OCS Study
MMS 2006-067

Sperm Whale Seismic Study in the Gulf of Mexico

Annual Report: Years 3 and 4

MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Annual Report: Years 3 and 4

Editors

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ABOUT THE COVER

The cover art shows a sperm whale breaching in the northwest Gulf of Mexico in June 2005 (photo by Craig Hayslip, Oregon State University).

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This report would not have been possible without the contributions of a large number of people. Each principal investigator (PI) of the Sperm Whale Seismic Study (SWSS) contributed to the progress of the research. Many participated in the cruises, contributed material for this report, and worked on data reduction and processing. The principal investigators, their affiliations, and their tasks are:

Ann E. Jochens	TAMU	Program Manager, PI for habitat characterization
Douglas C. Biggs	TAMU	Project Scientist, PI for habitat characterization
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Dan Engelhaupt	UDurham	PI for genetic analyses
Jonathan Gordon	Ecologic[1]	PI for photo-ID and mesoscale survey
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Nathalie Jaquet	TAMUG[2]	PI for photo-ID and mesoscale survey
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Robert L. Leben	CU	PI for habitat characterization - sea surface height
Bruce Mate	OSU	PI for S-tag whale tagging and tracking
Patrick Miller	WHOI[3]	PI for D-tag/CEE study
Joel Ortega-Ortiz	OSU	PI for S-tag study
Aaron Thode	SIO	PI for 3-D passive acoustic tracking study
Peter Tyack	WHOI	PI for D-tag/CEE study
Bernd Würsig	TAMUG	PI for photo-ID and mesoscale survey

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• 2004 S-tag cruise science team: Doug Biggs (Chief Scientist; TAMU), Alyson Azzara (TAMU), Marty Bohn (TAMU), Paul Clark (TAMU), R. Iliana Ruiz-Cooley (OSU), Carol DeLancey (OSU), Dan Engelhaupt (UD), Deborah Epperson (MMS), Glenn Gailey (OSU), Bill Green (TAMU), Ladd Irvine (OSU), Rhoni Lahn (OSU), Daniel Lewer (OSU), Bruce Mate (OSU), Mary Lou Mate (OSU), Michael Noack (OSU), Thomas Norris (SAIC), Joel Ortega (OSU), Carol Roden (MMS), Aaron Thode (SIO), Sarah Tsoflias (MMS), Eddie Webb (TAMU), and Elizabeth Zele (OSU).

• 2004 Mesoscale Population Study team: Jonathan Gordon (Chief Scientist, Legs 1 and 4; Ecologic), Nathalie Jaquet (Chief Scientist, Legs 2 and 3; TAMUG), Ricardo Antunes, Steve

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[3] presently at the University of St. Andrews, UK

Brown (Skipper, TAMUG), Raul Diaz-Gamboa (TAMUG), Thomas Gordon (TAMUG), Christoph Richter (TAMUG), and Trudi Webster (TAMUG).

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2004 Mesoscale Population Study team: Jonathan Gordon (Chief Scientist, Legs 1 and 4; Ecologic), Christoph Richter (Chief Scientist, Legs 2 and 3; TAMUG/Ecologic), Ricardo Antunes (TAMUG), Pip Bauerlein (Skipper; TAMUG), Sierra Deutsch (TAMUG), Raul Diaz-Gamboa (TAMUG), Sam DuFresne (TAMUG), and Thomas Gordon (TAMUG).

Without the hard work of the ships' masters and crew, the science teams would not have been able to complete their tasks successfully and safely. So we extend sincere thanks to Captain Dana O. Dyer III and the crew of the *R/V Gyre*. The dedicated shore-based efforts of Desmond Rolf, Sandy Green, and Bill Green of the *Gyre* TAMU Marine Operations went above and beyond the call of duty and contributed to the success of the study. We also thank Dr. Norman Guinasso and Mr. John Walpert of TAMU GERG for their assistance with preparing the 38-kHz ADCP, and Mr. Tomas Follett of OSU for facilitating delivery of S-tag whale location information to SWSS scientists during their cruises.

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ACRONYMS

ADCP	Acoustic Doppler current profiler
AGU	American Geophysical Union
B-probe	Bioacoustics probe
CCAR	Colorado Center for Astrodynamics Research, University of Colorado
CDT	Central Daylight Time
CEE	controlled exposure experiment
CHL	chlorophyll
CTD	conductivity-temperature-depth sensor
CU	University of Colorado
DGPS	Differential Global Positioning System
D-tag	Digital-recording acoustic tag (tag name and SWSS program component)
EDT	Eastern Daylight Time
GDAS	*Gyre* Data Acquisition System
GERG	Geochemical and Environmental Research Group at TAMU
GPS	Global Positioning System
GulfCet	Gulf of Mexico Cetacean Study
IAGC	International Association of Geophysical Contractors
IRFC	Industry Research Funders Coalition
ITM	Information Transfer Meeting
LC	Loop Current
LCE	Loop Current eddy
MCS	middle continental slope
MMS	Minerals Management Service, U.S. Department of the Interior
MPS	Mesoscale Population Study of SWSS
MRD	Mississippi River Delta
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
ONR	Office of Naval Research
OSU	Oregon State University
Photo-ID	Photographic-Identification
PI	Principal Investigator
PMEL	Pacific Marine Environmental Laboratory
QA/QC	quality assurance/quality control
RHIB	Rigid-Hulled Inflatable Boat
R/V	research vessel
SAIC	Science Applications International Corporation
SCF	surface chlorophyll fluorescence
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SIO	Scripps Institution of Oceanography
SRB	Science Review Board
SSH	Sea surface height
SSS	Sea surface salinity
SST	Sea surface temperature
S-tag	Satellite-tracked radio tag (tag name and SWSS program component)

ACRONYMS
(continued)

SWAMP	Sperm Whale Acoustic Monitoring Program
SWSS	Sperm Whale Seismic Study
TAMU	Texas A&M University
TAMUG	Texas A&M University-Galveston
TAMRF	Texas A&M Research Foundation
TDTR	Time Depth and Temperature Recorder
UD	University of Durham, UK
USA	University of St. Andrews, UK
USF	University of South Florida
UTC	Universal Coordinated Time
WHOI	Woods Hole Oceanographic Institution
WSE	Warm Slope Eddy
XBT	expendable bathythermograph probe
3-D	three-dimensional

1 EXECUTIVE SUMMARY

1.1 Introduction

This is the third annual report of the Sperm Whale Seismic Study (SWSS). SWSS is a multi-institutional, interdisciplinary study supported by the Minerals Management Service (MMS) of the U.S. Department of the Interior under Cooperative Agreement 1435-01-02-CA-85186 for *Cooperative Research on Sperm Whales and their Response to Seismic Exploration in the Gulf of Mexico* through the Texas A&M Research Foundation. Under SWSS, scientists from Ecologic, Oregon State University (OSU), Scripps Institution of Oceanography (SIO), Texas A&M University (TAMU), Texas A&M University-Galveston (TAMUG), University of Colorado (CU), University of Durham (UD), University of St. Andrews (USA), and Woods Hole Oceanographic Institution (WHOI) develop and implement scientific research plans in coordination with MMS, the Office of Naval Research (ONR), National Science Foundation (NSF), and Industry Research Funders Coalition (IRFC).

The principal study tasks and associated institutions are: Satellite-tracked radio tags (S-tags) by OSU; Digital-recording acoustic tags (D-tags) and Controlled Exposure Experiments (CEEs) by WHOI and USA; Habitat characterization by TAMU; Photo-identification and mesoscale population studies (MPS) by Ecologic and TAMUG; Biopsy/genetic analyses by UD; 3-D passive acoustic tracking by SIO; Program management by TAMU; and Data management by TAMU. All fieldwork associated with sperm whales was conducted pursuant to approved permits from the National Marine Fisheries Service (NMFS). The program objectives and task goals are set out in the first annual report (Jochens and Biggs 2003).

1.2 Field Measurements in 2004

The 2004 field work consisted of an S-tag cruise in May/June 2004 and an MPS cruise in June-August 2004. Near real-time remote sensing images of sea surface height, ocean color, and sea surface temperature were obtained before and during the cruises and emailed to the scientists at sea on the S-tag and MPS cruises.

The S-tag cruise was conducted 24 May through 19 June 2004 out of Galveston, TX, aboard the R/V *Gyre*. There was an unplanned 48-hour port stop in Gulfport, MS, on 2-4 June, so that engine repairs could be made to the primary tag boat, and a 40-hour unplanned stop in the lee of the Mississippi River Delta on 14-15 June to escape bad weather offshore that was generated by a tropical cyclone. The 23-person science team searched for and tagged sperm whales in the northern Gulf of Mexico between 93.5°W and 86.5°W in water depths ranging from 500 m to 2200 m. Because bad weather made conditions unsafe for launch and operation, the small tag boats were deployed on only nine days during the cruise. Also as a consequence of the poor weather, no bioacoustic probe (B-probe) deployments were attempted. A total of 8 whales were tagged, all in the Mississippi Canyon area. A total of 18 sperm whale flukes were photographically captured. Of these, four were of whales tagged in 2004 and one each tagged in 2003 and 2002. A total of four skin samples were collected during the cruise, all of which were from whales tagged with satellite-monitored tags. A new towed passive acoustic hydrophone array was deployed from the starboard side of the R/V *Gyre* to test various algorithms for acoustically tracking sperm whales in range and depth. When towed in conjunction with the

Ecologic array deployed on the port side, the acoustic team sought to determine three-dimensional characterizations of selected sperm whales. Habitat characterization data collection consisted of sea surface temperature, salinity, and chlorophyll fluorescence data logged every minute from a continuous flow pumped from ~3.5 m depth, chlorophyll extracted from water samples at 74 locations for calibration of the fluorescence to chlorophyll fluorescence, ocean current velocity in the upper 300 and 1000 m from, respectively, 153-kHz and 38-kHz hull-mounted acoustic Doppler current profiler (ADCP) instruments, temperature profiles from 70 expendable bathythermograph (XBT) probes, and temperature-salinity profiles from five casts using a vertically profiling conductivity-temperature-depth (CTD) instrument.

The MPS cruise was mobilized on 12-20 June. Major mobilization activities were to reconfigure and provision the 46' Hunter-class motor sailboat, *Summer Breeze*, into a research platform for the cruise. The cruise left out of St. Petersburg, FL, on 20 June and returned on 11 August 2004. During the four legs of this cruise, the region of the northern Gulf of Mexico between 90.5°W and 84.5°W was surveyed acoustically and visually for sperm whales. The primary study area was the area between the 500 and 1500-m depth contours in the region of high oil/gas platform density and anthropogenic activity off the Mississippi River Delta and in the Mississippi Canyon, although observations also were made between the 200 and 500-m isobaths during transits to/from port and between 1500 and 2100-m depths to assess the effects on whale behavior of off-margin flow of riverine water by a cyclone-anticyclone pair. The primary goals of the cruise were to expand baseline information on population size, habitat use, social organization, movements and behavior of sperm whales and to help determine natural variability and potential responses to anthropogenic activities. Other integral tasks were to determine distribution and movements of sperm whales in relation to natural changes in environmental conditions, investigate population structure and calving rate, investigate residency of known individuals in the northern Gulf of Mexico. When the opportunity arose, data were collected to allow study of the behavioral reactions to acoustic emissions from platforms and seismic ships, and to make opportunistic calibrated recordings of rig noise. The goals were achieved mainly by photo-identification and length measurements of individuals made during follows of groups extending over 10 to 60 hours, recordings of vocalizations and anthropogenic sounds, and collection of 6 biopsy samples.

1.3 SWSS Planning Meeting of 2005

Seventeen SWSS speakers made presentations at the all day SWSS session held at the 23rd MMS Information Transfer Meeting on 12 January 2005 in Kenner, LA (McKay and Nides 2005). A SWSS planning meeting followed on 13 January 2005 to discuss activities for a two-year extension of SWSS. Attendees included representatives from all SWSS components, MMS, ONR, NMFS, and industry. Four of the five members of the SWSS Science Review Board (SRB) attended. The goal of this meeting was to determine the tasks and objectives of the two year extension of SWSS. As a result of recommendations of the SRB and participating agency and science personnel, it was decided the extension would consist of field work in summer 2005 followed by a year of analysis and synthesis, with the final Synthesis Report to come out in 2007.

1.4 Field Measurements in 2005

The 2005 field work consisted of an S-tag cruise in June and an MPS cruise in June-August. Near real-time remote sensing images of sea surface height, ocean color, and sea surface temperature again were used in pre-cruise planning and were provided to the scientists at sea.

The S-tag cruise was conducted from 2000 CDT 2 June through 1700 CDT 30 June, with mobilization on 30 May to 2 June and demobilization on 30 June to 2 July. The cruise was conducted aboard the R/V *Gyre* out of the home port of Galveston, TX. There were two port calls: one unplanned at Port Aransas, TX, on 13 June to allow an ill crew member to be replaced and one planned at Harbor Island, TX, on 19 June to exchange science personnel. The study region was the northwestern Gulf. The 23-member science team collected data between about 500 m to 2200 m water depths from west of approximately 93°W to just north of the border with Mexico. In the first ever deployment of tags on sperm whales in the northwestern and deep water central Gulf, 12 S-tags were successfully attached. The bioacoustics probe (B-probe) was successfully deployed twice with 1.5 hours and 2 hours of dive data collected. Twenty-two biopsies from sperm whales were obtained. Three samples from rough-toothed dolphins were also collected and stored for later analyses. Twenty-three individuals were photo-identified. Passive acoustic monitoring data, suitable for three-dimensional sperm whale tracking analyses, were recorded. High quality acoustic recordings were obtained of clicks. Using 70-kHz and 38-kHz instruments, fishery echosounder data on the deep scattering layer were collected simultaneously with observations on sperm whales. Physical oceanographic data were collected, including 38-kHz ADCP current velocity and acoustic backscatter intensity measurements, continuously logged temperature, salinity, and chlorophyll fluorescence data at 3.5-m depth, filtered chlorophyll measurements from 3.5-m depth, and 82 XBT and 4 CTD profiles.

The second summer of MPS fieldwork was conducted out of St. Petersburg, FL, again using the *Summer Breeze*. The cruise was conducted between 1600 EDT 13 June through 1900 EDT 3 August 2005. Mobilization occurred June 4-11. Passage of Hurricane Arlene caused about a 2-day delay in departure. Demobilization was August 3-6. The marina on the return was changed from that of the departure because Hurricane Dennis demolished the marina of departure. The fieldwork was conducted in 4 legs of roughly 2 weeks each. Weather, in the form of tropical storm events A through E, crew illnesses, and engine trouble caused there to be more time on shore than planned. In addition to Hurricanes Arlene and Dennis causing lost weather days, Tropical Storm Cindy and Hurricane Emily also resulted in unplanned time ashore. Tropical Storm Bret caused only anxious watching. Illnesses, ranging from ear and eye infections to an infected foot, resulted in unplanned time ashore as well. Finally nearly a week was lost on shore when the engine malfunctioned and the boat had to be sailed to Galveston, TX, for repairs. The management of the Small Boat Basin of Texas A&M University-Galveston graciously provided assistance to SWSS in the form of docking space, shore connections, and general help to the sailboat personnel while repairs were being done. Despite these difficulties, the team collected unique data, observing that in summer 2005 there seemed to have been a substantial change in along-margin distribution of whale groups. They observed maturing males rather than mixed groups in the region of the designated survey areas, and they found that the more "typical" mixed group assemblages were only encountered well to the west of DeSoto Canyon and Mississippi Canyon.

2 INTRODUCTION

The first and second annual reports for the Sperm Whale Seismic Study (SWSS) detailed the program objectives, tasks, and participants, and the data collection and processing for the S-tag and D-tag cruises in field years 1 and 2, as well as presenting preliminary technical discussions (Jochens and Biggs 2003, 2004). This report focuses on the data collection and analysis efforts during field years 3 and 4 of the study. No results are presented in this report. The SWSS Summary Report, 2002-2004, presented results by program elements, without extensive synthesis (Jochens et al. 2006). The SWSS Synthesis Report will be finalized in 2007.

2.1 Program Participants

SWSS is a multi-institutional, interdisciplinary study supported by the Minerals Management Service (MMS) of the U.S. Department of the Interior under Cooperative Agreement 1435-01-02-CA-85186 for *Cooperative Research on Sperm Whales and their Response to Seismic Exploration in the Gulf of Mexico*. Additional direct support for SWSS activities in years 3 and 4 was provided by the National Fish and Wildlife Foundation (NFWF) and the Industry Research Funders Coalition (IRFC), which is a coalition of the International Association of Geophysical Contractors (IAGC) and five oil and gas exploration and production companies.

The principal academic SWSS scientists conducting the study are

Ecologic: Jonathan Gordon (also at the University of St. Andrews, UK)
Oregon State University (OSU): Bruce Mate, Joel Ortega-Ortiz, and Kelly Benoit-Bird
Provincetown Center for Coastal Studies: Nathalie Jaquet
Scripps Institution of Oceanography (SIO): Aaron Thode
Texas A&M University (TAMU): Ann Jochens (SWSS Program Manager), Douglas Biggs, Matthew Howard (SWSS Data Manager), and John Wormuth
Texas A&M University-Galveston (TAMUG): Bernd Würsig
University of Colorado (CU): Robert Leben
University of Durham, UK (UD): Daniel Engelhaupt
University of St. Andrews, UK (UStA): Patrick Miller
University of South Florida (USF): Chuanmin Hu
Woods Hole Oceanographic Institution (WHOI): Peter Tyack and Mark Johnson

The principal study tasks and associated institutions are: Satellite-tracked radio tags (S-tags) by OSU; Digital-recording acoustic tags (D-tags) and Controlled Exposure Experiments (CEEs) by WHOI and UStA; Habitat characterization by TAMU, CU, USF, and OSU; Photo-identification and Mesoscale Population Studies (MPS) by Ecologic, Provincetown, and TAMUG; Biopsy/genetic analyses by UD; 3-D passive acoustic tracking by SIO; Program management by TAMU; and Data management by TAMU. All activities associated with marine mammals are conducted pursuant to approved permits from NOAA Fisheries.

The SWSS fieldwork for years 3 and 4 was conducted in, respectively, summer 2004 and summer 2005. Both years consisted of an S-tag cruise aboard the R/V *Gyre* and a Mesoscale Population Study (MPS) cruise aboard the motor-sailor, *Summer Breeze*. Table 2.1 shows the cruises with start and end dates. In addition to the major funding support of MMS, the funding support for the year 3 fieldwork included funds from NFWF, which covered costs associated with the *Summer Breeze* bareboat charter for the MPS cruise, and from the IRFC, which provided support for the MPS cruise and analysis, purchase of the 3-D passive acoustic tracking hydrophone array, and enhanced data analysis of S-tag whale and seismic shot location data. IRFC also provided funding support in year 4 for purchase of new depth-recording S-tags, upgrades of the 3-D passive acoustic tracking hydrophone array, and continuation of the enhanced data analysis of S-tag whale and seismic shot location data.

Table 2.1

SWSS Cruises Conducted in 2004 and 2005

Year	Ship	Cruise	Cruise ID	Dates
2004	R/V *Gyre*	S-tag	04G05	05/24/2004 - 06/19/2004
2004	*Summer Breeze*	MPS	MPS1	06/20/2004 - 08/11/2004
2005	R/V *Gyre*	S-tag	05G09	06/02/2005 - 06/30/2005
2005	*Summer Breeze*	MPS	MPS2	06/13/2005 - 08/03/2005

2.2 Program Activities for Year 3 (April 2004 - March 2005)

The field effort in year 3 consisted of two cruises between May and August 2004. The S-tag cruise was on the R/V *Gyre*, sailing out of Galveston, TX. The cruise dates were 24 May through 19 June 2004. Cruise work consisted of S-tag deployments, visual and passive acoustic observations, habitat characterization data (remote sensing fields of sea surface eight and ocean color, CTD and XBT temperature and salinity profiles, shipboard ADCP measurements of currents, and continuous near-surface temperature, salinity, and fluorescence/chlorophyll measurements), skin sampling for genetic typing, and a full 3-D passive acoustic tracking study. The study area was between 93.5°W and 86.5°W in water depths ranging from 500 m to 2200 m.

The second cruise was the MPS cruise, conducted aboard a quiet vessel, the 46' Hunter sailboat *Summer Breeze*. It left St. Petersburg, FL, on 20 June 2004 and returned on 11 August 2004. The MPS study area was the region of the northern Gulf of Mexico between 90.5°W and 84.5°W, primarily between the 500 and 1500-m depth contours. Water depths out to 2100 m were searched. Data were collected on the social behavior of sperm whale groups using photographs, photogrammetry, passive acoustic recordings, and visual observations as groups were followed for 1-3 days each. In addition to social behavior data, continuous near-surface temperature and CTD profiles were collected on this cruise and remote sensing fields were obtained.

A number of presentations on SWSS results were made at scientific conferences in year 3, three publications were submitted to and accepted by scientific journals, and one Master of Science thesis was successfully defended. The publications and thesis are:

1. Miller, P. J. O., M. P. Johnson, and P. L. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proc. Roy. Soc. B*. **271**, 2239-2247. DOI: 10.1098/rspb.2004.2863.
2. Sindlinger, L. R., D. C. Biggs, and S. F. DiMarco. 2005. Temporal and spatial variability of ADCP backscatter on a continental slope. *Continental Shelf Research*. **25**, 259-275. (SWAMP).
3. Thode, A. 2004. Tracking sperm whale (*Physeter macrocephalus*) dive profiles using a towed passive acoustic array. *J. Acoust. Soc. Am.* **116** (1), 245-253.
4. Kaltenberg, A. M. 2004. 39-kHz ADCP Investigation of Deep Scattering Layers in Sperm Whale Habitat in the Northern Gulf of Mexico. M.S. Thesis, December 2004. Department of Oceanography, Texas A&M University, College Station, TX. 102 pp.

A SWSS-related presentation was made at the Aquatic Sciences Meeting of the American Society of Limnology and Oceanography (ASLO) in February 2005. The oral presentation was:

1. Kaltenberg, A.M., A.D. Thode, D. C. Biggs, and S.F. DiMarco. 2005. Measurement of ADCP backscatter from deep scattering layers while tracking the dive depth of foraging sperm whales. Session TS44, Biocomplexity in Marine Ecosystems, ASLO Aquatic Sciences Meeting. February 2005, Salt Lake City, UT.

