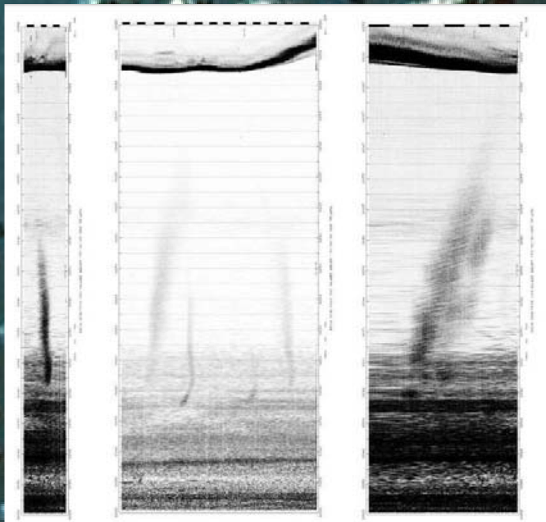
HYFUX

Remote Sensing and Sea-Truth Measurements of Methane Flux to the Atmosphere

DE-NT005638

Ian MacDonald

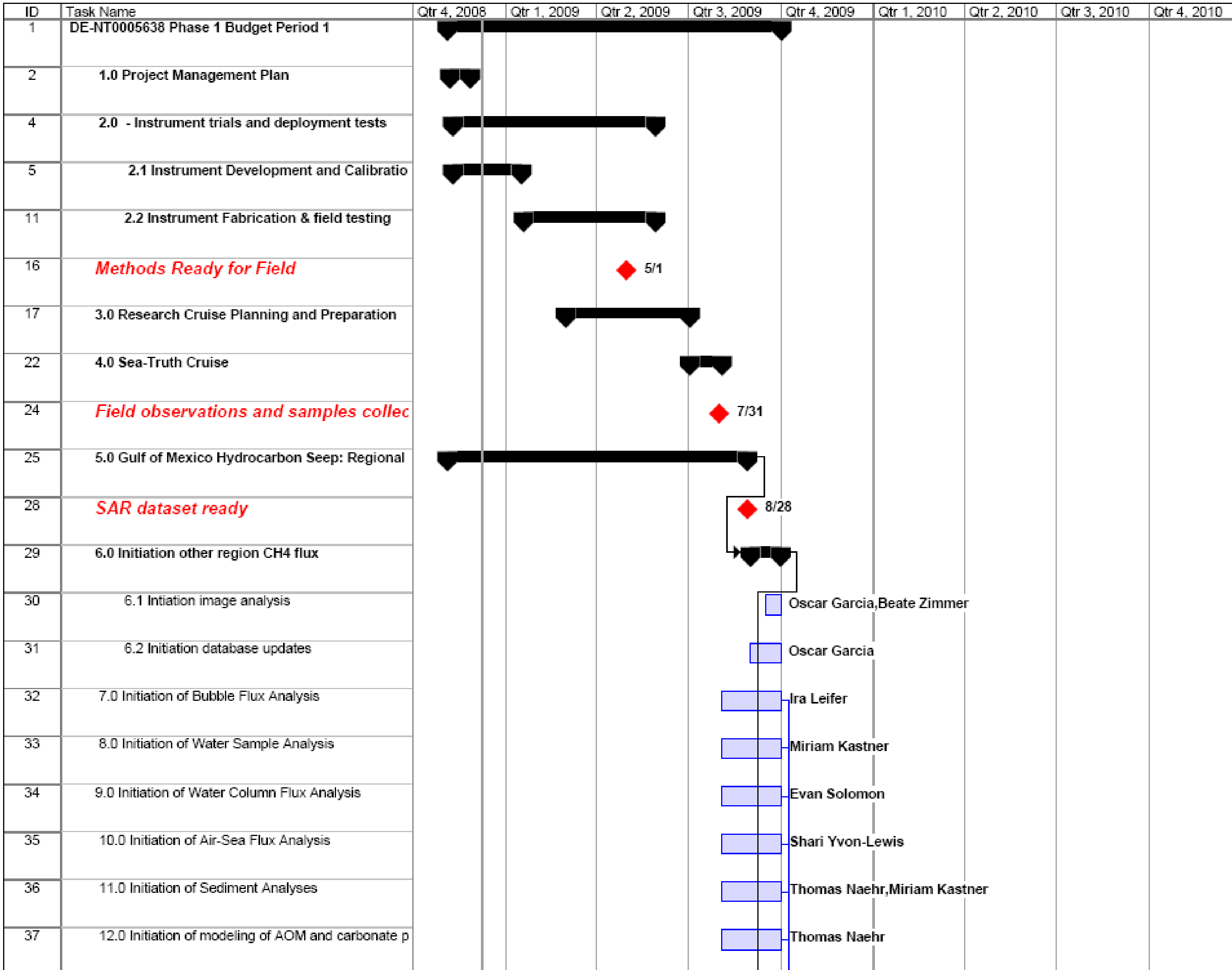
Texas A&M University - Corpus Christi



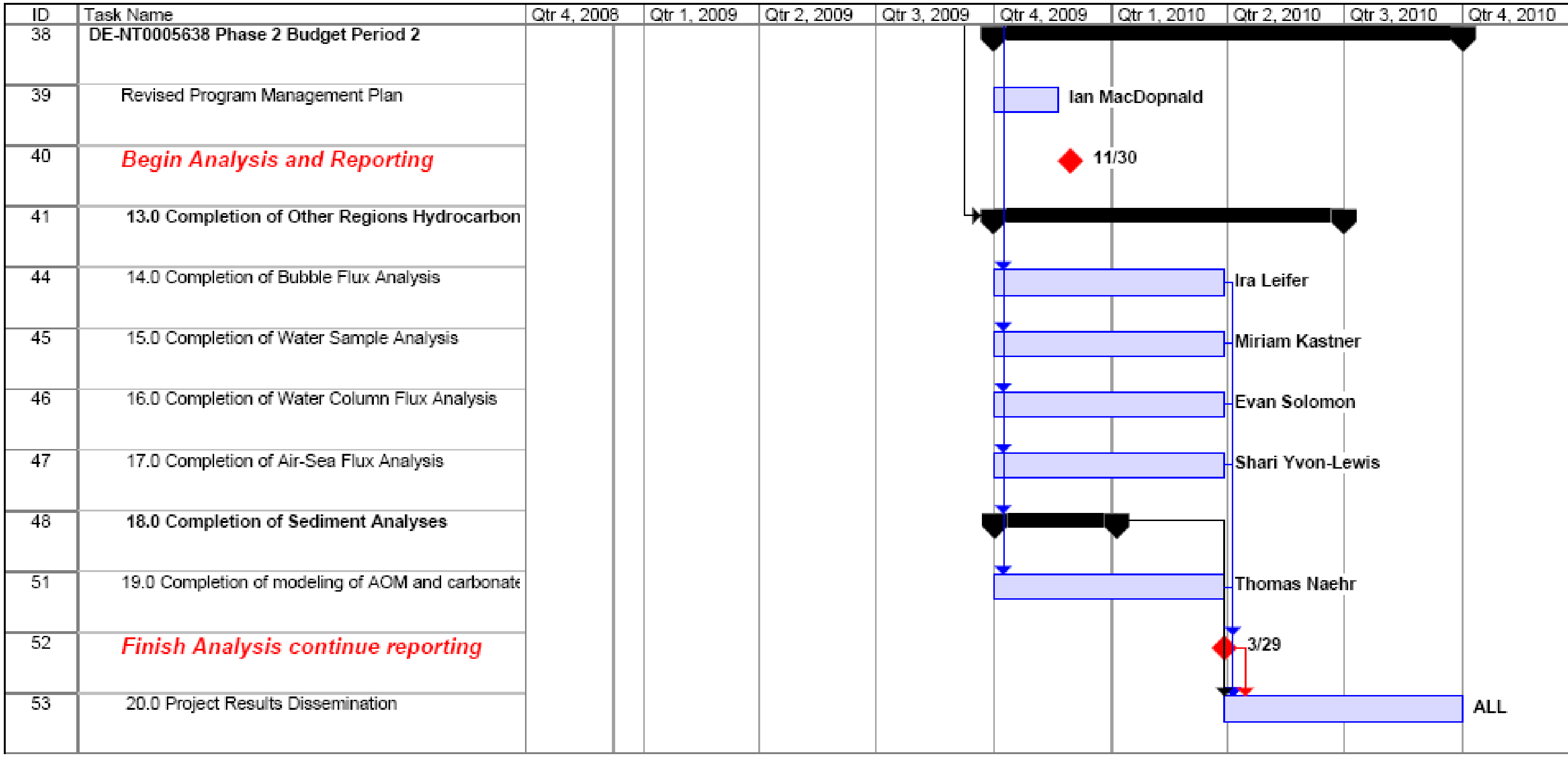
Project Goals & Objectives

- Constrain the flux of methane from gas hydrate on continental margins
  - Use remote sensing inventories to enumerate methane sources in the Gulf of Mexico and selected margins.
  - Make careful measurements of CH_4 concentrations in bubble-streams from gas hydrate deposits: seafloor, water column, air-water interface.
  - Model precipitation of carbonate as function of pore-fluid CH_4 concentrations
  - Model fluxes at sites ~500, 1000, 1500 m.
  - Extrapolate to basin-wide fluxes.

Project GANTT 2008-2009



Project GANTT 2009-2010



Project Investigators

- Texas A&M University - Corpus Christi
  - Ian MacDonald, Thomas Naehr, Beate Zimmer, Oscar Garcia
- Scripps Oceanographic Inst
  - Miriam Kastner, Evan Solomon
- Texas A&M University – College Station
  - Shari Yvon-Lewis
- UC Santa Barbara
  - Ira Leifer
- Univ. Southern Mississippi
  - Vernon Asper, Kevin Martin

Air-Sea Flux
(Shari Yvon-Lewis, TAMU)

Photos of the equilibrator, a GC system and the 4 pump pumpboard for reference. We will have a 2 unit pump-board on this cruise (~1/2 the width).

Equilibrator – just outside of main lab on R/V Ron Brown

Pump Board inside main lab of R/V Ron Brown

Saturation Anomaly Instrument (on a 1.5m table)

Bubble Flux
(Ira Leifer, UCSB & Kevin Martin U. S. Miss)

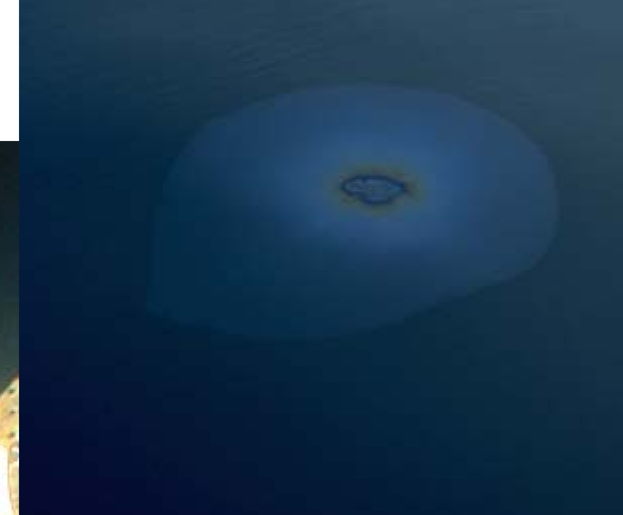
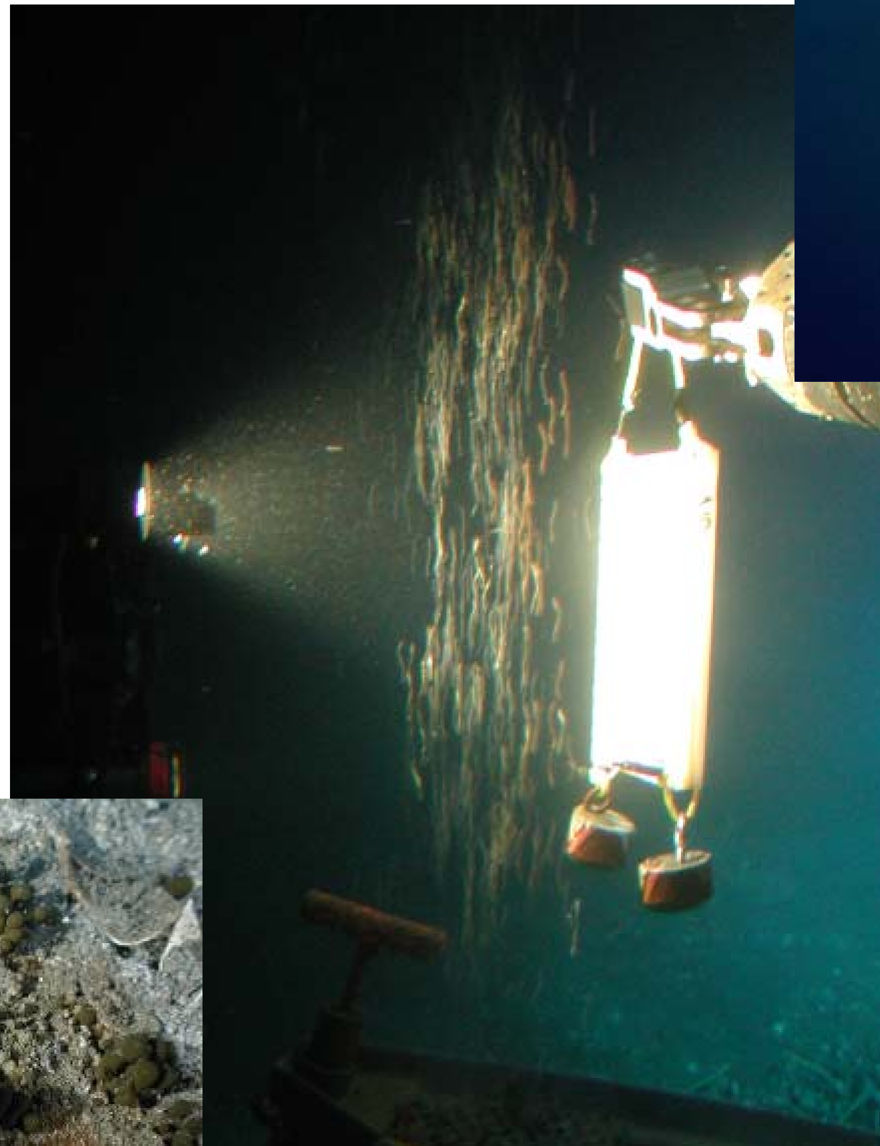
- SONAR location and quantification of bubble streams.
- Modeling bubble flux through water column.
- Bubbleometer measurement of gas venting.

