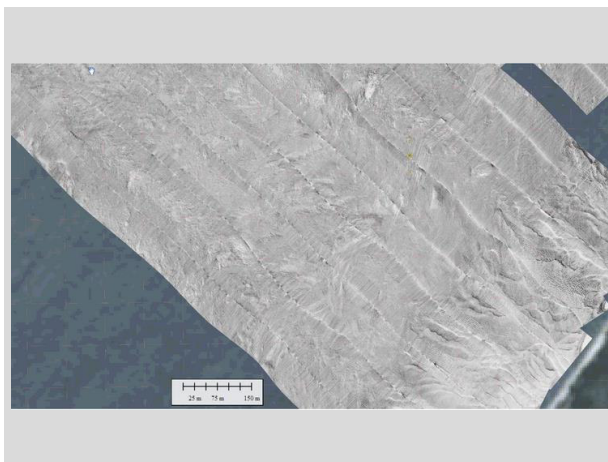




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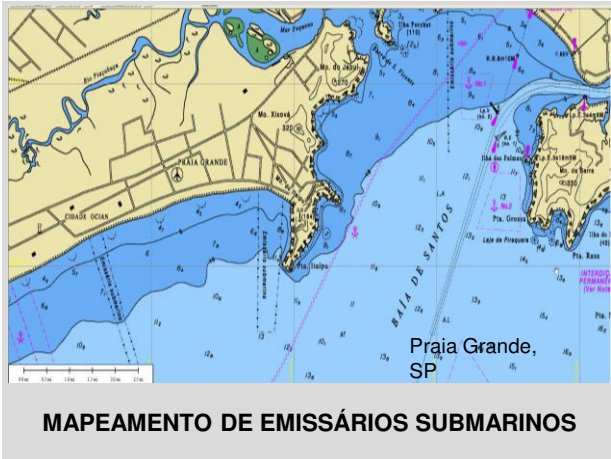
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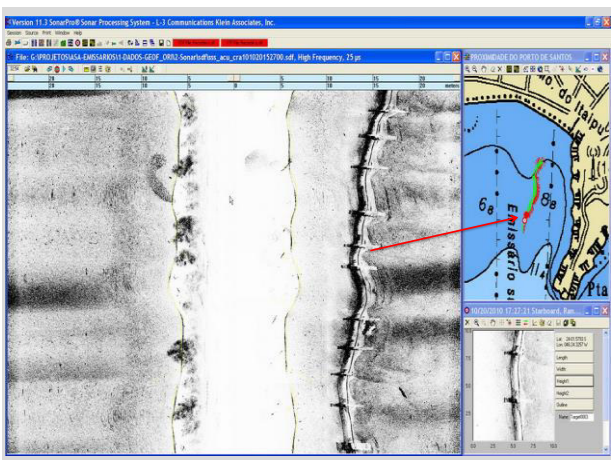
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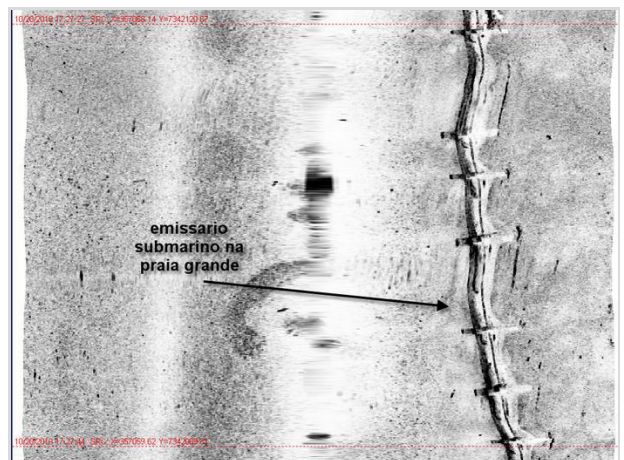
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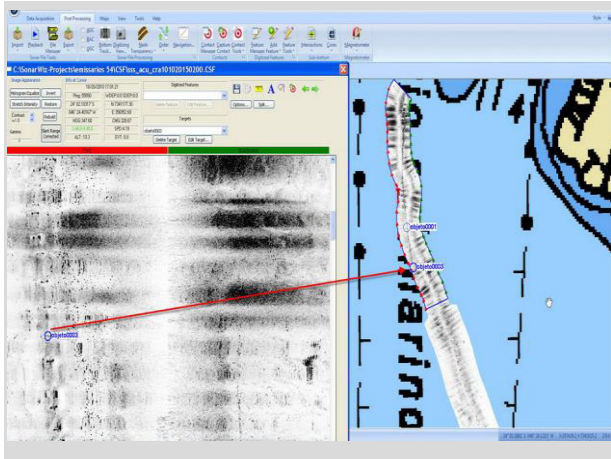
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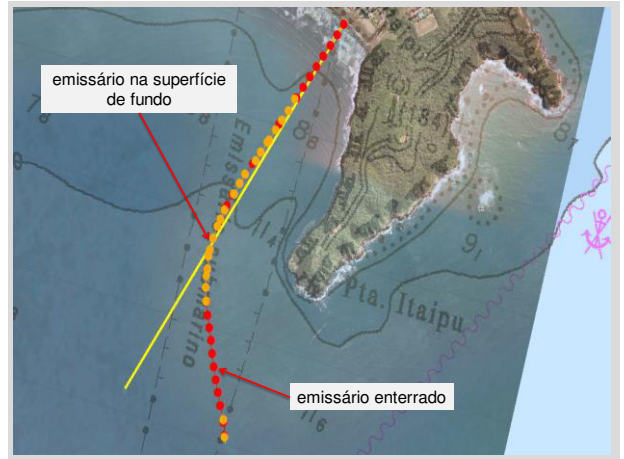
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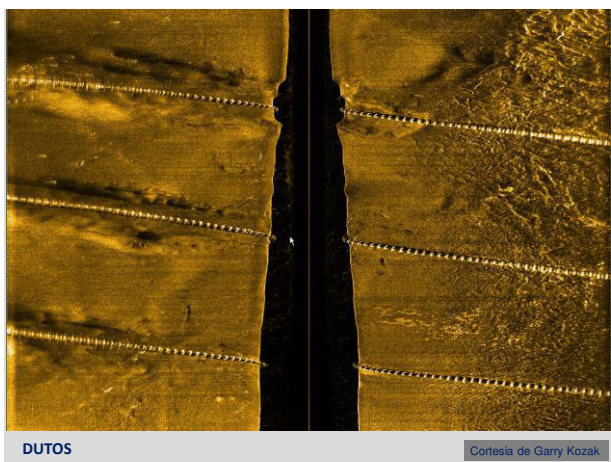
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165



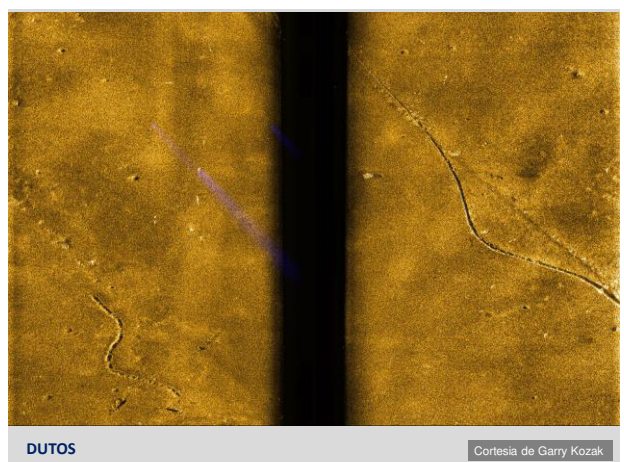
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DUTOS

Cortesia de Garry Kozak

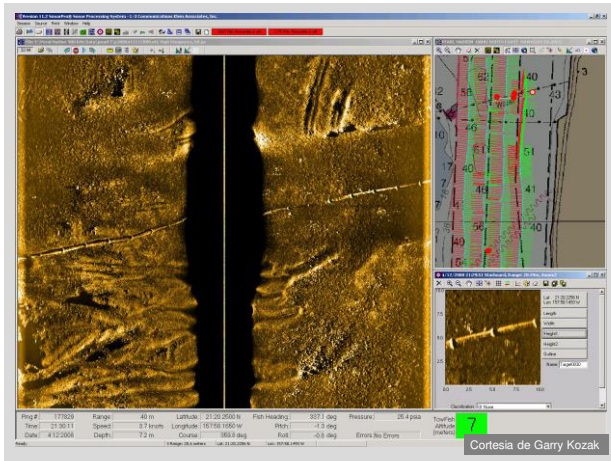
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DUTOS

Cortesia de Garry Kozak

168



169

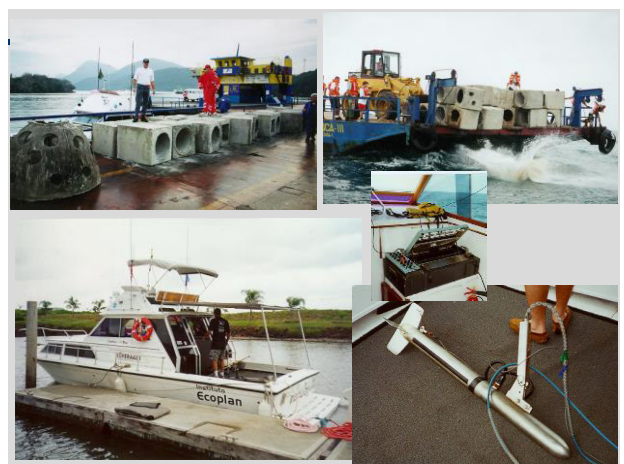


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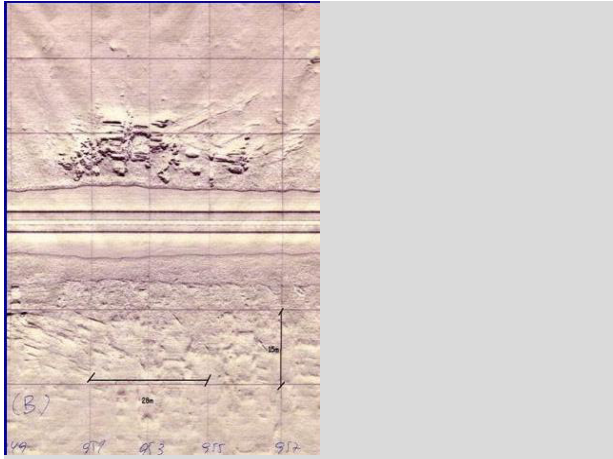
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Projeto IPT - Ecoplan

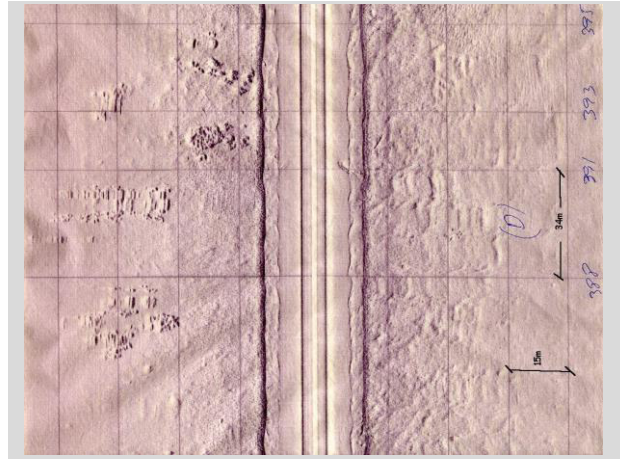
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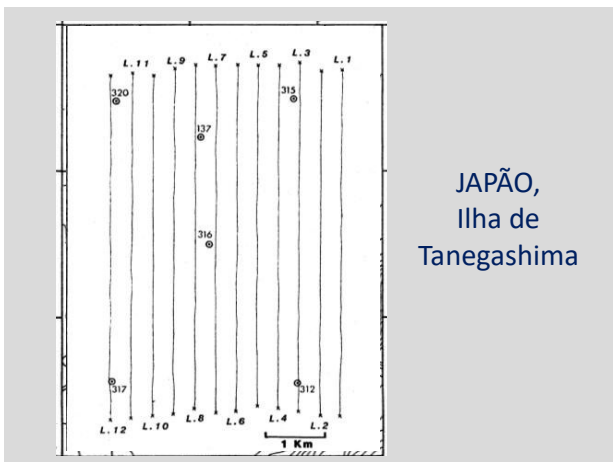
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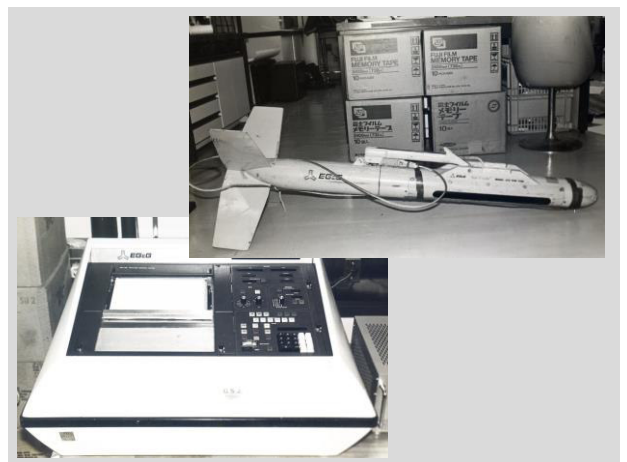


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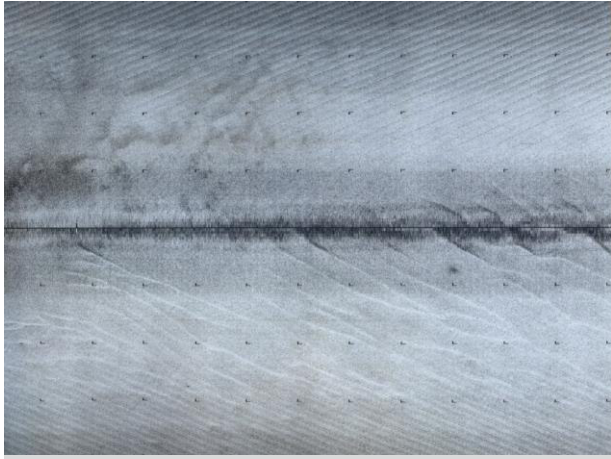