Seventeen science talks were presented by SWSS scientists at the all day session on 12 January 2005 for the Sperm Whale Seismic Study at the 23rd MMS Information Transfer Meeting. The written presentation summaries for the 17 SWSS science talks were published in McKay and Nides (2005). The talks, in order of presentation with the speaker's name underlined, were:

1. Overview of Sperm Whale Seismic Study (SWSS). Ann Jochens (Texas A&M University)
2. Seasonal Movements, Range, and Aspects of Sperm Whale Diving Behavior. Bruce Mate (Oregon State University)
3. Social Structure of Satellite-tracked Sperm Whales in the Gulf of Mexico. Joel Ortega-Ortiz and Bruce Mate (Oregon State University), Dan Engelhaupt (University of Durham)
4. Habitat Characterization of Satellite-tracked Sperm Whales in the Gulf of Mexico. Joel Ortega-Ortiz and Bruce Mate (Oregon State University), Robert Leben (University of Colorado), Douglas Biggs and Matthew Howard (Texas A&M University)
5. Seismic Survey Activity and the Proximity of S-Tagged Whales. Martha Winsor and Bruce Mate (Oregon State University)
6. Brief Outline of Sperm Whale Airgun Controlled Exposure Experiments (CEEs). Peter Tyack (Woods Hole Oceanographic Institution)
7. Diving, Foraging and Vocal Behavior of Sperm Whales. Stephanie Watwood (Woods Hole Oceanographic Institution), Patrick Miller (St. Andrews University), Mark Johnson, Peter Madsen, and Peter Tyack (Woods Hole Oceanographic Institution)
8. The Sounds of Airguns as Recorded on Sperm Whales and Methods to Quantify Acoustic Exposure. Peter Madsen and Mark Johnson (Woods Hole Oceanographic Institution), Patrick Miller (St. Andrews University), and Peter Tyack (Woods Hole Oceanographic Institution)
9. Preliminary Modeling of DTAGS Acoustic Arrivals from the Gulf of Mexico in 2002 and 2003. James Lynch, Stacy DeRuiter, Peter Tyack, Arthur Newhall, and Ying-Tsong Lin (Woods Hole Oceanographic Institution)

10. Controlled Seismic Airgun Exposures: Effects on the Movement and Foraging Behaviour of Sperm Whales. Patrick Miller (St. Andrews University), Mark Johnson, Peter Tyack, Peter Madsen, and Stephanie Watwood (Woods Hole Oceanographic Institution)
11. D-tag/CEE Concluding Remarks. Peter Tyack (Woods Hole Oceanographic Institution)
12. Mesoscale Sperm Whale Studies in the Gulf of Mexico I: Responses to Seismic Line Starts, Acoustic Length Measurements, Codas and Cultural Organization. Jonathan Gordon (Ecologic and University of St. Andrews), Nathalie Jaquet (Texas A&M University-Galveston), Ricardo Antunes (Ecologic and University of St. Andrews), Luke Rendell (University of St. Andrews) and Bernd Würsig (Texas A&M University-Galveston)
13. Sperm Whales in the Northern Gulf of Mexico: Abundance, Habitat Use, and Aspects of Social Organization. Nathalie Jaquet (Texas A&M University-Galveston), Jonathan Gordon (Ecologic and University of St. Andrews) and Bernd Würsig (Texas A&M University-Galveston)
14. Gulf of Mexico Sperm Whales – A Genetic Perspective. Dan Engelhaupt (University of Durham)
15. Three-dimensional tracking of sperm whales using passive acoustics. Aaron Thode (Scripps Institution of Oceanography)
16. Physical Environment of the Northern Gulf of Mexico During Summers 2002-2004. Ann Jochens, Matt Howard, Steve DiMarco, and Doug Biggs (Texas A&M University)
17. Analysis Of The Mesopelagic Community In Areas Of Feeding And Non-feeding By Sperm Whales In The Northern Gulf Of Mexico. John Wormuth (Texas A&M University)

A SWSS planning meeting followed the ITM session. It was held to determine activities for a two-year extension. Based on recommendations of participants, the extension was to consist of field work in summer 2005, a year of analysis, and publication of the Synthesis Report in 2007.

2.3 Program Activities for Year 4 (April 2005 - March 2006)

Field work in year 4 consisted of two cruises between June and August 2005. The S-tag cruise was out of Galveston, TX, on the R/V *Gyre* (Figure 2.1) from 2-30 June 2005. The study area shifted from the region associated with the Mississippi River Delta, which was the focus of field work in the three previous SWSS years, to the northwest Gulf. The area covered was over the slope from ~92.5°W to the U.S.-Mexico border at 26°N in water depths of 800 m to ~3000 m. The main focus area was west of 94°W and centered approximately along the 1000-m isobath. The cruise consisted of S-tag deployments (Figure 2.2), visual and passive acoustic observations (Figure 2.3), habitat characterization data (remote sensing fields of sea surface height and ocean color, CTD and XBT temperature and salinity profiles, shipboard ADCP measurements of currents, and continuous near-surface temperature, salinity, and fluorescence/chlorophyll measurements), skin sampling for genetic typing, and a full 3-D passive acoustic tracking study.

The second cruise was the MPS cruise aboard the *Summer Breeze* (Figure 2.4), which departed St. Petersburg, FL, on 13 June 2005 and returned 3 August 2005. The MPS study area was the region of the northern Gulf of Mexico approximately between 94°W and 85°W, primarily between the 500 and 1500-m depth contours. This cruise gathered data on the social behavior of sperm whale groups from photographs (Figure 2.5), photogrammetry, passive acoustic recordings, and visual observations as the groups were followed for 1-3 days each. In addition to social behavior data, continuous near-surface temperature and CTD profiles were collected on this cruise and remote sensing fields were obtained.

In SWSS year 4, a number of presentations on SWSS results were made at scientific conferences and five publications were published by scientific journals based in part or in whole on SWSS work. The publications are:

1. Biggs, D., A. Jochens, M. Howard, S. DiMarco, K. Mullin, R. Leben, F. Muller-Karger, and C. Hu. 2005. Eddy forced variations in on-margin and off-margin summertime circulation along the 1000 m isobath of the northern Gulf of Mexico, 2000-2003, and links with sperm whale distributions along the middle slope, pp 71-85. In Circulation in the Gulf of Mexico: Observations and Models, W. Sturges and A. Lugo-Fernández, Editors. Geophysical Monograph Series, Volume 161, American Geophysical Union, 360 pp.
2. Jaquet, Nathalie. 2006. A simple photogrammetric technique to measure sperm whales at sea. *Marine Mammal Science*. In press.
3. Madsen, P.T. 2005. Marine mammals and noise: Problems with root mean square sound pressure levels for transients *J. Acoust. Soc. Am*. **117** (6), 3952-3957.
4. Thode, A. 2005. Three-dimensional passive acoustic tracking of sperm whales (*Physeter macrocephalus*) in ray-refracting environments. *J. Acoust. Soc. Am.* 118 (6) 3575-3584.
5. Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack. 2006. Deep diving foraging behavior of sperm whales (*Physeter macrocephalus*). *J. Animal Ecology*, **75**, 814-825.

Figure 2.1. SWSS S-tag cruise on R/V *Gyre* in the northwestern Gulf of Mexico in June 2005.

Figure 2.2. SWSS tag boat operations were sometimes hindered by waterspouts that formed during local squalls on the S-tag cruise in June 2005.

Figure 2.3. SWSS R2 boat with scientists at work collecting photo-identification shots on the S-tag cruise in June 2005.

Figure 2.4. SWSS Mesoscale Population Study sailboat, *Summer Breeze*, at a port stop in Galveston, TX, in July 2005.

Figure 2.5. Whale observations being collected during the SWSS Mesoscale Population Study cruise in summer 2005.

A number of talks and posters that included information from SWSS were presented at the 16th Biennial Conference on the Biology of Marine Mammals, which was held in San Diego, CA, on December 12-16, 2005. Among the talks given were:

1. Habitat Characterization of Satellite-Tracked Sperm Whales in the Gulf of Mexico. Ortega-Ortiz, Joel G. ; Mate, Bruce; and Engelhaupt, Dan.
2. A New View of Sperm Whale Social Organization: Potential Influences of History, Habitat and Predation. Jaquet N., D. Gendron, J. Gordon and B. Würsig.
3. Quantification and Acoustic Propagation Modeling of Airgun Noise Recorded on Dtag-tagged Sperm Whales in the Gulf of Mexico. DeRuiter, Stacy L.; Lin, Ying-Tsong; Newhall, Arthur E.; Madsen, Peter T.; Miller, Patrick J.O.; Lynch, James F.; Tyack, Peter L.
4. The Communication Capacity of Sperm Whale Echolocation Clicks. Miller, Patrick J.O.; Johnson, Mark, P.; Madsen, Peter T.

Posters were:

1. Acoustic Length Measurement in Sperm Whales: Temporal Integration Improves Consistency of Inter Pulse Interval Measurement. Antunes, Ricardo; Würsig, Bernd; Jaquet, Nathalie; Gordon, Jonathan.
2. Fluke Scarring to Determine Anthropogenic and Predatory Interactions of Sperm Whale Populations. Guerrero-De la Rosa, Fabiola J.; Jaquet, Nathalie; Gendron, Diane; Gordon, Jonathan; Würsig, Bernd.

Three SWSS presentations were given at two other science conferences. These were:

1. Thode, A. 2005. 3-D tracking of sperm whale dive profiles from a mobile towed array platform. Presented at the 2nd International Workshop on Detection and Localization of Marine Mammals Using Passive Acoustics, held in Monaco on 16-18 November 2005.
2. Ortega-Ortiz, J.G and B.R. Mate. 2006. Sperm Whales in a Subtropical, Mesoscale Upwelling System: Temporal Variability. Presented in Session OS11A, Operational Applications of Ocean Satellite Observations I, 20 February 2006. AGU/ASLO/TOS 2006 Ocean Sciences Meeting, Honolulu, HI.
3. Biggs, D.C. and A.E. Jochens. 2006. Sperm Whales in a Subtropical, Mesoscale Upwelling System: Spatial Variability. Presented in Session OS15C, Operational Applications of Ocean Satellite Observations III, Posters, 20 February 2006. AGU/ASLO/TOS 2006 Ocean Sciences Meeting, Honolulu, HI.

2.4 Report Organization

This is the third annual report for SWSS. Section 1 of this report is the executive summary. The data acquisition of the tag measurements, visual and acoustic observations, genetic samples, and physical and biological oceanographic data, as well as a discussion of changes in methodology for data collection, are detailed in Section 3 for the S-tag cruises and Section 4 for the MPS cruises. Other instrumentation and methods for data collection, quality assurance/quality control (QA/QC), and analysis were as reported in the first and second SWSS annual reports (Jochens and Biggs 2003, 2004). All times are reported in Universal Coordinated Time (UTC) unless stated otherwise. References are given in Section 5.

3 DATA COLLECTION ON S-TAG CRUISES

The data collection effort for the S-tag cruises conducted in 2004 and 2005 are summarized here. This information summarizes the daily and final cruise reports.

3.1 S-tag Cruise 2004

General Introduction

R/V *Gyre* cruise 04G05 surveyed for sperm whales in the northern Gulf of Mexico between 93.5°W and 86.5°W. The cruise departed Galveston, TX, at 2300 CDT on 24 May 2004 and returned at 0800 CDT on 19 June 2004. An unplanned 48-hour port stop was made in Gulfport, MS, on 2-4 June, so that engine repairs could be made to the primary tag boat. A second unplanned stop of 40 hours was made on 14-15 June to escape bad weather offshore. For that weather stop, the ship anchored in the lee of the Mississippi River Delta to avoid high winds and 5-7 foot seas generated by a storm in the central Gulf. Because of the two unplanned stops, the cruise track was divided into three legs (Figure 3.1.1).

The primary goal of the cruise was to tag animals with satellite-tracked radio tags (S-tags). Tagging was done from small boats, along with photo-identification (photo-ID) and biopsy sampling for genetic typing. Other integral tasks for the survey effort were to acoustically determine three-dimensional (3-D) dive profiles and to gather physical and biological oceanographic data for characterization of the habitat in which whales were encountered. SWSS Principal Investigators (PIs) who participated on the cruise were Doug Biggs (Chief Scientist), Bruce Mate (Tag Team Leader), Dan Engelhaupt (Biopsy), Joel Ortega (Visual Team Coordinator), and Aaron Thode (3-D passive acoustic monitoring). These PIs and their supporting teams, together with Deborah Epperson, Carol Roden, and Sarah Tsoflias of MMS, constituted the 23-person science party (Table 3.1.1).

On two SWSS cruises on *Gyre* in summer 2003, the greatest success in locating whales was in water depths of 800-1000 m (Jochens and Biggs 2004). Additionally, transmissions from most of the whales that had been radio-tagged in summers 2002 and 2003 showed they stayed in or near this depth range most of the time (Jochens et al. 2006). Thus the visual and acoustic search effort on the 2004 S-tag cruise was centered on water depths of 800 m to 1000 m.

During Leg 1, the middle continental slope (MCS) in the north central Gulf was surveyed by starting at 93.5°W and working as far east as 87.5°W to the head of DeSoto Canyon (Figure 3.1.1a). The survey then continued along the eastern side of DeSoto Canyon, heading south to about 28°N before moving north again on a course farther offshore into deeper water. For Leg 2, the ship returned to the MCS in the north central Gulf to survey from the southwest side of Mississippi Canyon as far east as the *Petronius* tower in the Viosca Knoll lease block 786 (Figure 3.1.1b). However, most of the effort during Leg 2 focused on the Mississippi Canyon. For Leg 3, the ship deadheaded from the bad weather anchorage to the Mississippi Canyon for tagging efforts on 16-17 June before returning to Galveston (Figure 3.1.1c).

The search for sperm whales over the MCS was conducted both acoustically and visually. Either one or two hydrophone arrays were towed, one off the port quarter and the other off the starboard quarter of the stern. BigEyes were generally manned from 0700 – 2000 CDT each day, except during rain squalls or when breeze and sea conditions exceeded Beaufort 4.

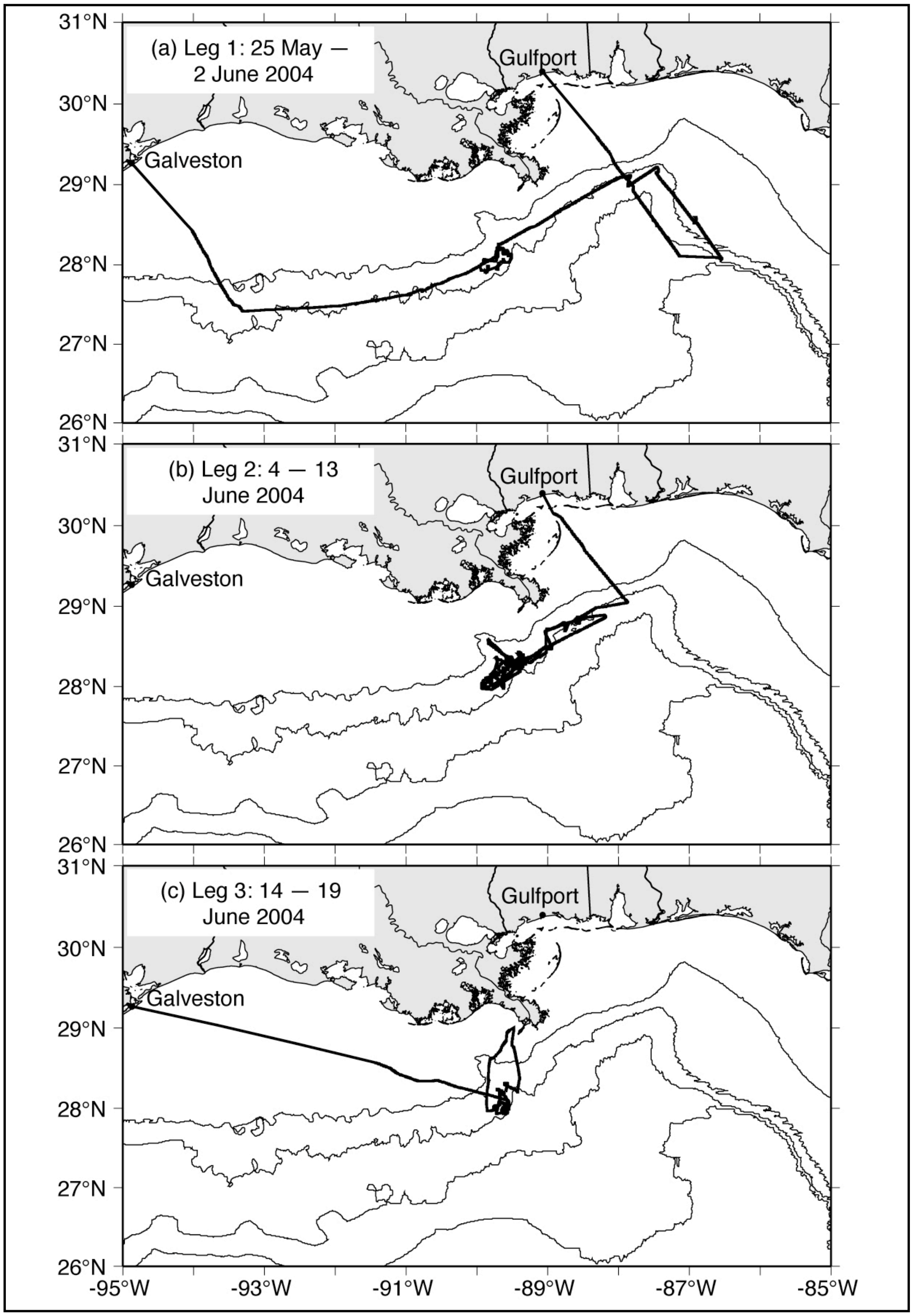

Figure 3.1.1. Cruise tracks for 2004 S-tag cruise. Contour lines indicate 200, 1000, 2000, and 3000 m water depths.

Table 3.1.1

Science Team for the SWSS 2004 S-tag Cruise

Responsibility	Participant
Oceanography	Doug Biggs (Chief Scientist)
	Alyson Azzara
Tagging team	Bruce Mate (tagging)
	Mary Lou Mate (video)
	Ladd Irvine (boat driver)
	Dan Engelhaupt (biopsy/genetic typing)
	Joel Ortega (visual team coordinator, tagging)
Photo-ID team	Daniel Lewer
	Glenn Gailey
Visual team	Carol Roden
	Deborah Epperson
	Rocio Cooley
	Rhoni Lahn
	Michael Noack
Acoustic team	Thomas Norris (acoustic team coordinator)
	Aaron Thode (3-D passive acoustic tracking)
	Sarah Tsoflias
	Elizabeth Zele
TAMU Techs	Paul Clark (Electronics Tech)
	Eddie Webb (Electronics Tech)
	Bill Green (Deck Engineer)
	Marty Bohn (Deck Engineer)

The *Gyre* carried three rigid-hull inflatable boats (RHIBs) for this cruise: RHIB-1 (principal tag boat) was a 6.4 m OSU-owned Zodiac Hurricane powered by an inboard Volvo diesel; RHIB-2 (back-up tag boat and principal photo-ID boat) was the 7.5 m MMS-owned R2 with two 4-stroke 150 HP Yamaha outboard engines; RHIB-3 was a 4.5 m Avon Searider with a 70 HP 2-stroke Johnson outboard engine. Two RHIBs were deployed when weather and sea conditions allowed, one for radio-tagging and biopsy/genetic typing and the other for photo-identification and photogrammetry. During the west to east survey of the deepwater MCS on 25 May – 1 June on Leg One, RHIBs were launched on 2 days. On these 2 days, the tag boat encountered sperm whales either individually or in groups of 2-9 animals. During Leg Two while surveying in and around Mississippi Canyon over deepwater on 4-13 June, RHIBs were launched on 6 days. During Leg Three only the largest of the two RHIBs could be launched and that was on 17 June.

Accomplishments of SWSS 2004 S-tag Cruise

The 2004 S-tag cruise concentrated mainly on the region of the Mississippi Canyon. All tags and biopsies were from this region. Major accomplishments of the SWSS 2004 S-tag cruise included:

1. Eight satellite tags (S-tags) were successfully attached, all in the Mississippi Canyon area. This accomplishment continues the time series of tagged sperm whales from this area.

2. Four biopsies from sperm whales were obtained. These data will allow genetic comparisons with the whales in the central Gulf, as well as in other populations

3. Passive acoustic monitoring data, suitable for 3-D sperm whale tracking analyses, were recorded, allowing further advancements in the passive acoustic monitoring of sperm whales.

4. In spite of inclement weather, the visual team searched for sperm whales on 18 days with 517 location fixes recorded.

5. The acoustic team identified at least 31 unique acoustic contacts of geographically separated groups of sperm whales.

6. Also in spite of poor weather, one or two RHIBs were safely launched and recovered on 9 days in a variety of wind, rain, and wave conditions.

7. Sightings of other cetaceans and leatherback turtles were made; information was recorded.

8. Eighteen fluke pictures were taken for photo-identification of individuals; six had been tagged in 2002, 2003, or 2004.

9. Physical oceanographic data, including remote sensing of ocean color and sea surface height fields, were used to help locate areas with whales for tagging.

Permits

Radio-tagging and Photo-ID and Biopsy/Genetic Typing activities were conducted in accordance with federal permits from NMFS to Bruce Mate/Oregon State University (permit 365-1440-01), and to Dan Engelhaupt/University of Durham (permit 909-1465-01).

Satellite-Tracked Radio Tag Work from Small Boats

The objectives for summer 2004 were to deploy up to 20 S-tags and as opportunity would allow, to also attach B-probes. The tag plan was to put about 12-15 S-tags on whales along the northern shelf break in the central Gulf (where S-tags have been applied in the past) and put the rest on whales farther offshore that may more consistently inhabit deepwater areas. B-probe deployments of opportunity were to allow acquisition of depth and vocalization records to be used in the design and development of a future GPS-linked S-tag. However, the cruise was characterized by the consistently worst weather (most unstable April-May-June) ever experienced by *Gyre* Captain Dana Dyer in 34 years working in the Gulf. Because there were only nine days in which the RHIBs could be launched during the 25-day cruise, all the tag boat time was dedicated to S-tag deployment at the expense of B-probe work.

In general, the pre-cruise planned track line was followed, using acoustics and visual observers during daylight hours while cruising at less than 6 kts during reasonable weather. Acoustic detection was used by itself at night and during periods of inclement daylight weather. On the latter occasions, the ship sometimes traveled at higher speeds for 15-25 minutes and then dropped to low speed (2.5-3.5 kts) to listen with greater range than could be obtained at 4-6 kt speeds. On a few occasions the ship transited at 8 or more knots without acoustics in order to make it to a prime survey area by daylight.

Prior to the cruise, six 2003-tagged whales were reporting recent locations. As the cruise began, the number dropped to four tags, which were reporting in the region of the Mississippi River Delta (MRD). While in transit from Texas, all of the tagged whales left the MRD; one going east to the western slope of the DeSoto Canyon and three going into the Mississippi Canyon. From a mark-recapture perspective, the high proportion of tagged whales in Mississippi Canyon suggested a very high abundance of whales would be found in that region.