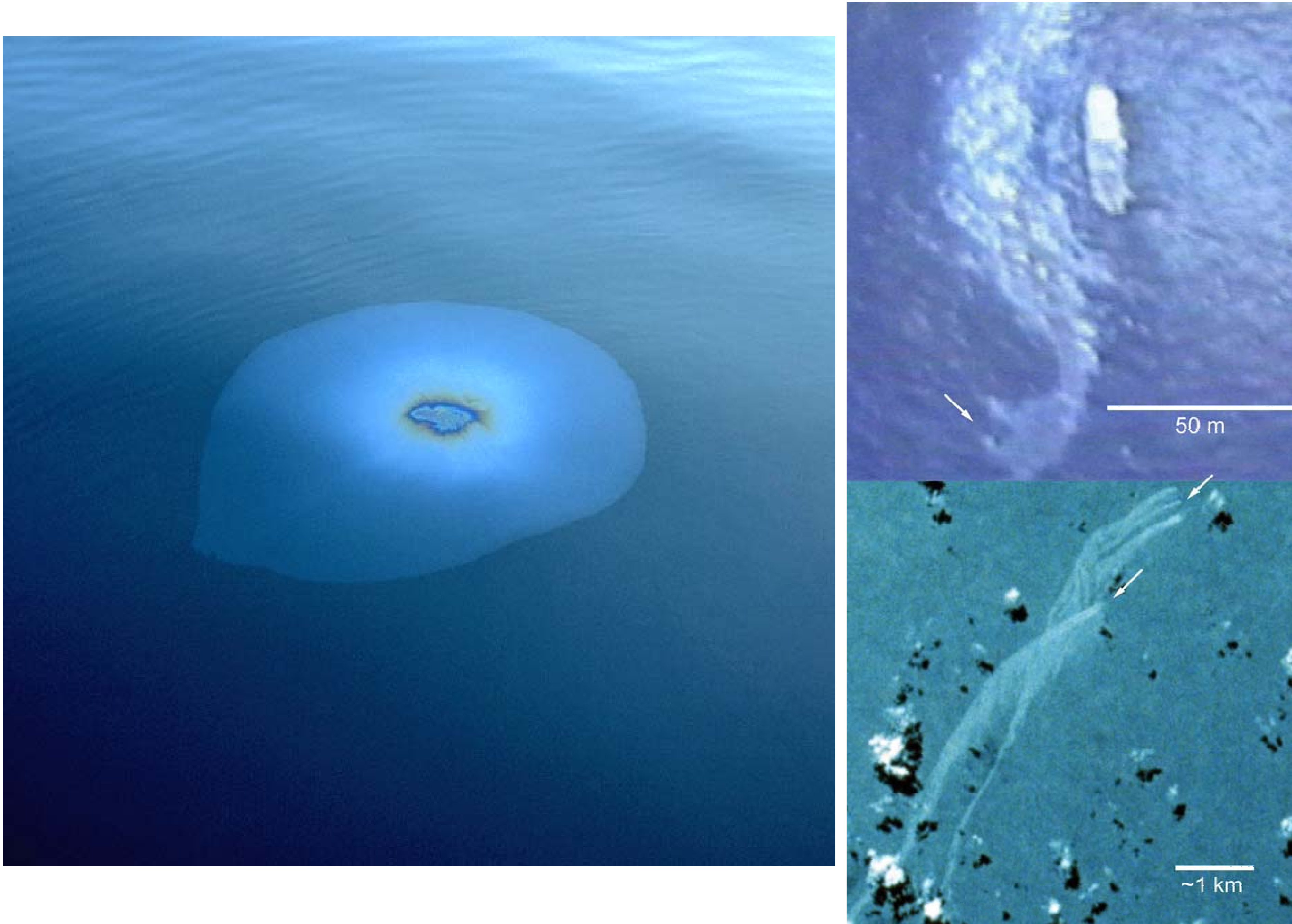
Water Column Concentrations
(Miriam Kastner & Evan Solomon, Scripps)

- Collect and analyze water-column samples
- CH_4
- $\delta^{13}C$

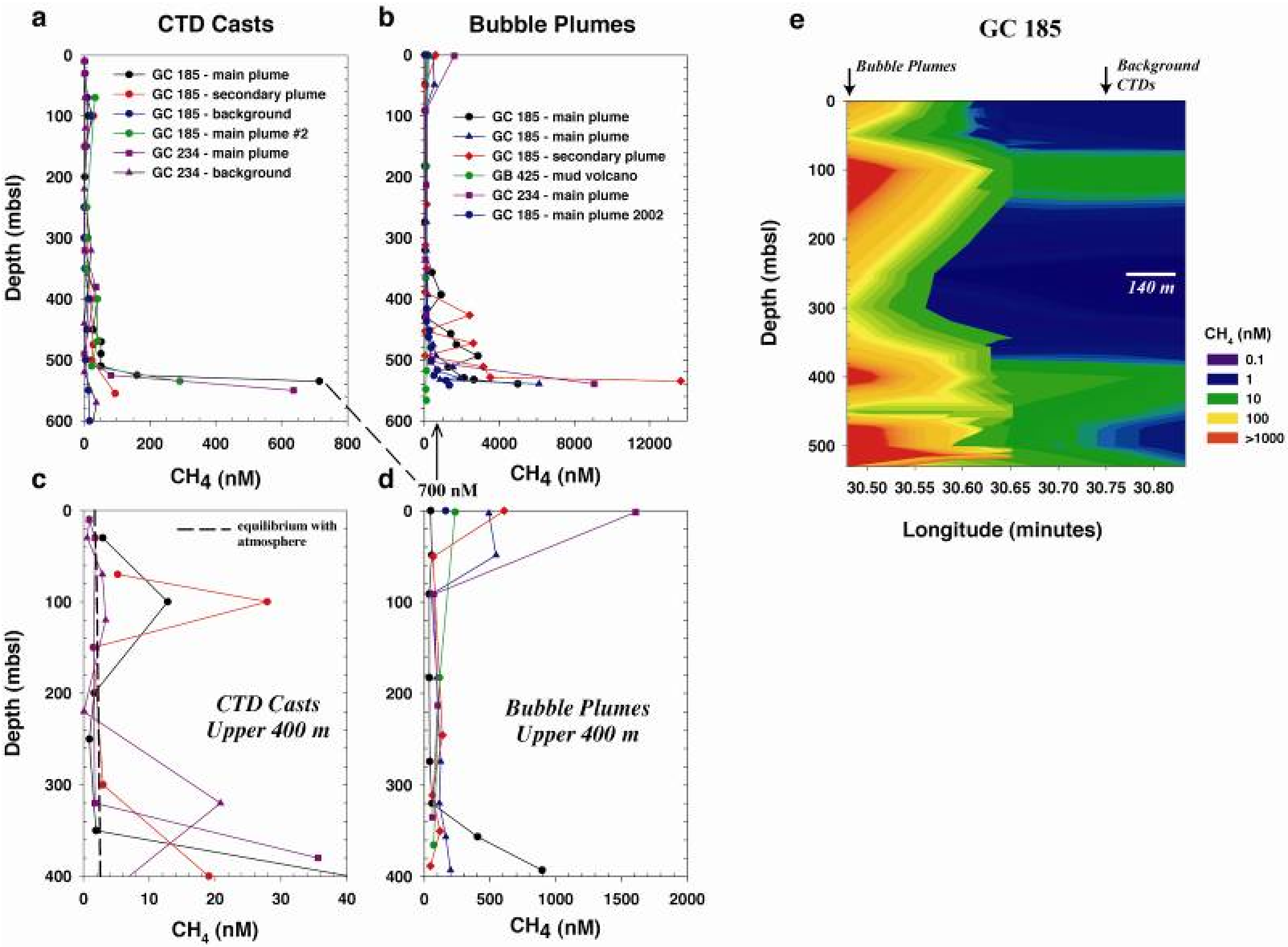
Carbonate Precipitation
(Thomas Naehr, TAMUCC)

- Seep carbonate system: AOM and authigenic $CACO_3$ precipitation.
- Remote sensing inventory of seep locations.



50 m
~1 km

Seep Methane Maxima



The bubble emission flux distribution can then be converted into volume and mass fluxes and integrated to obtain total values for the seep vent.

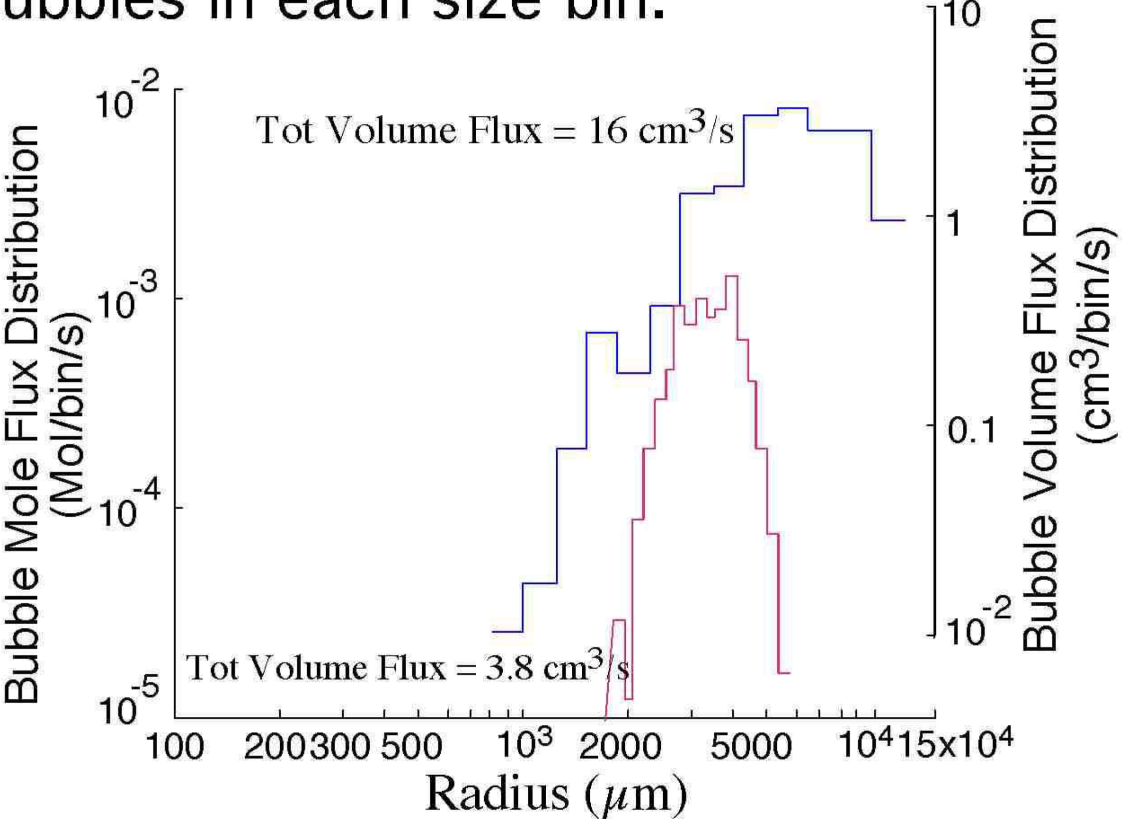
These are the volumes and masses a flux capture device would receive from bubbles in each size bin.

Pulsing Seep

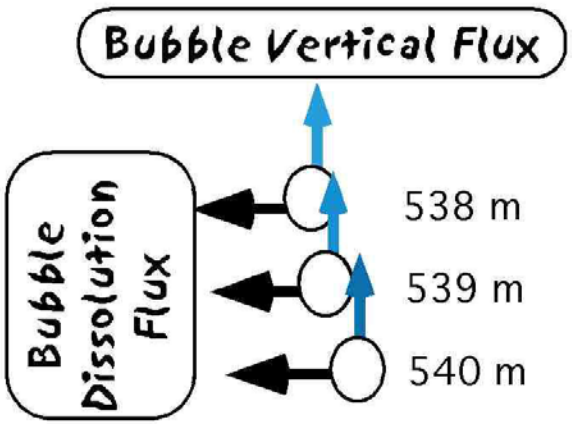
Tot Mole Flux = 0.039 Mol/s
Tot Mole Flux = 140 Mol/hr
Tot Mole Flux = 3400 Mol/dy
Tot Mole Flux = 1.2×10^6 Mol/yr
Tot Mass CH_4 = 1.7×10^4 kg/yr