JAPÃO,  
Ilha de  
Tanegashima

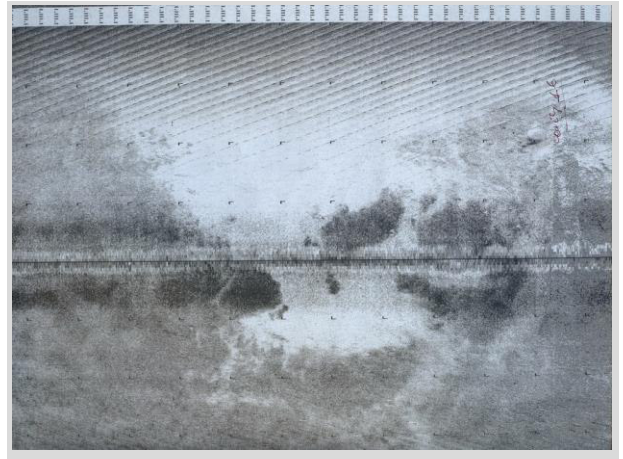
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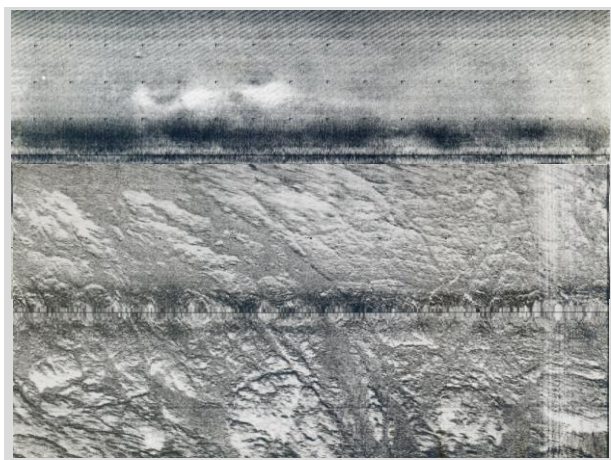
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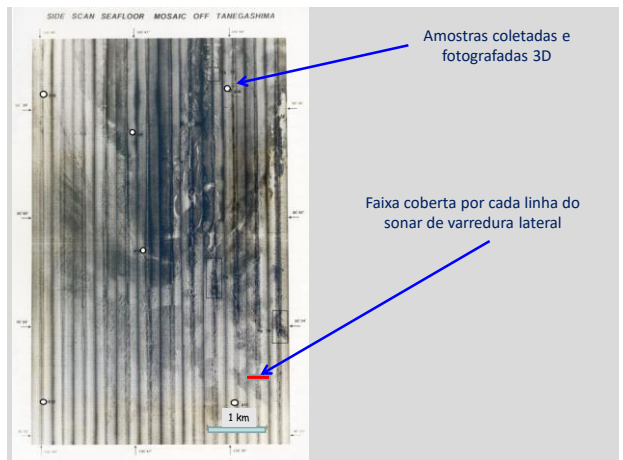
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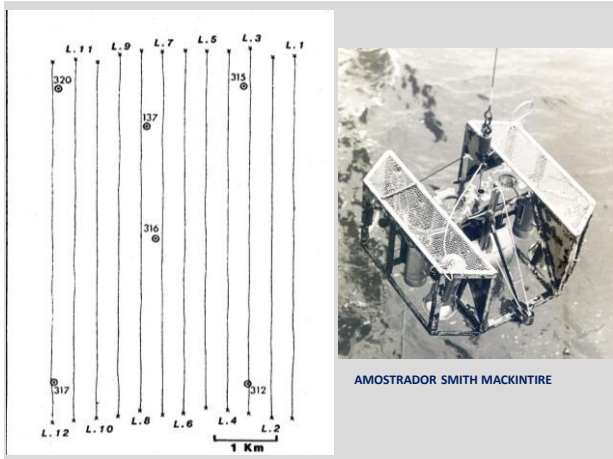
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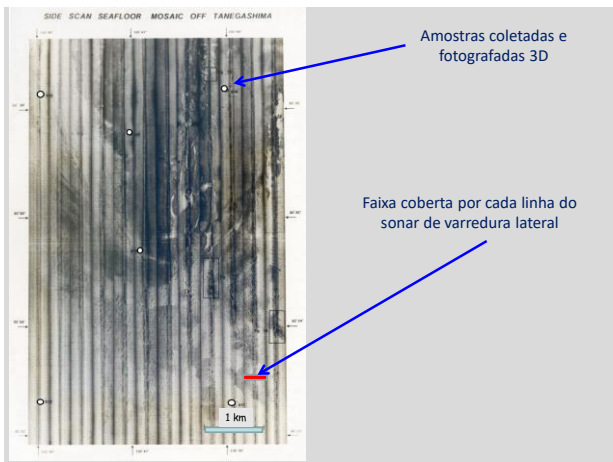
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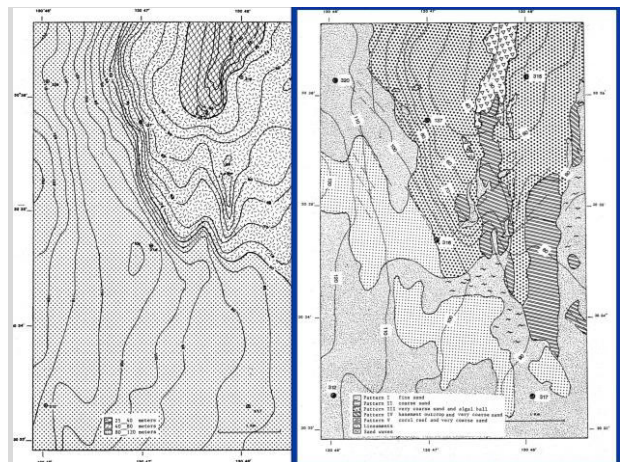
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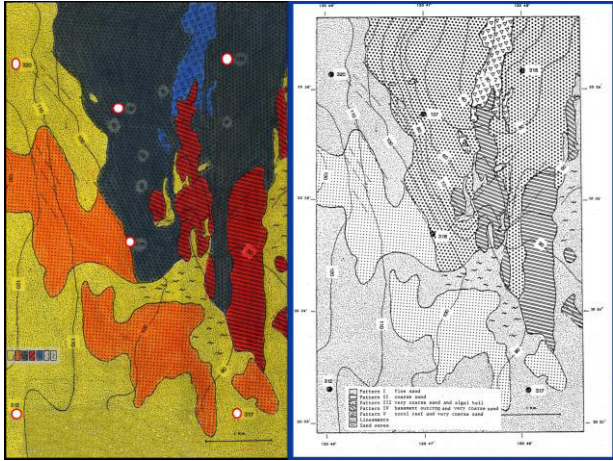
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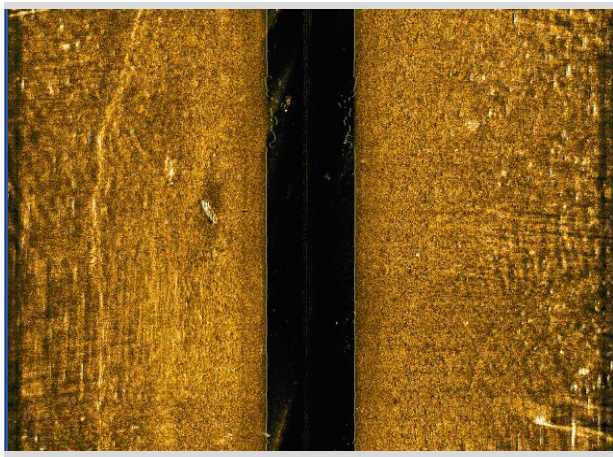
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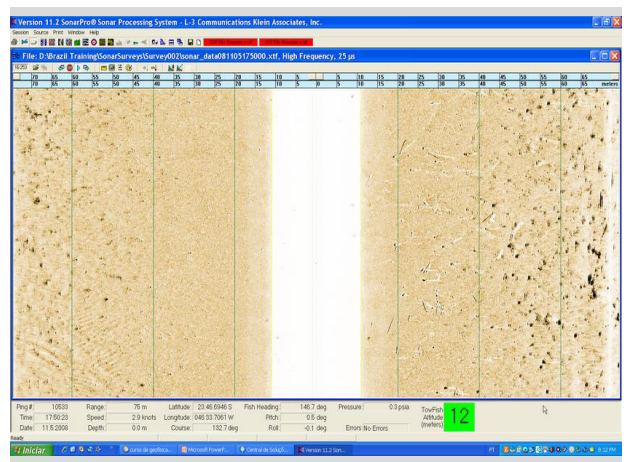
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## Reservatório Billings, SP

186

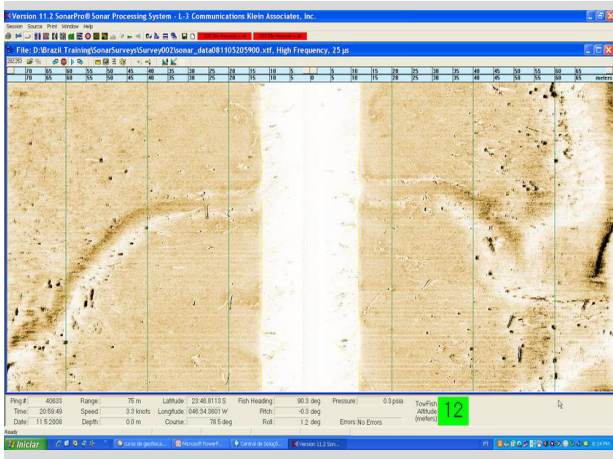


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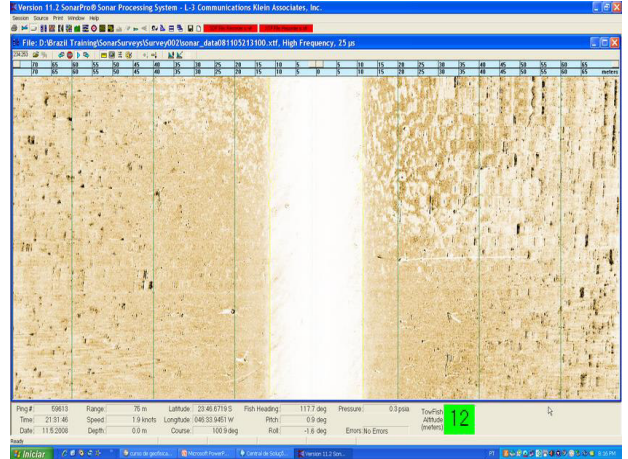


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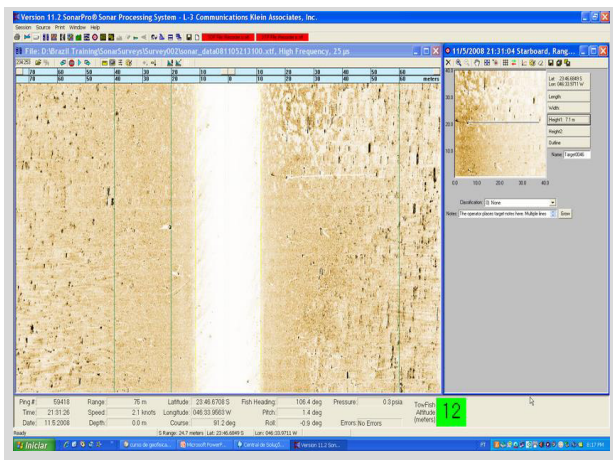




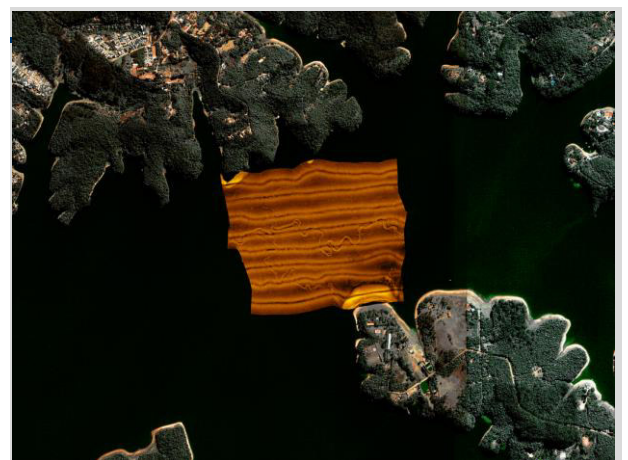
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194



195



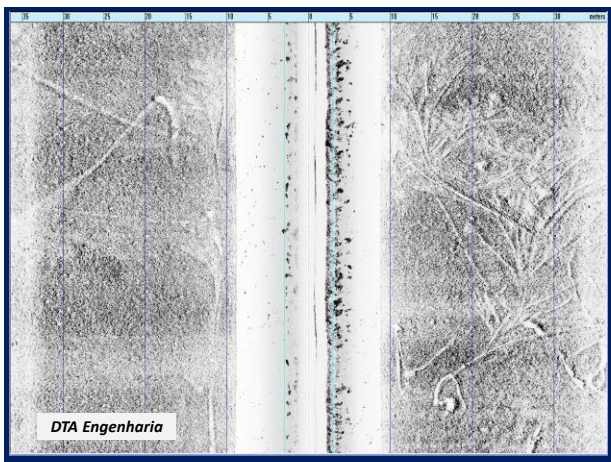
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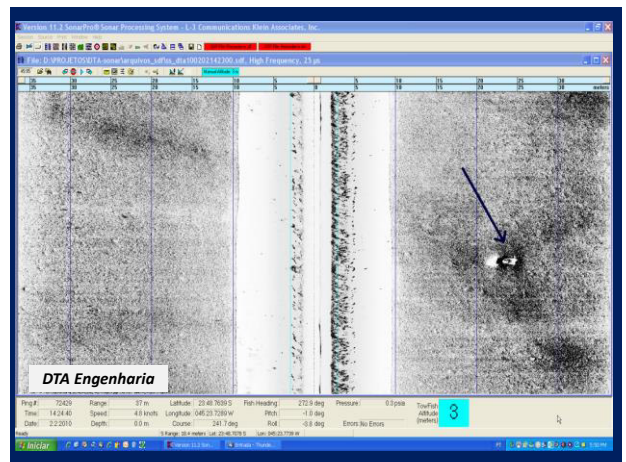
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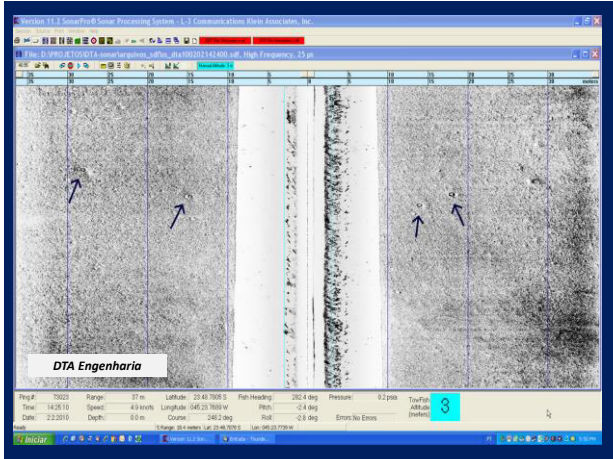
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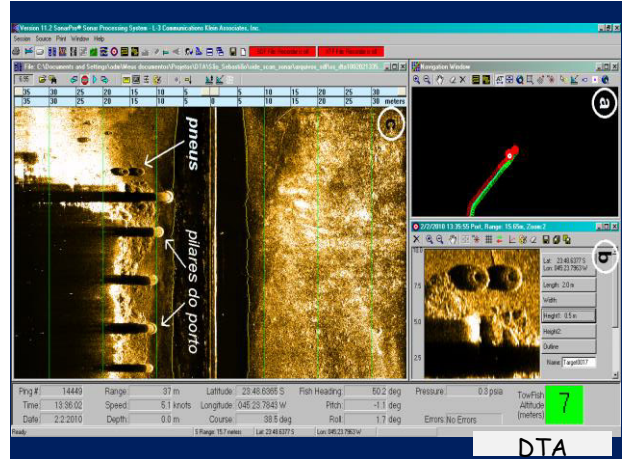
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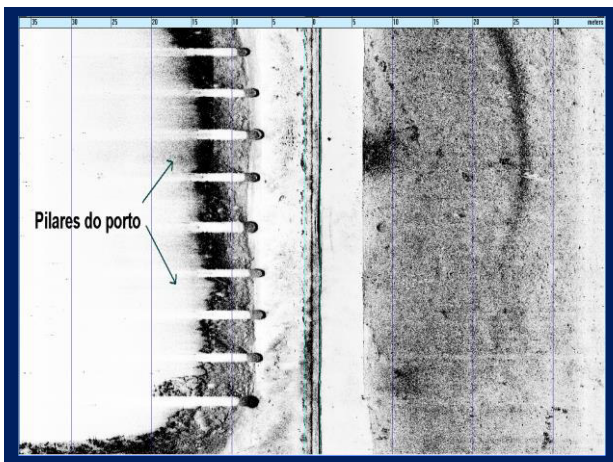
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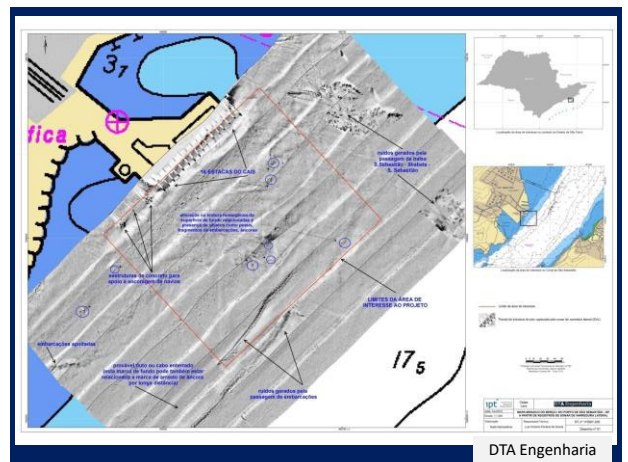
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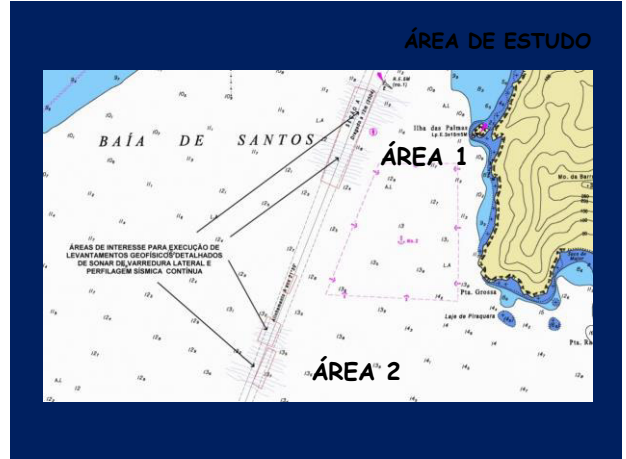
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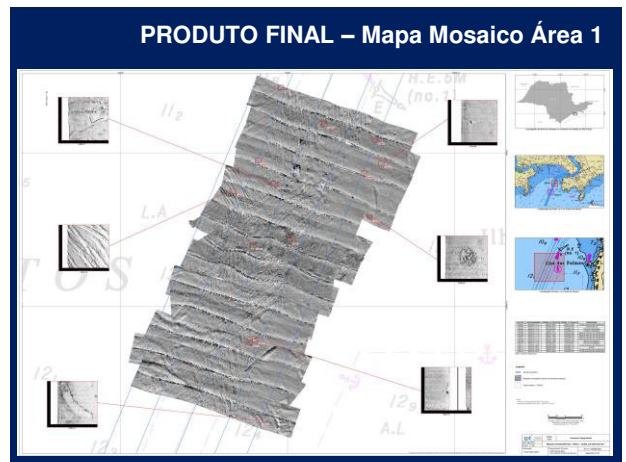


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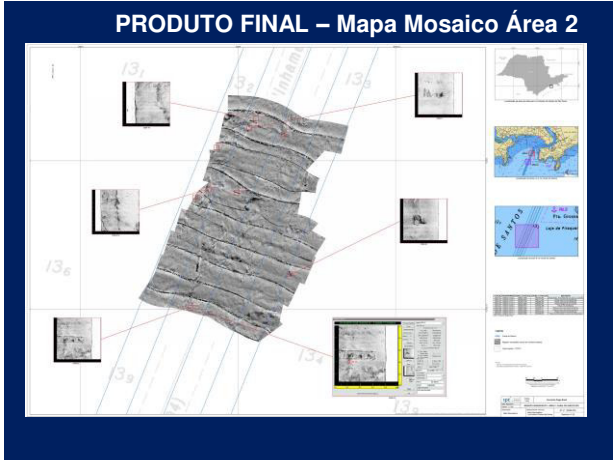
Mapear as características do assoalho marinho (fundo e subfundo) com relação às interferências ao processo de dragagem do canal.