The weather was not good during the first transit of Leg 1 through the Mississippi Canyon. After transiting the canyon, the ship headed east at night through the MRD and western DeSoto Canyon, cruising at high speed to get to the most northeast survey point. From this point, the ship surveyed along the southeast transect en route to a turning point 155 km southeast of DeSoto Canyon. Only three whales were encountered on this transect. The ship then surveyed northwest, parallel to the southwest survey track but in deeper water 43 km farther west. Only one whale was encountered during this transect. The team was disappointed that whales were so scarce in this area and decided that the area did not deserve further attention this summer. On 28 May, a 2003-tagged whale (PPT # 1385) was re-sighted. On 29 May, a tagged whale with an all yellow antenna was photographed from the bow of the *Gyre*, showing that it was a 2002-tagged animal.

Leg 2 began after an unscheduled two-day port call in Gulfport to repair the tagging vessel (RHIB-1). During Leg 2, the MRD area was surveyed. No whales were sighted as the ship surveyed southwest to the Mississippi Canyon area. The recent locations of 2003-tagged whales in the central and eastern regions of the Mississippi Canyon were used as a template to design the survey path within the Mississippi Canyon.

Eight whales total were tagged in the Mississippi Canyon area: three on 6 June, four on 10 June, and one on 17 June (Figure 3.1.2). Data summarizing the whales, tags and antenna color combinations are given in Table 3.1.2. All tags were well deployed with good antenna orientation, although one tag attachment was lower on the flank than ideal. Biopsies were successfully obtained from the first three tagged whales (two at the time of tagging and one several days later) and the last. Others were not biopsied because (1) on two the tag was applied too late to provide a biopsy target, (2) on one the biopsy dart stayed in the whale too long to be recovered, and (3) one was missed. On 7 June, a tagged whale from a previous year was seen with a 2004-tagged whale.

Between the two days of tagging, bad weather occurred on all but one day, while surveying the MRD to the *Petronius* platform east of the DeSoto Canyon. This day was absolutely beautiful with Beaufort 0 and 1 conditions prevailing. Because the tagging platform on RHIB-1 had broken, the R2 RHIB and the *Gyre*'s RHIB were used to acoustically survey 3 miles on either side of the *Gyre*. This provided an acoustic detection swath essentially 10 miles wide as the ship traversed the most traditionally dependable areas for finding sperm whales in the entire Gulf under ideal sighting conditions. Surprisingly, not a single whale was seen or heard during the 13-hour survey period. This result was a shock to all of those on board. With no sightings in the MRD and very few in the eastern Gulf, the ship returned to Mississippi Canyon, which was the only area where whales had been dependably found on this cruise. Leg 2 ended when bad weather forced the ship to take shelter for two days on the west side of the MRD.

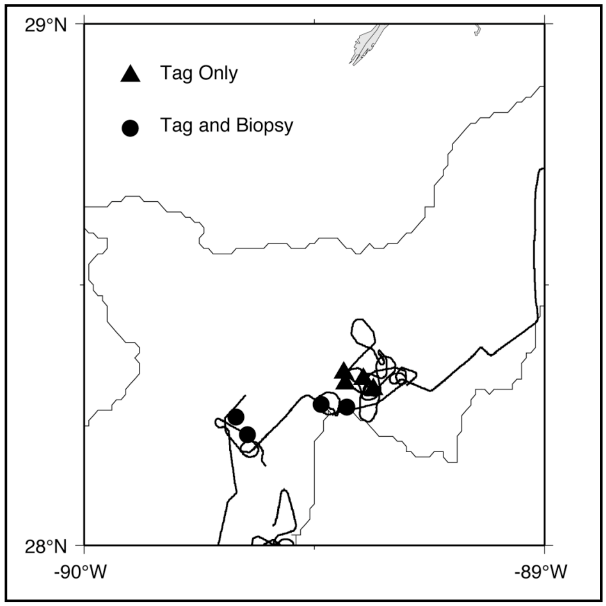

Figure 3.1.2. Locations of S-tag deployments and biopsies in 2004. The cruise track for the days on which tags were deployed is shown (thick lines). Bathymetry contours (thin lines) show the 200-m and 1000-m isobaths.

Table 3.1.2

S-tag Deployments, Biopsy Samples, and Photo-ID Images on the 2004 S-tag Cruise

PTT No.	Tag No.	Tag Base Color	Tag Tip Color	Date/Time (UTC)	Latitude (°N)	Longi-tude (°W)	Animal size	Tag location (side)	Biopsy	PhotoID
5660	1	Red	White	Jun-06-2004 14:30	28.266	-89.429	9 m	Right	04060601	
5670	2	Blue	Yellow	Jun-06-2004 15:51	28.271	-89.485	8.5 m	Right	04060701	
2083	3	All	yellow	Jun-06-2004 23:00	28.247	-89.670	8.5 m	Right	04060602	
845	4	All	white	Jun-10-2004 17:05	28.332	-89.436	9.5 m	Left		
1390	5	Yellow	Red	Jun-10-2004 17:46	28.311	-89.433	9 m	Left		PM04aGM0028*
838	6	All	blue	Jun-10-2004 18:51	28.320	-89.394	9.5 m	Right		
1387	7	Black	White	Jun-10-2004 19:45	28.300	-89.372	9 m	Left		PM04aGM0037
841	8	All	red	Jun-17-2004 20:02	28.213	-89.645	8 m	Left	04061701	PM04aGM0047

Leg 3 began as soon as rough weather calmed enough that seas became navigable for the *Gyre*. After conducting a nighttime box core at the head of the Mississippi Canyon, the ship arrived at the beginning waypoint of the survey midway along the western edge of the Mississippi Canyon on the morning of 16 June. The swells were too large to launch boats; these conditions persisted all day. By mid-morning, sperm whales had been found in the southwest portion of the canyon. The ship stayed with them all day and all night as it moved east into the central axis of the canyon. On the morning of the 17th, the R2 was launched for tagging by 0715 CDT with both acoustic and visual teams reporting at least 4 whales in the general area. One tag was deployed. Although this was applied at just 1.5 m distance, it was the only one not to deploy completely. It had excellent vertical antenna orientation, but the tag was exposed 11 cm. One of the 2003 tags still transmitting was similarly exposed when it was deployed. This 2003-tag has not been re-sighted to determine if it remained exposed or became more completely embedded with time.

In general, almost half of the whales encountered during the cruise were less than 7.5 m, which is below our self-imposed limit for tagging size. Within the Mississippi Canyon, two operational and one inoperative 2003 tags were re-sighted. This included the re-sighting on the last field day of PTT #5710, which had provided routine locations in the Mississippi Canyon throughout the entire cruise. Its tag, like the other observed 2003 tags, looked virtually identical to the day it was applied with no swelling or tissue degradation or scarring. All of the previously tagged whales themselves looked excellent as well, with no outward signs of emaciation or disease. Whales that were seen with marks or scars that were suggestive of tags showed small areas of scarring, occasionally associated with a small divot and/or very limited swelling around the immediate site. The largest of these was about 3.5 cm scar in a small divot (up to 1.5 cm deep) with a small raised lip (up to 1/2" high) around the lost tag site.

During the course of the cruise, an automatic direction finder was used to obtain bearings to 2003-tagged whales on four different occasions during their infrequent transmit cycles. Up to two whales were heard during a single period, but each time there were circumstances which prevented us from actually relocating the whales, mostly due to heavy sea states.

Photo-ID Work from Small Boats

On the 2004 S-tag cruise a total of 19 sperm whale flukes were photographically captured and 17 different individuals were identified. Of those, three were 2004-tagged whales and four were individuals previously photo-identified. One whale, which had been identified in 2002, was tagged in 2004. Three individuals photo-identified (two tagged) in 2003 were re-sighted in 2004.

Of the 2004 tags deployed, all but one (PPT #5660, red/white) were photographed on the animal with a definitive description of tag placement and condition (for details, see Table 3.1.2). At least two 2003-tagged animals were observed with their tags still in place. One of these was photographed (PTT #5710), although the photo is not ideal. Three animals with what could be considered tag scars were photographed and described.

Biopsy Tissue Collection/Genetic Typing Work from Small Boats

Biopsy sampling techniques were combined with satellite-monitored tagging during the 2004 *Gyre* S-tag cruise in the northern Gulf of Mexico. A total of four skin samples were collected during the cruise, all of which were from whales tagged with satellite-monitored tags (see Tables 3.1.2 and 3.1.3; Figure 3.1.2). All tissue samples obtained were expected to provide ample material for genetic applications. Sub-sections of all biopsy samples taken during the cruise were stored for a potential stable isotope analysis to be conducted in the future. No significantly large males (whales that appear to be sexually and physically mature based on estimated sizes) were encountered and therefore none were sampled.

Overall, the combination of satellite-monitored tagging and biopsy sampling was successful, but less so than previous years due mainly to long delays caused by weather and mechanical problems with RHIB-1. Although a biopsy sample was obtained from each of two members in one group (both of which have satellite tags to match) and one individual member from two separate groups, no samples were collected from the other four S-tagged whales due to several unavoidable factors (see tagging above). Degrees of relatedness will be tested between the two whales found within Group 1 (Table 3.1.3), allowing us to continue to answer questions on how related and unrelated whales found within groups in the northern Gulf of Mexico maintain long or short term associations over space and time. A change in the pre-cruise plan track inhibited the primary biopsy goal to acquire samples from 'new' whales located in the southeast, southwest and deepwater (>2000 meters) areas.

Table 3.1.3

Tissue Samples Collected During 2004 S-tag Cruise
(Sample number code gives the date (yymmdd) followed by the consecutive number for multiple samples taken on any given day (01 to 04).)

Sample No.	S-tag No.	Tissue Type	Group No.	Approx. No. of Whales in Area	Latitude (°N)	Longitude (°W)
04060601	5660	Biopsy	1	7	28.2664	-89.4285
04060602	2083	Biopsy	1	7	28.2467	-89.6693
04060701	5670	Biopsy	2	8	28.0311	-89.9294
04061701	841	Biopsy	3	10	28.2128	-89.6449

Visual Survey and Monitoring

A visual observation station was established on the flying bridge consisting of three stand-mounted 25x150 "big-eye" binoculars and a data entry station. At least three observers maintained a continuous watch during daylight hours (0700 – 2000 CDT) while R/V *Gyre* surveyed/tracked in water depths > 500 m during suitable weather. A rolling watch system was implemented such that each observer stood a 1.5-hour watch followed by 1.5 hours rest. While on watch observers moved between roles on the flying bridge every 30 minutes. Two observers scanned with big-eye binoculars while the third person entered data into the Logger program on a laptop computer. Logger is a data collection and depiction program written by Douglas Gillespie and made freely available by the International Fund for Animal Welfare to assist marine conservation projects. The watch order was chosen so that observers with complimentary skills and levels of experience were distributed through the rotation. The visual team operated in two modes: "survey" and "tracking". During survey mode, each observer on the big-eye binoculars searched from 10 degrees on the opposite side of the ship to 90 degrees on their side while the third person (data recorder) concentrated on the near field using only naked eye and 7x50 binoculars. The visual team operated in concert with the acoustic team to maximize sperm whale detection, 'searching' whenever the ship followed predetermined survey tracks, with or without the RHIBs to augment sightings or acoustic contacts. Survey tracks were determined the evening before as having a high probability for finding whales (i.e., searching an area or areas reported to have a satellite-tagged whale).

Once sperm whales were sighted, the visual team switched to tracking mode. The main objective during tracking mode was to register time, location, whale movements, and direct the small boats towards the whales as soon as possible. Therefore, while tracking sperm whales, the observers did not regularly scan the whole sector on their side and rather focused on the area where sperm whales were sighted. The recorder gathered information from the observers and acoustic team and communicated it to the small boats. The computer program Fixin', developed by Joel Ortega (OSU), was used to calculate location of whales from bearing angle and reticle measurement obtained with the big-eye binoculars. Fixin' was also used to quickly estimate the range (km) and magnetic heading from the boat to the whales.

The locations of all first sightings, dives (fluke-ups), and whale headings were recorded in Logger as well as notes on any behaviors observed by the visual team and/or behaviors reported by RHIB teams. During tracking mode, whale and boat locations determined with the program Fixin' were automatically sent to Logger for data recording. Logger plots of these locations and whale headings were used to plan vessel movements.

In tracking mode the visual and acoustic teams worked closely together. The aim was to amalgamate all information on the location and behavior of whales (visual data, acoustic data from the *Gyre*'s arrays, and acoustic information from the RHIB boats' directional hydrophones) to form a comprehensive view of the whales' movements and behavior. The visual team also requested course and speed changes from the *Gyre* bridge to keep the vessel in a position in which its visual coverage of whale aggregations (which typically spread over several miles) was optimal. The officers on the *Gyre* bridge responded professionally to the numerous requests for course changes, while navigating the vessel safely around other shipping and oil rigs.

For all three legs combined, the visual team searched for sperm whales on 18 days. A total of just under 200 hours was spent by the observers either on survey effort or tracking whales (Table 3.1.4, see also Figure 3.1.3). This cumulative effort only counts the hours when the computer recording was operating on the flying bridge and does not count the additional time the visual observers were on watch inside on the ship's bridge (i.e., during rain or other inclement weather).

A total of 517 sperm whale location fixes were recorded (Table 3.1.4; see also Figure 3.1.4). However, many of these sightings are of the same individual when the vessel was in tracking mode. Additionally, 23 sightings of other cetacean species and 3 sightings of leatherback turtles were recorded during the cruise (Table 3.1.5).

<u>Acoustic Detection and Monitoring</u>

Hardware: The passive acoustics monitoring system consisted of two linear hydrophone arrays referred herein as the Ecologic array (manufactured by Ecologic Ltd., UK) and the "Norris array" (manufactured by Don Norris of Biomon, USA). Both arrays were equipped with pressure sensors to allow real-time depth measurements to be made. The Ecologic array was deployed from the port side and the Norris array was deployed on the starboard side of the R/V *Gyre* so that the last element in both arrays was approximately 350 m from the stern of the ship.

Ecologic Towed Array: The active section of the Ecologic array had sections consisting of 2 hydrophone elements (Benthos AQ-4) and respective pre-amplifiers that provided 30dB gain and a 100Hz hi-pass filter. The transducer elements were positioned 3 m apart and housed in an approximately 10-m long polyurethane tube that was filled with non-hazardous isopar oil. The hydrophone array was attached to 400 m of strengthened tow cable with a hair-fairing sheath to reduce noise caused by cable strumming. A pressure sensor (Keller PA-9SE-50 50bar 4-20mA sensor) was located at the end of the active section of the array to measure array depth.

Hydrophone and pressure sensor signals were fed via a deck cable into the acoustic acquisition system located in the acoustics lab of the R/V *Gyre* (Figure 3.1.5). Two channels from the Ecologic array were passed to a high-pass filter/gain breakout box (Magrec HP 27/ST). Depth sensor data were sent from the break-out box to a panel meter (Asahi Keiki A5000) that was used to digitize and display the readings. The digitized signal was passed from the panel meter to a computer via a serial port connection.

Table 3.1.4

Day-by-day Synopsis of Visual Survey Effort

Day	Effort (hr)	Sperm whale location fixes
05/26/04	11.6	0
05/27/04	12.8	2
05/28/04	11.4	54
05/29/04	11.9	23
05/30/04	7.5	0
05/31/04	9.0	2
06/01/04	7.6	0
06/05/04	10.4	4
06/06/04	13.5	49
06/07/04	12.7	70
06/08/04	12.8	52
06/09/04	12.1	51
06/10/04	12.5	75
06/11/04	12.6	50
06/12/04	12.7	0
06/13/04	3.9	1
06/16/04	12.3	21
06/17/04	11.9	63
TOTAL	199.2	517

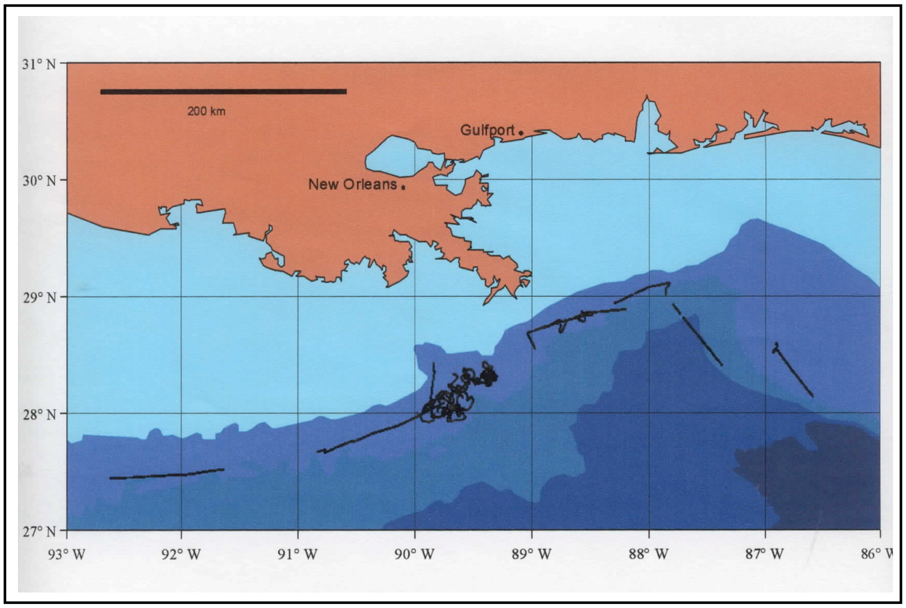

Figure 3.1.3. Visual survey effort during the 2004 S-tag cruise. Depth contour lines are 200, 2000, and 3000 m.

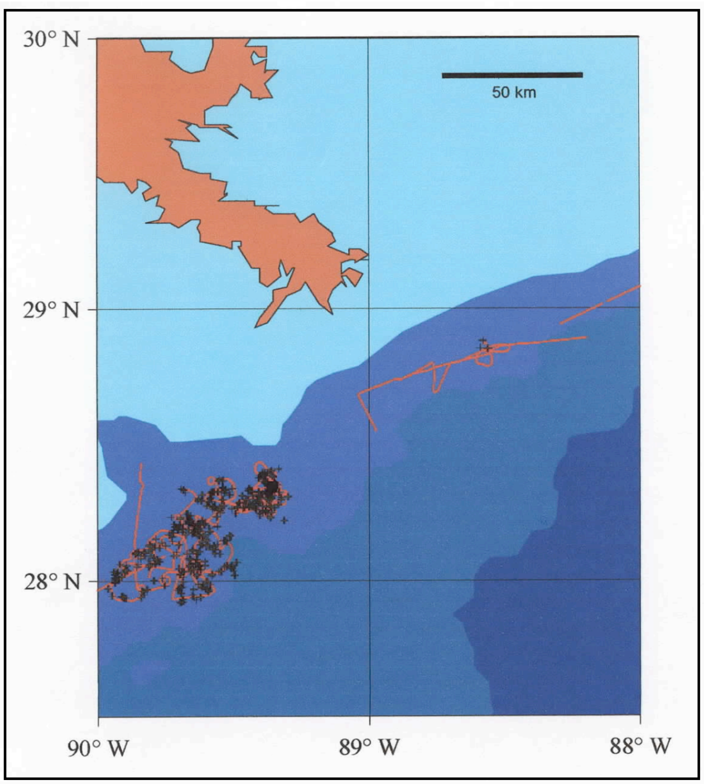

Figure 3.1.4 Visual survey effort and locations of sperm whale sightings in and around Mississippi Canyon. Depth contours are 200 and 2000 m.

Table 3.1.5

Visual Sightings of Species Other Than Sperm Whales on the 2004 S-tag Cruise

Date and Time (UTC)	**Longitude (°W)**	**Latitude (°N)**	**Species Name**	**Number of Animals**
05/26/2004 05:47:52 PM	-92.17098	27.47148	Pantropical spotted dolphin	25
05/27/2004 12:58:14 PM	-90.77998	27.68957	Clymene dolphin	60
05/27/2004 05:58:16 PM	-90.45324	27.78789	Pantropical spotted dolphin	1
05/28/2004 02:22:10 PM	-89.54980	28.11313	*Kogia* sp.	1
05/31/2004 03:01:35 PM	-86.90150	28.58620	Pantropical spotted dolphin	30
06/05/2004 04:13:14 PM	-88.50606	28.86719	Turtle	1
06/05/2004 06:39:15 PM	-88.58700	28.84084	Turtle	1
06/05/2004 09:19:16 PM	-88.63786	28.81322	Turtle	1
06/05/2004 10:29:47 PM	-88.74529	28.78658	Melon-headed whale	5
06/05/2004 11:22:47 PM	-88.82139	28.76379	Bottlenose dolphin	14
06/05/2004 11:59:47 PM	-88.85890	28.75025	Risso's dolphin	8
06/06/2004 05:47:15 PM	-89.46320	28.26229	Unidentified beaked whale	1
06/06/2004 06:24:45 PM	-89.49114	28.27686	Unidentified dolphin	6
06/06/2004 06:52:46 PM	-89.51766	28.28757	Unidentified whale	1
06/06/2004 07:57:46 PM	-89.55801	28.25280	*Kogia* sp.	2
06/12/2004 01:35:22 PM	-89.03558	28.67468	*Kogia* sp.	1
06/12/2004 02:02:22 PM	-89.00020	28.70156	Unidentified dolphin	10
06/12/2004 02:48:53 PM	-88.91727	28.73335	Risso's dolphin	2
06/12/2004 03:15:23 PM	-88.88828	28.74225	*Kogia* sp.	1
06/12/2004 04:04:23 PM	-88.82046	28.76954	Risso's dolphin	20
06/12/2004 04:05:53 PM	-88.81831	28.77075	Risso's dolphin	2
06/12/2004 05:54:54 PM	-88.75516	28.69169	Unidentified whale	3
06/12/2004 06:07:24 PM	-88.74313	28.70295	Ziphius (Cuvier's) beaked whale	2
06/12/2004 06:53:24 PM	-88.71579	28.76553	Risso's dolphin	6
06/12/2004 08:03:25 PM	-88.62161	28.82520	Bottlenose dolphin	8
06/12/2004 10:13:55 PM	-88.45791	28.86784	Pantropical spotted dolphin	50

Norris Towed Array: The second hydrophone array was the 440-m 8-element towed array, developed by Biomon, Inc., for the 3-D passive acoustic tracking project (see below). This system included two pressure sensors and two pairs of closely spaced hydrophones (sub-arrays). A pair of hydrophones from each sub-array was used to determine bearings to individuals for tracking and locating vocalizing sperm whales. Signals from the towed array were passed to the acoustic lab via a deck cable and fed into a breakout-box that included panel meters for the depth sensors (Figure 3.1.5). Four of the hydrophone inputs were passed through a high-pass filter (Krone-Hite Model 3944) before the signals were recorded to digital audio hard drive. This system is described in further detail later in the 3-D acoustic tracking section of this cruise report.