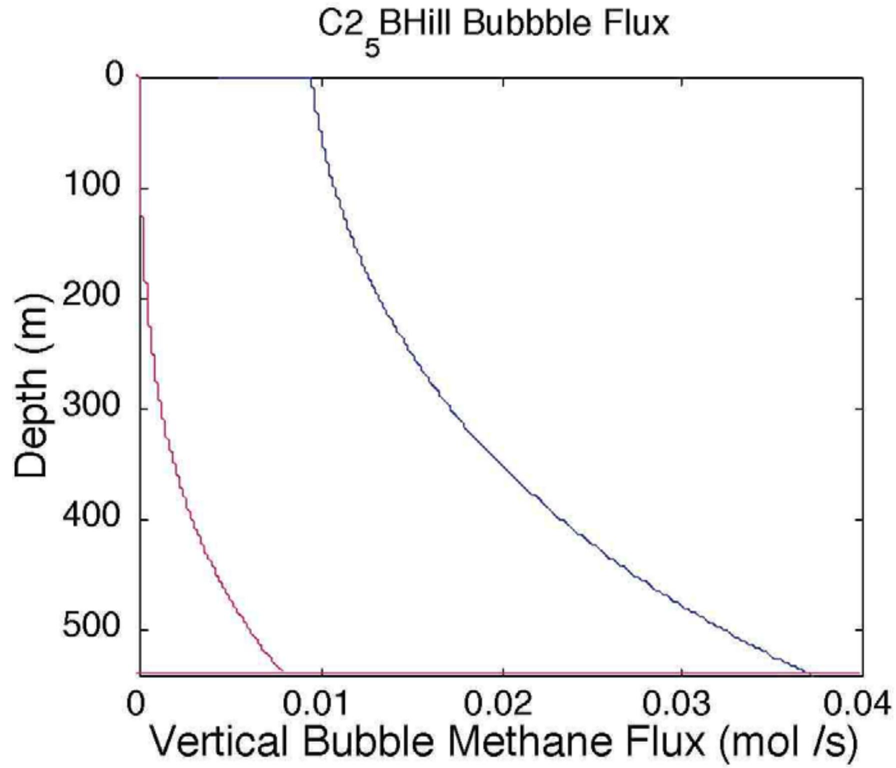
Steady Seep

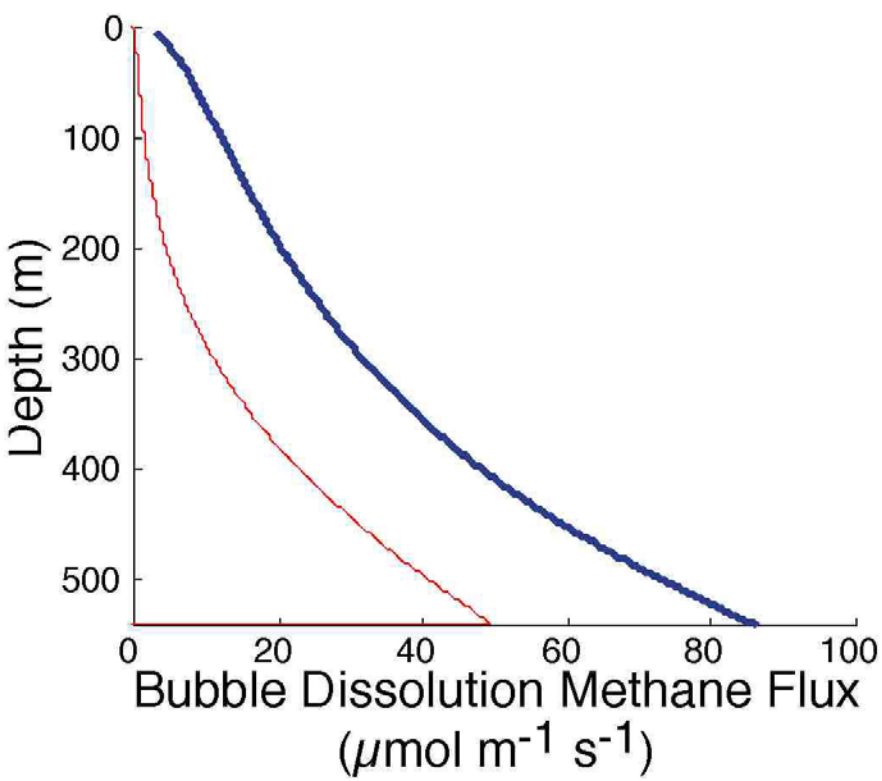
Tot Mole Flux = 0.0081 Mol/s
Tot Mole Flux = 29.1 Mol/hr
Tot Mole Flux = 699.4 Mol/dy
Tot Mole Flux = 2.55×10^5 Mol/yr
Tot Mass CH_4 = 4.08×10^3 kg/yr



Combining the calculated bubble composition at each depth with the seep vent flux distribution, the dissolution flux for each meter of rise and the amount of methane remaining in all bubbles can be calculated. Dissolution is greatest at the bottom. This simulation does not include bubble break-up, thus the very large bubbles observed easily made it to the surface, tripling in size.





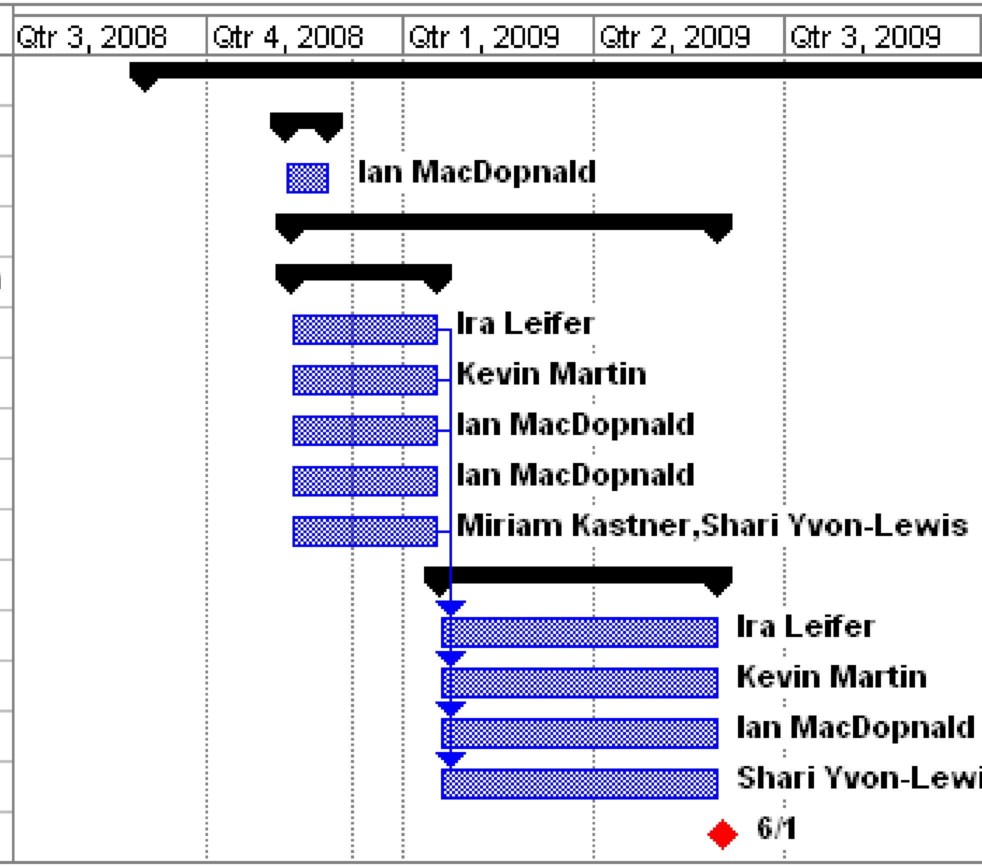


Summary

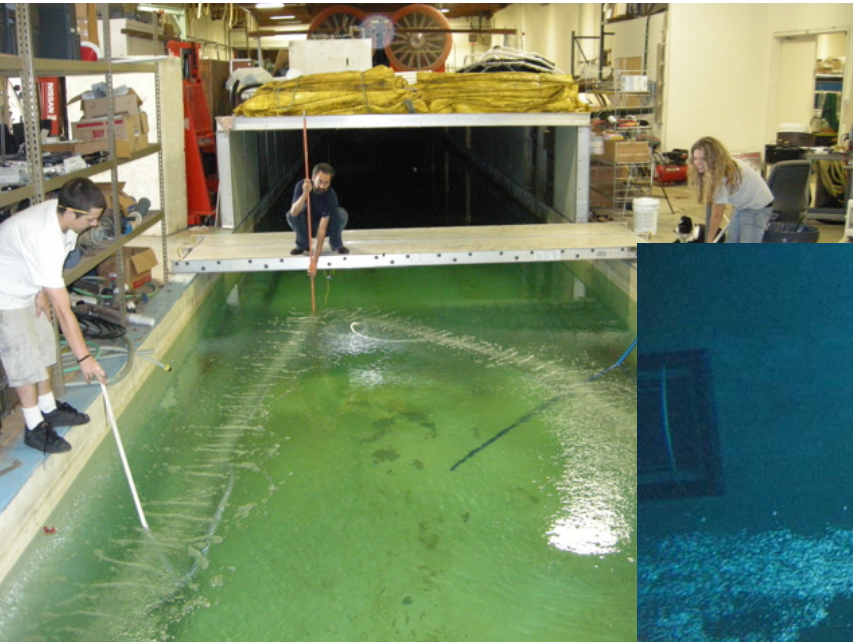
- Discharge from medium-flux seeps (e.g. gas hydrate deposits) generates perennial slicks.
- Oil and gas interact in complex ways to affect transfer to the ocean and atmosphere.
- Discharge from high-flux seeps (e.g. mud volcanoes) can be episodic and highly variable.
- Need to constrain number of GH deposits & cross-section of typical seep gas plumes.

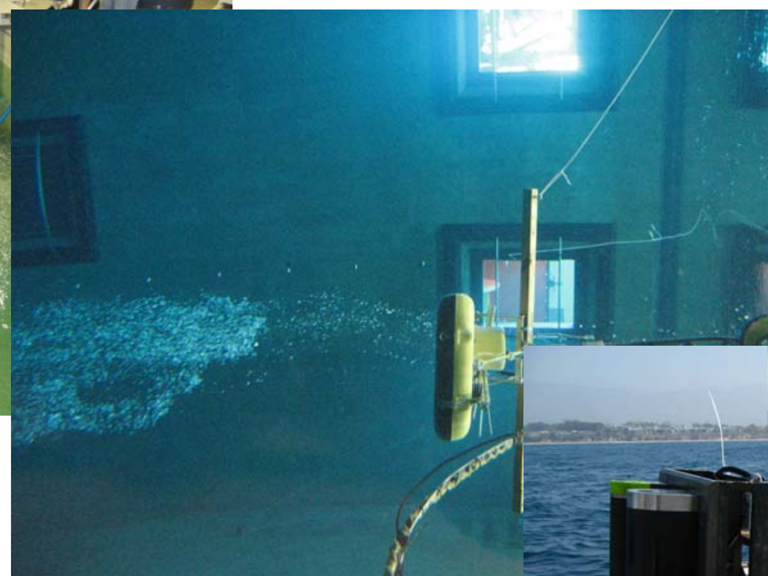
Instrument Acquistion/Calibration
Q4 2008 - Q2 2009

Task Name
DE-NT0005638 Phase 1 Budget Period 1
1.0 Project Management Plan
1.1 Technology Status Assessment
2.0 - Instrument trials and deployment tests
2.1 Instrument Development and Calibration--teech
2.1.1 Sonar sensing of bubble data
2.1.2 Bubble flux recording device
2.1.3 Dye-release device
2.1.4 Equipment elevator
2.1.5 Obtain GC for shipboard analysis of CH4
2.2 Instrument Fabrication & field testing
2.2.1 Sonar
2.2.2 Bubble flux
2.2.3 Dye release
2.2.4 Air-sea flux measurement
l Methods Ready for Field