**DRAGA BBVSIL** | **ipt**

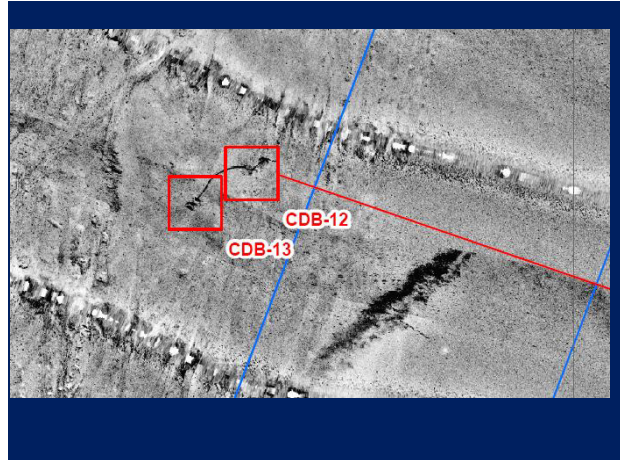
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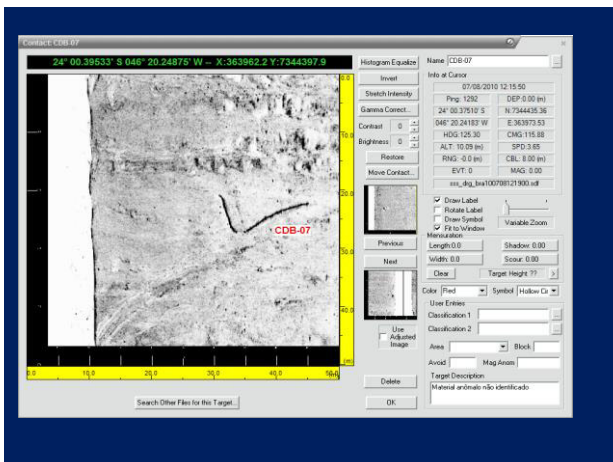
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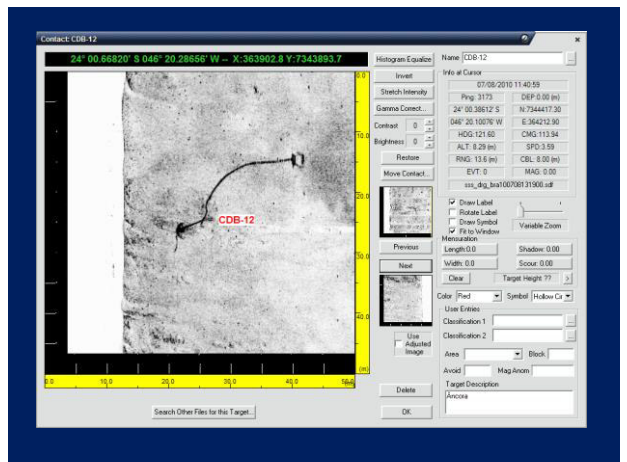
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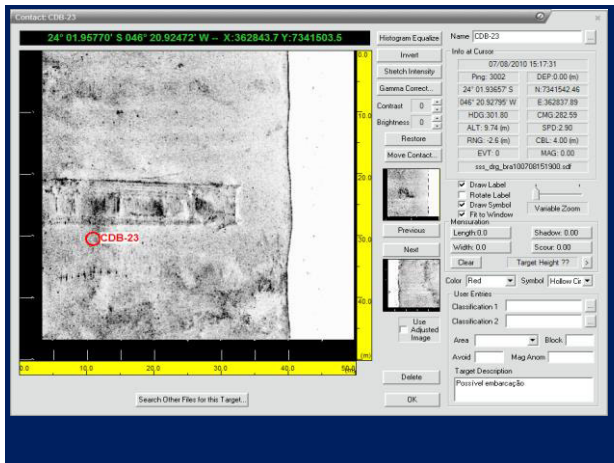
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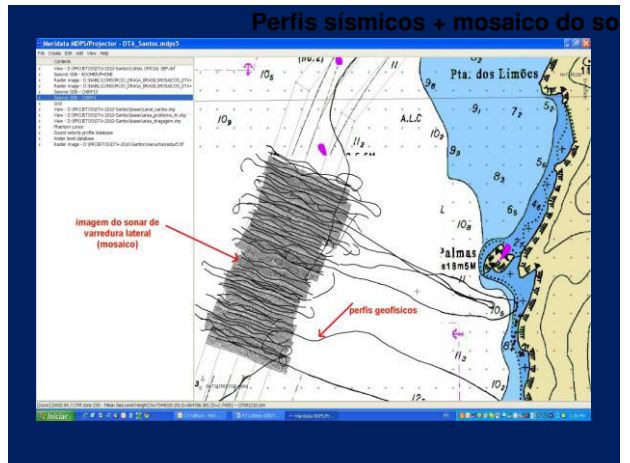
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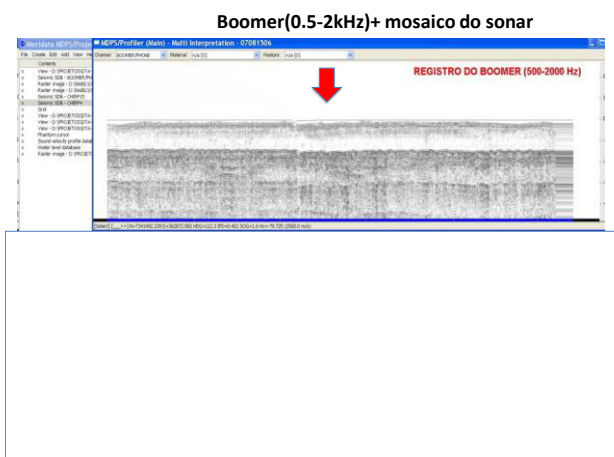
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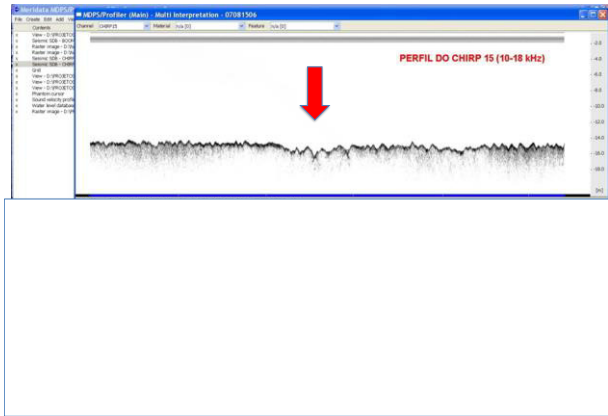


215



216

Chirp (10-18kHz)+ mosaico do sonar



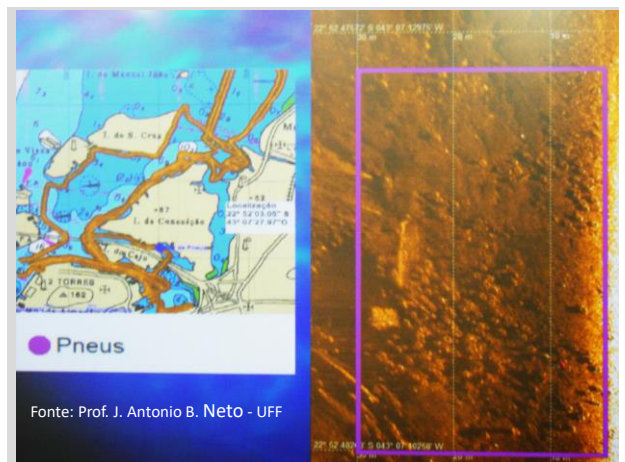
217

# MAPEAMENTO DE LIXO

218



219



220



# MANCHAS DE ÓLEO

Mapeamento com o Sonar de Varredura Lateral

221

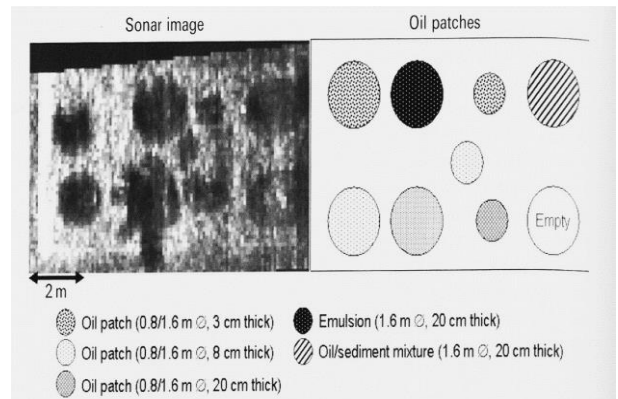
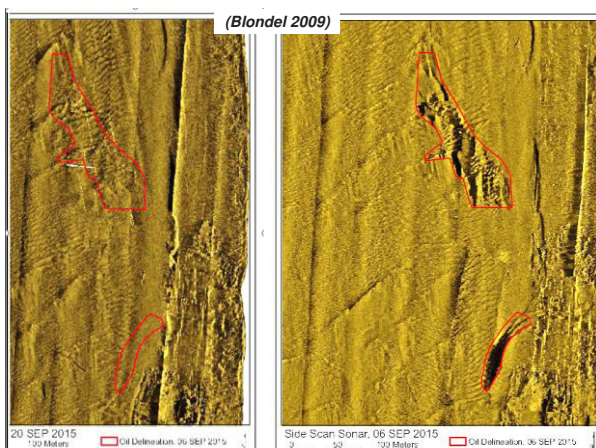


Imagem do sonar de varredura lateral de alta resolução mostrando alterações texturais da superfície de fundo devida a ocorrência de vazamento de óleo. (Blondel 2009).

222



223

Interpall 2004  
Presentation no. 465

#### Sonar detection and monitoring of sunken heavy fuel oil on the seafloor

F. Partiaot, E. de Nanteuil, F. Merin, B. Zerr, Y. Guedel, X. Lartour, J.-M. Augustin, P. Cervinka, J. Marchal, J.P. Sessarego, R. K.Hansen

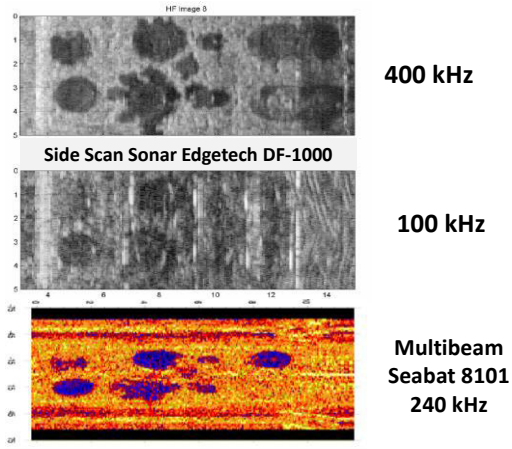
Cedre, rue Alain Colas, CS 41836  
29218 Brest Cedex 2 (France)  
francois.partiaot@le-cedre.fr

#### Abstract

The oil products transported at sea that have the potential to become suspended in the water column and sink after weathering or mixing with sediment are quite numerous: asphalt, carbon black-oil, bunker C, fuel oil n°5 and 6. In many accidents and accidents part of the spilled heavy oil product has actually sunk and has been difficult to track because of the lack of means of detection. To compensate this gap, a comprehensive sonar experiment has been performed through the use of a large seawater tank on the bottom of which several patches of three different heavy fuel oils have been laid on top of a sandy layer. In this facility several kinds of sonar have been tested as for their response according to their frequency, resolution and type (side scan sonar, multibeam/panoramic sonar, 3D acoustic camera).

The results proved to be very valuable according to the acoustic specificity of the products involved. Indeed the acoustic properties are similar to those of the seawater when considering density and sound speed, however the attenuation is much more important and its variation has been measured from 100 kHz to 500 kHz preliminary to the testing. The results of the sonar experiment that have been obtained do confirm the capability of current sonars to detect heavy oil patches over sand seafloors, and should make it possible to select the most adequate survey strategy according to the oil patches dimensions and thickness and to the environmental conditions.

224

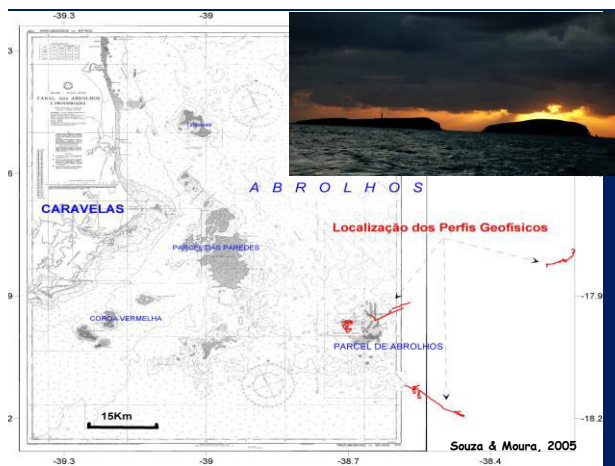


225

# Abrolhos Ba

Projeto IPT- CI Conservation International

226



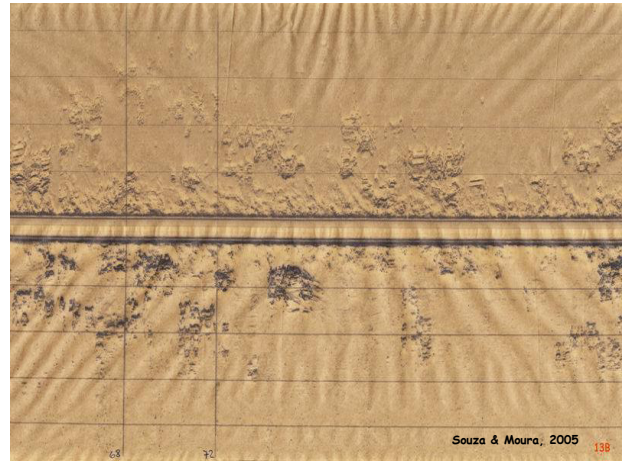
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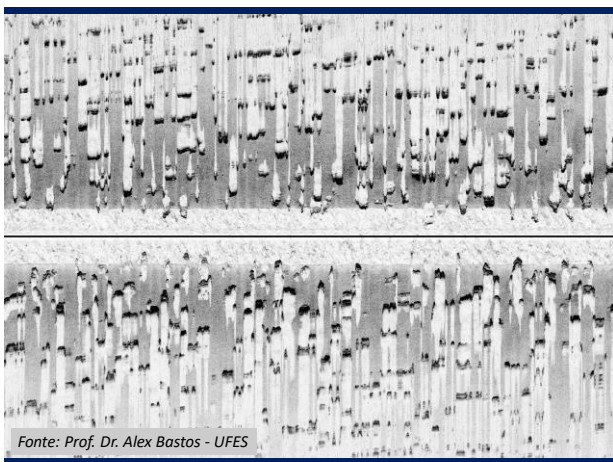
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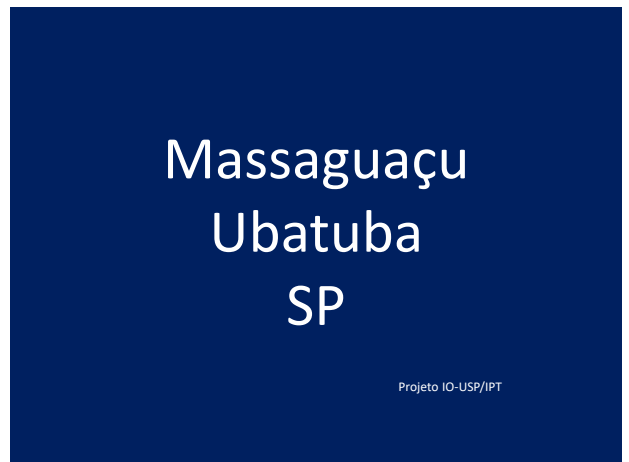
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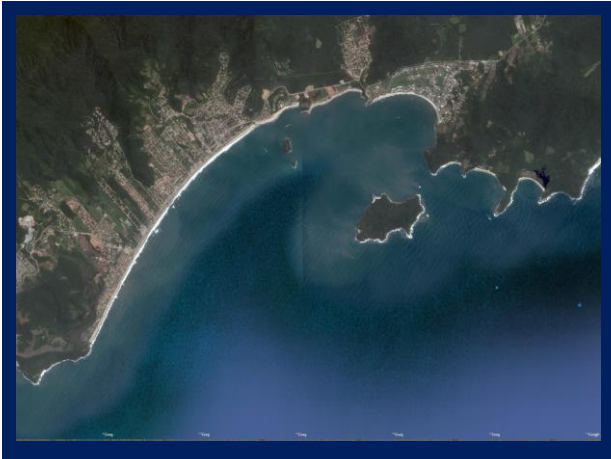
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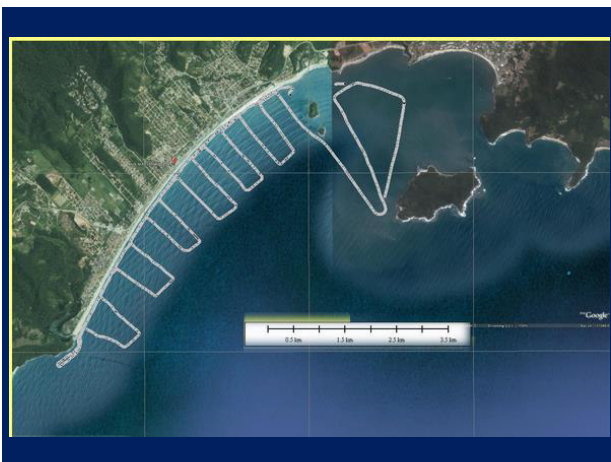
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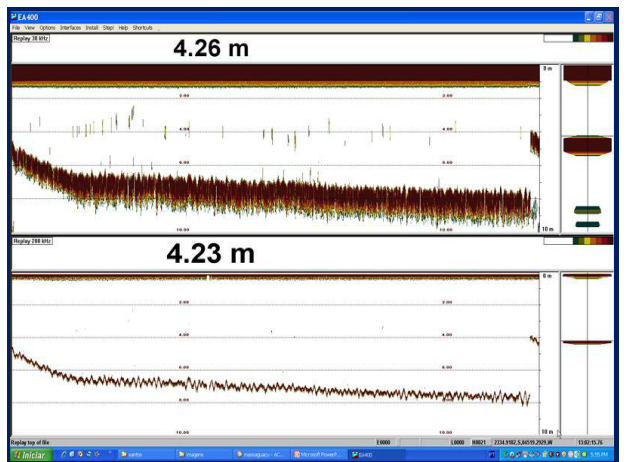
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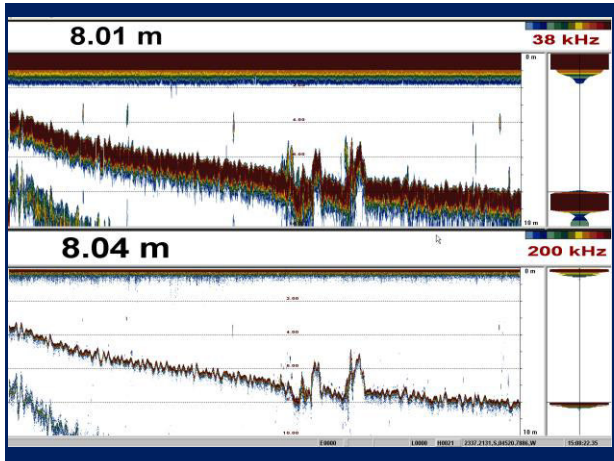
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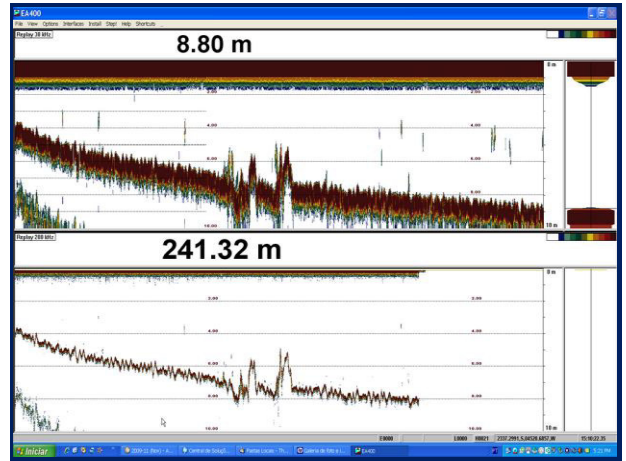
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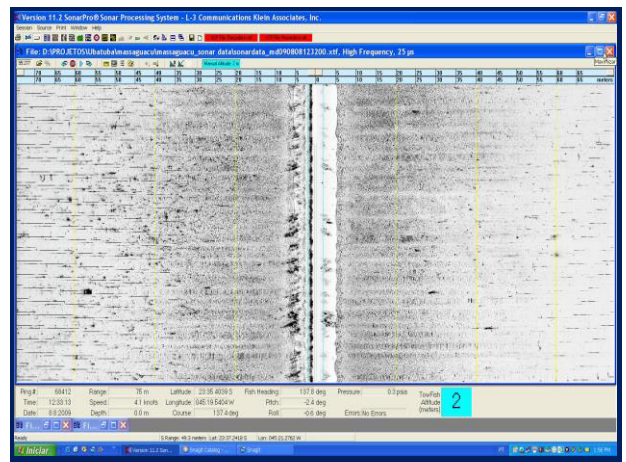
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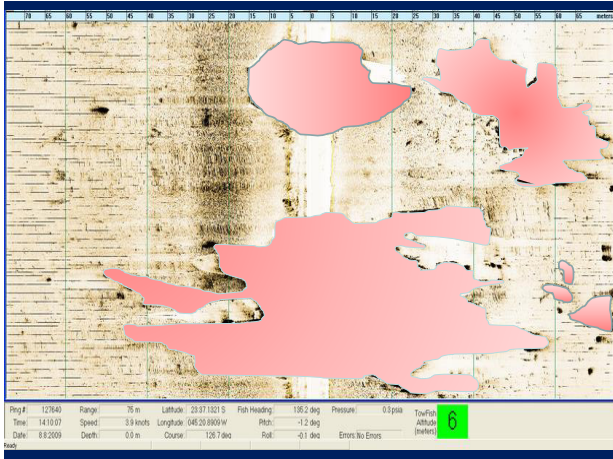
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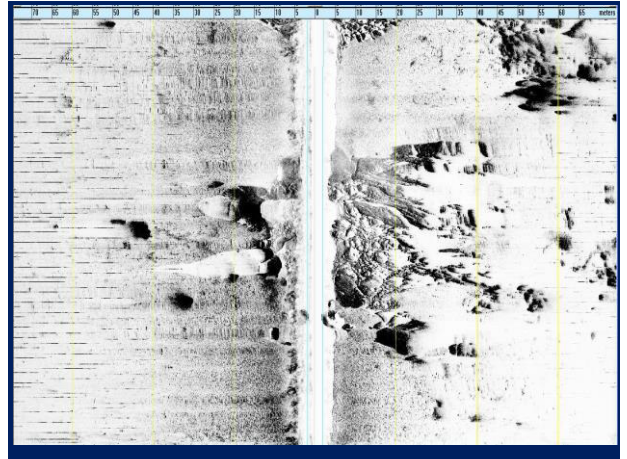
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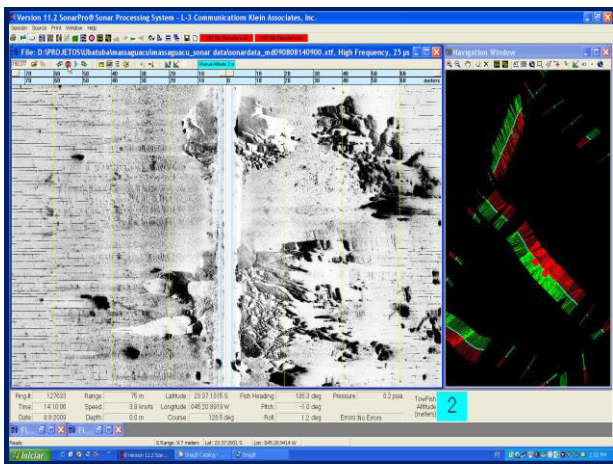
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242