Signal Conditioning and Recording System: Acoustic signals from the Norris array and the Ecologic array were passed to a multi-channel digital audio recorder (Alesis ADAT HD24-X0). Both channels of the Ecologic array also were sent to an external sound card (Sound Blaster Audigy 2NX) for digitization and data acquisition. Signals from both arrays were sent to a 12-

channel audio mixing board (Behringer Eurorack UB1204-Pro). The mixing board was used for signal conditioning (for monitoring from headphones and speaker outputs) and to allow the user to select and send different channels to various devices (e.g., computers, speakers). A graphic equalizer was used for additional signal conditioning for the signal sent to the external speakers for monitoring. All recorded signals were sent to recording devices "pre-mixer and pre-equalizer" so that the only signal conditioning, beyond what occurred from the array pre-amplifiers, was high-pass filtering (usually 80 or 100 Hz corner frequency) and amplification. Signals from all the arrays could be recorded on the multi-channel Alesis recorder, which allowed time-synched recordings of all channels. The 2-channel signals from the ecologic array could be recorded to computer hard-drive using ISHMAEL running on a lap-top computer.

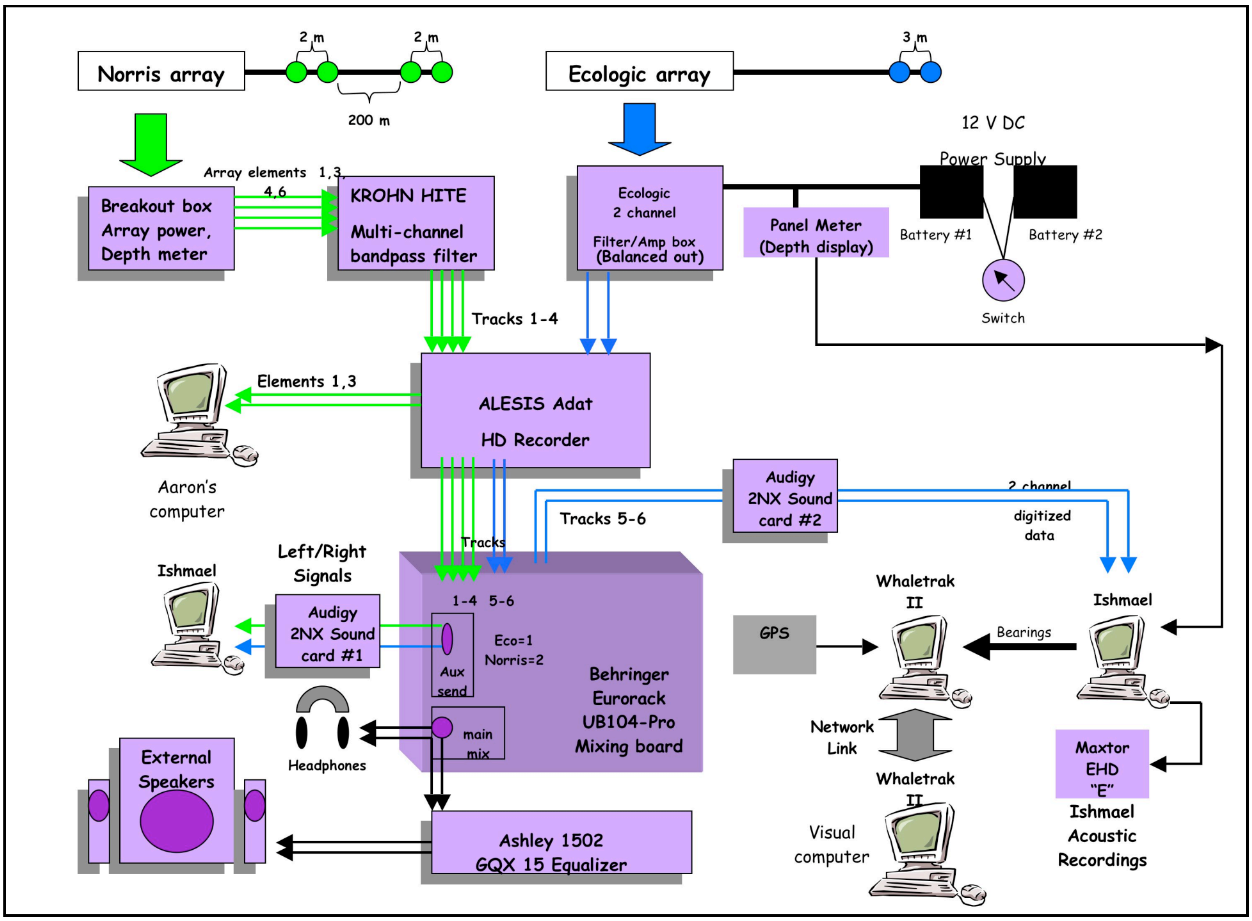

Figure 3.1.5. Schematic of passive acoustic recording system on the 2004/2005 S-tag cruises.

Sperm Whale Tracking and Monitoring: For the purposes of sperm whale monitoring, a dual hydrophone array configuration (Norris and Ecologic array) was used to form a two dimensional directional array to eliminate the right-left ambiguity that usually results with a single linear array. One element of the Norris array was in conjunction with a single element of the Ecologic array for left-right bearing determination when actively tracking sperm whales. The relative bearings were displayed using either Rainbow Click (2004), or more commonly ISHMAEL (2004 and 2005) software.

Hydrophone tow depth was dependent upon tow speed, array buoyancy, drag (mostly due to cable thickness), and cable length. With all the cable deployed and traveling at 3.5 knots (typical tracking surveying speed) the hydrophone elements towed at an approximate depth of 50 m. Tow depth increased to ~ 100 m when the ship slowed to 1.5-2 knots. During transit times between listening periods, the R/V *Gyre* typically maintained a speed of 6 knots resulting in a tow depth of approximately 20m. These data were digitally displayed on a panel meter and automatically logged using a Labview interface developed by Eddie Webb. Hydrophone tow depths did not directly affect system performance other than related to noise from the R/V *Gyre*, and when animals were close to the array.

Software: Signal acquisition, processing and data-logging software consisted of "Rainbow Click", "Logger" (by Douglas Gillespie International Fund for Animal Welfare) and "Ishmael" (written by Dave Mellinger of NOAA/PMEL Newport, Oregon). Rainbow Click and Ishmael provide real-time signal acquisition, processing, signal display and bearing-to-source determination capabilities. Rainbow Click and Ishmael were used primarily to monitor hydrophone signals, calculate bearings-to-source (sperm whales), and display bearing tracks of animals. Rainbow Click calculates bearings to individual sperm whale clicks, using the time delay of clicks arriving at the 2 hydrophone elements of a single array. This information is displayed on a time-bearing plot with different colors used to represent potentially different animals. Logger was used for acoustic, location, and environmental data acquisition and display as well as providing tracking capabilities. Logger also acquired GPS data, displayed tracks of the research vessel and automatically plotted bearings to animals. Ishmael provided real-time spectrographic display capabilities as well as the capability to automatically calculate bearings and plot the bearing-time history sperm whale clicks. "Whaltrak" was used with Ishmael to plot user selected bearings to whale sources as well as the ship track. All three programs ran continuously during monitoring.

Passive Acoustic Monitoring, Surveys and Tracking: A team of 3-4 bio-acoustic personnel provided 24-hour acoustic monitoring while underway. Acoustic monitoring was conducted during standard sperm whale surveys (coordinated with visual survey effort), and when searching and tracking sperm whales for tagging purposes. Logger was set up to automatically record acoustic data (48 kHz sample rate) for 1 minute every 15 minutes. The bio-acoustician on watch also listened during the same 1 minute period with a headset to monitoring the pair of hydrophones from the array being recorded. This recording/monitoring scheme coincided with an acoustic data form that was filled out by the bio-acoustician on watch. During survey and passive whale tracking the estimated group size of sperm whales was estimated, the relative loudness of cetacean vocalizations and relative loudness of seismic survey and other noise were scored and entered into the Logger program. Continuous recordings were made (48 kHz sample rate, 2-channels) of all acoustic signals of interest (e.g. sperm whale clicks, codas and creaks, dolphins whistles, unusual biological or anthropogenic sounds). All acoustic data from logger were stored to hard disk (Maxtor Drive E) and backed up on a second hard drive (Maxtor Drive F). Additional data forms (e.g. survey effort, acoustic recording settings) were completed by bio-acousticians as needed.

Once detected, sperm whales were tracked using the Rainbow Click/Logger (RC-L) or Ishmael/Whaltrak (I-W) software combinations. The main purpose of this procedure was to provide the visual and the tagging team with information about the bearings and, when possible, distances to vocalizing sperm whales. To achieve this, the bio-acoustics team utilized the tandem arrays and RC-L and I-W software running on the two different computers. One array and associated computer station was used to determine horizontal bearings to the source (this measurement was right-left ambiguous) and the second array and computer station was used to resolve the left/right ambiguity. When only a few animals were being tracked (e.g. < 5), it often was possible to differentiate which group of sperm whales was on which side of the ship (by correlating bearing plots on each computer). Using this technique, it was possible to determine the bearing and direction of sperm whales relative to the array without having to turn the ship (as is necessary when using a single array). In addition, the cessation of clicking for individuals or groups of sperm whales being tracked was noted, and this information was passed on to the visual team (cessation of clicking usually is an indication that an animal or group of animals is coming to the surface).

A range spreadsheet developed by Aaron Thode calculated the intersection of two bearings using the forward and rear pairs of hydrophones on the Norris array (Figure 3.1.6). This allowed animal locations to be determined nearly instantaneously from a short series of clicks. These methods greatly enhanced the ability of the acoustic team to locate and track individual animals, which provided greater ability to guide the RHIBS to animals for the purpose of tagging.

Night-time effort was conducted both to survey for concentrations of sperm whales and to track large (> 4-5) group through the night so that the visual and tagging team were in the area to work with them in the morning. Night-time surveys frequently consisted of transiting along predetermined survey transects. All detections of sperm whales and other cetaceans were recorded in Logger and an Excel spreadsheet. This information was used to determine areas of high whale density for planning tagging activities.

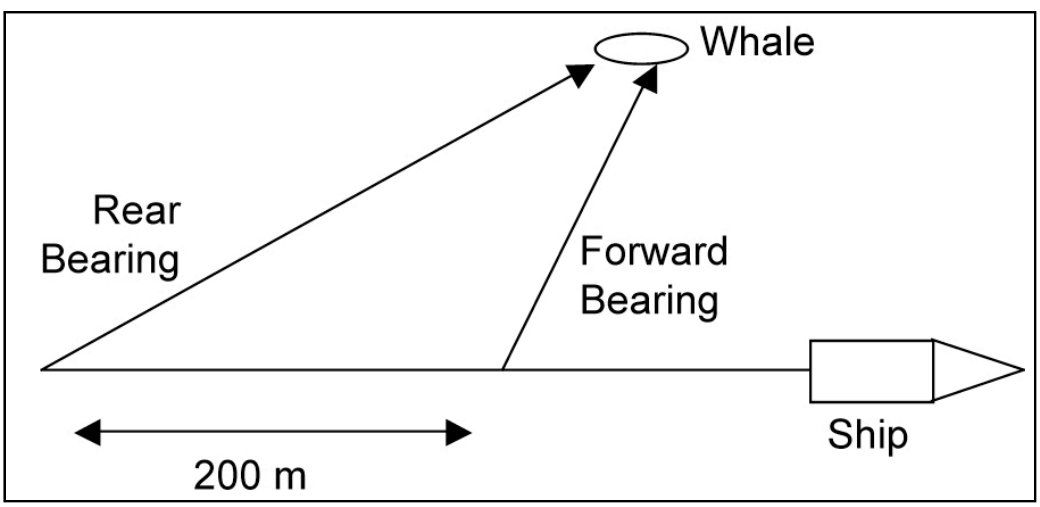

Figure 3.1.6. Geometry of tandem array for finding range of animal. If the bearings between the arrays are different, the range to the animal can be triangulated.

Acoustic Tracking Results: Approximately 350 hours of acoustic monitoring/surveying were completed during 20 days at sea (Table 3.1.6). At least 31 unique acoustic contacts of sperm whales (i.e., geographically separate groups of animals) were made (Table 3.1.7). In some cases groups were tracked for several hours, so groups may have merged or split. During night time surveys, 12 detections of unique sperm whale groups (21% of the total of detections) were made at night. In addition to monitoring for cetacean vocalizations, the presence of anthropogenic noise was noted. In addition to the sperm whale detections, approximately 25 acoustic detection of odontocetes, delphinids, or other unidentified cetaceans were made (Table 3.1.8).

Air-gun surveys were heard during 99 (7.3%) of approximately 1350 one-minute listening periods every 15 minutes (Table 3.1.9). All were west of 89.5°W. Only two sperm whale groups were detected when seismic activity was detected, representing 3.5% of the total sperm whale groups detected acoustically. However, these data are likely biased by sampling effort and lack of a systematic/random survey design and are not intended to imply any causal relationship.

Table 3.1.6

Synopsis of Acoustic Effort

Description	Quantity
Total hours of effort	350.36
Number of workable days	20
Full days of effort	11
Partial days of effort*	9
Total days of effort	20

* days were considered "partial" if < 20 hours of effort

Table 3.1.7

Synopsis of Acoustic Detections

Description	Number of detections	% of total acoustic detections	% total of sperm whale detection
Total acoustic detections	57	100	
Unique sperm whale (SW) detection	31	54.4	
SW detection occurring at night	12	21.1	38.7
SW detection occurring during seismic activity	2	3.5	6.5

Table 3.1.8

Acoustic Detections of Cetaceans Other Than Sperm Whales on 2004 S-tag Cruise

Date	Species	Best estimate* of group size	UTC first detection	UTC last detection	Latitude (°N)	Longitude (°W)
05/26/04	unidentified dolphin	>3	0540	0726	27.4218	-93.2042
05/26/04	unidentified dolphin	>3	0927	0956	27.4388	-92.8602
05/26/04	*Stenella attenuata*	>3	1746	1810	27.4717	-92.1557
05/26/04	unidentified dolphin	>3	2203	2215	27.5020	-91.8092
05/27/04	unidentified dolphin	>3	0111	0140	27.5443	-91.5007
05/27/04	unidentified dolphin	>3	0439	0551	27.5832	-91.2498
05/27/04	unidentified dolphin	>3	0635	1058	27.6198	-91.0057
05/27/04	unidentified dolphin	>3	1250	1316	27.6917	-90.7738
05/27/04	*Stenella attenuata*	>3	1801	1835	27.7947	-90.4380
05/28/04	unidentified dolphin	>3	0151	0330	28.1552	-89.7247
05/29/04	unidentified dolphin	>3	1321	1340	27.9788	-89.8498
05/31/04	unidentified dolphin	>3	0038	0046	29.1627	-87.5507
05/31/04	unidentified dolphin	>3	0420	0547	29.0595	-87.3927
05/31/04	unidentified dolphin	>3	0728	0744	28.9302	-87.2685
05/31/04	*Stenella attenuata*	>3	1425	~1500	28.5683	-86.9048
05/31/04	unidentified dolphin	>3	1813	1838	28.5187	-86.8835
06/01/04	unidentified dolphin	>3	0145	0457	28.0952	-86.7115
06/06/04	unidentified dolphin	>3	0032	~0100	28.7305	-88.9032
06/06/04	unidentified dolphin	>3	1031	1054	28.3030	-89.2667
06/07/04	blackfish/unidentified cetacean	>3	0456	~0525	28.2193	-89.7413
06/10/04	unidentified dolphin	>3	0214	~0230	28.3092	-89.3123
06/10/04	unidentified dolphin	>3	0435	0446	28.3295	-89.3772
06/12/04	*Stenella attenuata* and *Tursiops truncatus*	150	1745	1108	28.8722	87.5962
06/13/04	unidentified dolphin	>3	1520	1530	28.2492	-89.3975
06/16/04	probable blackfish	>3	1504	1531	28.0005	88.1353
06/17/04	unidentified dolphin	>3	1112	1122	27.9538	-89.6288

Total Detections = 26
*Best estimate of group size: if more than 3 animals detected, value is given as ">3"

Over 6.92 Gb Rainbow Click files and approximately 50 Ishmael autolog files were written to the hard drive. These files are created by the Rainbow Click and Ishmael during signal acquisition and can be used to replay or post-process bearing versus time of sperm whale click series. A total 1385 acoustic files were written using the Logger software (Table 3.1.10). These are formatted as ".wav" files at 48 kHz sample rate (24 kHz bandwidth) and 2 channels. For each 15 minute listening period a one minute "Autorec" file was automatically written and saved automatically by Logger (during pre-determined sampling periods, or manually selected periods). Approximately 1141 one- minute autorec files (~13 gB) were written. In addition, 244 continuous recordings (30 Gb) were manually recorded to archive various sperm whale, dolphin whistles, anthropogenic noise and other sounds. Finally, approximately 200 hrs of continuous recordings were made to the ADAT Hard Drive recorder in addition to the samples above.

Table 3.1.9

Summary of Detection of Seismic Activity on the 2004 S-tag Cruise

Date	Begin Time (UTC)	End Time (UTC)	Position at Begin Time		Position at End Time	
			Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)
5/26/04	0417	1215	27.4367	-93.3203	27.4492	-92.6357
5/26/04	2115	To 5/27	27.4893	-91.8853		
5/27/04	From 5/26	1404			27.6910	-90.7133
5/27/04	1915	1944	27.8243	-90.3783	27.8385	-90.3383
5/28/04	1120	1516	28.1557	-89.5998	28.1277	-89.5082
5/29/04	0745	0945	27.8308	-89.8752	27.9052	-89.8553

Table 3.1.10

Summary of Acoustic Recordings on the 2004 S-tag Cruise

Description	No. of files	% total files	Total Gb
Auto recordings	1141	82.4	13
Continuous recordings	244	17.6	30
Total	1385	100	43

Three-Dimensional Passive Acoustic Sperm Whale Tracking

In 2004 a new towed acoustic array was deployed from the starboard side of the R/V *Gyre* during the S-tag cruise, to test various algorithms for acoustically tracking sperm whales in range and depth. When used in conjunction with the Ecologic array deployed on the port side, a full three-dimensional fix should be possible.

The new array was designed and built by Don Norris of Biomon, Inc., Santa Barbara, CA. The Dual Aperture array, or Norris array, is an 8-sensor, 440-m towed underwater hydrophone system. It is composed of two sub-arrays in tandem, a forward and an aft array, interconnected by an in-line pair of underwater connectors. Each array has three acoustic sensors separated by one meter from each other and one pressure sensor located about 5 ft in front of the leading acoustic sensor in each array subsection. The two arrays are separated by about 200 m length (from the #3 or tail hydrophone in the front array measured to the pressure sensor in the aft array). The tail of the array (the aft section) has a disconnectable 70 ft drogue (restricting line type).

The front of the leading array is terminated in a 37 pin shell type in-line connector that mates to a similar connector on a topside breakout box. The topside breakout box contains a 15 volt power supply for the hydrophones, two Omega DP 41 Process indicators for the pressure sensors, power switches for the two indicators and a power switch for the hydrophone power supply, and 6 output BNC connectors for the six acoustic sensors. The breakout box uses standard 120 VAC 60 Hz input power. At first we were concerned that using AC line power instead of a DC battery might contaminate the signal, but these fears proved to be unfounded.

Data from two hydrophones in the forward array and two hydrophones in the rear array were filtered using a Khron-hite model 3944 filter/amplifier before being recorded onto an Alesis ADAT HD24XR hard disk digital recorder, along with two channels from the Ecologic array. Thus a total of six hydrophones were sampled at 96 kHz and stored in 24 bit WAV format. The start time of each recording was entered into both an Excel spreadsheet and the Acoustic Team Microsoft Access database. At first the signal was not filtered or amplified, but beginning on June 1 the signal was high-pass filtered above 100 Hz to eliminate potential DC and high-amplitude line noise. Beginning on June 13 (Song 18 HD 5) an additional 20 dB of gain was added before recording.

The two pressure sensors were sampled by two process indicators in the breakout box, and both a digital LED display and a serial port signal were produced. The serial port signals, sent at 9600 baud, odd parity, and 1 stop bit, were sampled by a dedicated laptop. The serial ports were first sampled using Hyperterminal between May 28 and June 4. In the meantime, Eddie Webb of TAMU wrote a Labview program to timestamp the sampled array depths. The program was used starting June 4 and was used for the rest of the cruise.

The array was initially deployed without any additional weight on the cable, but it was found that the forward array was being towed too shallow to detect surface reflections needed for range-depth fixing. Thus more weight was added to the cable in two stages: on May 30 a 15 lb. anchor chain was taped about 30 ft forward of the forward pressure transducer, and on June 4 three shaped lead weights (borrowed from the Pascagoula MS NMFS lab) were attached forward of the anchor chain, for an estimated total of 30 lb. of weight added to the cable. The resulting tow depth for the forward array was 30 m at 3 knots, and the rear array at about 55 m depth, which was judged to be acceptable.

Brief timeline of events: The array was shipped to Galveston, TX, three days before cruise departure, where it was discovered that a deck cable connector had not been built into the array. With the assistance of Eddie Webb, a section of the forward array cable was cut to form a deck cable and a cable connector mailed by Don Norris was built. During 25–28 May, we worked on getting the depth acquisition system up and running.

On May 27 the array hit a longline, causing superficial surface damage to the rear pressure transducer and one of the rear hydrophones. A hook was found embedded in the rope drogue, which was subsequently removed. The rear pressure transducer was streamlined, and no further incidents were experienced through June 17.

On May 30 ship noise from the *Gyre* was used to align the Ecologic and Norris array cable lengths so that left/right ambiguities could be resolved without turning the vessel. We found that the arrays would often collide whenever ship speed changed suddenly, or during sharp turns, and particularly during both. No sustained damage from the collisions was visible on either array.

By May 30 data of sufficient quality for eventual 3D tracking was being collected, and by June 4 the array setup attained its final form. Over the next two weeks a dive computer was attached to the forward and rear arrays to confirm the accuracy of the pressure transducers. Beginning June 13 digital inclinometers were also attached to the array cable to collect data for testing a variant of the 3-D tracking algorithm.

One June 11 a simple technique for obtaining whale slant range was tested. By measuring the bearings to an animal simultaneously from the forward and rear arrays, the distance to the whale could be triangulated (Figure 3.1.6). On this day a single whale was tracked and the tagging boats were placed within 500 m of the surfacing animal. The ranging algorithm was made into a spreadsheet that became a standard part of the acoustic watch.

We also gained experience on how to tow the arrays as deep as possible while maintaining ship steerage. We found that having the ship face into the swell worked well, as was moving with the current on measured with the ADCP. On June 13 the arrays were towed at their deepest depth yet—120 m on the rear array. The *Gyr*e seems to be most acoustically quiet at about 600 engine rpm.

As of June 16, 180 hours of data were recorded. Data were recorded whenever dolphins or sperm whale clicks were audible. Total data volume was about 1 Terabyte.