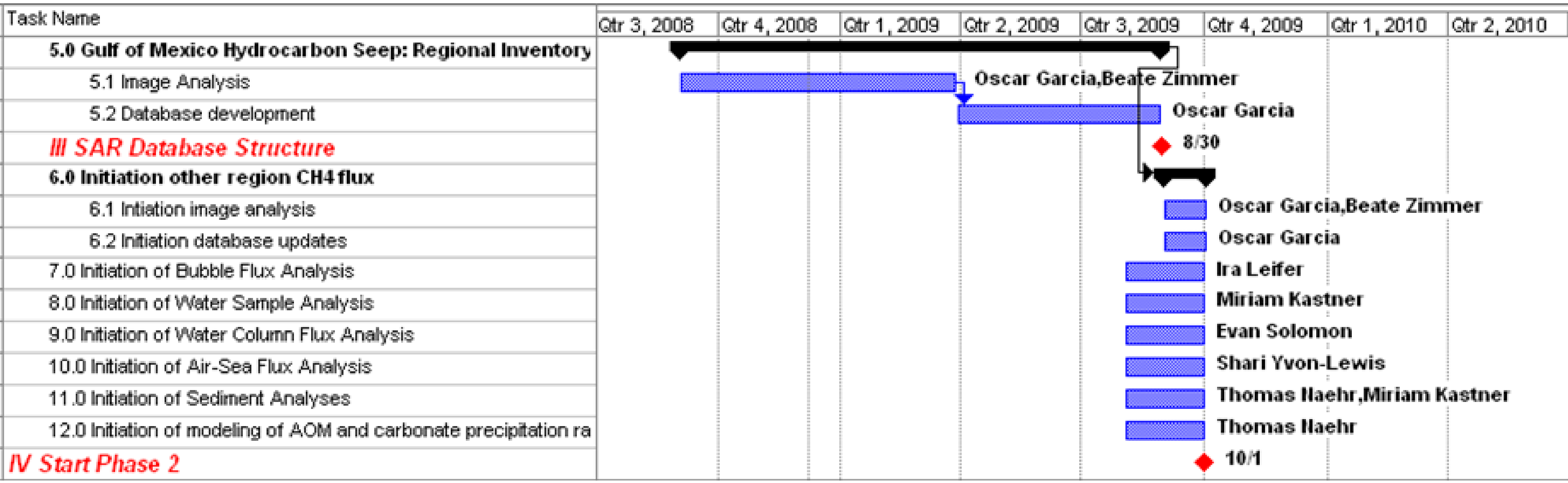


Field testing at Leifer lab & Santa Barbara Channel

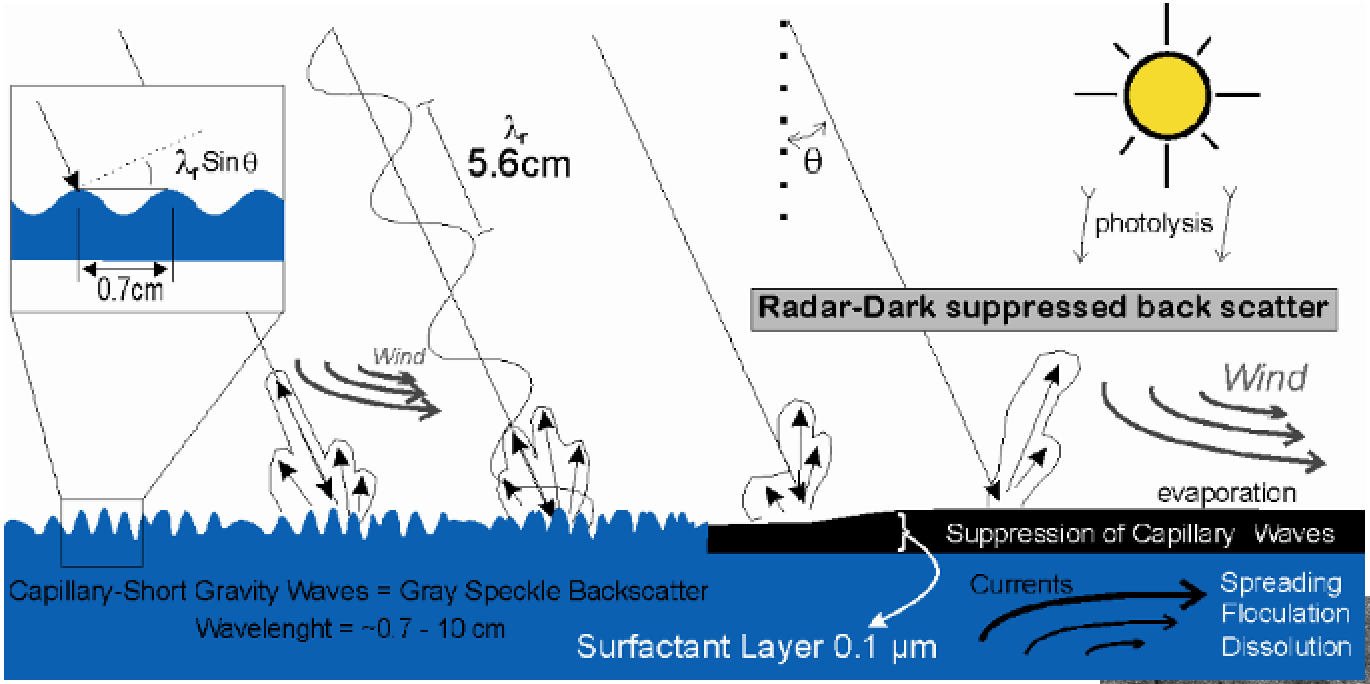


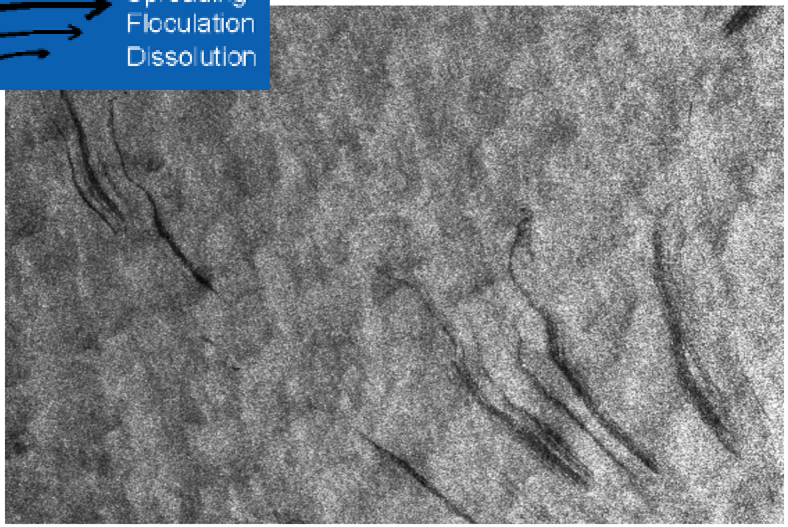


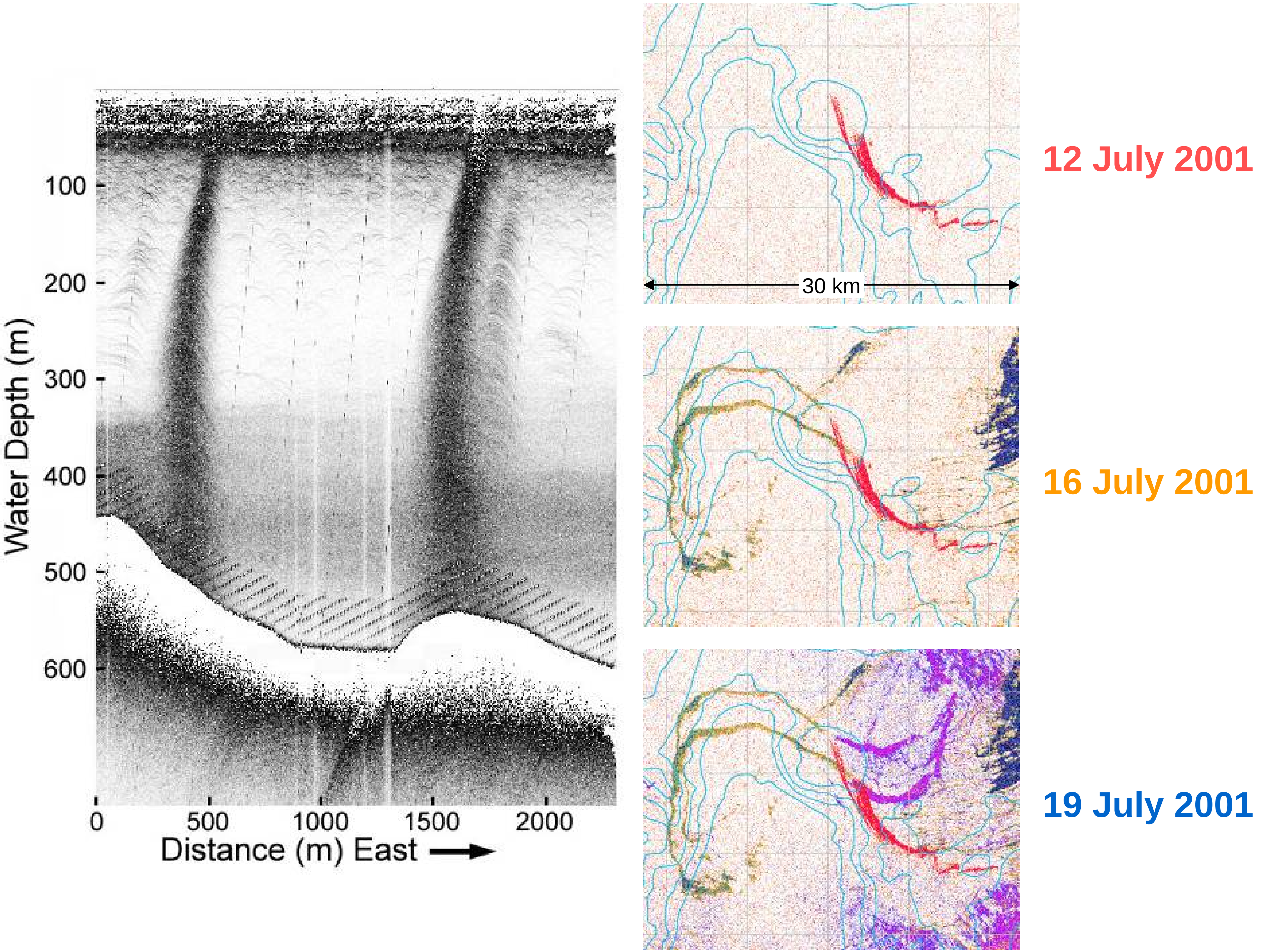
Remote-Sensing Inventory of Seeps
Q3 2008 - Q3 2009



Surfactant layers (slicks) generate strong contrast with SAR backscatter

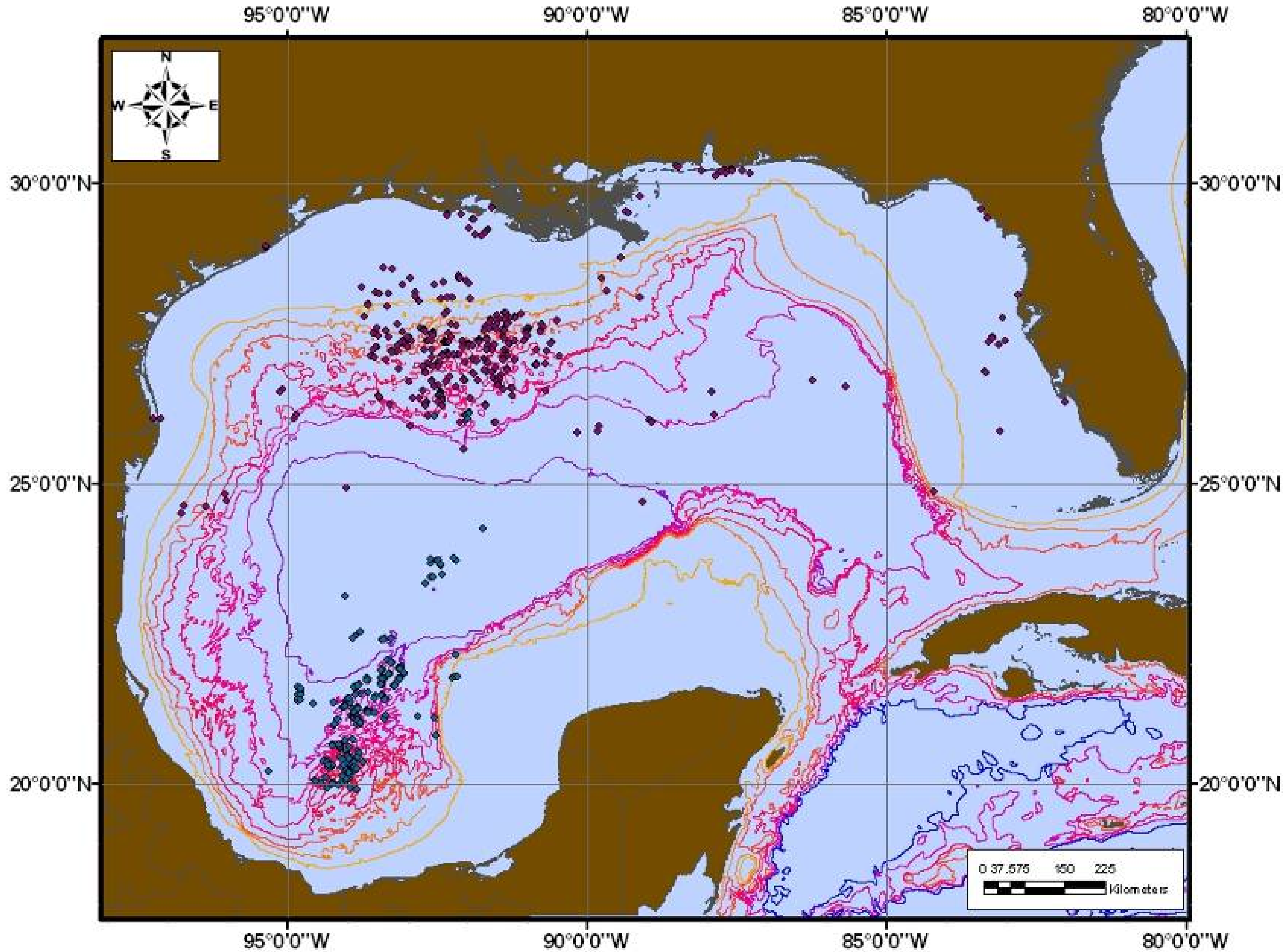




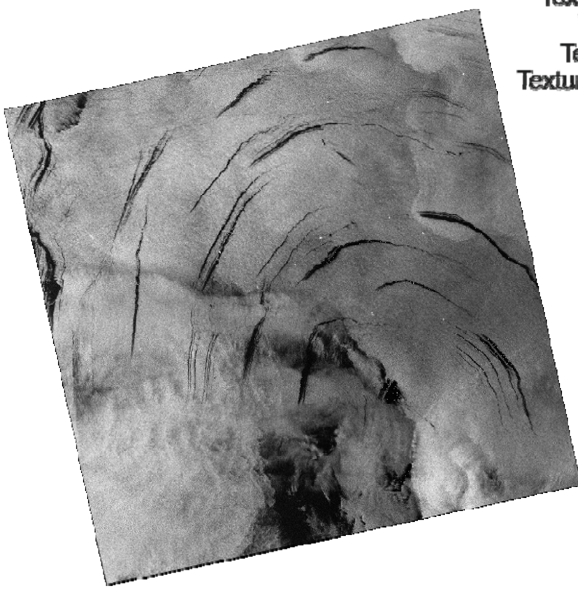


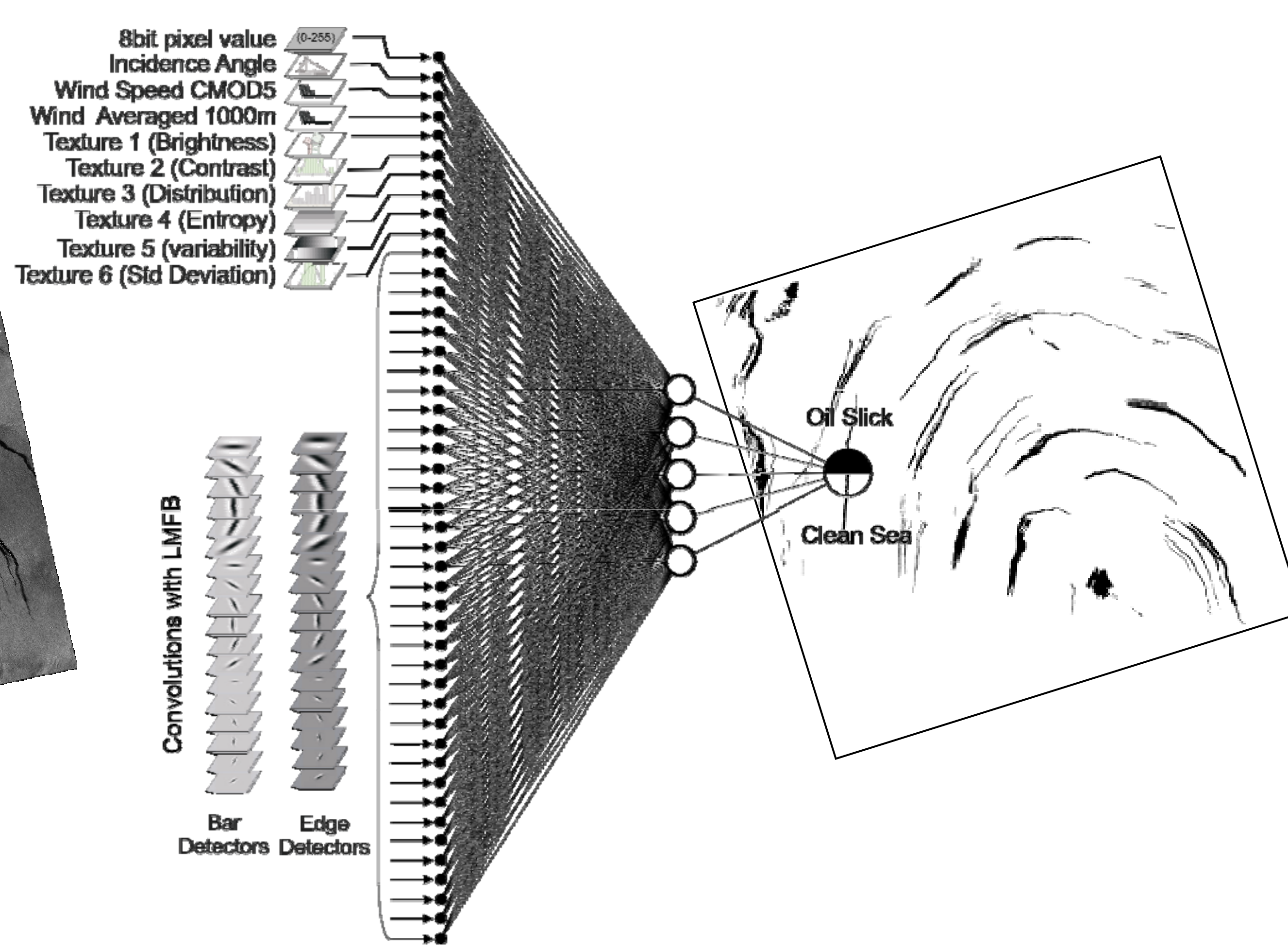
Water Depth (m)
100
200
300
400
500
600
0
500
1000
1500
2000
Distance (m) East
30 km
12 July 2001
16 July 2001
19 July 2001