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244



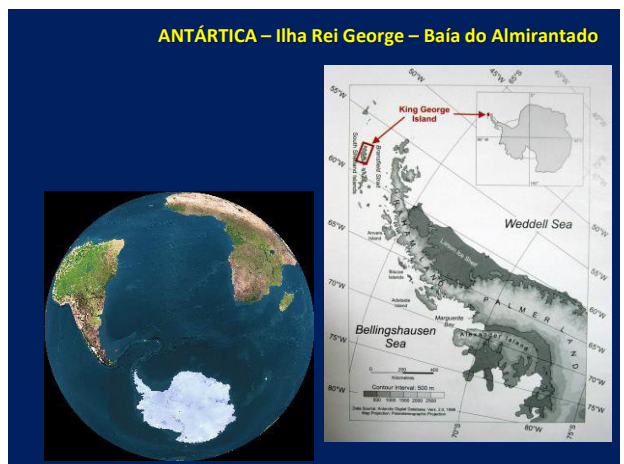
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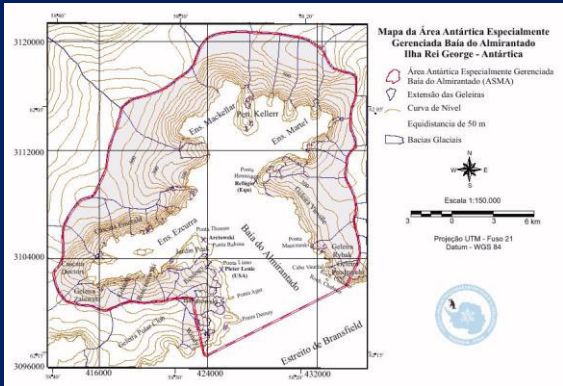


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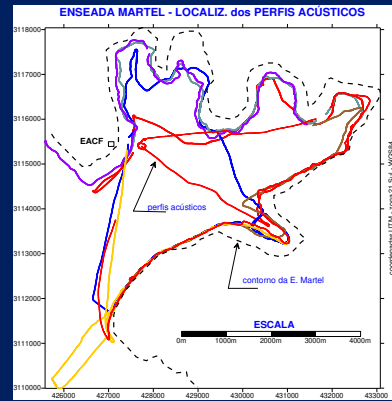
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**BAÍA DO ALMIRANTADO – ILHA REI GEORGE**



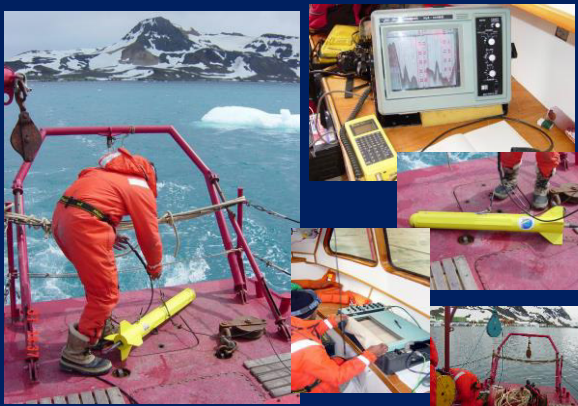
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**SONAR DE VARREDURA LATERAL – Enseada Martel**



250

**SONAR DE VARREDURA LATERAL – I. REI GEORGE – DEZ 2002**



251

**SKUA – EMBARCAÇÃO DE APOIO DA EACF**

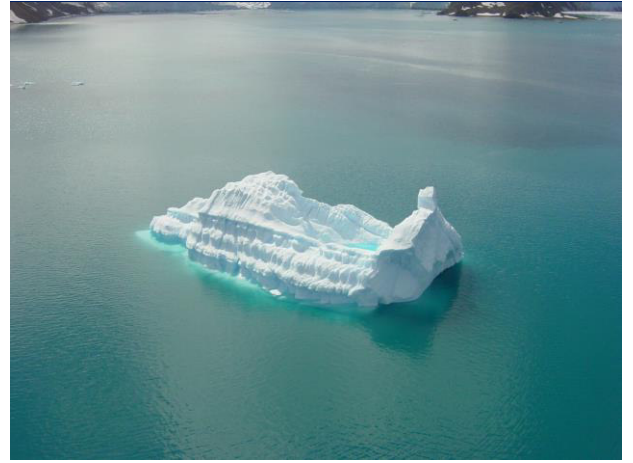


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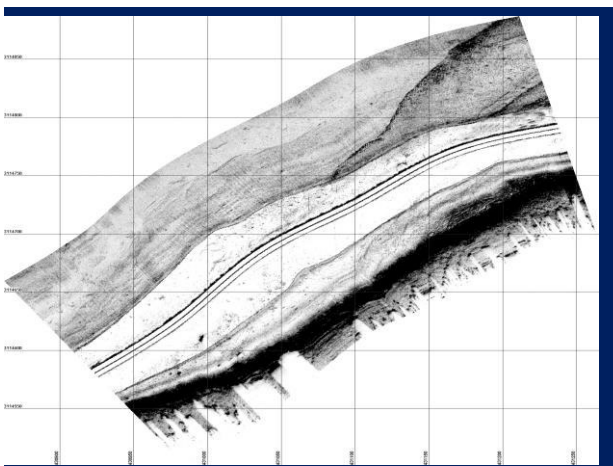




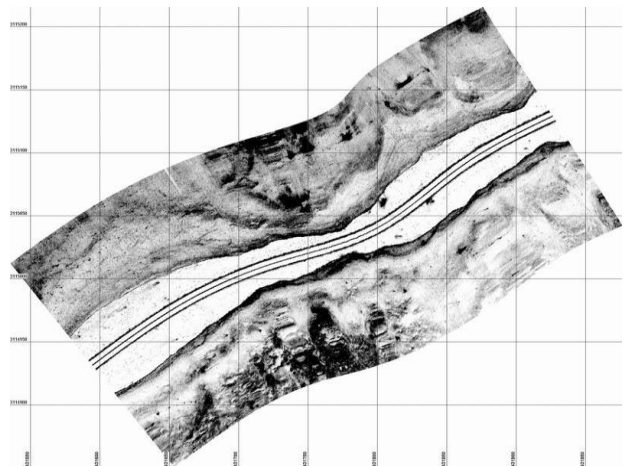
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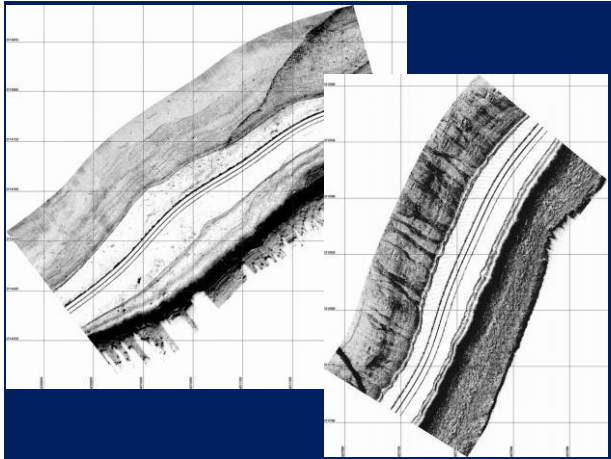
254



255



256



257



258



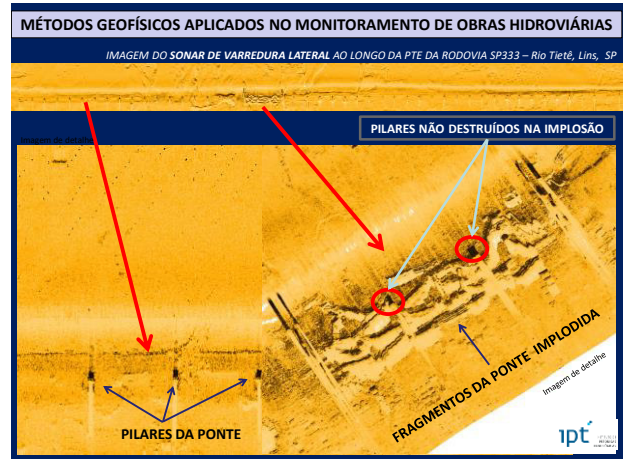
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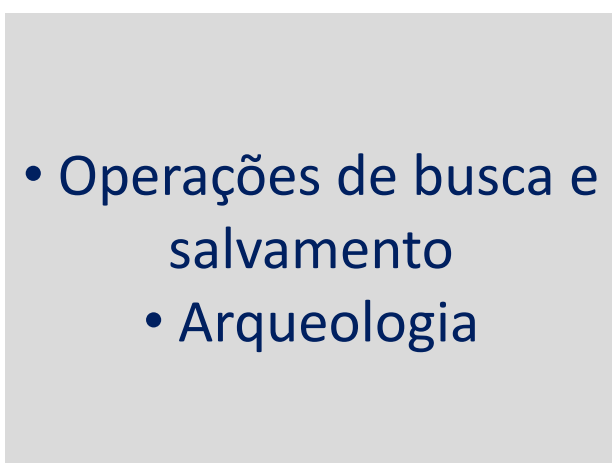
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261