Oceanographic Habitat

When the cruise track was seaward of the continental shelf break, routine monitoring was done for surface temperature (SST), surface salinity (SSS), and surface chlorophyll fluorescence (SCF) in real time with a pumped, continuous flow system to show when and where river plumes and/or thermal fronts were transited (see cruise track in Figure 3.1.1). Conditions below the surface were monitored with Acoustic Doppler Current Profilers (ADCPs), expendable bathy-temperature probes (XBTs), and a vertically profiling conductivity-temperature-depth (CTD) instrument. *Gyre*'s Data Acquisition System (GDAS) recorded SST and SSS data once per minute from surface water pumped from ship's hull depth of 3.5 m through SeaBird temperature and conductivity sensors and SCF data from water pumped through a Turner Designs Model 10 fluorometer.

Seventy XBT probes were deployed to profile temperature in the upper 760 m while the MCS was surveyed (Table 3.1.11; Figure 3.1.7). CTD casts were made with a Sea Bird Electronics SeaCat internally-recording CTD at 5 locations (Table 3.1.12; Figure 3.1.7). At most XBT and CTD stations, water samples were filtered and the filters were analyzed to determine chlorophyll concentrations for calibration of the flow-through fluorometer (Tables 3.1.11 and 3.1.12). XBTs generally were dropped every 10 nautical miles (18 km) while surveying the MCS, and every 20 nautical miles while surveying in deepwater on the eastern side of DeSoto Canyon. Six Sippican T7 XBTs left from previous cruises and 54 Sippican Deep Blue XBTs were used. Ocean current velocity in the upper 300 m and upper 1000 m was monitored continuously with RD Instruments hull-mounted 153 kHz ADCP and 38 kHz ADCP, respectively. Table 3.1.13 shows the configurations used for these instruments on the cruise.

Table 3.1.11

XBT and Extracted Chlorophyll Stations on S-tag 2004 Cruise

XBT No.	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	15°C depth (m)	Sfc temp (°C)	Sfc salin	Sfc fluor (mvolts)	Extracted CHL (µg/L)
1	05/26/04	0637	27.423	-93.148	197	26.4	35.61	79	0.09
2	05/26/04	0934	27.438	-92.880	202	26.1	36.35	75	0.08
3	05/26/04	1312	27.453	-92.540	214	26.4	36.16	79	0.10
4	05/26/04	1500	27.462	-92.338	187	26.4	36.06	77	0.10
5	05/26/04	1834	27.475	-92.093	194	26.5	35.77	79	0.10
6	05/26/04	2102	27.487	-91.907	201	26.7	35.98	79	0.09
7	05/26/04	2305	27.513	-91.720	204	26.9	35.78	83	0.10
8	05/27/04	0103	27.538	-91.540	204	26.3	35.88	79	0.07
9	05/27/04	0310	27.565	-91.362	197	26.5	35.56	78	0.07
10	05/27/04	0623	27.597	-91.175	202	26.5	35.65	81	0.09
11	05/27/04	0920	27.622	-90.988	206	26.6	35.66	80	0.10
12	05/27/04	1224	27.678	-90.812	240	26.7	36.08	81	0.11
13	05/27/04	1517	27.728	-90.632	264	26.4	36.21	76	no sample
14	05/27/04	1757	27.787	-90.453	303	26.3	36.06	76	0.07
15	05/27/04	1950	27.842	-90.330	294	26.4	36.12	76	0.07
16	05/27/04	2155	27.893	-90.153	285	26.6	36.11	77	0.06
17	05/27/04	2322	27.993	-89.948	242	26.6	36.21	80	0.08
18	05/28/04	0039	28.078	-89.777	222	26.6	34.80	91	0.12
19	05/28/04	0355	28.212	-89.682	241	26.8	33.12	97	0.12
20	05/28/04	1410	28.117	-89.553	230	26.7	34.57	87	0.16
21	05/28/04	2307	27.965	-89.698	218	26.9	35.02	88	0.12
22	05/29/04	0545	27.825	-89.800	239	26.8	36.25	78	0.08
23	05/30/04	0149	28.252	-89.682	241	27.3	33.13	95	0.15
24	05/30/04	0302	28.332	-89.512	239	27.0	34.00	100	0.20
25	05/30/04	0414	28.415	-89.347	226	27.3	31.06	813	5.03
26	05/30/04	0527	28.485	-89.170	243	27.6	32.24	328	1.65
27	05/30/04	0641	28.577	-89.003	202	27.5	32.87	645	4.78
28	05/30/04	0752	28.663	-88.840	202	27.8	31.57	455	3.08
29	05/30/04	0911	28.752	-88.670	165	27.3	35.58	106	0.16
30	05/30/04	1031	28.838	-88.505	202	26.9	36.42	97	0.10
31	05/30/04	1149	28.922	-88.338	202	27.1	36.17	94	0.12
32	05/30/04	1305	29.002	-88.170	200	27.1	36.42	72	0.12
33	05/30/04	1434	29.087	-87.977	212	27.1	36.43	75	0.12
34	05/30/04	2037	28.988	-87.988	212	27.3	35.89	78	0.10
35	05/30/04	2337	29.113	-87.638	214	27.2	36.21	75	0.10
36	05/31/04	0140	29.208	-87.475	228	27.3	36.36	75	0.09
37	05/31/04	0508	29.058	-87.392	211	27.4	36.39	79	0.08
38	05/31/04	0736	28.932	-87.270	222	27.4	36.40	80	0.07
39	05/31/04	0959	28.800	-87.153	237	27.4	36.37	78	0.09
40	05/31/04	1223	28.667	-87.037	224	27.5	36.35	83	0.11
41	05/31/04	1634	28.547	-86.917	223	27.9	36.36	75	0.12
42	05/31/04	1956	28.413	-86.805	225	27.9	36.27	77	0.10
43	05/31/04	2216	28.255	-86.682	251	27.9	36.26	79	0.10
44	06/01/04	0055	28.080	-86.538	188	27.9	36.33	75	0.09
45	06/01/04	0410	28.098	-86.823	207	27.9	36.38	75	0.09
46	06/01/04	0717	28.110	-87.110	194	27.8	36.40	77	0.09
47	06/01/04	1038	28.320	-87.300	184	27.5	36.40	74	0.11
48	06/01/04	1338	28.522	-87.463	218	27.6	36.37	73	0.11

Table 3.1.11

XBT and Extracted Chlorophyll Stations on S-tag 2004 Cruise (continued)

XBT No.	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	15°C depth (m)	sfc temp (°C)	sfc salin	sfc fluor (mvolts)	Extracted CHL (mg/L)
49	06/01/04	1721	28.755	-87.653	218	27.8	34.92	79	0.12
50	06/05/04	0727	28.990	-88.243	bad probe	27.5	34.32	86	0.14
51	06/05/04	1147	28.840	-88.587	194	27.4	34.70	97	0.33
52	06/05/04	2316	28.767	-88.812	186	27.8	32.16	233	2.14
53	06/06/04	0156	28.723	-89.000	178	28.2	28.19	411	3.40
54	06/06/04	0700	28.380	-89.085	194	28.0	28.50	737	8.81
55	06/06/04	1428	28.268	-89.388	265	27.6	33.00	332	3.40
56	06/06/04	2251	28.230	-89.693	239	27.8	35.56	84	0.15
57	06/07/04	0153	28.352	-89.715	224	28.2	35.97	78	0.09
58	06/11/04	2355	28.142	-89.800	220	28.6	35.84	77	0.10
59	06/12/04	2105	28.850	-88.558	209	29.7	31.59	106	0.30
60	06/13/04	0004	28.885	-88.272	197	29.2	35.78	75	0.09
61	06/13/04	0257	28.782	-88.363	194	29.0	34.02	85	0.12
62	06/13/04	0408	28.702	-88.542	200	29.2	32.82	87	0.10
63	06/13/04	0539	28.628	-88.713	200	29.5	32.65	91	0.12
64	06/13/04	0716	28.550	-88.880	195	29.2	31.09	107	0.18
65	06/13/04	0845	28.475	-89.052	189	29.5	31.08	124	0.37
66	06/13/04	1020	28.383	-89.210	184	28.8	35.99	79	0.18
67	06/13/04	1237	28.345	-89.347	202	28.4	35.90	78	0.12
68	06/14/04	0903	28.453	-89.408	191	28.3	36.11	78	0.10
69	06/16/04	1058	28.538	-89.830	225	28.1	33.37	194	1.15
70	06/16/04	1238	28.347	-89.830	214	27.8	31.53	326	2.26

Table 3.1.12

CTD and Extracted Chlorophyll Stations on S-tag 2004 Cruise

CTD No.	Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	15°C depth (m)	Sfc temp (°C)	Sfc salin	Sfc fluor (mvolts)	Extracted CHL (μg/L)
1	05/26/04	0244	27.477	-93.353	205	26.1	35.31	80	0.07
2	05/27/04	1606	27.755	-90.565	273	26.3	36.30	77	0.09
3	05/30/04	1556	29.112	-87.832	198	27.1	36.43	75	0.12
4	06/04/04	2227	29.457	-88.252	n/a	27.0	33.56	210	1.27
5	06/09/04	0208	28.287	-89.480	214	28.0	35.93	77	0.10

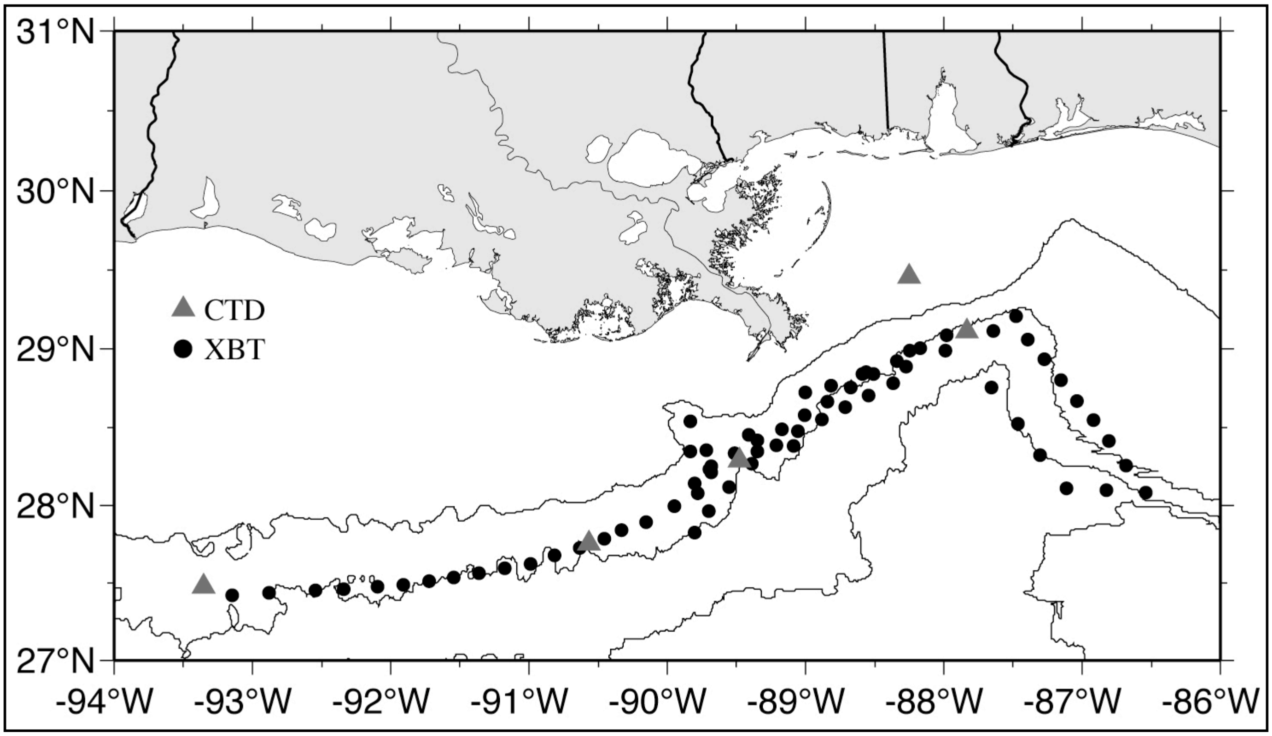

Figure 3.1.7. Locations of CTD and XBT stations on the 2004 S-tag cruise. Bathymetric contours shown are the 200, 1000, 2000, and 3000-m isobaths.

Table 3.1.13

ADCP Configuration Summary for S-tag Cruises in 2004 and 2005

Parameter	150-kHz	38-kHz
Year	2004	2004, 2005
Instrument type	narrow-band	broad-band
Frequency (kHz)	150	38
Transducer pattern	Concave	flat
Depth cell length (m)	4	16
Maximum number of depth cells	60	63
Segment time (minutes)	5	5
Time between pings (sec)	1	3
First bin depth (m)	11.6	41.1
Transit pulse length (m)	4	16
Blank after transmit (m)	4	16
Navigation type	DGPS	DGPS
Data recorded	raw, navigation, 5-min averaged, 20-min averaged	raw, navigation, 5-min averaged, 20-min averaged
Total usable segments in 2004	1725	4449
Total usable segments in 2005	NA	5008

The pre-cruise sea surface height (SSH) map for 21 May 2004 (Figure 3.1.8) indicated that surface currents over the middle continental slope (MCS) should be on margin near 93°-92°W and off margin near 89°-88°W, along the western and eastern margins, respectively, of a clockwise-rotating warm-slope eddy (WSE) with long axis elongated W-E along the MCS from 92°-89°W. The SSH analysis further indicated that to the east of the WSE was a counter-rotating (cyclonic) circulation, as shown by the region of SSH anomaly from –15 to –20 cm over the MCS from 88.5°W to 86.5°W. In deepwater south of the MCS, the SSH analysis indicated the northern boundary of a large deepwater anticyclonic (clockwise) Loop Current eddy (LCE) reached to about 27°N in the eastern Gulf. This LCE was named “Titanic Eddy” or LCE T. The altimetry indicated LCE T, which had begun to pinch off from the Loop Current in early May 2004, was still attached to the Loop Current on 21 May and that the northern portion, which was expected to break away, had a SSH anomaly of greater than 50 cm.

Subsequent SSH analyses for 26 and 31 May and for 3, 8, and 10 June showed only minor variations on this same general geometry for the eddy field. The cyclonic circulation in DeSoto Canyon intensified a little as indicated by an increase in the SSH anomaly from –15 to –20 cm over a large area of deepwater DeSoto Canyon by 10 June. The location of the northern edge of Titanic Eddy remained south of 27°N in the eastern Gulf, and the eastern edge of the elongated WSE was found between 90°W and 88°W.

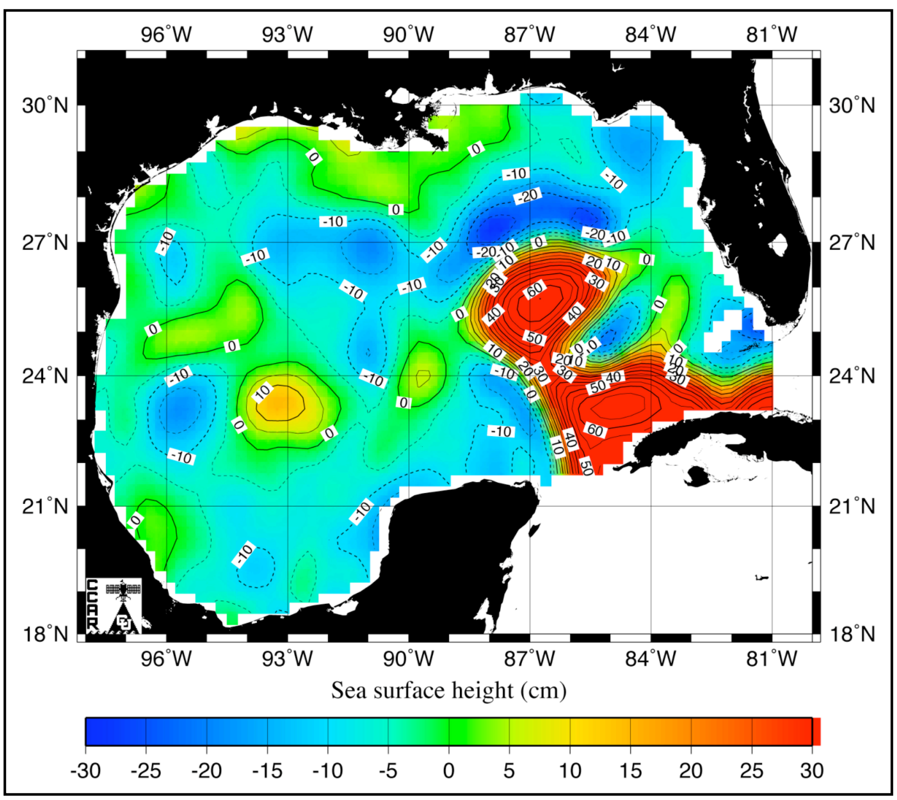

Figure 3.1.8. Sea surface height field for 21 May 2004.

The surface currents running clockwise around the WSE outside the interior region between 91.5°W to 89.5°W were expected to entrain the low salinity, higher chlorophyll shelf water near the mouth of the Mississippi River and transport this "green" water to the east and off the margin between Mississippi Canyon and the west side of DeSoto Canyon. Data from the flow-through system, XBT drops, and CTD stations confirmed there was on margin flow along the MCS near 93°W and off margin flow between 90°W and 88°W. Between 92.5°W and 89.8°W, SSS was generally > 35 and the water appeared azure blue in color; SCF in this "blue" water generally was less than 85 mvolts, equivalent to < 0.15 µg CHL/L. In contrast, in "green-brown" water area of off-margin flow on the east side of the WSE, SCF reached 800-1200 mvolts, equivalent to 5-12 µg CHL/L.

When the green-brown water off-margin flow was first crossed during the survey from west-to-east on 29-30 May, it extended from 89.7°W to 88.6°W. In the core of the brown water, SST averaged 1°C greater than adjacent water, SSS dipped as low as 31, and SCF was elevated to 800-900 mvolts. This off-margin flow was crossed again one week later, during the return east-to-west survey on 5-7 June. At that time, the green-brown water extended from 89.65°W to 88.75°W. In the core of the brown water, SSS now dipped as low as 23 and SCF was elevated to 1200-1300 mvolts.

During daylight on 6 June, windrows of freshwater aquatic plants were observed in the core of the brown water off-margin flow. Floating clumps of water hyacinths and pickerel weed appeared to be quite freshly exported out to sea, since some clumps that were gaffed and brought aboard were green and turgid (Figure 3.1.9). The off-margin flow was recrossed two more times, during daylight on 12 June and again during the night of 12-13 June. During these crossings, SSS in the core of the green-brown water dipped to 27-29. However, this time SCF only reached 150-200 mvolts, equivalent to 0.8-1.5 µg CHL/L. The windrows of freshwater vegetation were still present, but by 12-13 June all of the windrows were brown rather than green in color, and the individual clumps of water hyacinths were quite wilted.

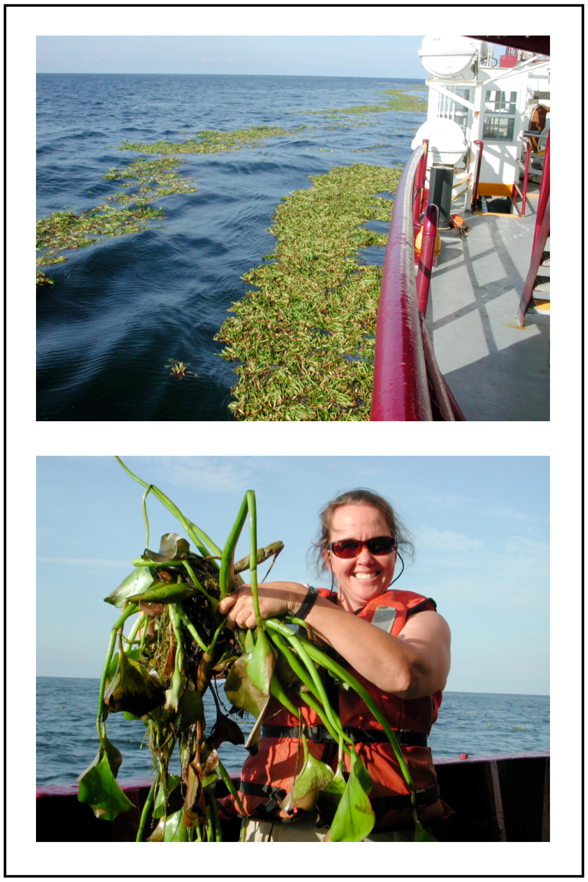

Figure 3.1.9. Transit through windrows of floating freshwater vegetation on 5 June 2004. Deborah Epperson of MMS holds a big clump of water hyacinth and pickerel weed that she gaffed and brought aboard as we passed through this floating vegetation.

3.2 S-tag Cruise 2005

Introduction

R/V *Gyre* cruise 05G09 surveyed for sperm whales in the northern Gulf of Mexico between approximately 96°W and 93°W on 2-30 June 2005. The primary goal was to tag animals with satellite-tracked radio tags (S-tags) and bioacoustic probes (B-probes). Tagging was done from small boats, along with photo-identification (photo-ID) and biopsy sampling for genetic typing. Other integral tasks for the survey effort were to acoustically determine three-dimensional dive profiles (3-D passive acoustic tracking of sperm whales), to collect fishery echosounder measurements, and to gather physical and biological oceanographic data for characterization of the habitat in which whales were encountered. Table 3.2.1 lists the 23 members of the scientific party and their responsibilities.

Table 3.2.1

Science Team for the SWSS 2005 S-tag Cruise

Responsibility	Participant	Participation
Oceanography team	Ann Jochens (Chief Scientist)	Legs 1 and 2
	Alyson Azzara (Leg 1 assisted with acoustics)	Legs 1 and 2
	Chris Wingard (fisheries echosounder; Leg 1 assisted with acoustics)	Leg 1
Tagging team	Joel Ortega (Tag Team Leader)	Legs 1 and 2
	Dan Engelhaupt (biopsy/genetic typing)	Legs 1 and 2
	Ladd Irvine (boat driver)	Legs 1 and 2
	Andy Szabo (video)	Legs 1 and 2
	Craig Hayslip (photographer)	Legs 1 and 2
Photo-ID team	Charlie Short (boat driver)	Legs 1 and 2
	Carol Roden (photographer)	Leg 1
	Glenn Gailey (photographer)	Leg 2
Visual team	Lars Bejder (Visual Team Coordinator)	Legs 1 and 2
	R. Iliana Ruiz-Cooley	Legs 1 and 2
	Rhoni Lahn	Legs 1 and 2
	Suzanne Yin	Legs 1 and 2
	Glenn Gailey	Leg 1
	Dave Lundquist	Leg 1
	Lee Benner	Leg 2
	Kyle Baker	Leg 2
Acoustic team	Aaron Thode (Acoustic Team Coordinator and 3-D passive acoustic tracking)	Leg 1
	Thomas Norris (Acoustic Team Coordinator)	Leg 2
	Sara Heimlich	Legs 1 and 2
	Deborah Epperson	Legs 1 and 2
	Bill Burgess	Leg 2
TAMU Techs	Paul Clark (Electronics Technician)	Legs 1 and 2
	Eddie Webb (Electronics Technician)	Legs 1 and 2
	Bill Green (Deck Engineer)	Legs 1 and 2
	Marty Bohn (Deck Engineer)	Legs 1 and 2

Mobilization for the cruise began on 30 May 2005 when the acoustics team arrived to begin set up of the acoustics lab. Other science team members arrived 31 May - 2 June and set up their various components. The cruise left Galveston, TX, at 2000 CDT on 2 June and returned to Galveston, TX, at 1700 CDT on 30 June 2005. The 28-day cruise was conducted in two legs. Leg 1 was from 3-19 June 2005, and Leg 2 was from 19-30 June 2005. The port call on 19 June was at Harbor Island, TX, to exchange personnel on the visual and acoustic teams. An unplanned port call was made to Port Aransas, TX, on 13 June to allow an ill crew member to disembark and a replacement to board. Thus Leg 1 is split into parts A and B.