Historic Seep Sites Detected in Satellite Imagery



Texture Classifying Neural Network Algorithm

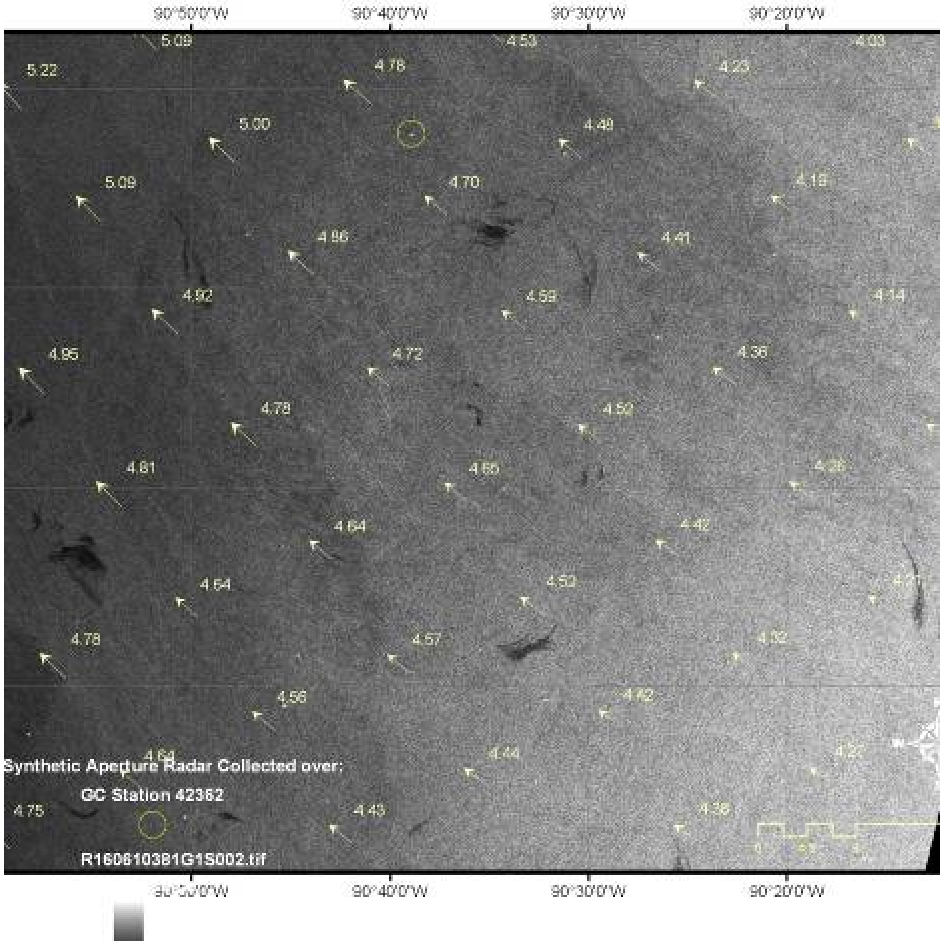


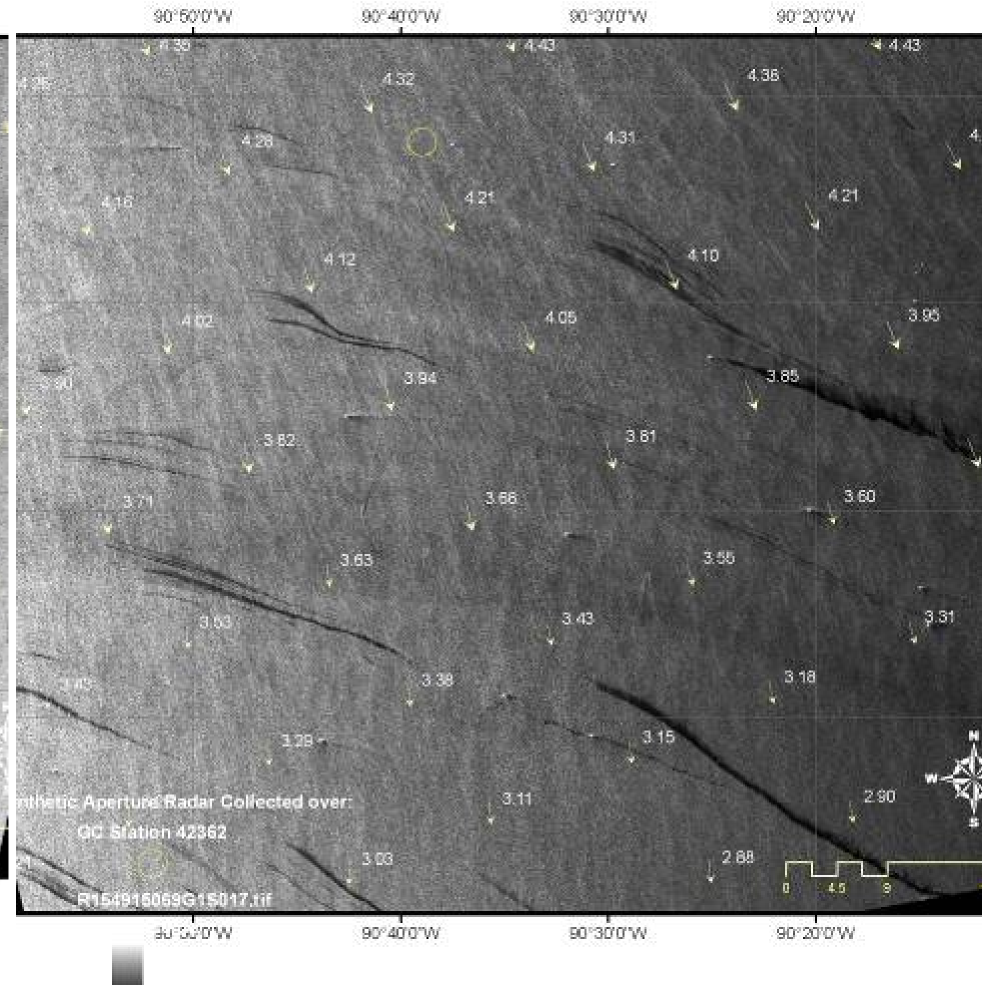


File size ~100 Mbyte

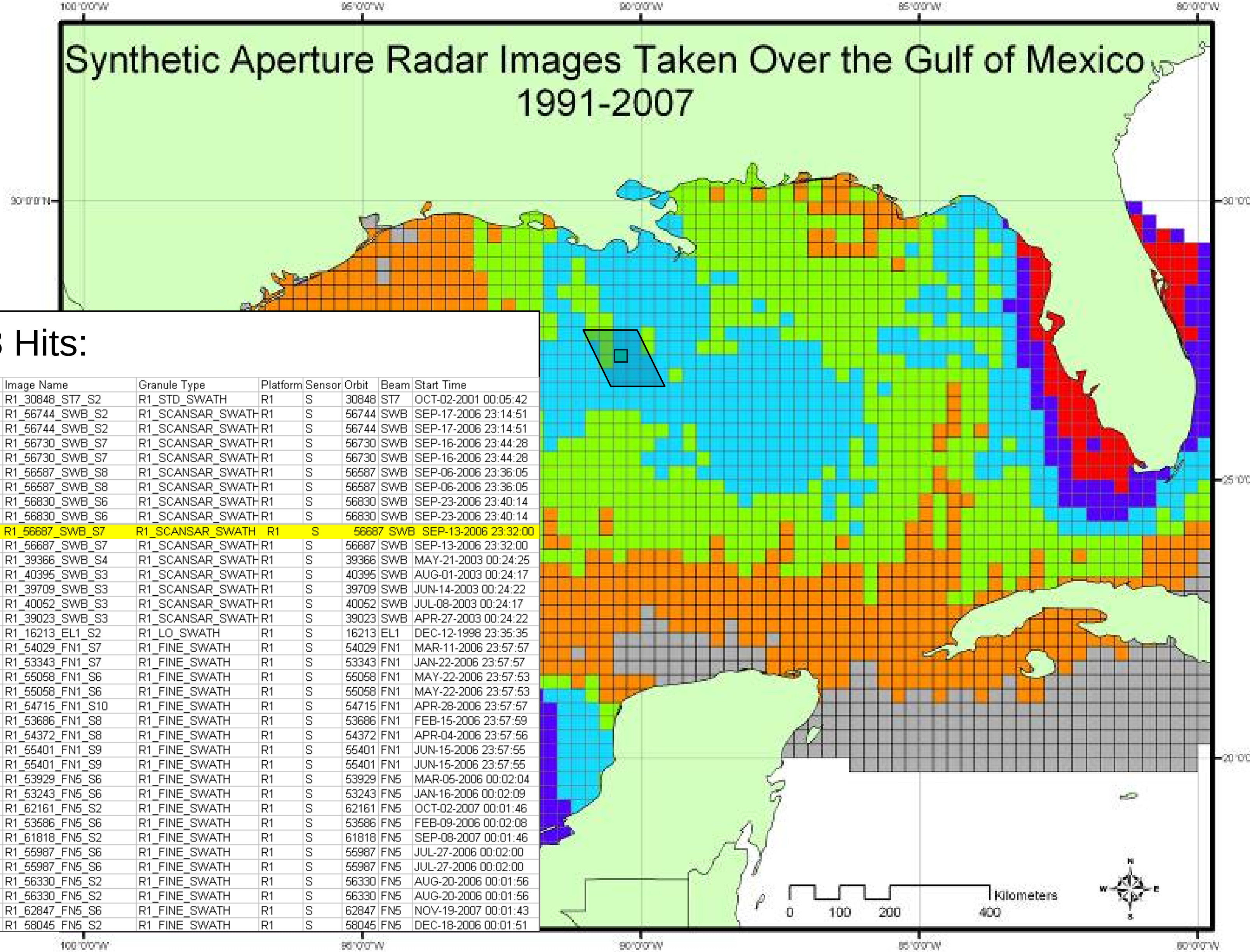
File size ~1 Mbyte

Similar Wind Conditions





On Line Data Availability



798 Hits:

Mission	Image Name	Granule Type	Platform	Sensor	Orbit	Beam	Start Time
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RADARSAT1	R1_56744_SWB_S2	R1_SCANSAR_SWATH	R1	S	56744	SWB	SEP-17-2006 23:14:51
RADARSAT1	R1_56744_SWB_S2	R1_SCANSAR_SWATH	R1	S	56744	SWB	SEP-17-2006 23:14:51
RADARSAT1	R1_56730_SWB_S7	R1_SCANSAR_SWATH	R1	S	56730	SWB	SEP-16-2006 23:44:28
RADARSAT1	R1_56730_SWB_S7	R1_SCANSAR_SWATH	R1	S	56730	SWB	SEP-16-2006 23:44:28
RADARSAT1	R1_56587_SWB_S8	R1_SCANSAR_SWATH	R1	S	56587	SWB	SEP-06-2006 23:36:05
RADARSAT1	R1_56587_SWB_S8	R1_SCANSAR_SWATH	R1	S	56587	SWB	SEP-06-2006 23:36:05
RADARSAT1	R1_56830_SWB_S6	R1_SCANSAR_SWATH	R1	S	56830	SWB	SEP-23-2006 23:40:14
RADARSAT1	R1_56830_SWB_S6	R1_SCANSAR_SWATH	R1	S	56830	SWB	SEP-23-2006 23:40:14
RADARSAT1	R1_56687_SWB_S7	R1_SCANSAR_SWATH	R1	S	56687	SWB	SEP-13-2006 23:32:00
RADARSAT1	R1_56687_SWB_S7	R1_SCANSAR_SWATH	R1	S	56687	SWB	SEP-13-2006 23:32:00
RADARSAT1	R1_39366_SWB_S4	R1_SCANSAR_SWATH	R1	S	39366	SWB	MAY-21-2003 00:24:25
RADARSAT1	R1_40395_SWB_S3	R1_SCANSAR_SWATH	R1	S	40395	SWB	AUG-01-2003 00:24:17
RADARSAT1	R1_39709_SWB_S3	R1_SCANSAR_SWATH	R1	S	39709	SWB	JUN-14-2003 00:24:22
RADARSAT1	R1_40052_SWB_S3	R1_SCANSAR_SWATH	R1	S	40052	SWB	JUL-08-2003 00:24:17
RADARSAT1	R1_39023_SWB_S3	R1_SCANSAR_SWATH	R1	S	39023	SWB	APR-27-2003 00:24:22
RADARSAT1	R1_16213_EL1_S2	R1_LO_SWATH	R1	S	16213	EL1	DEC-12-1998 23:35:35
RADARSAT1	R1_54029_FN1_S7	R1_FINE_SWATH	R1	S	54029	FN1	MAR-11-2006 23:57:57
RADARSAT1	R1_53343_FN1_S7	R1_FINE_SWATH	R1	S	53343	FN1	JAN-22-2006 23:57:57
RADARSAT1	R1_55058_FN1_S6	R1_FINE_SWATH	R1	S	55058	FN1	MAY-22-2006 23:57:53
RADARSAT1	R1_55058_FN1_S6	R1_FINE_SWATH	R1	S	55058	FN1	MAY-22-2006 23:57:53
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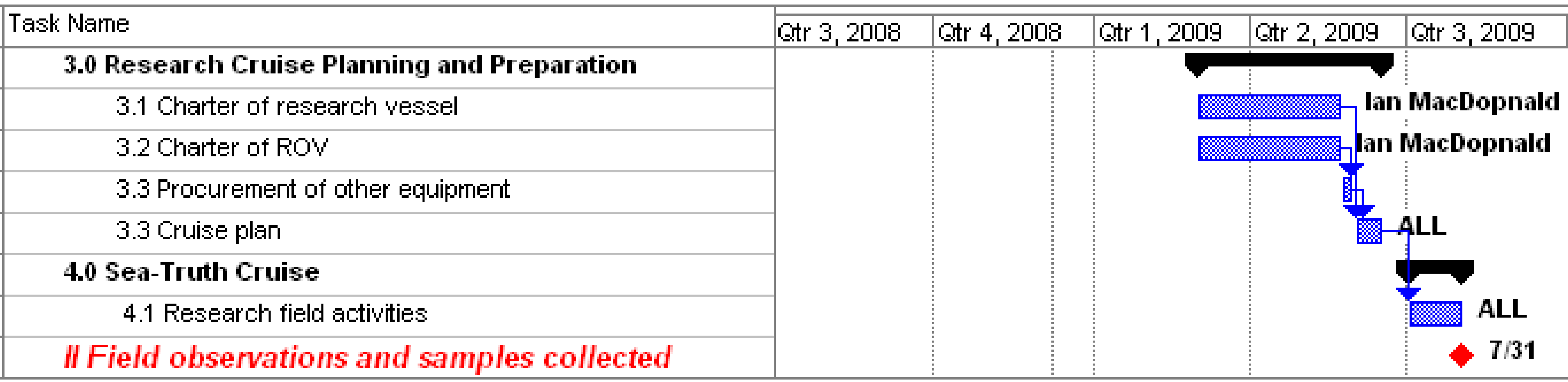
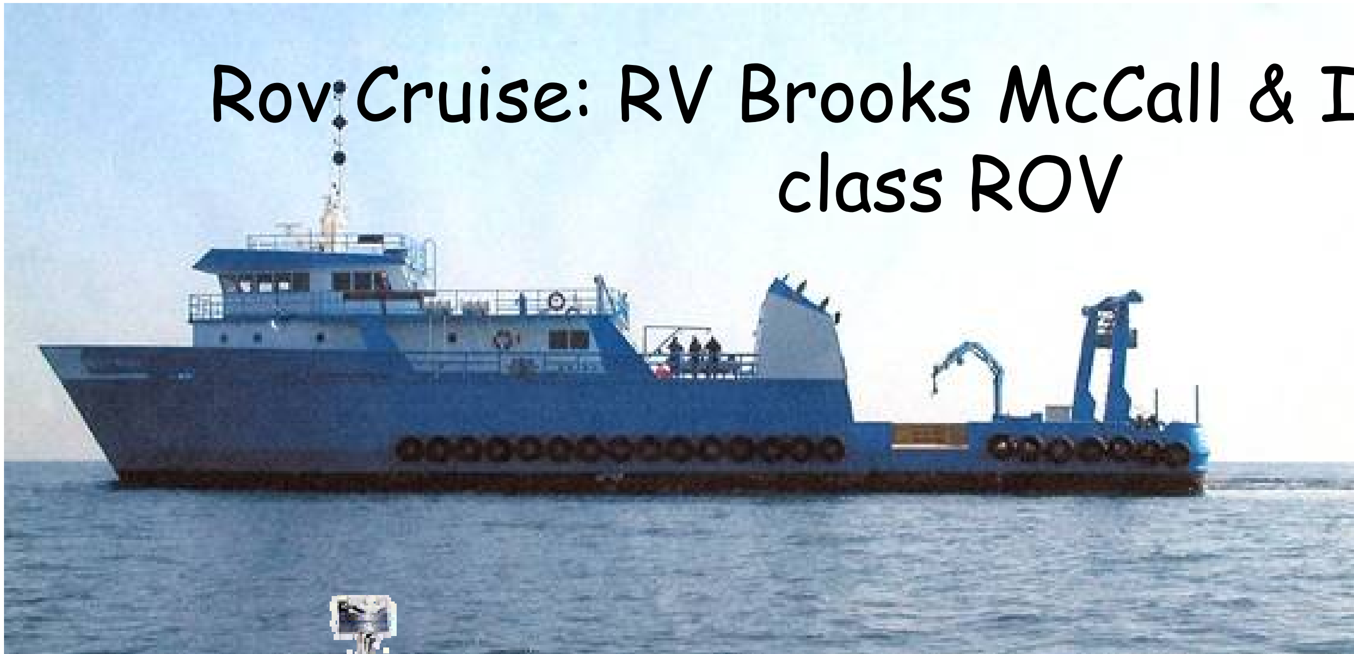
RADARSAT1	R1_62847_FN5_S6	R1_FINE_SWATH	R1	S	62847	FN5	NOV-19-2007 00:01:43