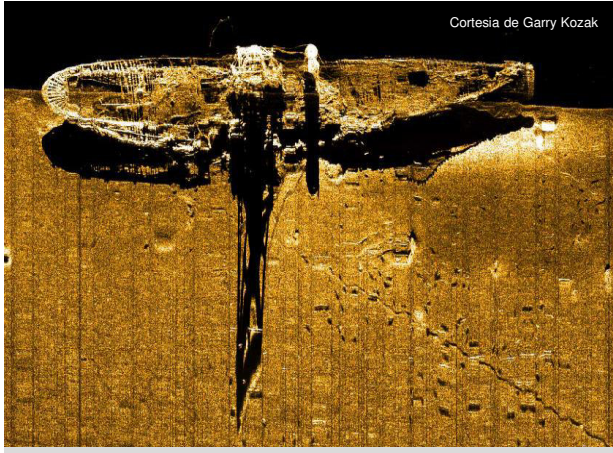
262



263

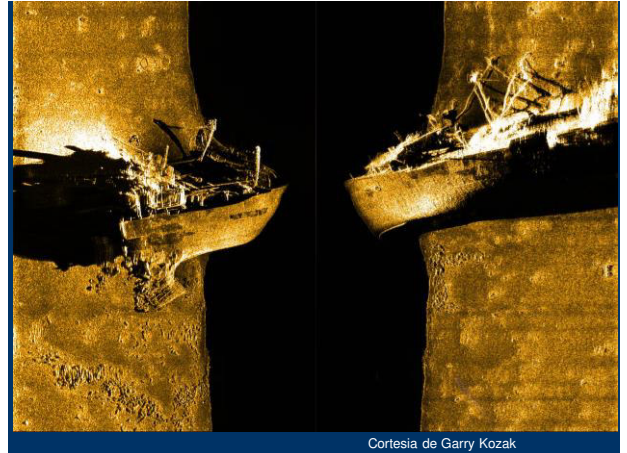


264



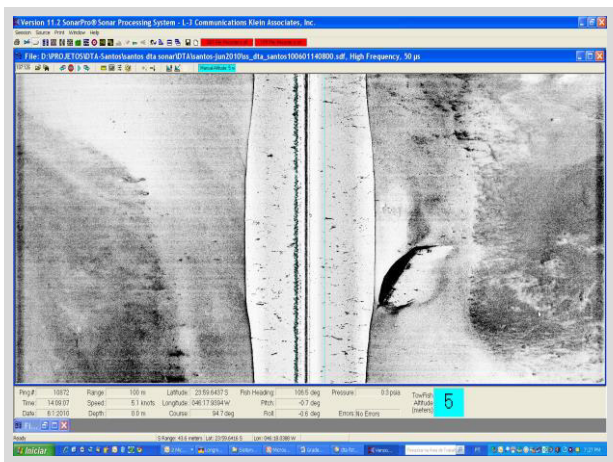
Cortesia de Garry Kozak

265

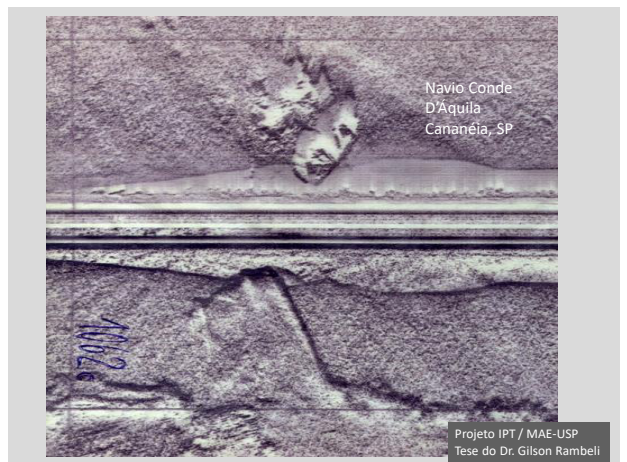


Cortesia de Garry Kozak

266



267



Navio Conde D'Aquila, Cananéia, SP

Projeto IPT / MAE-USP  
Tese do Dr. Gilson Rambeli

268



269



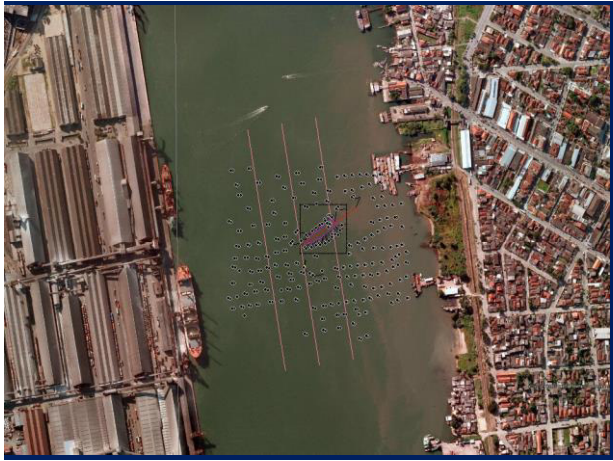
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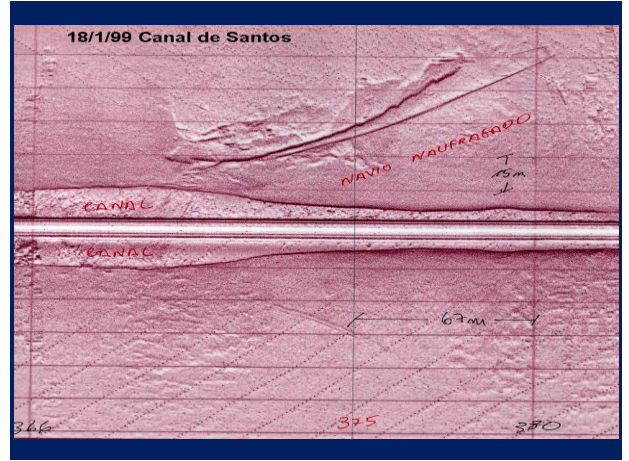
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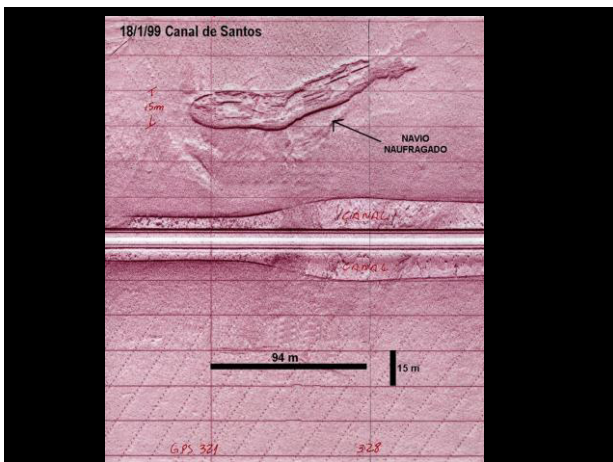
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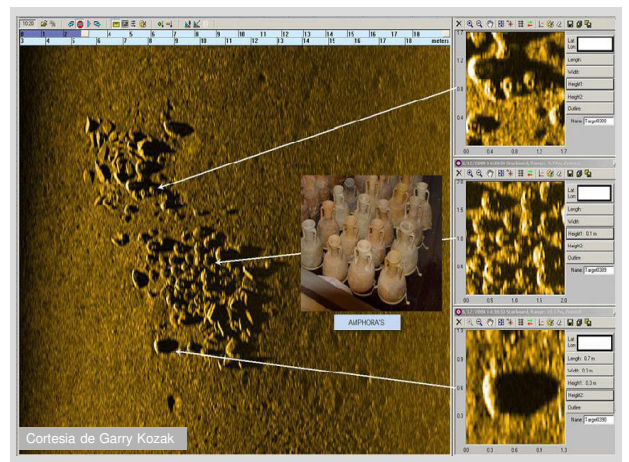
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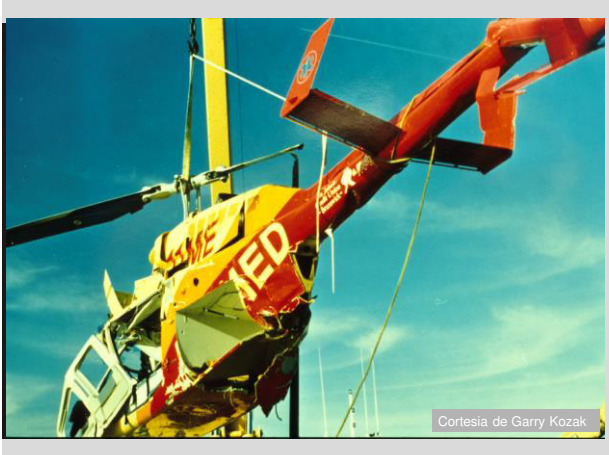
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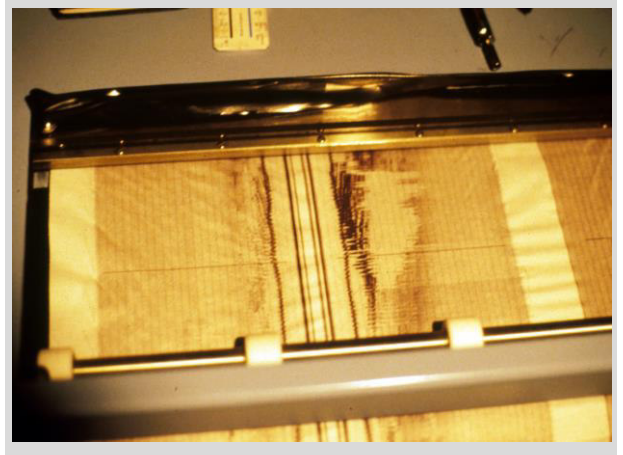
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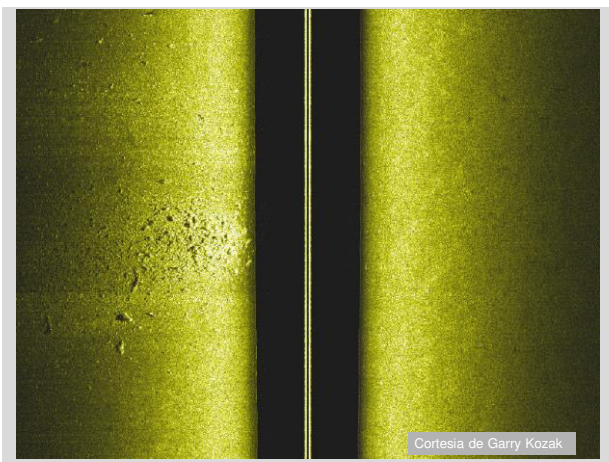
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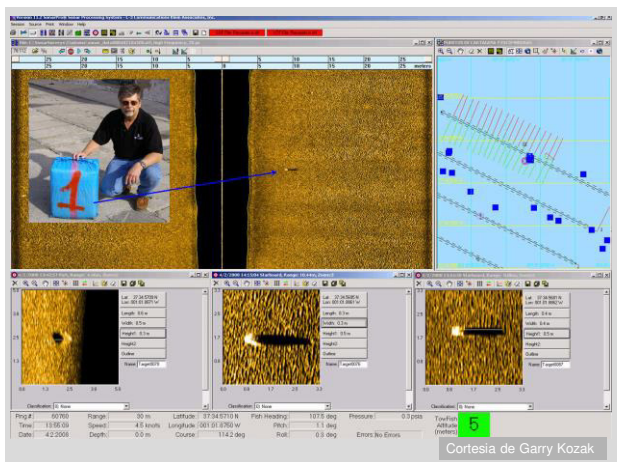
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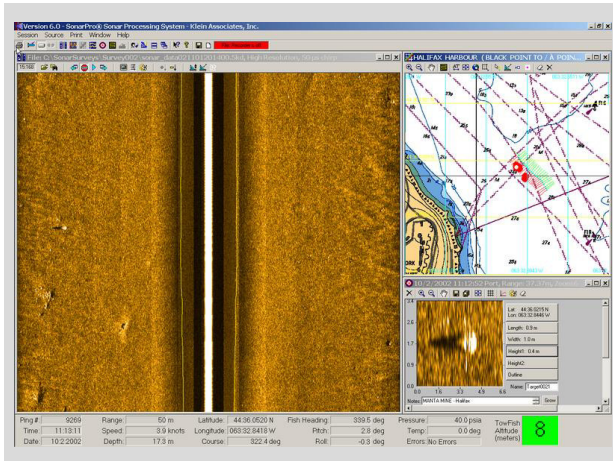
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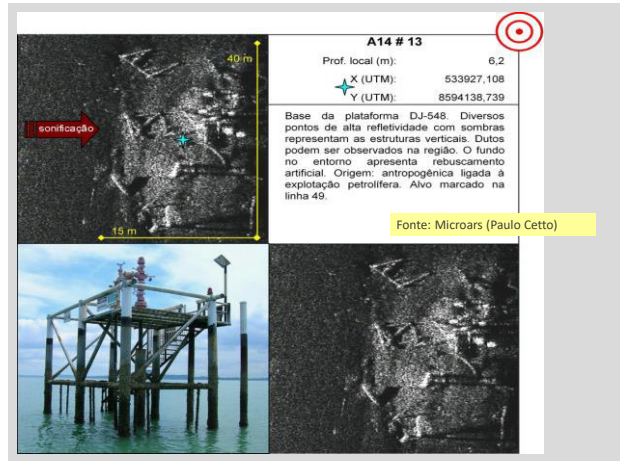
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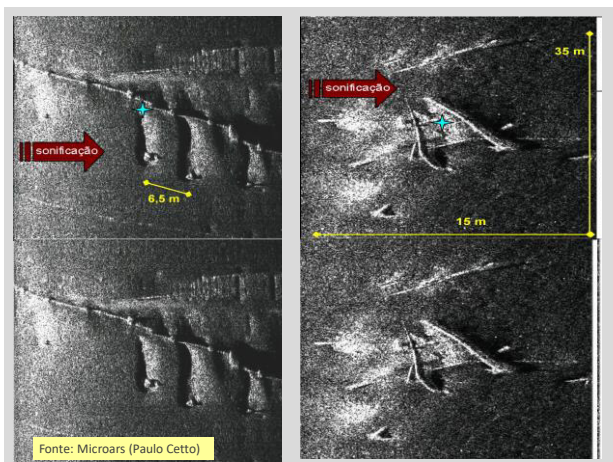
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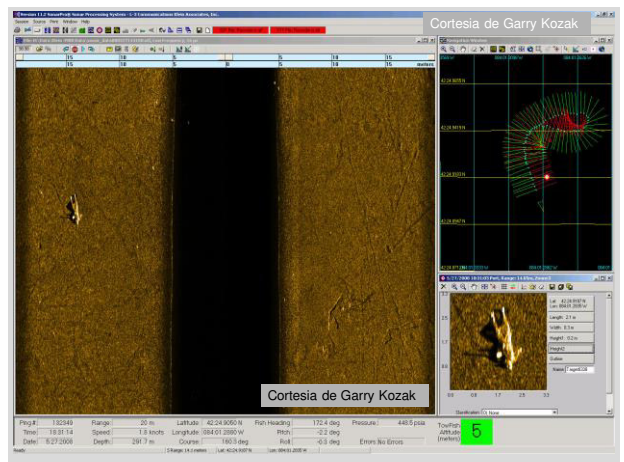
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282

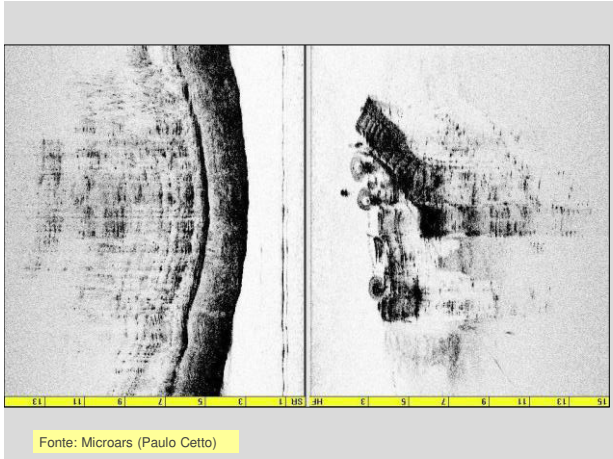


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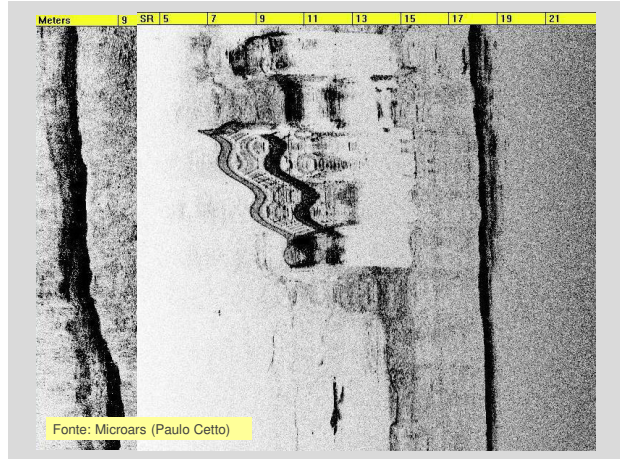


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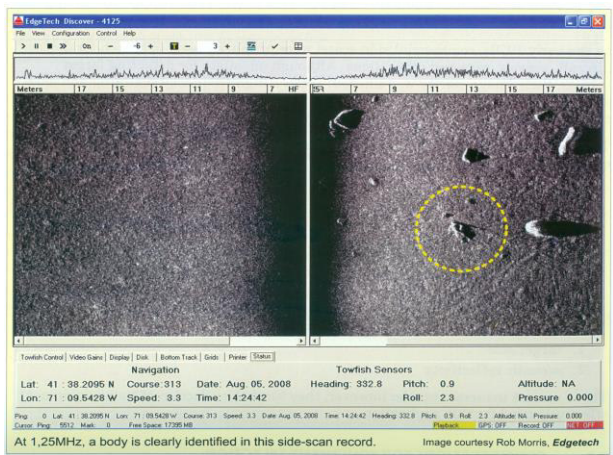




285



286



287



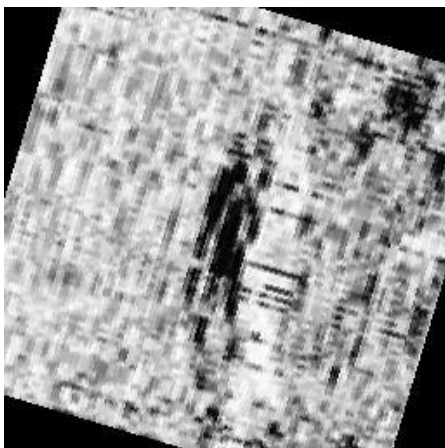
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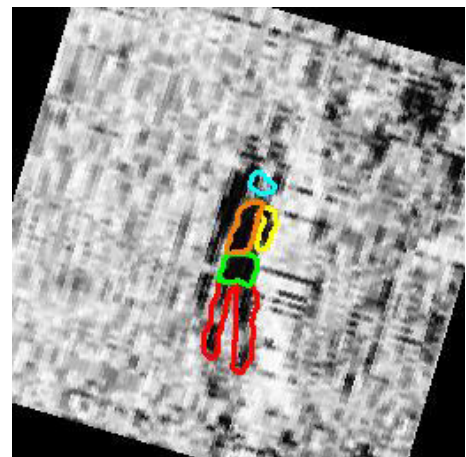
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290



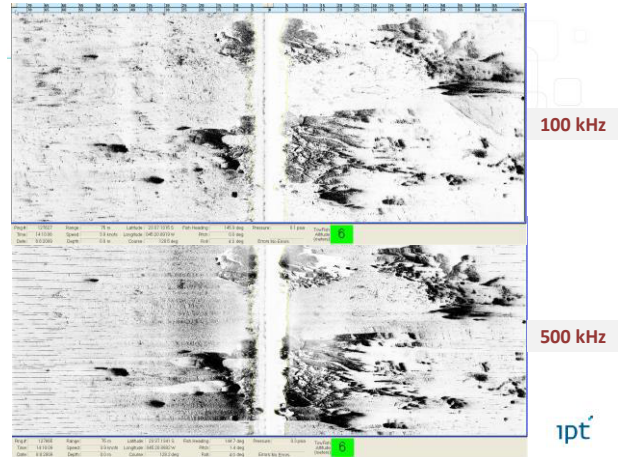
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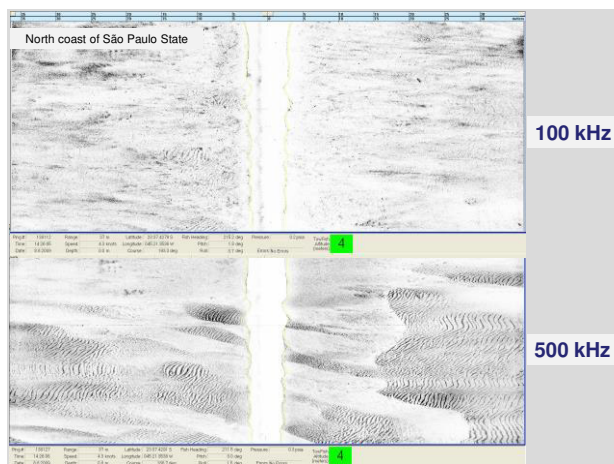
292

**QUAL A MELHOR  
FREQUÊNCIA PARA O SONAR  
DE VARREDURA LATERAL?**

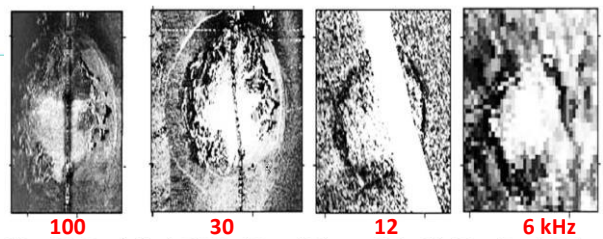
293



294



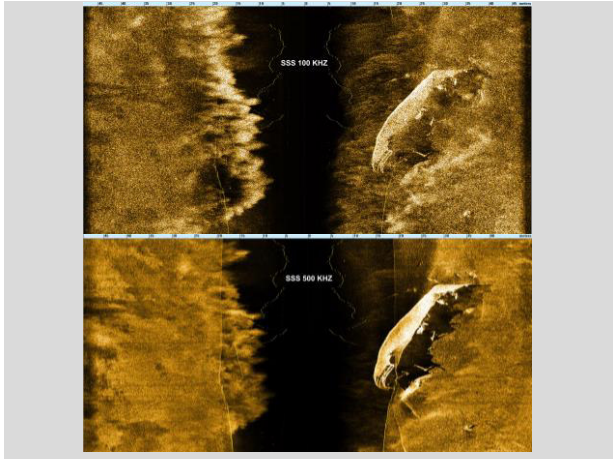
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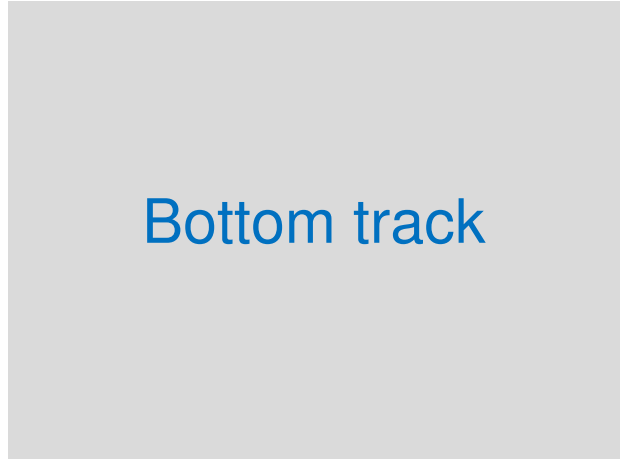
**Figure 2.11.** Compiled by the U.S. Naval Research Laboratory for its Global Ocean Mapping Project, this image shows the Hákon Mosby mud volcano (Barents Sea) imaged at decreasing frequencies: 100 kHz, 30 kHz, 12 kHz, and 6 kHz (left to right). High backscatter levels are bright, and the middle bands in the first three images correspond to the nadir of the sonar. The volcano is nearly 1 km in diameter. Both its size and its details get obscured as the frequency (and therefore the spatial resolution) decrease (adapted from an NRL 7420 graphic; Vogt and Gardner, 2001).