The geographic focus during this cruise was the northwestern Gulf of Mexico. The S-tag cruises in 2002-2004 tagged animals in the north central Gulf, mainly between Mississippi Canyon and DeSoto Canyon. Results from whales tagged in those years suggest an affinity of female whales for specific sites in the north central Gulf (e.g., see Chapter 6 in Jochens et al. 2006). However, during shipboard surveys conducted at the time that S-tags were active, sightings of sperm whale groups were recorded in areas different from those where tagged females whales were located. Moreover, some of the groups observed in those surveys included calves and were most likely female groups rather than immature males. Therefore, the goal for 2005 was to tag whales in areas different from previous years. Specifically the waters of the western Gulf and the deepwater central Gulf were selected for survey to compare the movement patterns and the home range of sperm whales from different regions of the Gulf.

At the time of the cruise, there were two anticyclone-cyclone eddy pairs in the northwestern Gulf (Figure 3.2.1). The geometry of the northern cyclone-anticyclone eddy pair created on-margin flow in the confluence of the two circulations and a region of off-shelf flow at about 94°W that was being driven by the southward flow on the east side of that anticyclone. The cruise track (Figure 3.2.2) consisted of three parts, separated by the two port calls. Leg 1A focused on the region of the cyclone (Figure 3.2.2a). Leg 1B surveyed across the cyclonic-anticyclonic eddy confluences. Leg 2 surveyed along the 1000-m isobath between 95°W and 93°W and in the deep waters about the 2000-m isobath between 96°W and 94°W. All work was in U.S. territorial or Exclusive Economic Zone (EEZ) waters.

Accomplishments of SWSS 2005 S-tag Cruise

The S-tag cruises in 2002-2004 concentrated on the region between the Mississippi Canyon and DeSoto Canyon. All tags and biopsies were from this region. The goal for the SWSS 2005 S-tag cruise was to attempt to put tags on and obtain biopsies from sperm whales in the western Gulf of Mexico. Data collected on the 2005 cruise were from west of approximately 93°W. The SWSS 2005 S-tag cruise had a number of accomplishments, including:

1. Twelve satellite tags (S-tags) were successfully attached. Ten were location-only and two were satellite tags with depth sensors. All 12 tags were successfully reporting locations as of July 6. This accomplishment will provide information that can be used to compare the distributions of whales tagged in the western Gulf with those tagged in the central Gulf.

2. The bioacoustic probe (B-probe) was successfully deployed on two occasions: one for 1 hour and one for 2 hours (this excludes the initial deployment of 37 seconds). These were the first deployments ever of a B-probe on sperm whales. The data possibly represent two different behaviors, with one shallow diving for most of the period recorded and the other deep diving.

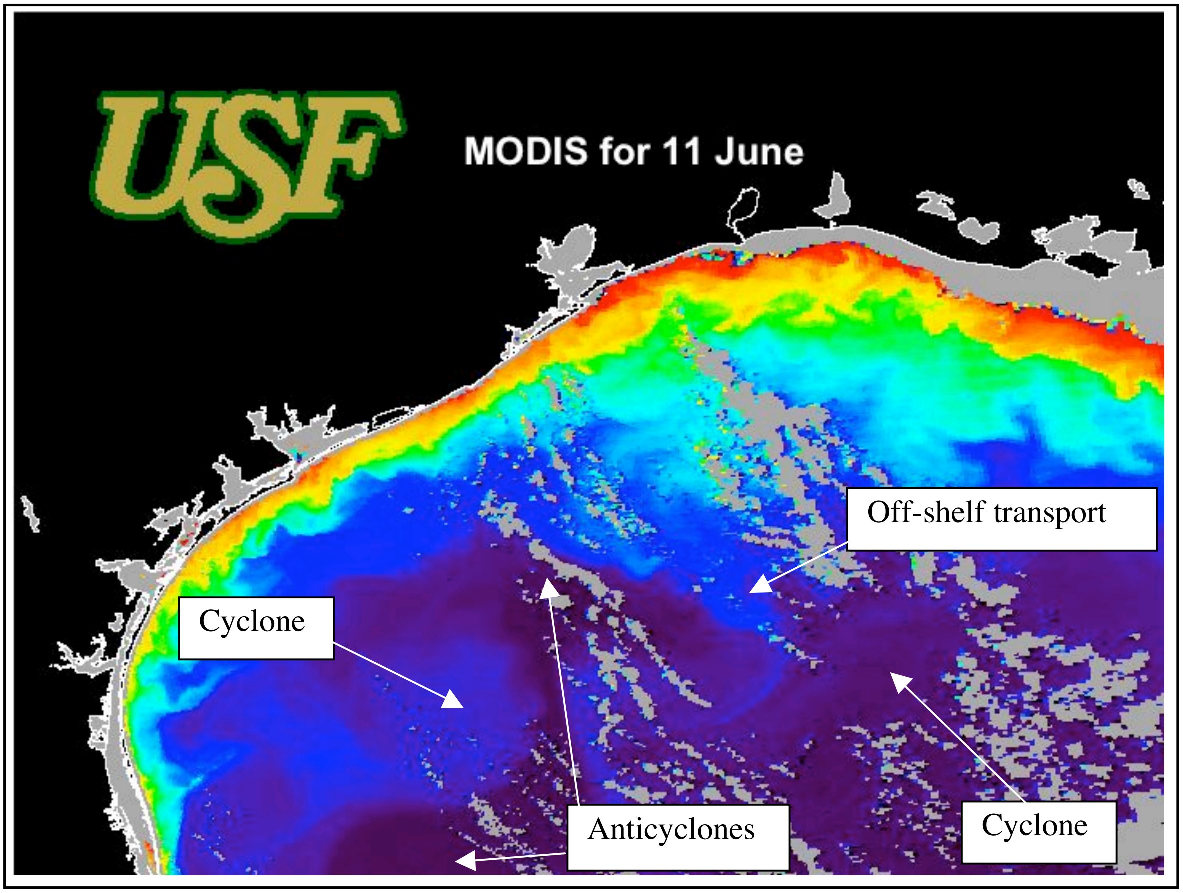

Figure 3.2.1. MODIS image for 11 June 2005. Image shows regions with enhanced productivity (reds to blues are biologically productive regions; purples are non-productive).

3. Twenty-two biopsies from sperm whales were obtained. These data will allow genetic comparisons with the whales in the central Gulf, as well as in other populations. Three samples from rough-toothed dolphins were also collected and will be stored for later analyses.

4. Passive acoustic monitoring data, suitable for 3-D sperm whale tracking analyses, were recorded. This accomplishment will allow further advancements in the passive acoustic monitoring of sperm whales.

5. High quality acoustic recordings were obtained of clicks, creaks, and codas.

6. Fishery echosounder data on the deep scattering layer were collected simultaneously with observations on sperm whales.

7. Physical oceanographic data, including remote sensing of ocean color and sea surface height fields, were successfully used to locate areas with whales for tagging.

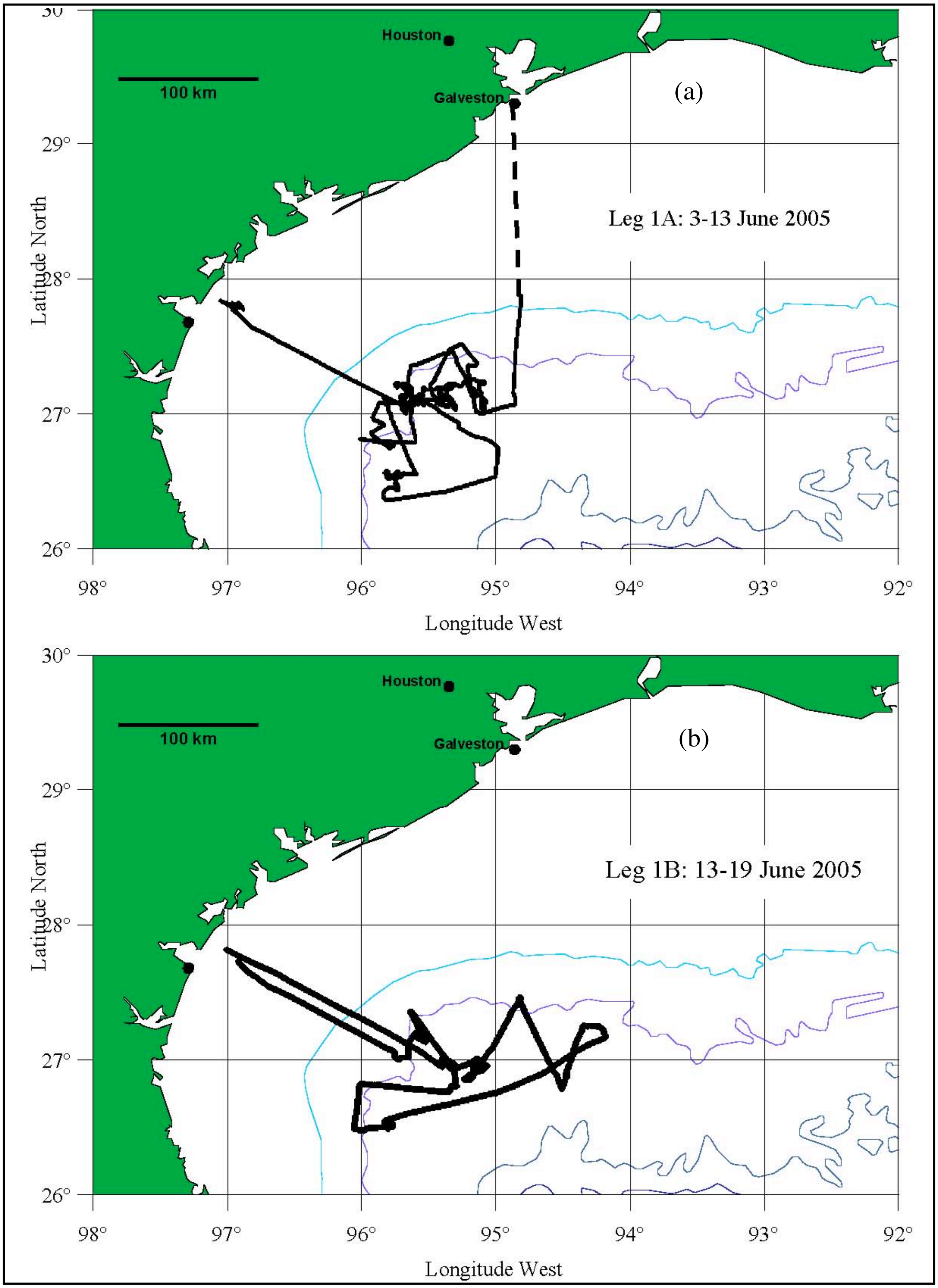

Figure 3.2.2. Cruise tracks for 2005 S-tag cruise. Bathymetry contours shown are 200, 1000, 2000, and 3000 m.

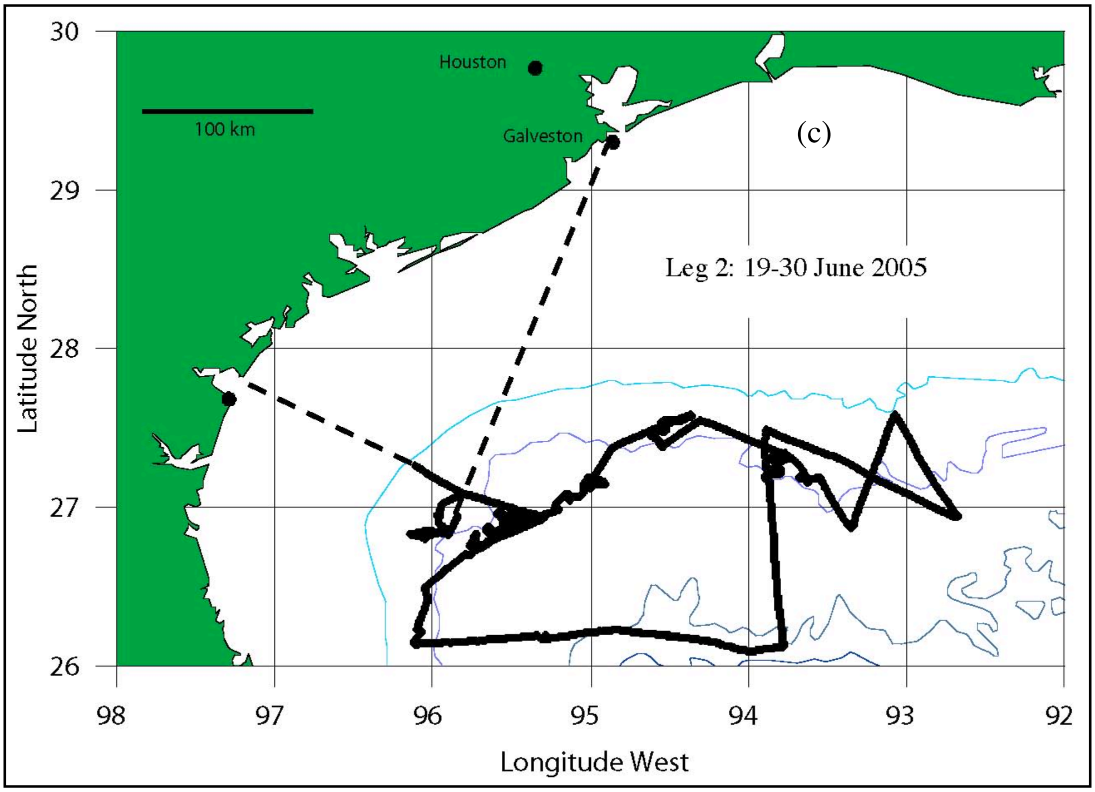

Figure 3.2.2. Cruise tracks for 2005 S-tag cruise. (continued)

8. The visual and acoustic teams, using the computer program "Whale Track II", were well coordinated and successfully navigated the tag boats to whales even in conditions with many white caps and rain.

9. Two RHIBs were safely launched and recovered most days in a variety of wind, rain, and wave conditions.

10. Sightings of other cetaceans, whale sharks, and birds were made and information on them was recorded.

11. Twenty-five fluke pictures were taken for photo-identification of individuals.

Permits

All work with sperm whales and other marine mammals encountered was conducted in accordance with the terms of permits issued by the U.S. National Marine Fisheries Service to Bruce Mate of Oregon State University (Permit No. 369-1757-00, Joel Ortega, Co-Investigator) and Dan Engelhaupt of the University of Durham (Permit No. 909-1726-00).

Satellite-tracked Radio Tag and B-probe Deployment

Small boats were deployed 17 times on 16 days during the 2005 SWSS S-tag cruise. The tagging boat spent a total of 109.75 hours on the water. Weather conditions were windy for most of the cruise days. There was one day with a Beaufort sea state of zero and one day with Beaufort 1. All other cruise days had Beaufort sea states ranging from 3 to 5.

Two types of satellite tags were deployed on sperm whales during the 2005 SWSS S-tag cruise: location-only tags and depth tags. A total of 12 tags were deployed: 10 location-only and 2 depth tags (Table 3.2.2 and Figure 3.2.3).

Table 3.2.2

S-tag and B-probe Deployment Locations

Date (mdy)	Time (UTC)	PTT#	Latitude (°N)	Longitude (°W)	Biopsy ID Number	Tag Type	Whale size (m)	Tag Base Color	Tag Tip Color	Deploy-ment Side
06/11/05	1445	5650	26.5518	-95.7190		Loc	8.00	White	Black	Right
06/11/05	1535	836	26.5665	-95.7318	05061101	Loc	8.50	Black	Black	Right
06/15/05	1452	5800	27.0100	-95.1177	05061501	Depth	7.50 - 8.00	White	White	Right
06/21/05	1659	5644	26.9498	-95.4015	05062101	Depth	8.00	Black	Red	Right
06/21/05	1852	846	26.9310	-95.4838	05062102	Loc	8.00	Black	Yellow	Right
06/21/05	1901	1386	26.9275	-95.4875	05062103	Loc	8.00	Blue	Red	Right
06/21/05	2246	5648	26.8908	-95.4578	05062104	Loc	7.50	White	Blue	Left
06/21/05	2343	5726	26.9092	-95.4852	05062105	Loc	8.50	White	Red	Right
06/24/05	1615	5701	27.2738	-93.8453	05062401	Loc	7.50	Red	Black	Right
06/27/05	0053	847	27.2880	-93.7752	05062601	Loc	8.25	Yellow	Black	Left
06/28/05	2252	5654	27.0168	-95.2075	05062803	Loc	8.00	Blue	White	Right
06/29/05	1516	5709	26.8153	-95.9828		Loc	8.00	Red	Blue	Right

Loc = Location only tag; Depth = Location plus depth tag

The new depth plus location tags were deployed on this cruise. Calibrations were done by deploying the tags on the CTD casts of June 3 and 7. This was followed by deployment of two depth tags on sperm whales on June 15 and 21. Location data from those tags were reported by ARGOS. However, the depth data received via satellite from the two deployed depth tags could not be decoded. Therefore, the decision was made to cancel deployment of more depth tags and to deploy location-only tags for the remainder of the cruise.

Not all the whales encountered during the cruise were approached for tagging. Only robust whales (i.e., no vertebrae distinguishable on the dorsum) estimated to be at least 7.5 meters long were approached for satellite tag deployment. No approaches were made on groups of whales that included a calf less than 6.5 m long. Some individuals greater than 6.5 m but not big enough for tag deployment were approached for biopsy or B-probe attachment.

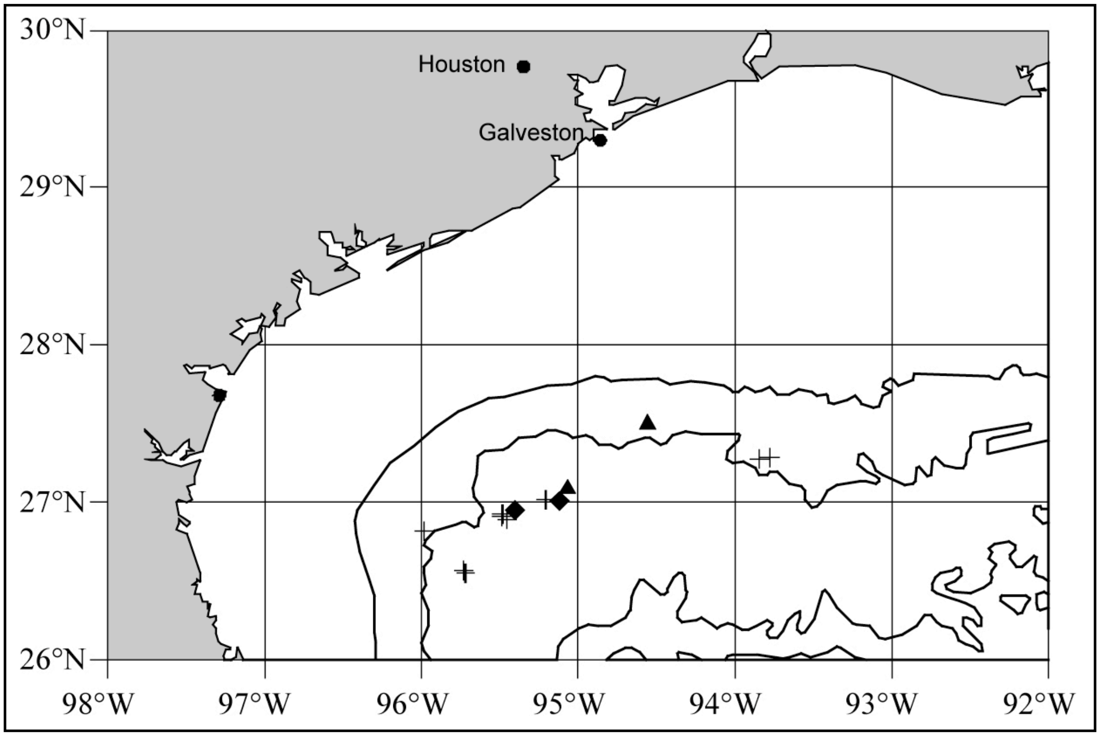

Figure 3.2.3. Tag deployment locations for the 2005 S-tag cruise. Shown are locations of the 10 location-only type tags (crosses), 2 depth plus location type tags (diamonds), and 2 B-probe type tags (triangles). Contour lines indicate the 200-m, 1000-m, 2000-m and 3000-m isobaths.

Three B-probe deployments were done. The first was not successful; the probe detached after 37 seconds. On the second and third deployments, the probe remained attached to the whale for, respectively, 1:55 and 1:07 hrs and recorded a dive to a depth of, respectively, 500 m and 822 m.

Overall, the sperm whales encountered during this cruise were smaller than those observed on previous SWSS S-tag cruises in the central and eastern Gulf of Mexico. Out of 61 whales observed within 200 meters of the tagging boat, only 29 were considered big enough for S-tag attachment. Moreover, only 2 of the tagged whales were estimated to be 8.5 m or larger.

Photo-ID Work from Small Boats

A total of 23 different individuals were photo-identified during the 2005 S-tag cruise. Of these, 20 were of good to excellent quality for photo-ID purposes. Flukes from 4 satellite tagged whales, 1 B-probe tagged whale, and 10 biopsied whales where photographed. Photographs or video that show tag placement and condition were taken of all tagged whales. Fluke photos taken during this cruise will be compared to the photo-ID database from previous cruises and to the Gulf of Mexico/North Atlantic catalogue.