RADARSAT1	R1_58045_FN5_S2	R1_FINE_SWATH	R1	S	58045	FN5	DEC-18-2006 00:01:51

Sea-Truth Cruise
Q1 2009 - Q3 2009



Rov Cruise: RV Brooks McCall & Inspection class ROV



- TDI-Brooks Int. Charter of RV Brooks McCAll
- Bill Bryant ROV group (TAMU)
- Veolia Services (ROV piloting)

- **LWH:** 48 inches, 37 inches, 48 inches
- **Frame:** Anodized Aluminum
- **Housing:** 2 x electronic pressure bottles
- **Weight in air:** 1300 lbs
- **Payload:** 20 lbs. (approx)
- **Depth:** 4,921 feet (1500 meters)
- **Buoyancy:** Solid cell syntactic foam
- **Power input:** 1000 VAC, 3 phase, 7kW
- **Thrusters:** 5 thrusters, 2 Hp, pressure compensated
- **Manipulators:** Hydro-lek 5 function, Hydro-lek Jaw
- **Speed (approx):** Horizontal 2.8 knots
- Vertical 1.2 knots
- Lateral 1.3 knots
- Turn 50 deg/sec
- **Lights:** 4 x 250W halogen
- 4 channel light dimmer
- **Camera (2):** Camera 1, color zoom CCD 0.1 lux
- Camera 2, color, 1 lux
- **Viewing P/T:** Pan angle 0-90 degrees
- Tilt angle 0-120 degrees

TAMU Sub-Fighter ROV

- **LWH:** 48 inches, 37 inches, 48 inches
- **Frame:** Anodized Aluminum
- **Housing:** 2 x electronic pressure bottles
- **Weight in air:** 1300 lbs
- **Payload:** 20 lbs. (approx)
- **Depth:** 4,921 feet (1500 meters)
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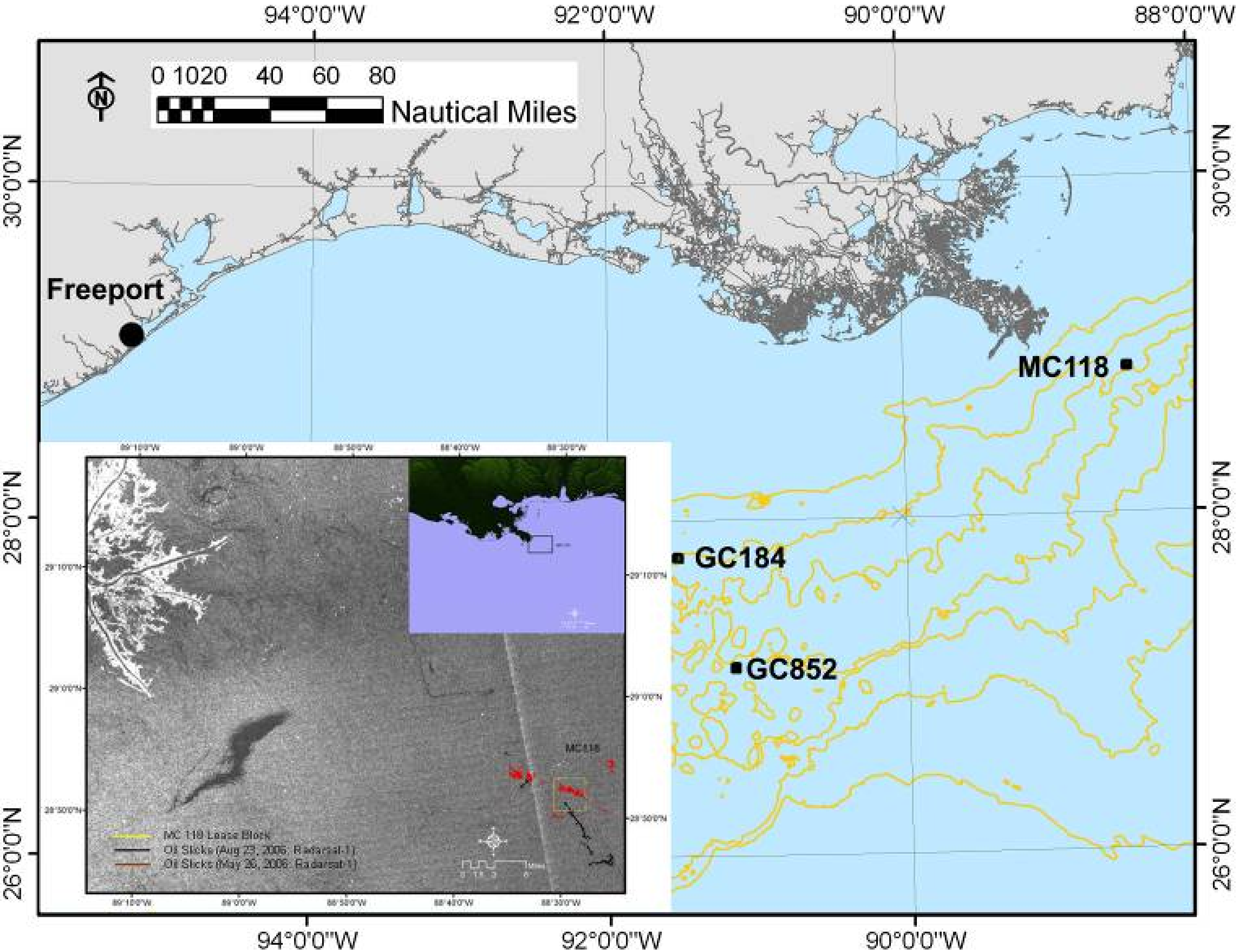
- **Power input:** 1000 VAC, 3 phase, 7kW
- **Thrusters:** 5 thrusters, 2 Hp, pressure compensated
- **Manipulators:** Hydro-lek 5 function, Hydro-lek Jaw
- **Speed (approx):** Horizontal 2.8 knots
- Vertical 1.2 knots
- Lateral 1.3 knots
- Turn 50 deg/sec
- **Lights:** 4 x 250W halogen
- 4 channel light dimmer
- **Camera (2):** Camera 1, color zoom CCD HR, 480 TV lines, 0.1 lux
- Camera 2, color, 460 lines, 1 lux
- **Viewing P/T:** Pan angle 0-90 degrees
- Tilt angle 0-120 degrees
- **Telemetry:** Fiber MUX 907
- 3 video channels
- 2 x RS 485 channels
- 2 x RS 232 channels
- 10 Mbit Ethernet
- **Sensors:** Depth sensor, accurate .15%
- Kongsberg MS1000 sector scanning sonar
- **Other:** Auto depth
- Auto heading
- Digital control of thrusters and lights

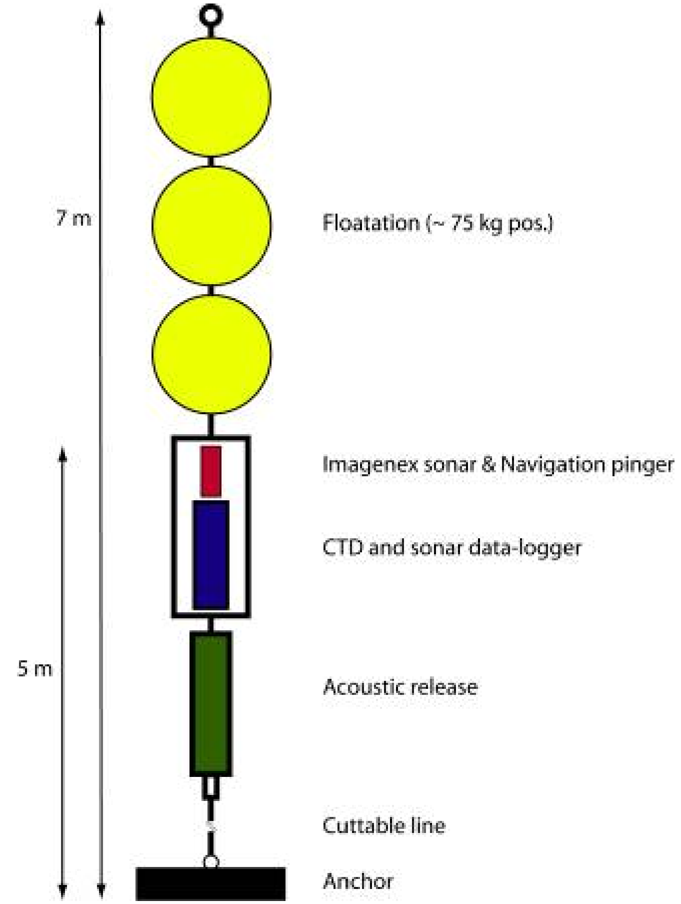
Study Sites


94°0'0"W
92°0'0"W
90°0'0"W
88°0'0"W
30°0'0"N
28°0'0"N
26°0'0"N
0 10 20 40 60 80
Nautical Miles
N
Freeport
MC118
GC184
GC852
MC118