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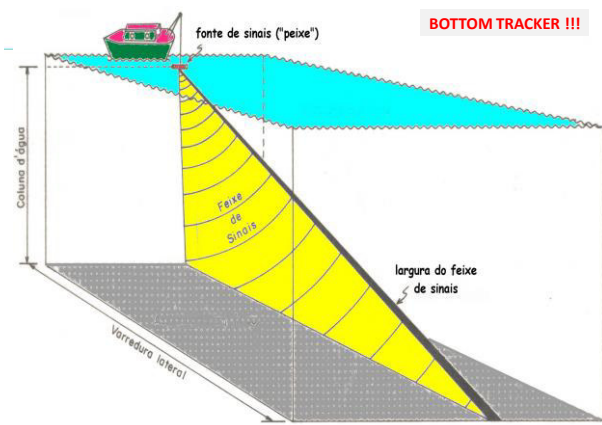




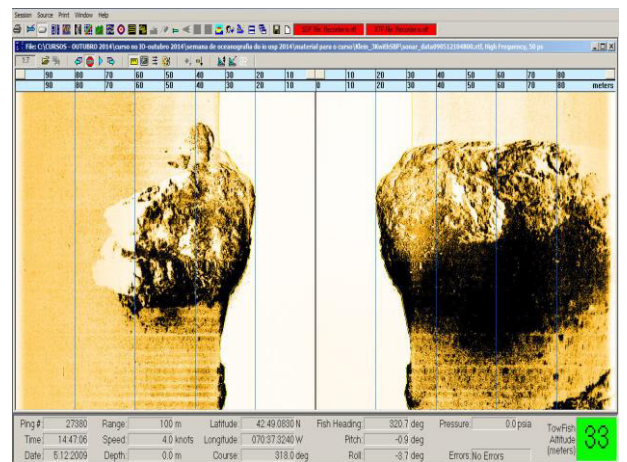
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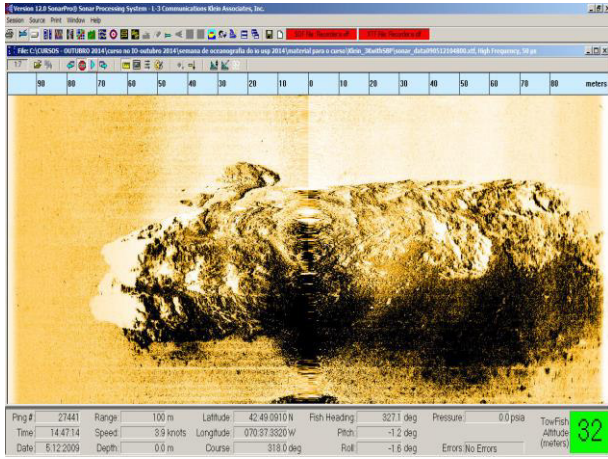
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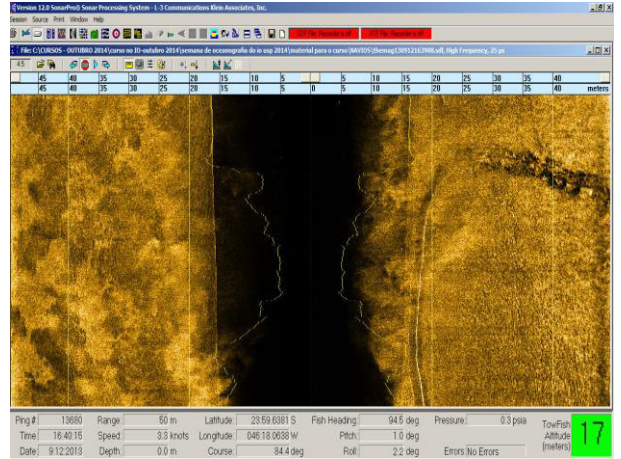
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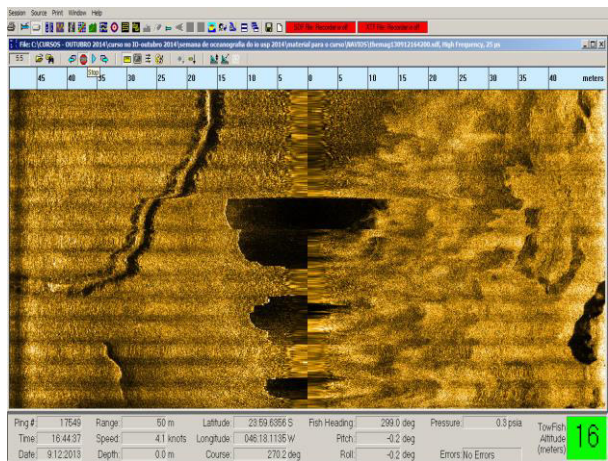
300



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302



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## SIDE SCAN SONAR

**A escolha da frequência adequada:**

- ❖ 100 kHz → mapeamento de grandes áreas
- ❖ 300 kHz → resolution
- ❖ > 900 kHz → very high resolution

★ REAL-TIME DUAL FREQUENCY

★ MOSAICO EM TEMPO REAL

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## AVANÇOS TECNOLÓGICOS NO IMAGEAMENTO DE SUPERFÍCIES SUBMERSAS

- SISTEMAS MULTIFASE: BATIMETRIA + SONAR DE VARREDURA LATERAL
  - MULTIPULSO
  - TRI-FREQUENCIAS
  - GAP FILLER
- SISTEMAS AUTÔNOMOS

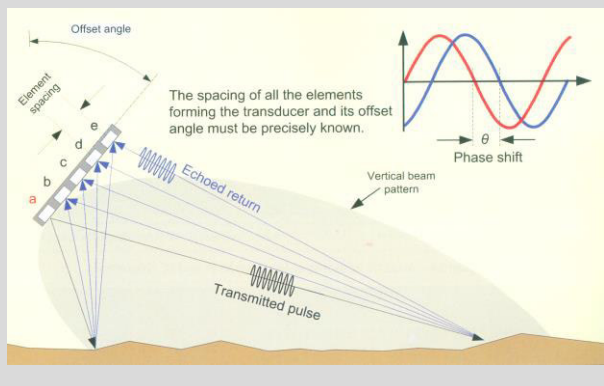
305



Cedido por Garry Kozak

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## INTERFEROMETRIA / MULTIFASE



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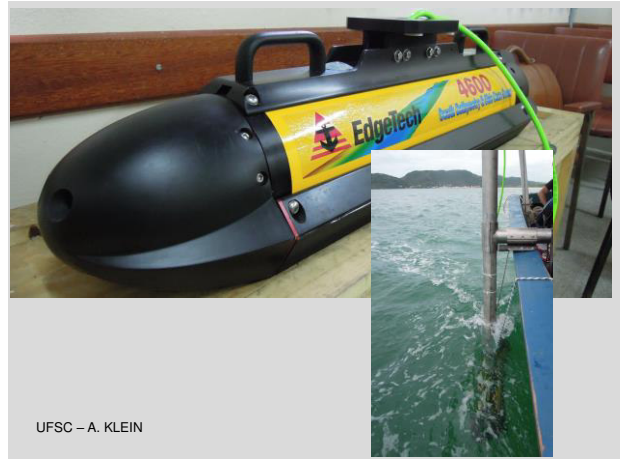
INTERFEROMETRIA + SONAR

IMAGENS CEDIAS PELA EDGE TECH

308



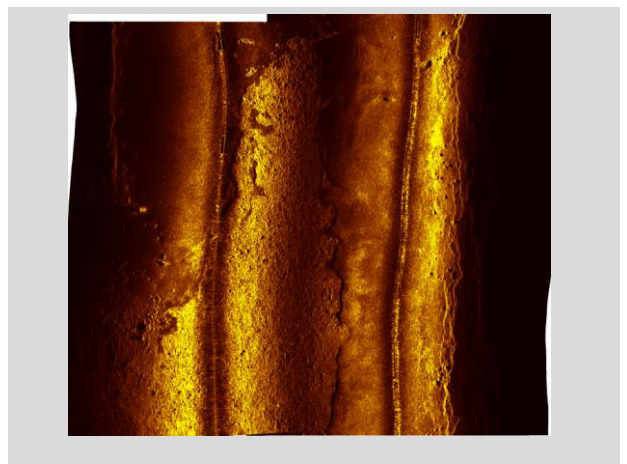
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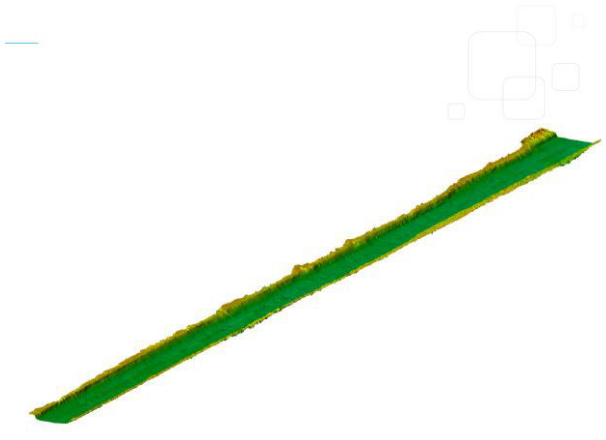
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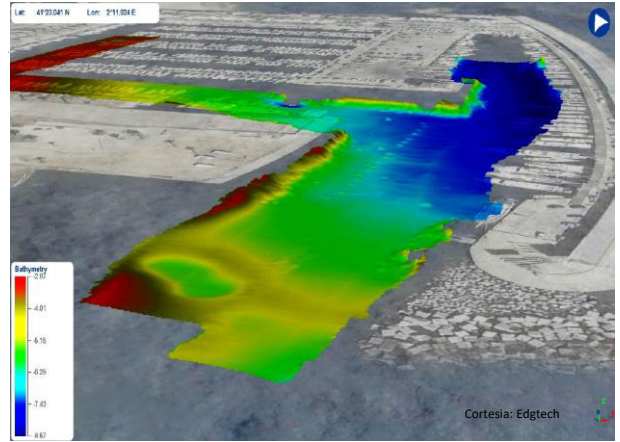
311



312



313



314



EdgeTech 6205

**SONAR DE VARREDURA LATERAL + INTERFEROMETRIA**



Klein 3 Hydrochart 500

315



Edgetech 6205 + Sonarwiz  
Rio de Janeiro – out 2014

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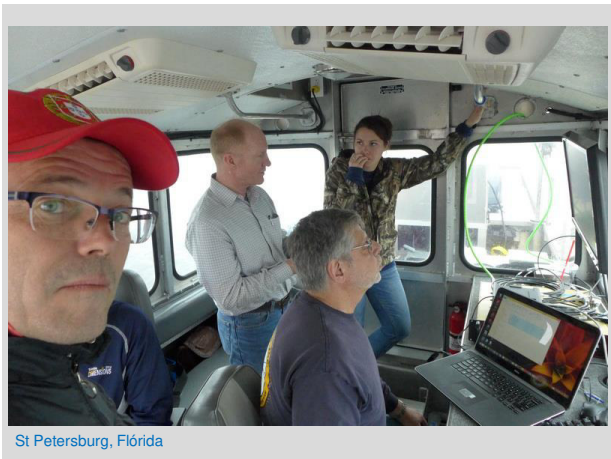


317



St Petersburg, Florida

318



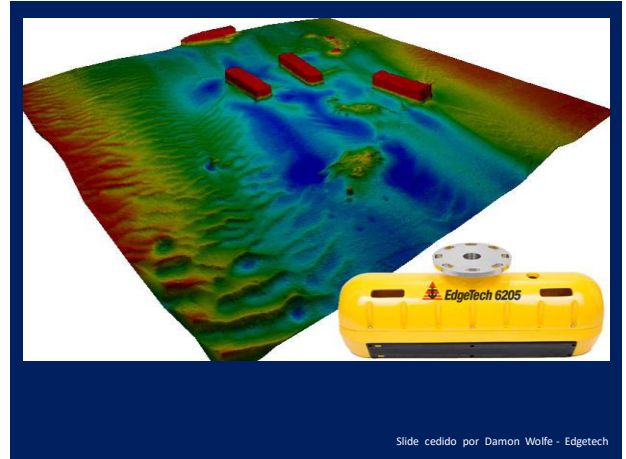
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320



321

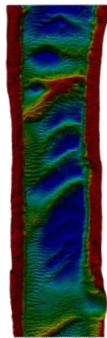
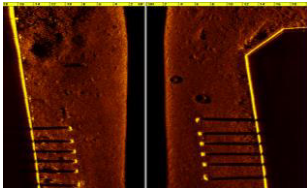


Slide cedido por Damon Wolfe - Edgetech

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### EdgeTech's New MPES Technology

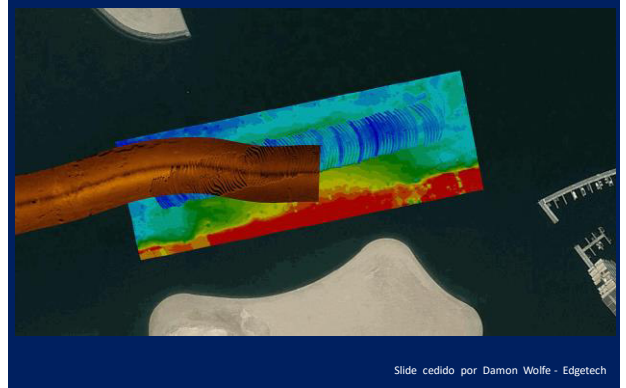
- Multi-Phase Echo Sounder (MPES)
- Cobertura de até 10 x a coluna d'água
- Obedece as especificações da IHO Special Order (9x)
- Abertura superior a 200° (Swath Coverage)
- Registro simultâneo de Sonar de dupla frequência
- Alta resolução
- Superior Integridade e Qualidade dos dados



Slide cedido por Damon Wolfe - Edgetech

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### SONAR DE VARREDURA + BATIMETRIA (INTERFEROMETRIA)



Slide cedido por Damon Wolfe - Edgetech

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**Why MPES?**

- Many MBES Systems on the Market
  - Not Suitable for Shallow Water
    - Limited Swath Angle (Typical 130° or less)
    - No Side Scan Imagery (Limited to Backscatter)
- Typical Interferometry Systems Too Noisy w/ Nadir Gap
  - Efficiency Gains Lost due to Nadir Gap
  - Noisy Data = Lots of Data Cleaning



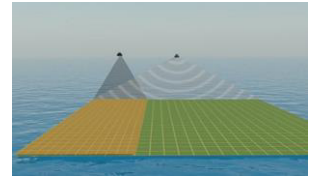
**SURVEYORS NEED SOLUTION FOR SHALLOW WATER SURVEY OPERATIONS!**

Slide cedido por Damon Wolfe - Edgetech

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**System Coverage – Shallow water**

- **Typical Single Head MBES**
  - Multi-Beam Echo Sounder (MBES)
  - Coverage around 3.5 to 4 x water depth
  - Line Spacing typically 3 x water depth
  - Limited to 130° Swath Coverage
- **Typical PDBS**
  - Phase Differencing Bathymetric Sonar
  - Coverage of up to 10 x water depth.
  - Gap at Nadir means full overlap required
  - Line Spacing typically 4 x water depth
  - Noisy Data
- **EdgeTech's New MPES Technology**
  - Multi-Phase Echo Sounder (MPES)
  - Coverage of up to 10 x water depth.
  - IHO Special Order compliant coverage over 9x water depth
  - Over 200° Swath Coverage

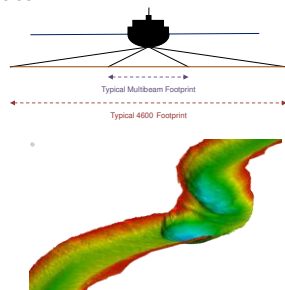


Slide cedido por Damon Wolfe - Edgetech

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**Benefits Summary : MPES Bathymetry**

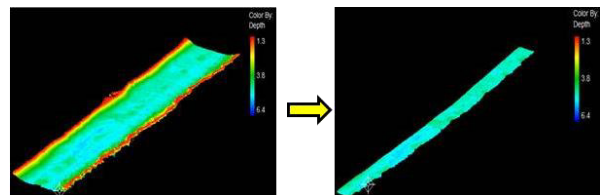
- Swath up to 12 x water depth, and IHO SO to up to 9 x water depth.
- Two Bathymetric frequency Options
  - 230 kHz, longer range
  - 540 kHz, higher resolution
- Better Spatial Resolution than Beam Formers, but without the Nadir gap traditionally associated with Interferometers