2005 Tissue Collection/Genetic Typing

Biopsy sampling techniques were combined with satellite-monitored tagging during the 2005 S-tag cruise in the northern Gulf of Mexico. A total of twenty-two skin samples were collected from sperm whales during the cruise, ten of which were from whales tagged with satellite-monitored tags and two of which were from whales tagged with the B-probe (Table 3.2.3; Figure 3.2.4). All tissue samples obtained were expected to provide ample material for genetic applications. Sub-sections of eighteen biopsy samples taken during the cruise were prepared and stored for eventual stable isotope analysis. No significantly large males (whales that appear to be sexually and physically mature based on estimated sizes) were encountered and therefore none were sampled. Opportunistic biopsy samples of rough-toothed dolphins (*Steno bredanensis*) were also collected (Table 3.2.4; Figure 3.2.4). These samples were stored for later analysis to assist in any future population structure studies relating to this species.

Table 3.2.3

Tissue Samples Collected from Sperm Whales During the 2005 S-tag Cruise
(Sample number code gives the date (yymmdd) followed by the consecutive number for multiple samples taken on any given day (01 to 05).)

Sample ID No.	S-tag PTT No.	Tissue Type	Group Number	Approx. # Whales in Area	Latitude (°N)	Longitude (°W)
05061101	836	Biopsy	1	14	26.5665	-95.7318
05061102		Biopsy	1	14	26.5450	-95.7998
05061501	5800	Biopsy	2	5	27.0100	-95.1177
05061502		Biopsy	2	5	26.9737	-95.1407
05061503		Biopsy	2	5	26.9537	-95.1365
05061801		Biopsy	3	5	26.9757	-95.4078
05061802		Biopsy	3	5	26.9595	-95.3978
05061803		Biopsy	3	5	26.9737	-95.3607
05062101	5644	Biopsy	4	8	26.9223	-95.4508
05062102	846	Biopsy	4	8	26.9310	-95.4838
05062103	1386	Biopsy	4	8	26.9275	-95.4875
05062104	5648	Biopsy	4	8	26.8908	-95.4578
05062105	5726	Biopsy	4	8	26.9092	-95.4852
05062401	5701	Biopsy	5	7	27.2738	-93.8453
05062402		Biopsy	5	7	27.3105	-93.8582
05062403		Biopsy	5	7	27.3528	-93.7833
05062601	847	Biopsy	6	3	27.2988	-93.7680
05062701	B-Probe	Biopsy	7	8	27.5020	-94.5535
05062702		Biopsy	7	8	27.5370	-94.5108
05062801	B-Probe	Biopsy	8	8	27.0837	-95.0742
05062802		Sloughed Skin	8	8	27.0657	-95.1240
05062803	5654	Biopsy	8	8	27.0168	-95.2075

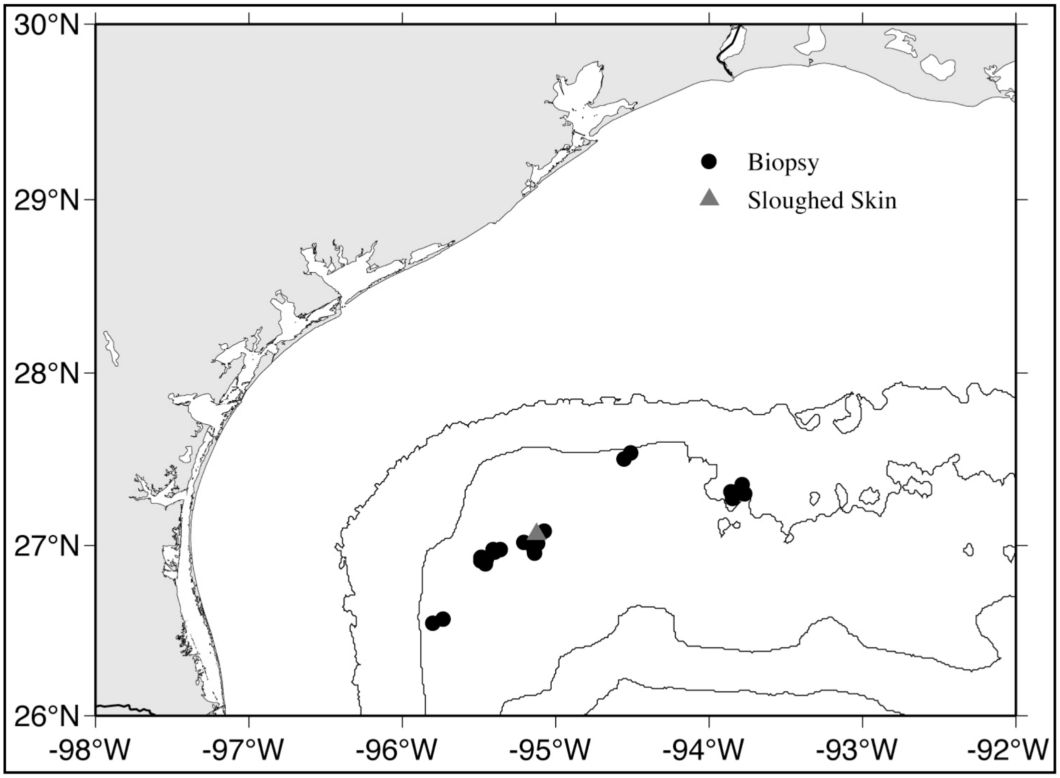

Figure 3.2.4. Locations of biopsy samples on the 2005 S-tag cruise.

Table 3.2.4

Tissue Samples Collected from Rough-toothed Dolphins During the 2005 S-tag Cruise
(Sample number code gives the date (yymmdd) followed by the consecutive number for multiple samples taken on any given day (01 to 03).)

Sample ID No.	Tissue Type	Group No.	Approx. # Dolphins in Area	Latitude (°N)	Longitude (°W)
05061601	Biopsy	1	20	26.8233	-94.5002
05061602	Biopsy	1	20	26.8183	-94.4928
05061603	Biopsy	1	20	26.8147	-94.4890

Rough-toothed dolphins (*steno bredanensis*)

Overall, the combination of satellite-monitored tagging and biopsy sampling was highly successful. A biopsy sample was obtained from multiple members of seven groups. Degrees of relatedness will be tested between whales found within groups and clusters, allowing development of answers to questions on how related and unrelated whales found within groups and clusters in the northern Gulf of Mexico maintain long or short term associations over space and time. Group 4 has five whales tagged, all of which have biopsy samples to match. This is very exciting as it should provide data to watch how related/unrelated whales move together or split apart through space and time. An interesting note is that the majority of whales found within the western Gulf of Mexico were 'small' whales averaging 7.5 meters in length (based on visual observations only). On only one occasion was a whale seen that may have been close to 9 meters in length. Future studies using proper photogrammetry techniques would allow further clarification. Young and old calves (based on visual observation estimates only) were sited in the area, suggesting several of these groups may fit the classic 'mixed group' scenario comprised of adult females and immatures of both sexes - similar to what is seen in other areas of the northern Gulf of Mexico. Gender results will add further clarification to this aspect.

<u>Visual Team Search and Track Effort</u>

Visual Team Methods: A visual observation station was established on the flying bridge that consisted of three mounted 25x150 "big-eye" binoculars and a data entry station. At least three observers maintained a continuous watch during daylight hours (0700 – 2000 CDT) weather permitting) while the R/V *Gyre* surveyed in water depths of 800 – 2200 m. A rolling watch system was implemented such that each observer stood a 1.5 hour watch followed by 1 or 1.5 hours rest. While on watch, observers moved between roles on the flying bridge every 30 minutes. Two observers scanned with big-eye binoculars while the third person entered data into the data acquisition software program (Whale Track II) on a laptop computer. Whale Track II is a data collection and depiction program written by Glenn Gailey for SWSS.

The watch order was chosen so that observers with complementary skills and levels of experience were distributed through the rotation. The visual team operated in two modes: "survey" and "tracking." During survey mode, each observer on the big-eye binoculars searched from 10 degrees on the opposite side of the ship to 90 degrees on their side while the third person, the data recorder, concentrated on data input and supported visual observations in the near field using only naked eye and Fujinon 7x50 binoculars. The visual team operated in concert with the acoustic team to maximize sperm whale detections, 'searching' whenever the ship followed predetermined survey tracks, with or without the RHIBs to augment sightings or acoustic contacts. Survey tracks were determined each preceding evening.

Once sperm whales were sighted, the visual team switched to tracking mode. The main objectives during tracking mode were to register time, location, whale movements, and direct the RHIBs towards the whales as rapidly as possible. Therefore, while tracking sperm whales, the observers did not regularly scan the whole sector on their side, but rather, they focused on the area where sperm whales were sighted. The recorder gathered information from the big-eye observers and acoustic team and communicated it to the RHIBs. The computer program Whale Track II was used to calculate location of whales using bearing and reticle measurements obtained with the big-eye binoculars. Whale Track II was also used to quickly estimate the range (km) and magnetic heading from the RHIBs to the whales.

Locations of first sightings, blows and dives (fluke-ups), and whale headings were recorded in Whale Track II with notes on any behaviors observed by the visual team or reported by RHIB teams (Figure 3.2.5). Information on relative locations of whales, RHIBS, and the R/V *Gyre* was then used to dictate the movement of the vessels to maximize tagging probabilities.

While in tracking mode the visual and acoustic teams worked closely together. The aim was to amalgamate all information on the location and behavior of whales (visual data, acoustic data from the *R/V Gyre*'s arrays, and acoustic information from the RHIBs directional hydrophones) to form a comprehensive overview of the whales' movements and behavior. Whale Track II proved useful in accomplishing this by allowing information about whale locations to be shared between acoustic and visual teams. The visual team also requested course and speed changes from the R/V *Gyre* bridge to keep the vessel in a position in which its visual coverage of whale aggregations, which typically spread over several miles, was optimal. The visual team acknowledges the valuable help from the officers on the *R/V Gyre* bridge who all responded to our numerous requests for course changes, while navigating the vessel safely around other vessels and oil rigs.

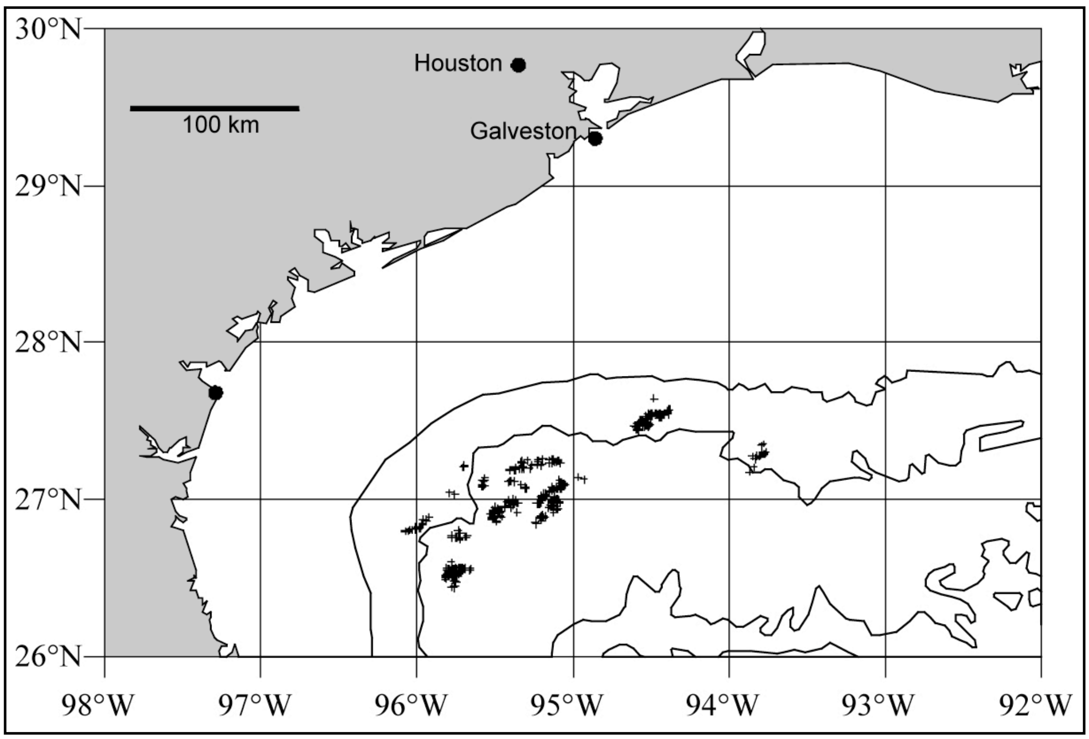

Figure 3.2.5. Locations of sperm whale fixes recorded by the S-tag visual team in 2005. Some whales were fixed more than once during tagging operations; these have not been filtered out from this information.

Visual Team Effort: In total, the visual team searched for sperm whales on 24 days. A total of 256 hours were spent by the observers either on survey effort or tracking whales (Table 3.2.5).

Visual Team Sightings: A total of 666 sperm whale location fixes were recorded (Table 3.2.5; Figure 3.2.5). However, many of these sightings are of the same individual when the vessel was in tracking mode. The estimated total of sperm whales encountered is 100 – 121 sperm whales during the SWSS 2005 cruise. Note that it is not known whether this estimate includes multiple counts of the same individuals encountered on different days. Additionally, 27 sightings of other cetacean species (Table 3.2.6) were recorded during the cruise.

Table 3.2.5

Visual Team Effort and Sperm Whale Sightings

Day (d/m/y)	**Effort (h:m)**	**Sperm whale location fixes**	**Number of different sperm whales encountered (estimate)**
04/06/05	1:30	0	3
05/06/05	8:01	17	10
06/06/05	11:01	0	0
07/06/05	6:04	19	8 – 10
08/06/05	8:40	0	0
09/06/05	12:56	63	6 – 12
10/06/05	11:07	0	0
11/06/05	13:21	129	10 -18
12/06/05	6:08	7	5 – 7
14/06/05	13:00	2	2
15/06/05	12:04	67	5 – 7
16/06/05	12:06	0	0
17/06/05	12:48	32	3 – 4
18/06/05	13:00	26	5 – 6
20/06/05	13:04	16	3 – 5
21/06/05	12:28	49	8 -12
22/06/05	13:05	0	0
23/06/05	11:07	0	0
24/06/05	9:17	7	6 – 8
25/06/05	11:00	0	0
26/06/05	13:17	13	3
27/06/05	12:18	120	12 – 15
28/06/05	12:35	73	8 – 12
29/06/05	6:09	26	3 – 5
TOTAL	256:06	666	100 - 121

Table 3.2.6

Cetacean Sightings, Other Than Sperm Whales, During the 2005 S-tag Cruise

Date (m/d/y)	Time (UTC)	Species name	Latitude (°N)	Longitude (°W)
06/06/2005	1027	Unidentified dolphin	27.1028	-95.4656
06/16/2005	0805	Unidentified dolphin	26.9471	-94.5996
06/16/2005	0941	Rough-toothed dolphins	26.8414	-94.5159
06/16/2005	1035	Rough-toothed dolphins	26.7835	-94.4566
06/16/2005	1050	Unidentified dolphin	26.9190	-94.4757
06/16/2005	1158	Rough-toothed dolphins	26.8694	-94.4737
06/16/2005	1259	Unidentified cetacean	26.9259	-94.4519
06/16/2005	1335	Unidentified cetacean	27.0520	-94.3616
06/16/2005	1405	Unidentified dolphin	27.0438	-94.4641
06/16/2005	1418	Unidentified cetacean	27.0475	-94.3867
06/16/2005	1439	Unidentified dolphin	27.0591	-94.4582
06/16/2005	1500	Unidentified dolphin	27.1489	-94.3681
06/16/2005	1627	Risso's dolphins	27.2110	-94.3661
06/17/2005	0730	Rough-toothed dolphins	26.7079	-95.1807
06/17/2005	0747	Unidentified dolphin	26.7219	-95.2047
06/20/2005	1648	Melon-headed whales	26.8051	-95.7347
06/22/2005	1126	Rough-toothed dolphins	26.1379	-96.1243
06/23/2005	0730	Unidentified cetacean	26.1893	-94.6350
06/25/2005	1315	Bottlenose dolphins	27.4921	-93.1113
06/25/2005	1448	Bottlenose dolphins	27.5441	-93.0472
06/26/2005	1955	Melon-headed whales	27.2973	-93.7941
06/26/2005	2004	Fraser's dolphins	27.3034	-93.7893
06/28/2005	1110	Clymene dolphin	27.2253	-94.9666
06/28/2005	1352	Unidentified cetacean	27.0666	-95.0809
06/29/2005	0930	Unidentified dolphin	26.8377	-95.9643
06/29/2005	1052	Pan-tropical spotted dolphins	26.8332	-96.0143
06/29/2005	1210	Rough-toothed dolphins	26.7972	-96.0551

Passive Acoustic Monitoring, Detection and Tracking

The passive acoustic monitoring, detection, and tracking work on the S-tag 2005 cruise followed the techniques used on the 2004 S-tag cruise, as described in Section 3.1.1. The primary difference between the two cruises was in the software used for tracking and recording sperm whales acoustically. Differences from the 2004 techniques are described below.

Sperm Whale Tracking and Monitoring: During the 2005 cruise, the use of one element of the Norris array and one element of the Ecologic array for left-right bearing determination was discontinued because of problems related to lining up the array elements from the two arrays.

We believe this was due to differences in array depths for the two arrays. Additionally, the depth sensor for the Ecologic array was not functioning properly during the 2005 cruise so these data were not logged. Instead a dive computer (Sunto Vyper) was used to collect a time-stamped series of data that could be used later to calibrate the array depths relative to tow-speeds.

Software: Signal acquisition, processing and data-logging software consisted of ISHMAEL (written by Dave Mellinger of NOAA/PMEL Newport, Oregon) and Whale Track II (developed by Glenn Gailey for OSU). ISHMAEL provided real-time signal acquisition, processing, signal display and bearing-to-source determination capabilities. ISHMAEL was also used to monitor and record 2 channel hydrophone signals via the SoundBlaster Audigy 2NX external sound card (96 kHz sample rate). Whale Track II was used to display the bearings on a geographic plot with different colors used to represent potentially different animals. Whale Track II also acquired GPS data, displayed tracks of the research vessel and logged ancillary data (e.g. effort, comments, etc. as entered by an operator). Whale Track II was networked with the visual team computer so that data could be exchanged between the two platforms via the network. All three programs ran continuously during monitoring.

Passive Acoustic Monitoring, Surveys & Tracking: The 4-person bio-acoustic team provided 24-hour acoustic monitoring while underway, and the procedures used on the 2004 cruise were also used in 2005. However, Logger was not used on the 2005 S-tag cruise. As in 2004, shift durations were 3-4 hours long and consisted of a single operator. Listening stations were conducted when searching for sperm whales, usually during transits between pre-determined waypoints. Typically, the vessel was slowed down to approximately 3 knots to decrease vessel noise and flow-noise. During the second leg, listening stations were conducted for 10 minutes every 20 min (i.e., twice per hour). During these listening stations, the bio-acoustician on watch used a headset to monitor the pair of hydrophones from the Ecologic array. This recording/monitoring scheme coincided with an acoustic data form that was filled out by the bio-acoustician on watch. Continuous recordings were made (96 kHz sample rate, 2-channels) of all acoustic signals of interest (e.g., sperm whale clicks, codas and creaks, dolphins whistles, unusual biological or anthropogenic sounds). All acoustic data were stored to hard disk and backed up on a second hard drive (Maxtor Drive F). Additional information (e.g., changes in survey effort, acoustic configuration settings) were noted by bio-acousticians as needed. In addition to monitoring for cetacean vocalizations, the presence of anthropogenic noise (e.g., seismic survey sounds) was noted in Whale Track II.

Once detected, sperm whales were tracked using the ISHMAEL and Whale Track II software system. The main purpose of this operation was to provide the visual and the tagging team with information about the bearings and, when possible, distances to vocalizing sperm whales. To achieve this, the bio-acoustics team used ISHMAEL and Whale Track II to determine horizontal bearings to the source. Because only one array was used, this measurement was right-left ambiguous. By turning the vessel to an arbitrary direction, it was possible to determine on which side of the ship the sperm whale(s) were located. This was achieved by examining the relative change in the bearing versus time plots displayed by ISHMAEL. Bearing tracks that decreased after the turn indicated that the ship had turned toward that sperm whale. Bearings that increased indicated that the associated animals were on the side of the ship opposite the turn direction. This information was conveyed to the visual tracking team as needed.

The cessation of clicking for individuals or groups of sperm whales, which usually is an indication that an animal or group of animals is coming to the surface, was conveyed to the visual team. This information was particularly useful for the RHIBS when tagging animals.

Night-time effort was conducted so that multi-channel recordings of sperm whales could be obtained for the 3-D passive acoustic tracking project and to track large (> 4-5) groups through the night so that the tagging team could work with them in the morning. Night-time surveys frequently consisted of transiting along predetermined survey transects (as determined by the chief scientists) until a group of whales was encountered. Usually, if the group was large enough (> 4-5 animals), an attempt was made to stay with the animals until morning so that tagging operations could occur. Groups of less than 4 animals were recorded using the Alesis recorder and were followed as described in the 3-D passive acoustic sperm whale tracking section below. All detections of sperm whales and other cetaceans were recorded in Whale Track II.

Acoustic Tracking Results: Approximately 574 hours of acoustic monitoring effort were completed over 26.5 days out of 28 days at sea. Effort was conducted on all workable days at sea with 1.5 days used for transiting to and from ports. A minimum of 27 unique acoustic contacts of sperm whale groups was made, with the unique groups being determined spatially. This estimate is only an approximation because of the difficulties of defining groups and because some groups may have merged or split or were spatially contiguous. In addition to the sperm whale detections, approximately 28 acoustic detections of odontocetes, delphinids, or other unidentified cetaceans were made.

Sperm whale clicks were detected in a total of 173 one hour periods (Table 3.2.7). Of these, seismic survey sounds were detected only during 4 one-hour periods. Dolphins sounds (whistles and/or echolocation clicks) were detected in 67 one hour periods, none of which included seismic survey sounds. All seismic sounds were heard during the first leg only. Ten minute listening stations were conducted consistently only during the second leg of the cruise and therefore were not summarized for the cruise.

Table 3.2.7

Number of 1-hour Periods with Type of Sounds Detected Relative to Presence or Absence of Seismic Survey Sounds

Type of Animal Sound	No Seismic Sounds Present	Seismic Sounds Present	Total Number of Periods
Sperm Whales	169	4	173
Dolphins	67	0	67
Total	236	4	240

A total 65 acoustic files consisting of 4.4 GB of data were written using the ISHMAEL software. These are formatted as ".wav" files at 96 kHz sample rate (24 kHz bandwidth) and 2 channels. In addition, over 100 hours of continuous recordings were made to the Alesis ADAT Hard Drive recorder, sampled at 96 kHz; these recordings are summarized in the 3-D passive acoustic sperm whale tracking report given below.