Cruise activities at each station

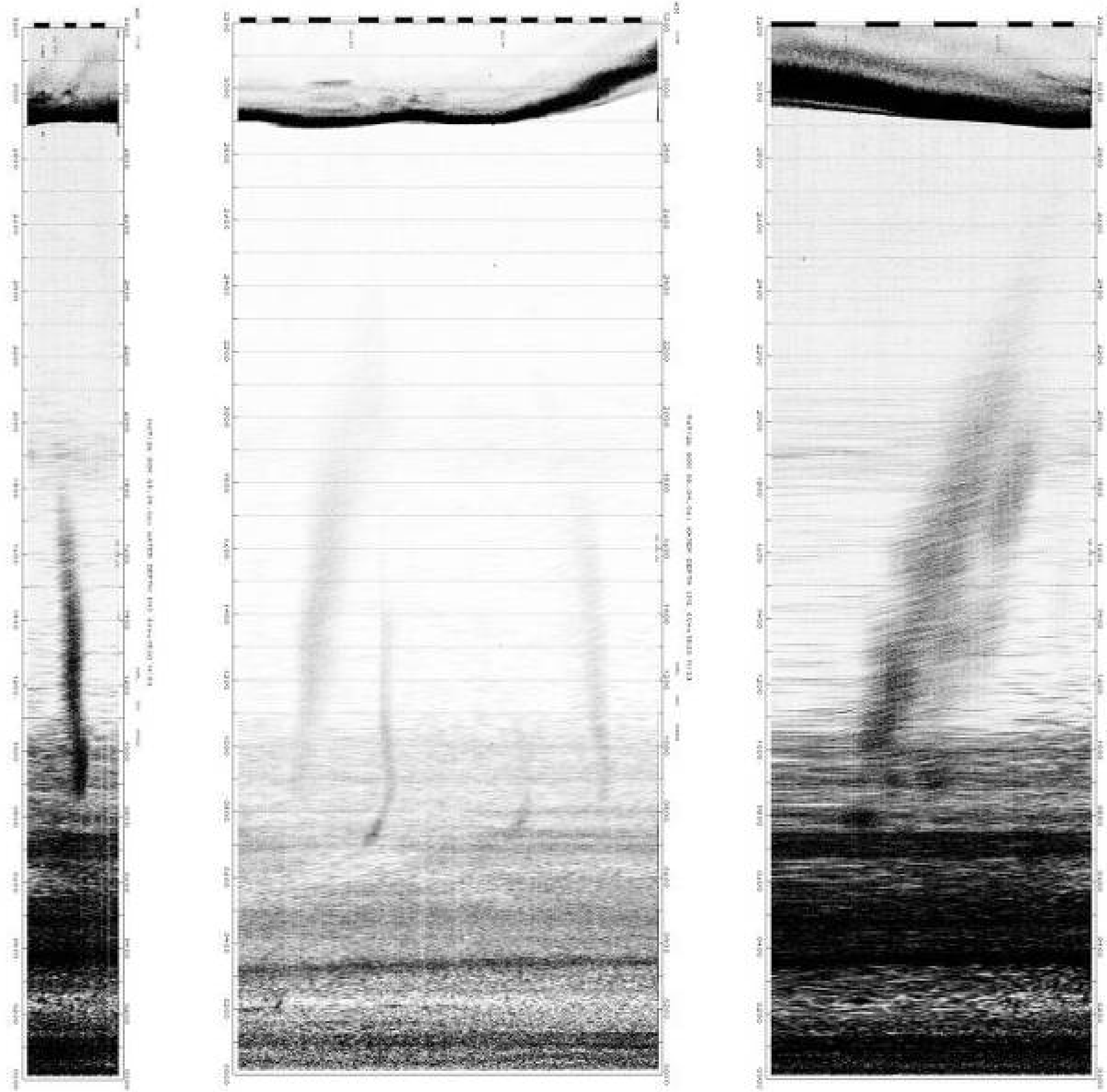
Activity		time required	time on station
1	Deploy ROV with bubble meter	2	2
2	Locate active vents fix position & depth	3	5
3	Deploy Bubble meter at active vent	3	8
4	Recover ROV	3	11
5	Deploy sonar mooring from surface ship	4	15
6	Collect CTD cast	2	17
7	Collect fine-scale grid of surface samples	6	23
8	Deploy ROV	2	25
9	Locate active vents & verify location of sonar array	1	26
10	Collect additional visual measurments of bubble stream	1	27
11	Collect push cores near vent	2	29
12	Recover ROV	3	30
13	Collect replicate CTD cast	4	34
14	Collect coarse-scale grid of surface samples	6	40
15	Collect background CTD cast away from site	2	42
16	Recover Sonar Mooring	1	43
17	Collect piston cores (2)	5	48

In situ instruments

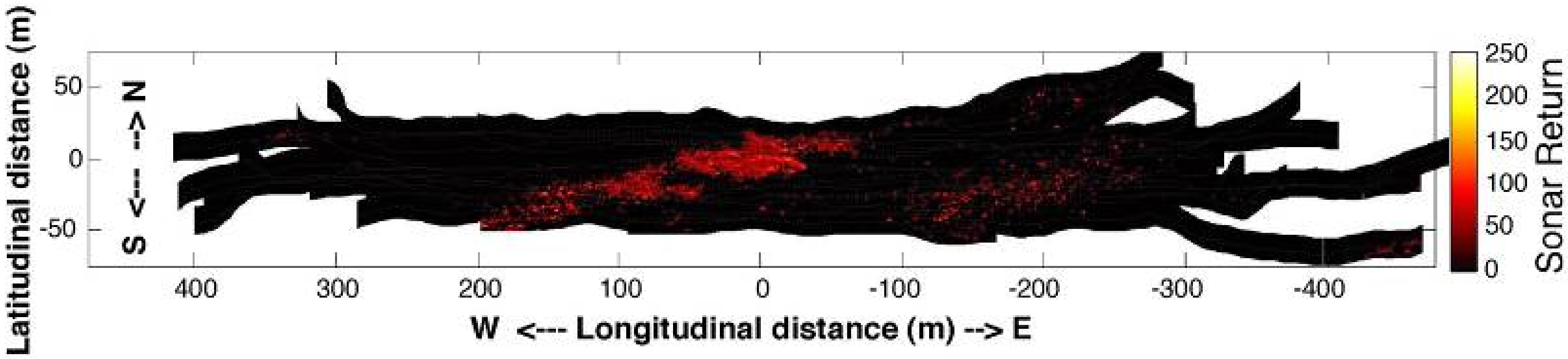


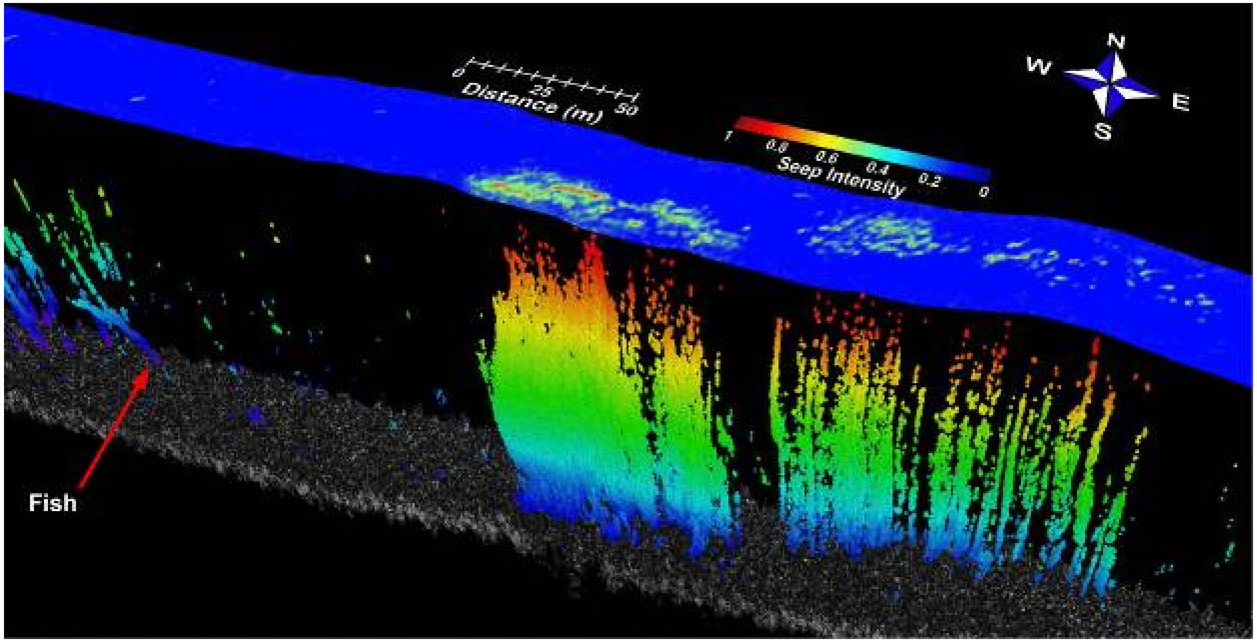
Gas Plumes from Chapopote

courtesy of Volkhard Speiss

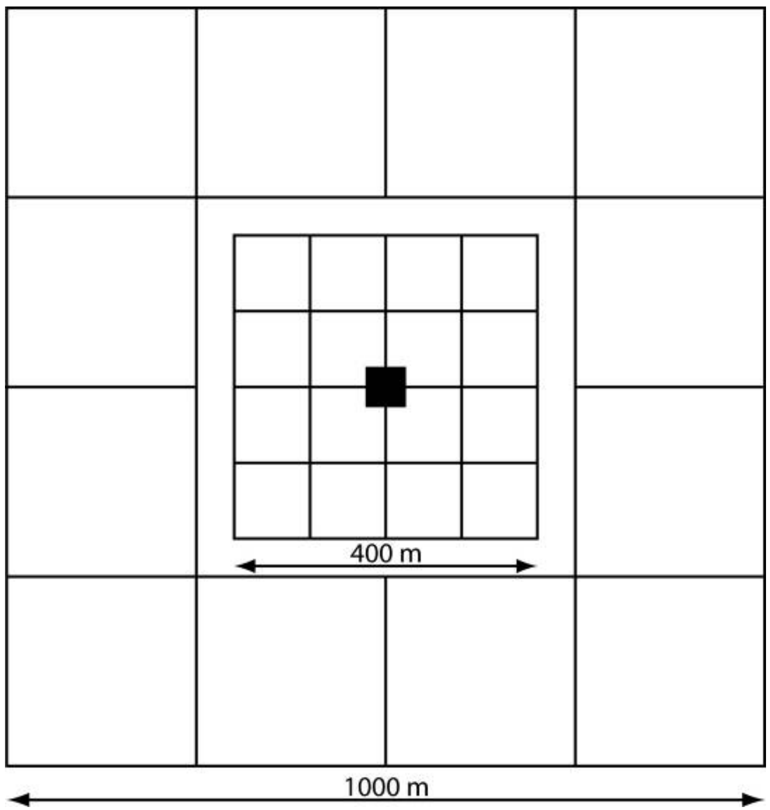


Side-scan Sonar Bubble Survey





Surface Sampling Grid

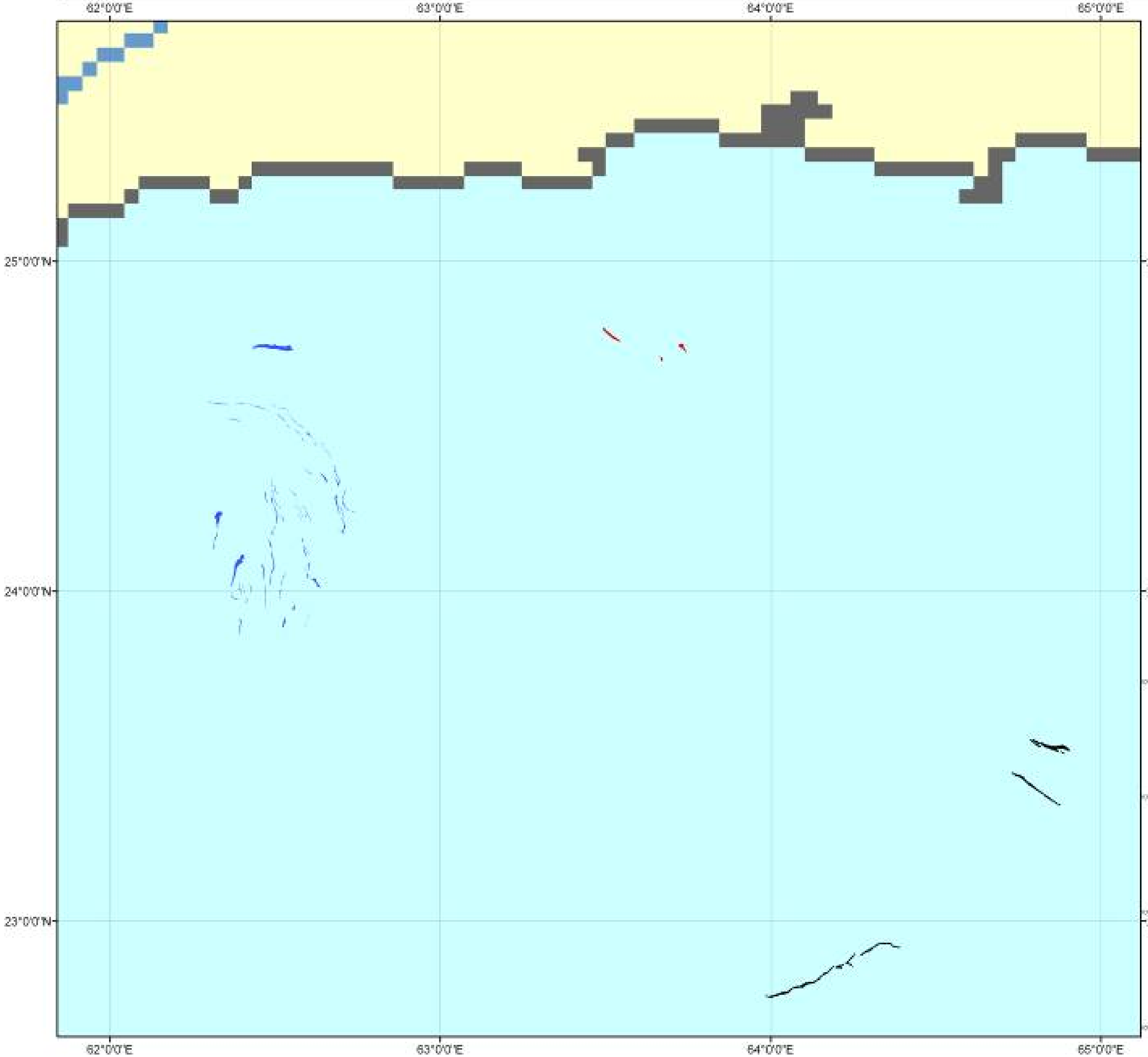


Water Column Sample in Plume

Analysis and Reporting Phase
Q3 2009 - Q3 2010

Task Name	Resource / Milestone
DE-NT0005638 Phase 2 Budget Period 2	
Revised Program Management Plan	Ian MacDopnald
V SAR Data for Global Seep Analysis	11/22
13.0 Other Regions Hydrocarbon Seep Inventory	
13.1 Image Analysis	Oscar Garcia,Ian MacDopnald
13.2 Database updates	Oscar Garcia,Ian MacDopnald
Sea-truth Sample Analysis	
14.0 Bubble Flux Analysis	Ira Leifer
15.0 Completion of Water Sample Analysis	Miriam Kastner
16.0 Water Column Flux Analysis	Evan Solomon
17.0 Air-Sea Flux Analysis	Shari Yvon-Lewis
18.0 Sediment Analyses	
18.1 Pore-water Analyses	Thomas Naehr,Miriam Kastner
18.2 Carbonate Analyses	Thomas Naehr
19.0 Modeling of AOM and carbonate precipitation rates	Thomas Naehr
VI Complete Sea-truth Sample Analysis	3/26
VII SAR Database Populated	3/26
20.0 Project Results Reporting & Publication	ALL

Sove Canyon Oil Slicks



- October 25, 1995
- June 13, 1995
- November 07, 2001

Synthetic Aperture Radar Images:

Granule Name	Date	Time	Satellite
J1_02429_STD_F389	JUL-22-1992	06:18:49	JERS-1
J1_18245_STD_F389	JUN-13-1995	06:23:36	JERS-1
J1_18260_STD_F389	JUN-14-1995	06:25:48	JERS-1
J1_20252_STD_F389	OCT-25-1995	06:29:41	JERS-1
R1_15485_ST3_F388	OCT-23-1998	01:44:21	Radarsat-1
R1_15485_ST3_F390	OCT-23-1998	01:44:34	Radarsat-1
R1_31363_SWB_F392	NOV-07-2001	01:39:17	Radarsat-1

Summary:

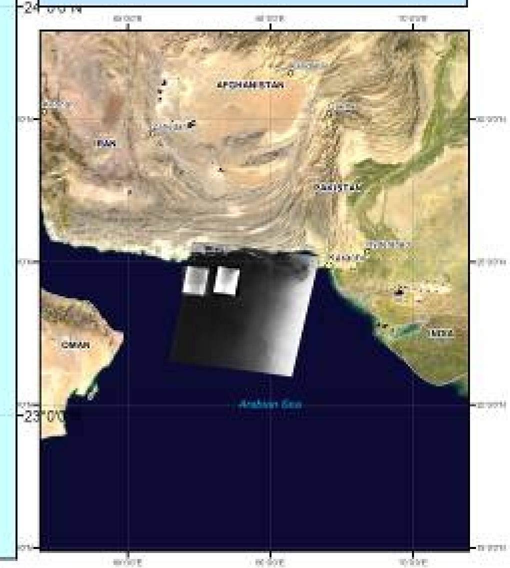
* Three from Seven SAR images showed oil slicks present in the area of interes.