Slide cedido por Damon Wolfe - Edgetech

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**MPES vs. MBES**

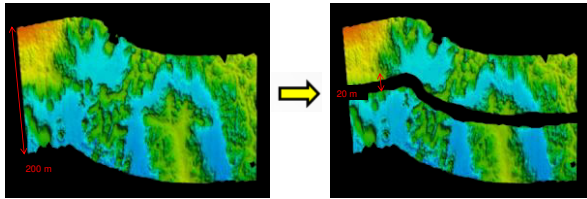


200° Swath Angle vs. 120° Swath Angle

Slide cedido por Damon Wolfe - Edgetech

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### MPES vs. PDBS

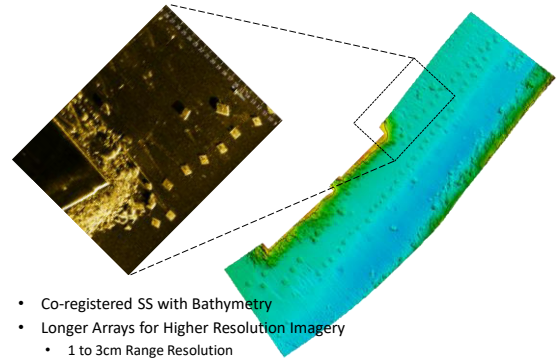


Full Swath Coverage vs. Nadir Gap

Slide cedido por Damon Wolfe - Edgetech

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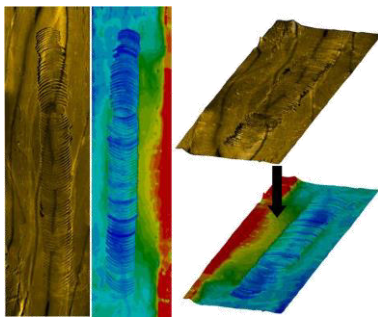
### Benefits : Side Scan Data



- Co-registered SS with Bathymetry
- Longer Arrays for Higher Resolution Imagery
  - 1 to 3cm Range Resolution

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### Co-Registered Bathymetry & Side Scan



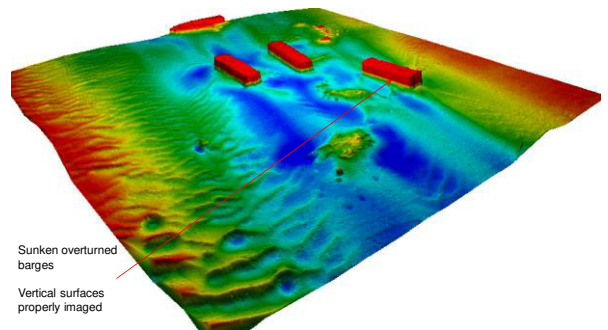
#### EdgeTech 6205

- Bathymetry & Simultaneous Dual Frequency Side Scan Sonar
- Precisely Co-Registered Bathymetry & Side Scan Imagery

Slide cedido por Damon Wolfe - Edgetech

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### Swath Bathymetry : Data Example

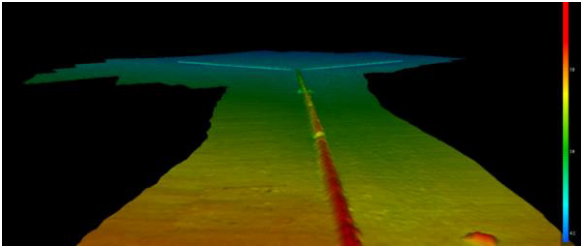


Sunken overturned barges  
Vertical surfaces properly imaged

Slide cedido por Damon Wolfe - Edgetech

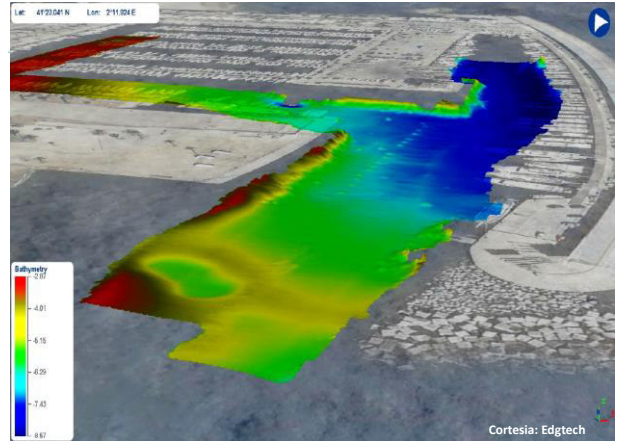
332

**Swath Bathymetry : Pipeline Data Example**



Slide cedido por Damon Wolfe - Edgetech

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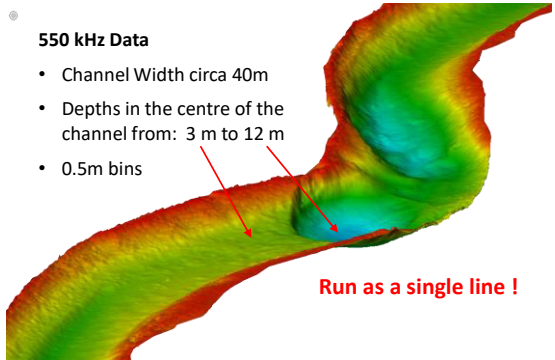
**Data: New River - Location**



Slide cedido por Damon Wolfe - Edgetech

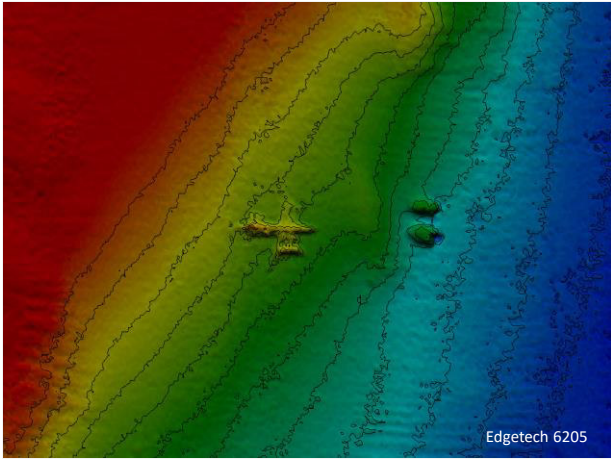
335

**Data: New River - Swath**



Slide cedido por Damon Wolfe - Edgetech

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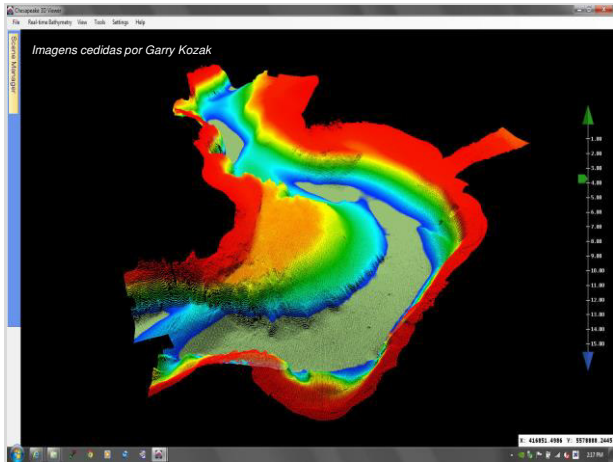
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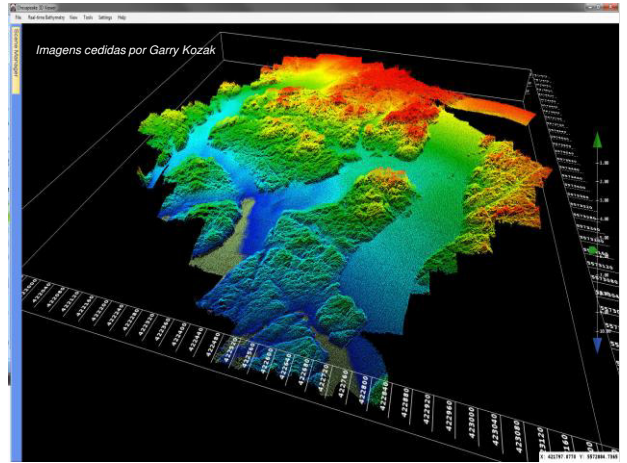
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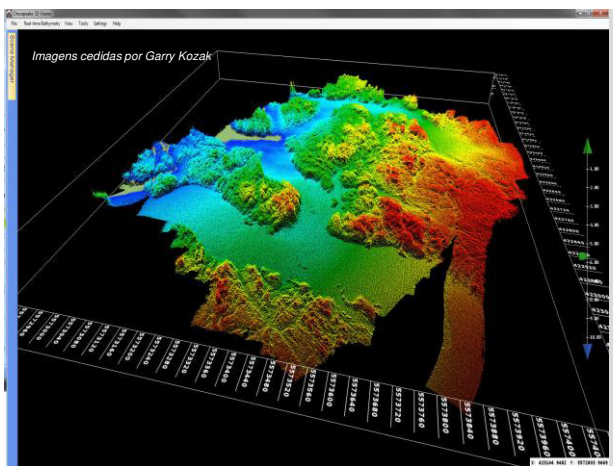
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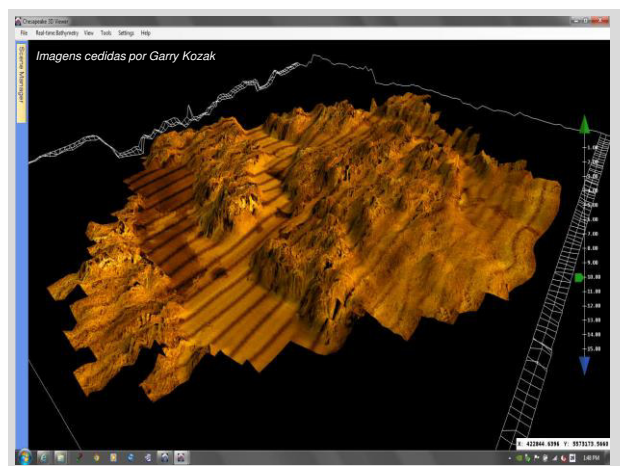
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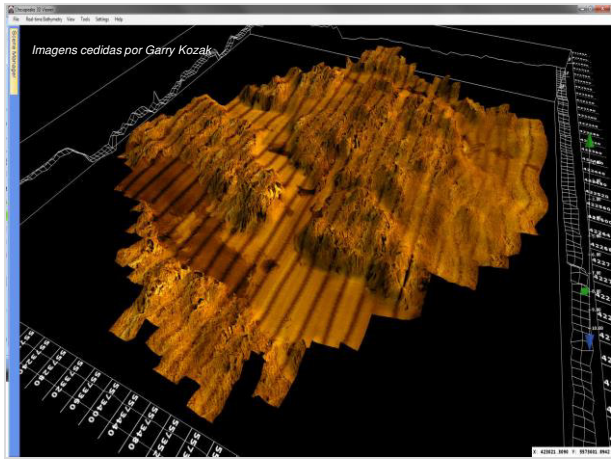
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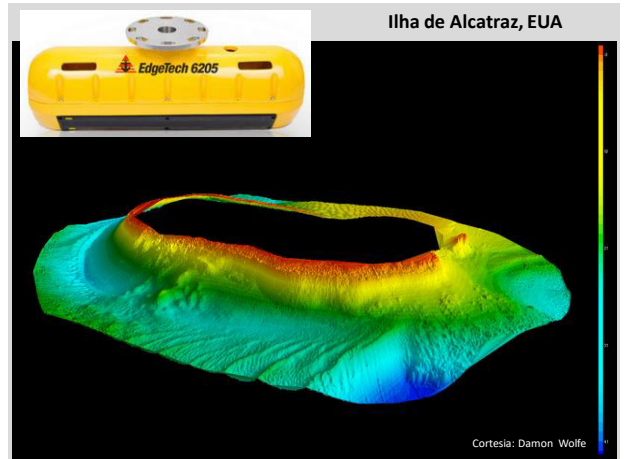
343



344



345



346



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**EDGETECH**  
**6205**  
Side Scan Interferométrico  
550/1600 kHz

Foto: Laps

348



**BATIMETRIA DE ALTA RESOLUÇÃO**  
**SONAR DE VARREDURA LATERAL INTERFEROMÉTRICO**  
**EDGETECH 6205**



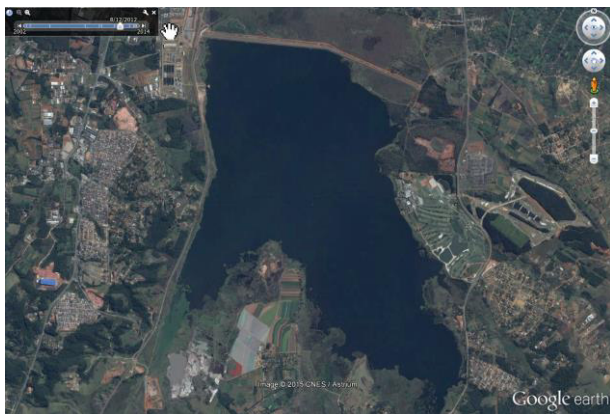
Foto: Laps

349



**EDGETECH 6205**  
 Side Scan Interferométrico  
 550/1600 kHz

350



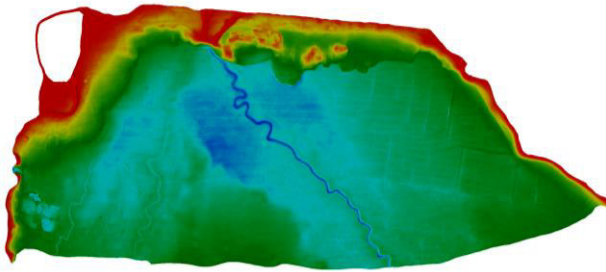
**RESERVATÓRIO TAIAPUÊBA – Lev. Batimétrico (parcial) de alta resolução**  
*Ensaios experimentais*

351



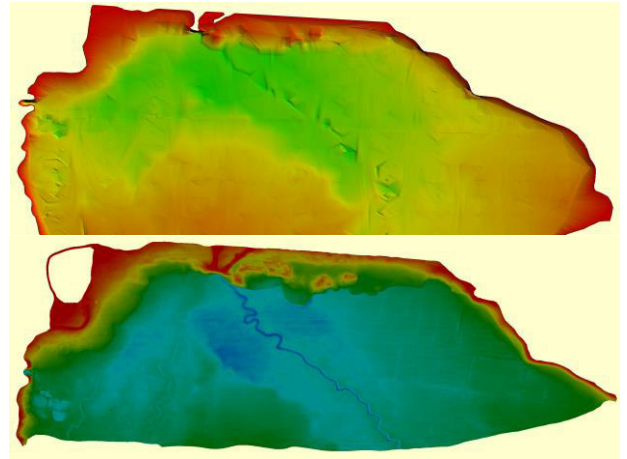
**RESERVATÓRIO TAIAPUÊBA – Área coberta pelo Lev. Batimétrico (20%)**

352

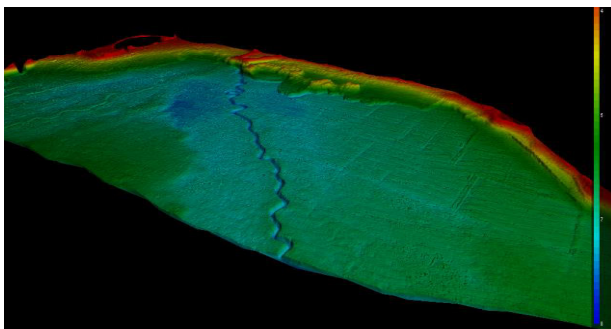


**Mapa Batimétrico (2D) de alta resolução do reservatório Taiaçupeba (cobertura de 20% da área total do reserv.)**

353

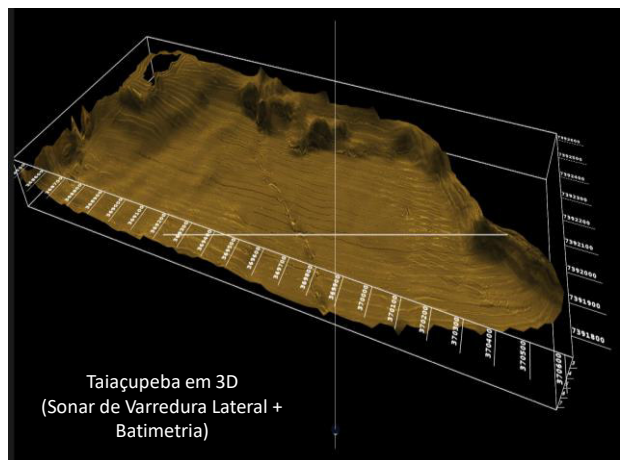


354



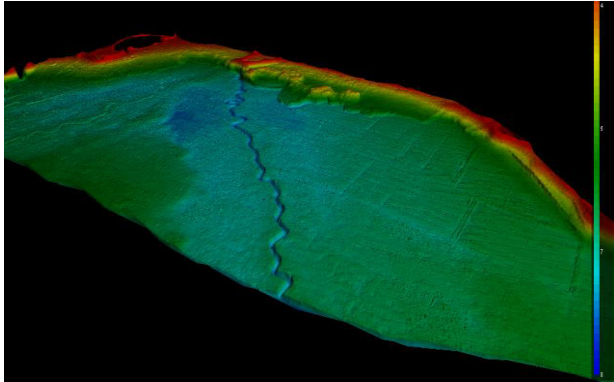
**Mapa Batimétrico (3D) de alta resolução do reservatório Taiaçupeba (cobertura de 20% da área total do reserv.)**

355



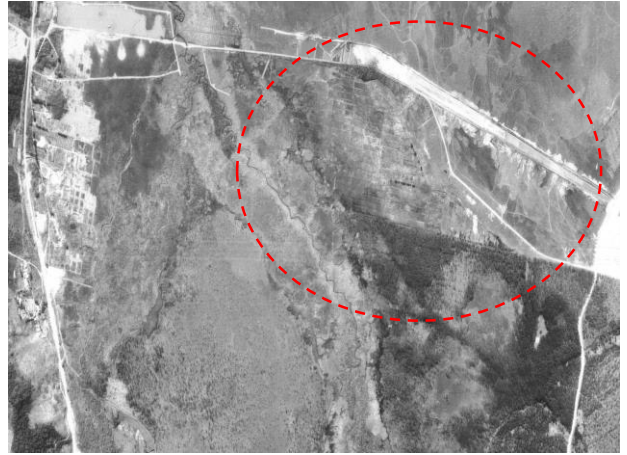
**Taiacupeba em 3D  
(Sonar de Varredura Lateral +  
Batimetria)**

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Mapa batimétrico (3D) de alta resolução  
*Reservatório Taiáçupeba, Suzano, SP*

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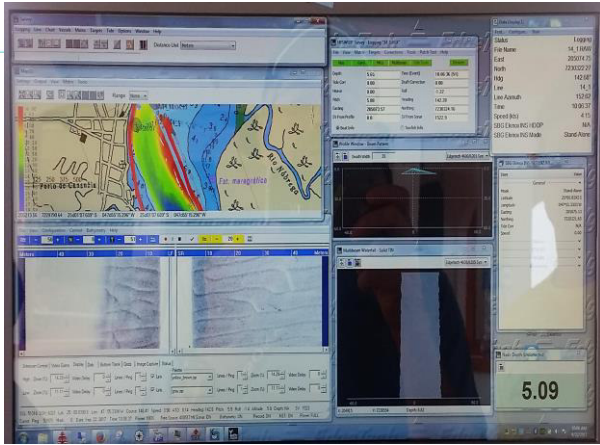
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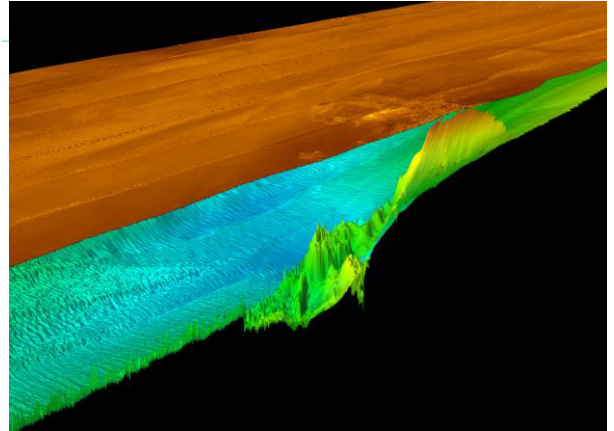
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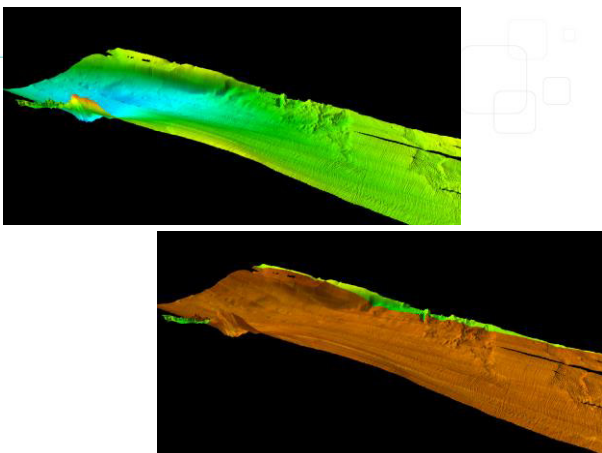
360



361



362



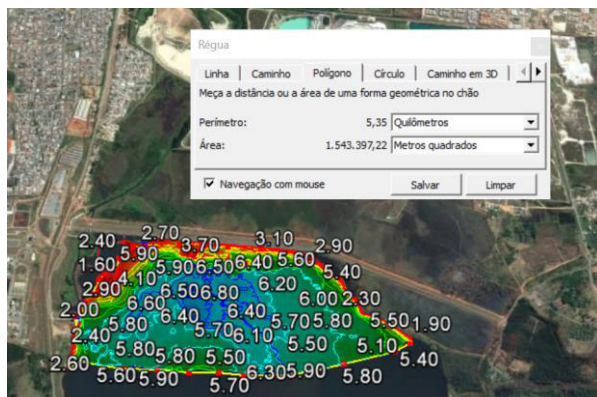
363



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135 mil pontos

1 pto a 250 cada metro



Planilha = 1,5 milhões de linhas = pontos **1 pto a cada metro**

365



**32 milhões de pontos  
seriam coletados !!!**

**Largura média do rio = 700 m**

**Extensão do rio = 30 km**

**Prof. média do rio = 7 m**

**Varredura lateral = 70 m**

**Numero de linhas long.= 11**

**Km Total = 11 linhas x 30 km =**

**330 km**

**6h/dia x 6km/h =**

**36 km/dia = 9.5 dias**

**250 x monofeixe**

366

#### VANTAGENS DO SISTEMA INTERFEROMÉTRICO

- Dados batimétricos de alta qualidade com varredura de 8 - 10 x a espessura da coluna d' água o que proporciona menor quantidade de linhas para cobrir uma mesma área, ou seja, economiza **tempo de levantamento**. Além disso, com varredura mais ampla, aumenta-se a **segurança do levantamento** já que não há necessidade de se aproximar muito das margens.
- O side scan emite dupla frequência simultaneamente o que garante **resolução** (possibilidade de mapear detalhes) e **alcance lateral** (possibilidade de se cobrir grandes áreas).
- Os dados gravados são relativamente limpos, tendo em vista a evolução dos **softwares internos** do sistema (*advanced multipath e wake suppression algorithms*), o que facilita o trabalho de pós-processamento.
- O sistema oferece **200 graus** de campo de visão o que permite mapear a superfície de fundo de um rio numa única 'passada'. Com um multibeam clássico talvez necessitasse duas ou três.
- O sistema interferométrico oferece maior resolução espacial, o que é atribuído à larga banda de frequências.

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#### INVESTIGAÇÃO ACÚSTICA DA SUPERFÍCIE DE FUNDO

##### • BATIMETRIA

(8, 12, 15, 24)  
**30, 33, 38, 50,**  
**200, 400, 700 kHz**

- Monofeixes
- ADCP
- Multifeixes
- Multifase/Interferometria

##### • IMAGEAMENTO

**100, 300, 400, 500,**  
**700, 900, 1600 kHz**

- Sonar de Varredura Lateral

368

**INVESTIGAÇÃO ACÚSTICA DA SUPERFÍCIE DE FUNDO**

**BATIMETRIA**

(8, 12, 15, 24)  
30, 33, 38, 50,  
200, 400, 700 kHz

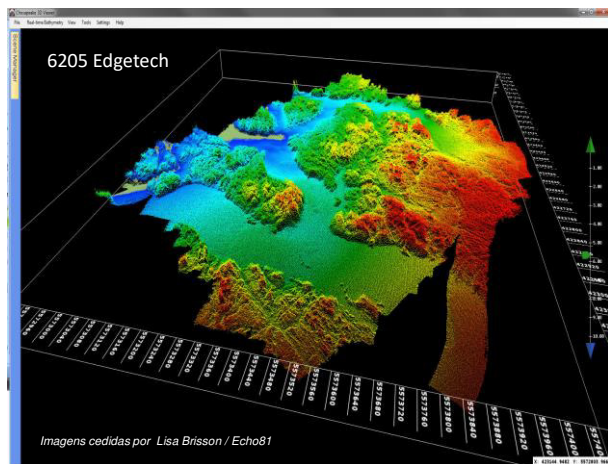
- Monofeixes
- ADCP
- **Multifeixes**
- **Multifase/Interferometria**

**IMAGEAMENTO**

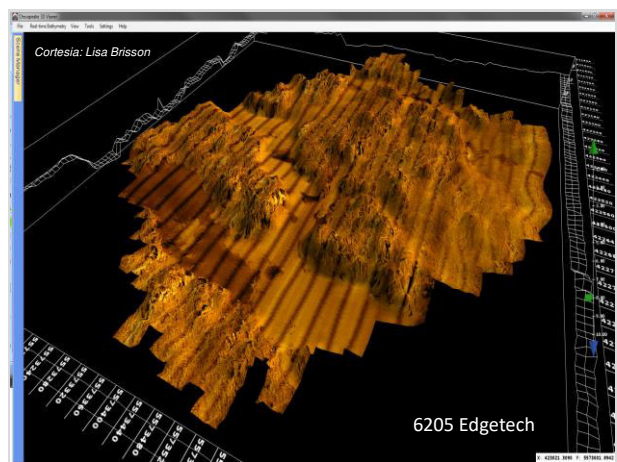
100, 300, 400, 500,  
700, 900, 1600 kHz

- **Multifeixes**
- **Multifase/Interferometria**
- **Sonar de Varredura Lateral**

369



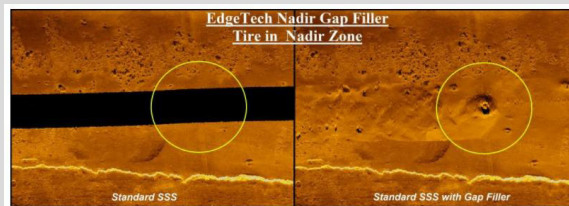
370



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**NADIR GAP FILLER**

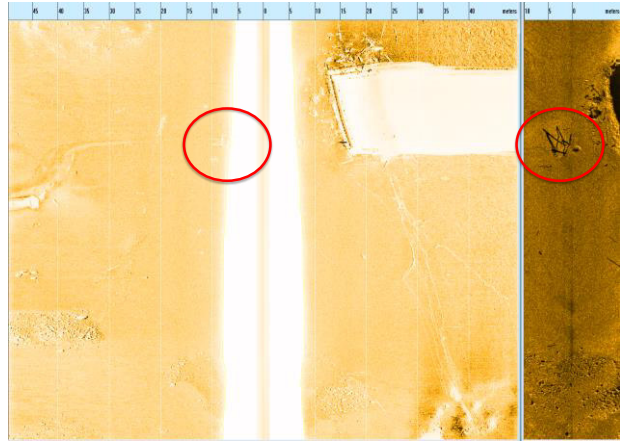
EdgeTech 2205



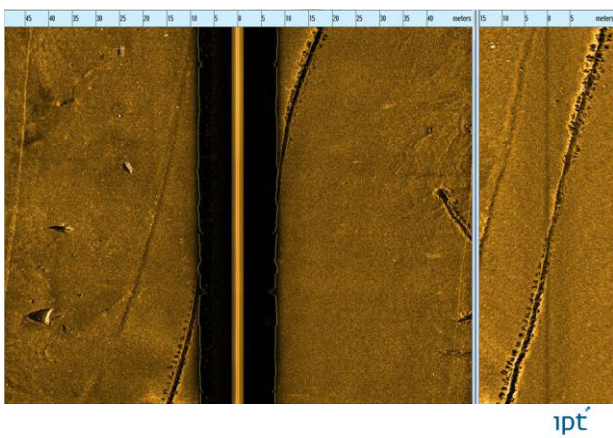
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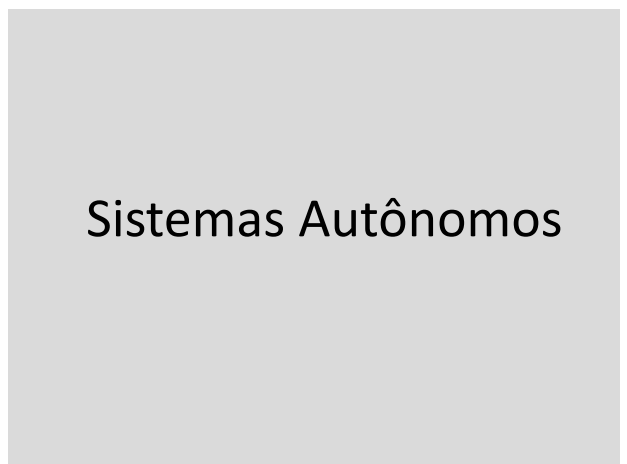
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375

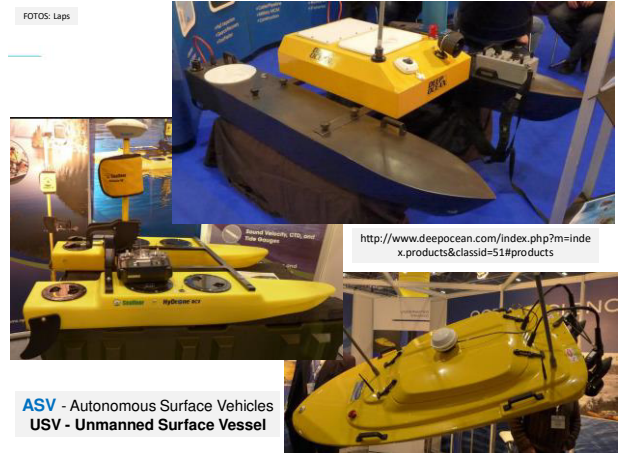


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# SISTEMAS AUTÔNOMOS

- Águas rasas (sup)
- Águas profundas (sub\_sup)

377

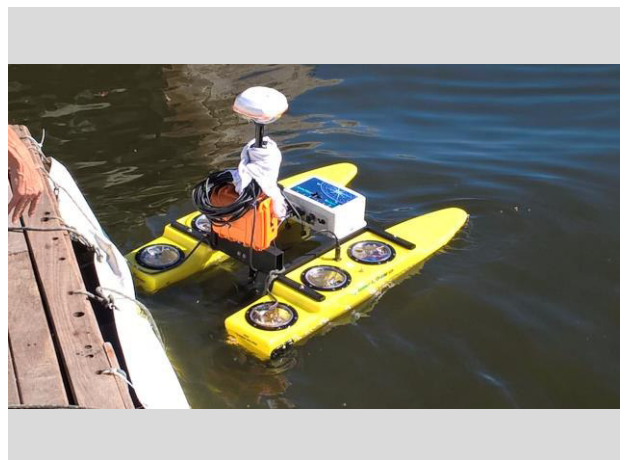


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Laurel China  
Remote Controlled USV-  
1750 with SONIC2020  
mount



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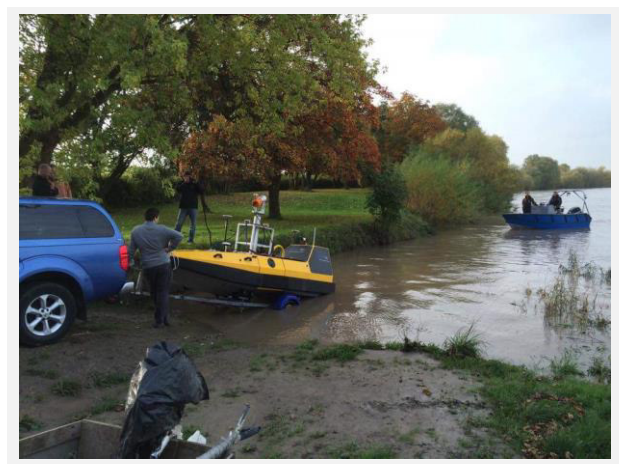


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382



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### Calypso

#### Inflatable unmanned survey platform

Calypso:

- Inflatable
- Fully autonomous
- Wide range of sensors
- Cloud data connection

Applications:

- Hydrographic survey
- Environmental research
- Inspection
- Security

.Ocean 386 / 7 USV and networked sensors

386

### Calypso

#### Autonavigation module

Calypso is connected via the 3G/4G or WiFi network to the cloud platform Atlantis.

The Atlantis cloud auto navigation module provides augmented maps on which the calypso can take decisions.

Based on the augmented maps the Calypso can plan his trajectory, can cover a selected area and will avoid objects depicted on the map

.Ocean 387 / 7 USV and networked sensors

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### Calypso

#### Atlantis

The onboard echo sounder provides a depth profile. Together with the navigation path this depth profile is depicted in the augmented Atlantis map.

The platform comes with a user friendly web based visualization tool.

The data can be combined with other survey data from all kinds of hydrographical equipment.

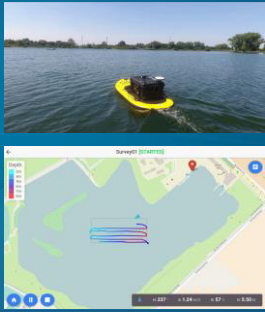
.Ocean 388 / 7 USV and networked sensors

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## Calypso

### Specifications

- Length board: 1800mm
- Width board: 925mm
- Draft: 210mm
- Weight: 25kg
- Payload: 150kg
- Speed: Max 3 knots
- Endurance: Minimum 4 hours @ 12V/100Ah
- Control: Cloud control and R/C
- R/C range: 5km open sight
- Propulsion: 2x 12V underwater rotors
- Data communication: 3G/4G, WiFi or local storage
- Sensor mount: 2x Ø100mm moon pools
- GPS accuracy: 3000mm
- Echosounder accuracy: 50mm
- Echosounder resolution: 10mm
- Echosounder opening: angle 8°
- Compass accuracy: 2°



.Ocean 389 / 7 USV and networked sensors

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## Calypso

### Contact

For more information on Calypso, please contact:

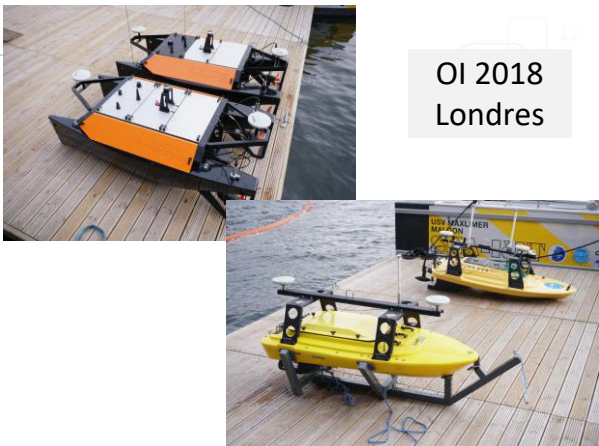
dotOcean NV  
 Gistelsesteenweg 294 B205  
 8200 Sint-Andries (Brugge)  
 Belgium

Phone: +32 (0) 50 68 30 54  
 Email: [info@dotocean.eu](mailto:info@dotocean.eu)

[www.dotocean.eu](http://www.dotocean.eu)

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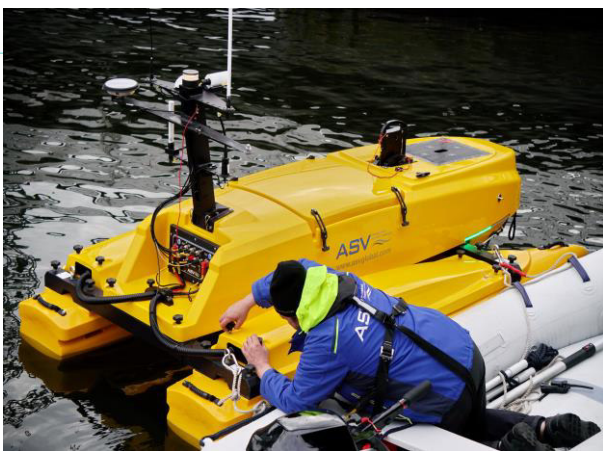
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