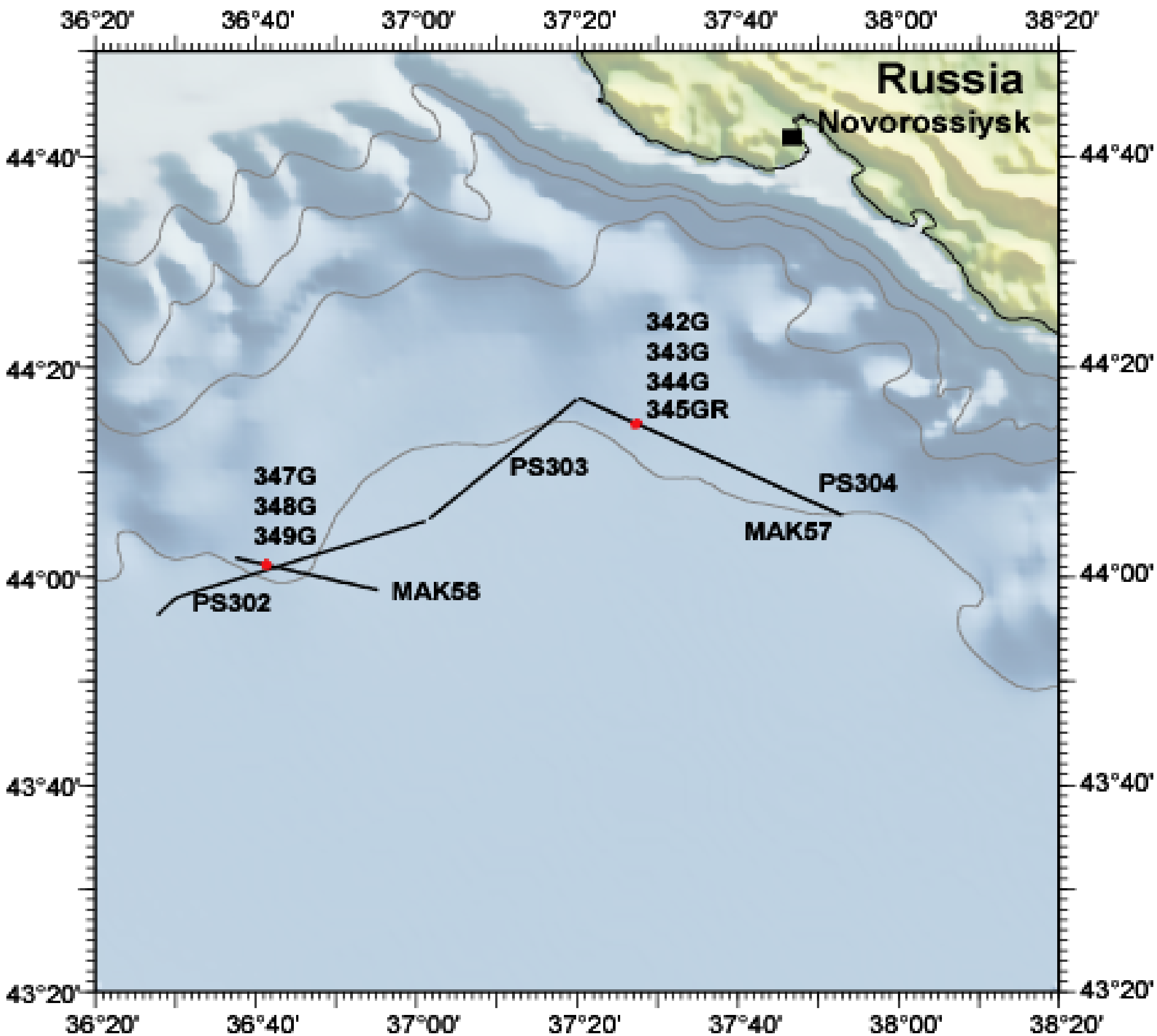
* Two images from Radarsat were useless due a strong wind present at the moment of the snapshot.

* All four images from JERS-1 are in good shape.

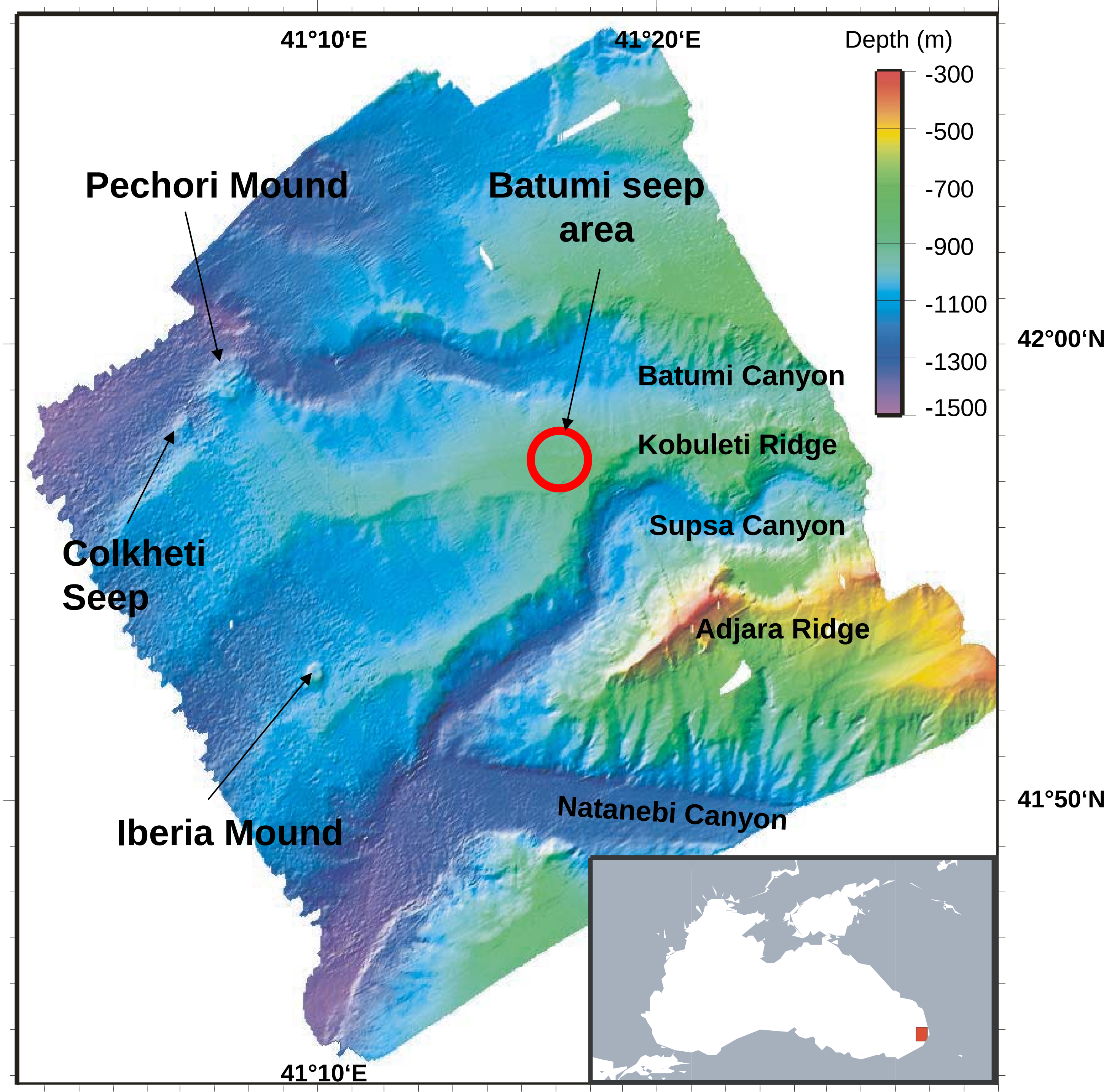
* Images taken by JERS-1 on Jul-22 and Oct-25 same year, covered the same spatial area, but only in the second one were detected oil slicks.

* Oil slicks were classified using the Supervised Texton Reaction Algorithm.





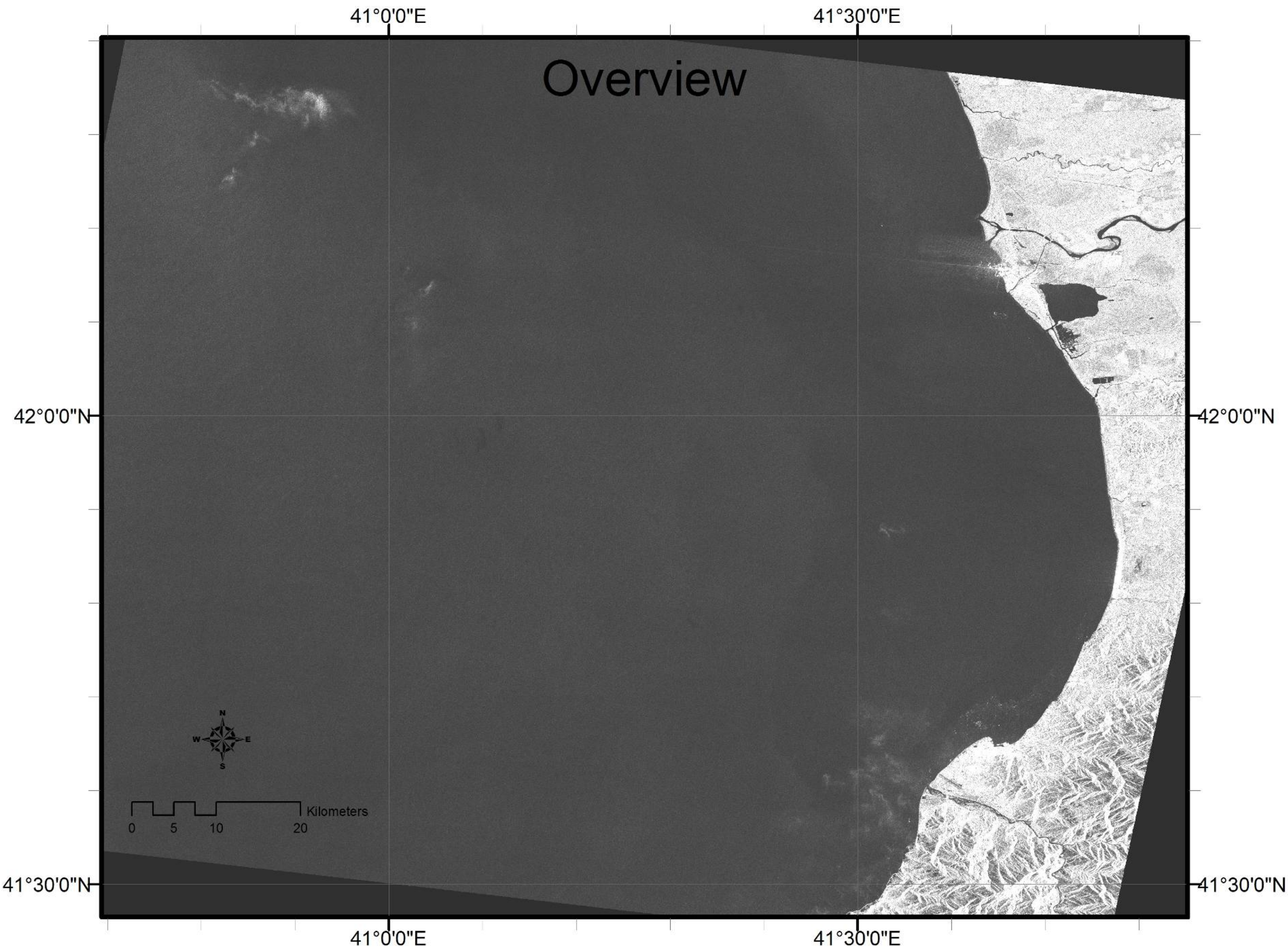
Russia
Novorossiysk
342G
343G
344G
345GR
347G
348G
349G
PS302
PS303
PS304
MAK57
MAK58
36°20'
36°40'
37°00'
37°20'
37°40'
38°00'
38°20'
44°40'
44°20'
44°00'
43°40'
43°20'



41°10'E
41°20'E
Depth (m)
-300
-500
-700
-900
-1100
-1300
-1500
42°00'N
42°00'N
41°50'N
41°50'N
41°10'E
Pechori Mound
Batumi seep area
Batumi Canyon
Kobuleti Ridge
Supsa Canyon
Adjara Ridge
Colkheti Seep
Iberia Mound
Natanebi Canyon

Risk Management

- Technical risk
  - Short-comings in performance of sampling and monitoring equipment
  - *Mitigation by field-testing methodology in Santa Barbara Channel*
- Weather risk
  - Gulf of Mexico hurricane / tropical storm could cancel cruise
  - *Mitigation by scheduling in July*



Overview
41°0'0"E
41°30'0"E
42°0'0"N
41°30'0"N
N
S
E
W
0
5
10
20
Kilometers