3-D Passive Acoustic Sperm Whale Tracking

The goal of the 3-D passive tracking component of the SWSS program is to develop and demonstrate the use of a single towed array cable for tracking sperm whales in three-dimensions using their vocalizations. By placing two sub-arrays a distance L apart on a cable, the slant range to a sound source can be determined. In addition, if echoes of the sound from the ocean surface can be detected, then the animal's depth can also be derived. The basic concept was demonstrated in 2003 and 2004. The three goals of the 2005 3-D tracking SWSS program were:

(1) to extend the tracking system to ranges beyond a kilometer by lengthening the amount of cable deployed;

(2) to test a first version of a real-time tracking algorithm, developed by combining the field-tested tracking program ISHMAEL with customized code written in MATLAB; and

(3) to simultaneously collect tracking data along with acoustic backscatter measurements, collected by a Simrad echosounder deployed by Chris Wingard under the direction of Kelly Benoit-Bird. The motivation behind these measurements is to search for potential correlations between whale foraging depths and the measured depths of any backscattering layers.

The tracking range of the system would have been extended by inserting an additional 200 m length of cable in between the two sub-arrays used in the 2004 work, creating a total separation of 400 m between the elements. Unfortunately, this extra cable length was prepared only just in time for the May 2005 cruise and, so, could not be thoroughly tested before being shipped to Galveston. On June 1 it was determined that the preamps on the rear hydrophone array were not able to drive the signal down the extra 20 ohm resistance of the cable, so when the cable was inserted no signal was strong enough to be detected on the hydrophones, although the pressure sensor signal was fine. On June 4 the cable insert was removed and stored on deck. Although the sub-array spacing was reduced to 200 m, the same as the 2004 deployment, the signal quality was still an improvement over 2004, as an additional 200 m length of cable had been inserted between the sub-arrays and the ship stern. The hydrophones were thus towed deeper and, as a result, the ship noise received at the hydrophones was much quieter. About 20 lb. of lead weight were added to the cable during the first deployment. Inclinometers were attached to the array to further quantify the effect on tracking of a slight vertical inclination of the towed array.

The new program Whale Track II was installed, debugged and configured for acoustic monitoring use. Acoustic observers would make notes on the presence of creak, codas, and other unusual sperm whale sounds, as well as whistles and echolocation clicks from dolphins. Whenever bottom echoes were heard the observers would record the fact, along with the ocean depth as read from either the Simrad or ADCP.

Close acoustic encounters with whales were obtained on June 4, with numerous codas and creaks also detected and recorded on a calibrated 24-bit system at 96 kHz sampling rate. Similar data were collected throughout June 5, even through the weather was too rough to permit other SWSS activities. Also on June 5 the 3-D tracking array deployed on the starboard side of the ship was aligned with an Ecologic array deployed on the port side in an attempt to make a system that could distinguish between port and starboard without requiring changes in ship heading. Although the alignment was successful, it was found that both array cables were deployed at substantially different depths, which precluded the ability to distinguish left from right.

By the afternoon of June 5 an early version of the real-time tracking system had been implemented. The focus of the initial code was to test to see if slant range to the whales could be instantaneously determined, by crossing bearings measured simultaneously from both sub-arrays. It was found that decent results could only be obtained when the data were sampled at 48 kHz or above; unfortunately, this sampling rate was too high for the Ishmael/MATLAB software to perform continuously; it became clear that the Ishmael software would have to be modified further to permit actual real-time tracking. Nevertheless, the system could be run for a few minutes at a time before it had to be stopped and restarted. The system was run off-and-on over the next two weeks--see an example of a real-time output over a five minute period in Figure 3.2.6. Further refinements of the real-time system, including adding a depth component, will be added and verified post-cruise.

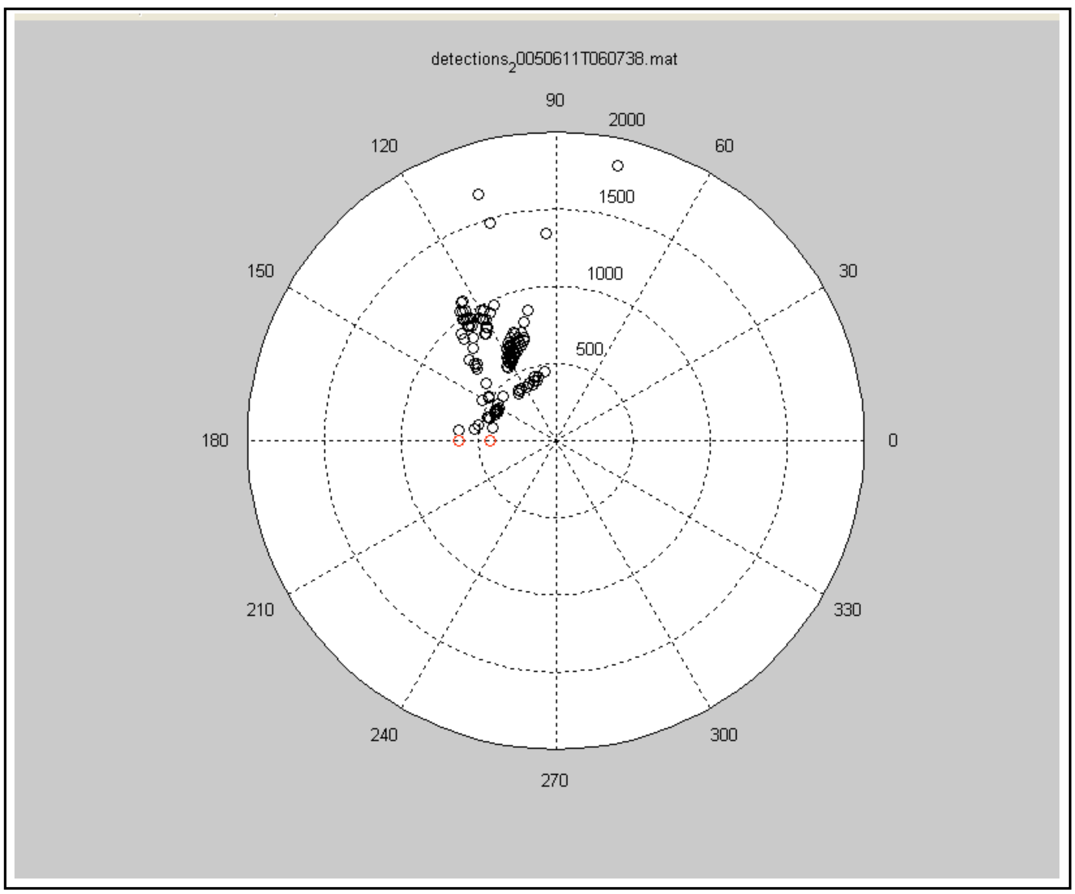

Figure 3.2.6. Real-time output of Ishmael/MATLAB software showing estimated range and bearing of 4 contacts over a 5-min interval starting at 6:07 AM on 11 June 2005.

Despite windy conditions and at times heavy swell, groups of sperm whales were acoustically located and tracked on June 4–12 and 15. Every day provided data of sufficient quality for 3-D tracking for at least some animals. On most of these days the 38 kHz fishery echosounder also was deployed. Although the PI was not present during Leg 2, acoustic and hydrophone depth data continued to be collected, and some of these data also may be usable for 3-D tracking.

One consistent and surprising feature of the acoustic tracking was how often sperm whale codas were detected in the Western Gulf. On every day mentioned above at least some codas were recorded. The morning of June 15 in particular, yielded some sounds that were neither creaks nor codas but seemed some combination of both (Figure 3.2.7). It seems likely that sperm whales made these sounds as no other dolphin sounds were recorded in the vicinity, and the bearings of the sounds were consistent with regular clicks produced by the sperm whales. The collection of such large numbers of creaks and unusual codas is a windfall for this work. Acoustic recordings of *stenella attenuata* have also been collected for testing a 2-D tracking algorithm for dolphins.

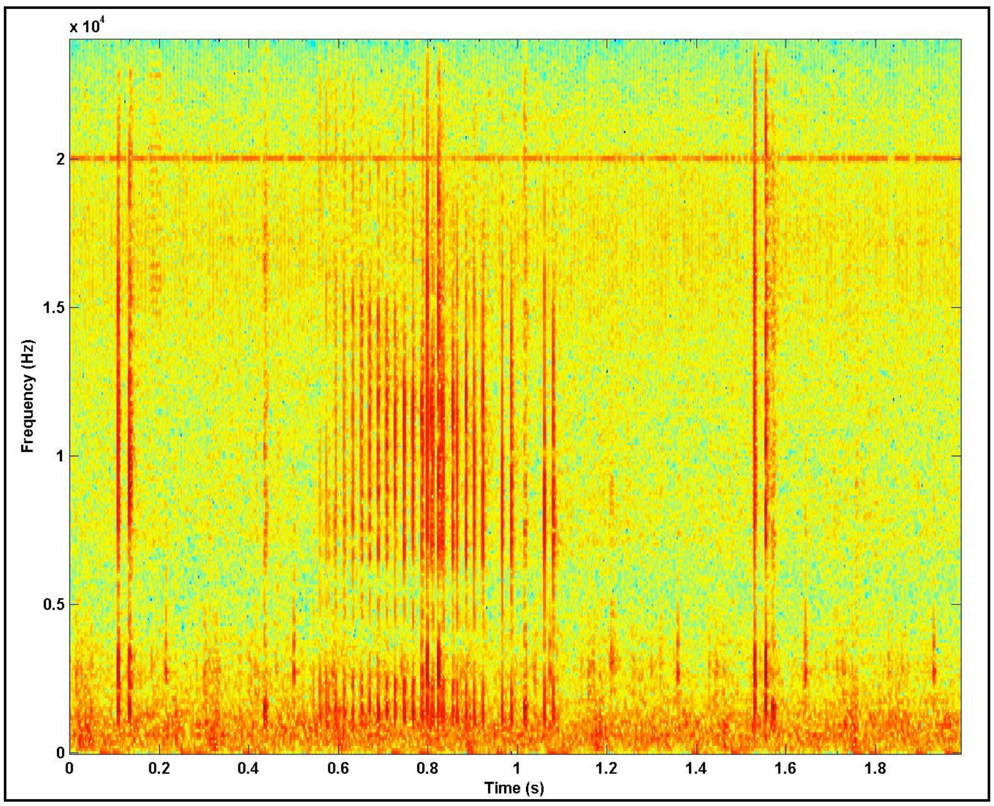

Figure 3.2.7. Spectrogram of unusual "croda" sound recorded on 15 June 2005. The croda is between 0.6 and 1.2 s on the time axis.

The electrical noise on the 3-D array increased consistently during the first leg of the cruise; thereafter, it stayed relatively the same throughout Leg 2. The forward pressure sensor was damaged just before Leg 2. Acoustic data were recorded on the array during both tagging sessions with the Burgess B-probe. We are curious to learn whether sperm whale sounds were simultaneously recorded on both the tag and the array.

Habitat Characterization

Habitat characterization data were collected to supplement rather than to compete for ship time with the tagging and acoustic survey efforts. Accordingly, most of the hydrographic data collection was carried out while the vessel was underway. Four activities were conducted: (1) continuous collection of near-surface observations of temperature, salinity, and fluorescence from the flow-through system with data logged once per minute, (2) except when turned off for other acoustic work, continuous collection of ADCP data from a 38-kHz phased array instrument with data binned every 5 minutes, (3) operation of a Simrad-60 fishery echosounder system that logged backscatter continuously from a 70-kHz fishery echosounder transducer and intermittently from a 38-kHz fishery echosounder transducer, and (4) collection of 4 CTD and 82 XBT profiles. Remote sensing fields of ocean color and sea surface height also were available.

Continuous flow-through sampling used water from an in-line flow that was pumped from the ship's hull depth of 3.5 m to laboratory sensors that measured sea surface temperature (SST), conductivity/salinity (SSS), and fluorescence (SCF). *Gyre*'s Data Acquisition System (GDAS) recorded SST and SSS data once per minute from the SeaBird temperature and conductivity sensors and SCF data from a Turner Designs Model 10 fluorometer. The 1-minute bin intervals give a horizontal resolution of about 0.25 km for the near-surface temperature, salinity, and fluorescence if the ship is underway at a cruising speed of 9 knots.

The fluorometer was calibrated by Doug Biggs and Alyson Azzara using samples collected from the Texas and Louisiana continental margin on cruise 05G06 in late April 2005, by filtering 1-liter samples taken from the flow line concurrently with recorded fluorescence and then measuring the extracted CHL in these samples. However, additional samples were collected during S-tag 2005. These will be used to compare and contrast with the April 2005 calibration sampling. Near-surface chlorophyll samples were taken at 76 locations, many of which were associated with XBT or CTD stations (Table 3.2.8).

A 38kHz ADCP phased-array instrument was installed on the *Gyre* to collect upper water current velocity and backscatter data (see Table 3.1.13 for ADCP configuration). The ADCP collects data in 16-m bins down to depths of 500 m while underway at 8 knots, and often to a depth of 1000 m when the ship slows to 4 knots or less. The ADCP was turned off whenever the 38 kHz fishery echosounder was on (see discussion of echosounder and associated table for times of echosounder operation). Table 3.2.9 shows the periods of operation of the 38 kHz ADCP.

CTD casts were made only when both hydrophone arrays were brought back on board. Since at least one array was deployed for most of the cruise, only four CTD casts were made. The casts were to approximately 1000 m using a SeaBird SeaCat CTD (Table 3.2.10; Figure 3.2.8). The first CTD cast was made after the 1000-m isobath had been reached at the start of the cruise and before the hydrophone arrays were deployed. The second was made when both arrays were brought on board on 7 June. The third was made when both arrays were brought back on board to go to Harbor Island for the unplanned port call. The fourth cast was made at the end of the cruise. Eighty-two XBTs were successfully deployed out of 84 probes (Table 3.2.10; Figure

3.2.8). Sampling was approximately every 10 nm when we were in the cyclone and about 20 nm when we were transiting.

Echosounder-based Sperm Whale Prey Assessments in the Gulf of Mexico

The objective of this study component is to assess the distribution and availability in space and time of potential prey for sperm whales in the Gulf of Mexico. This is part of the long term goal of understanding how anthropogenic noise may impact sperm whales and how this risk can be mitigated. Prey assessment was done in conjunction with measures of sperm whale distribution, diving behavior and vocalizations, and surface patterns of temperature, salinity, circulation and primary productivity (phytoplankton fluorescence) as part of the June 2005 SWSS S-tag cruise.

A two-frequency split-beam echosounder (Simrad EK60 at 38 and 70 kHz) was used from the R/V *Gyre* to measure the distribution of midwater organisms for the month long cruise in the Gulf of Mexico during June of 2005. The downward looking echosounder system has a maximum depth range of approximately 1200 to 1500 m. Raw echo data from each frequency was simultaneously saved to a laptop computer. The target (or echo) strength of animals detected individually will be calculated for each frequency and combined using mathematical scattering models. For animals detected in groups, numerical density will be estimated with an echo integration technique (MacLennan and Simmonds 1992). The Webster method (Webster 1973) will be used to determine the edges of patches in the prey. The position, depth and signal strength data from the echosounders will then be analyzed in ArcView Geographic Information System with 3-D Analyst in order to determine the vertical, horizontal and temporal distribution of potential prey animals.

Surveys using the 70 kHz echosounder (hull mounted) were conducted continuously throughout the cruise in conjunction with other field efforts. The 38 kHz echosounder (mounted on a overboard pole) was deployed during periods when whales were being tracked and for short time periods afterwards as the vessel moved away from whales (see Table 3.2.11). Special attention will be paid to times when sperm whales were tracked, including when animals were tagged and when vocalizations were used to locate the whales. Prey results will be compared between areas where whales were and were not seen or heard.

The total number of hours of operation of the 70 kHz echosounder was 562.23, which represents 100% operation. The 38 kHz echosounder was operated for 132.77 hours or 23.61% of the time. Table 3.2.11 shows the dates, times, and elapsed time for each echosounder.

Table 3.2.8

Locations of Near-surface Chlorophyll Sampling

Sample Name	Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	Station Number
3.1	06/02/05	1735	27.5932	-95.8410	test
3.2	06/02/05	2200	27.1532	-94.8677	CTD#1
4.1	06/03/05	1812	27.5112	-95.2447	XBT#3
4.2	06/03/05	2352	27.2167	-95.4853	XBT#4
4.3	06/03/05	0150	27.1370	-95.4638	test
5.1	06/04/05	1515	27.0837	-95.3373	XBT#5
6.1	06/05/05	2025	27.0822	-95.8033	XBT#6
6.2	06/05/05	0252	26.8372	-95.9113	XBT#8
7.1	06/06/05	1747	26.7925	-95.5997	XBT#9
8.1	06/07/05	1737	27.3612	-95.6183	XBT#10
9.1	06/08/05	1437	27.0390	-95.1057	XBT#11
10.1	06/09/05	2145	26.8250	-94.9933	XBT#12
10.2	06/09/05	0041	26.5283	-94.0280	XBT#13
10.3	06/09/05	0417	26.6117	-95.2537	XBT#14
11.1	06/10/05	1446	26.4967	-95.7468	near XBT#15
12.1	06/11/05	0820	27.0000	-95.8135	XBT#18
12.2	06/11/05	1550	27.2283	-95.7267	n/a
12.3	06/11/05	0356	27.0533	-95.6693	near CTD#3
14.1	06/13/05	0134	27.2033	-95.5175	XBT#19
14.2	06/13/05	0435	26.7997	-95.2702	XBT#20
15.1	06/14/05	1350	26.9687	-94.0820	XBT#22
15.2	06/14/05	2000	26.9682	-95.0397	
15.3	06/14/05	2110	26.8613	-95.7332	XBT#23
15.4	06/14/05	0250	27.1710	-94.9808	XBT#24
16.1	06/15/05	0526	27.4687	-94.7080	XBT#25
16.2	06/15/05	0920	27.2392	-94.7257	XBT#26
16.3	06/15/05	1538	26.8013	-94.4993	XBT#29
16.4	06/15/05	1925	26.8613	-95.7332	XBT#30
16.5	06/15/05	2326	27.2537	-94.3520	XBT#31
17.1	06/16/05	1459	26.6622	-95.3975	XBT#35
17.2	06/16/05	1839	26.5897	-95.7048	XBT#37
17.3	06/16/05	2310	26.5240	-95.8093	XBT#38
18.1	06/17/05	1340	26.7715	-95.4643	XBT#44
18.2	06/17/05	1750	26.9390	-95.3160	XBT#45
18.3	06/17/05	0125	26.9695	-95.3997	XBT#46
20.1	06/19/05	1356	27.0067	-95.5427	n/a
20.2	06/19/05	1525	27.1740	-95.6785	XBT#52
20.3	06/19/05	1851	26.8023	-95.5905	n/a
20.4	06/19/05	2050	26.7563	-95.7092	XBT#53
20.5	06/19/05	0120	26.7367	-95.7052	n/a
21.1	06/20/05	1300	26.9440	-95.5028	XBT#54

Table 3.2.8

Locations of Near-surface Chlorophyll Sampling
(continued)

Sample Name	Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	Station Number
21.2	06/20/05	1907	26.9107	-95.4547	n/a
21.3	06/20/05	0057	26.9227	-95.4388	n/a
21.4	06/20/05	0405	26.7885	-95.6417	n/a
22.1	06/21/05	1336	26.3095	-96.0703	XBT#57
22.2	06/21/05	1800	26.1428	-95.9837	XBT#58
22.3	06/21/05	1905	26.1448	-95.8845	n/a
22.4	06/21/05	2100	26.1537	-95.7238	XBT#59
22.5	06/21/05	0025	26.1903	-95.4953	n/a
22.6	06/21/05	0227	26.1007	-95.3892	XBT#60
23.1	06/22/05	1342	26.1915	-94.5453	XBT#62
23.2	06/22/05	1730	26.1408	-94.1908	XBT#63
23.3	06/22/05	1945	26.0993	-94.0452	n/a
23.4	06/22/05	2220	26.2405	-92.4375	XBT#64
23.5	06/22/05	0314	26.4572	-93.8170	XBT#65
24.1	06/23/05	1300	27.1928	-93.8928	n/a
24.2	06/23/05	1855	27.2680	-93.8243	n/a
24.3	06/23/05	2150	27.1703	-93.6283	XBT#69
24.4	06/23/05	0045	27.1703	-93.6283	n/a
24.5	06/23/05	0235	27.1908	-93.6777	XBT#70
25.1	06/24/05	1315	27.1102	-93.2562	n/a
25.2	06/24/05	1915	27.5773	-93.0670	XBT# 72
25.3	06/24/05	0132	27.1213	-92.8062	n/a
25.4	06/24/05	0417	26.9443	-92.6738	XBT#73
26.1	06/25/05	1310	27.3010	-93.4150	n/a
26.2	06/25/05	1855	27.4733	-93.8928	XBT#76
26.3	06/25/05	0104	27.2955	-93.7834	n/a
26.4	06/25/05	0435	27.4052	-93.9550	n/a
27.1	06/26/05	1335	27.4371	-94.5960	n/a
27.2	06/26/05	1826	27.4067	-94.5592	n/a
27.3	06/26/05	0152	27.5660	-94.3807	n/a
28.1	06/28/05	1430	27.1467	-94.9050	n/a
28.2	06/28/05	1930	27.0658	-95.1012	n/a
28.3	06/28/05	0113	26.9840	-95.2097	XBT#79
28.4	06/28/05	0406	26.9777	-95.4533	XBT#80
29.1	06/28/05	1325	26.8900	-95.9582	n/a

Table 3.2.9

Start-stop Times for 38-kHz ADCP Data Logging

Start Date (m/d/y)	**Start Time (UTC)**	**Stop Date (m/d/y)**	**Stop Time (UTC)**
06/03/2005	0330	06/03/2005	2359
06/04/2005	1602	06/05/2005	0328
06/06/2005	1345	06/07/2005	2302
06/08/2005	1310	06/09/2005	0216
06/09/2005	1326	06/10/2005	0116
06/10/2005	0833	06/12/2005	0053
06/12/2005	0126	06/12/2005	1701
06/13/2005	0315	06/13/2005	1235
06/14/2005	0152	06/15/2005	1606
06/15/2005	2257	06/16/2005	0831
06/16/2005	0850	06/16/2005	1834
06/16/2005	1946	06/17/2005	2254
06/18/2005	0101	06/18/2005	2019
06/19/2005	0016	06/19/2005	1349
06/20/2005	0205	06/21/2005	1605
06/22/2005	0050	06/22/2005	2115
06/23/2005	0026	06/25/2005	0317
06/25/2005	0320	06/27/2005	1509
06/28/2005	0048	06/28/2005	1759
06/29/2005	0113	06/30/2005	1403

Table 3.2.10

CTD and XBT Stations on the 2005 S-tag Cruise
(Of 84 XBTs, 2 collected no data.)

Event	Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	15°C Isotherm Depth (m)	Chl Sample Taken?	Surf. Temp. (°C)	Surf. Salinity	Approx. Water Depth (m)
CTD1	06/03/2005	2214	27.2602	-94.8628	229	Y	26.972	33.990	~1250
XBT1	06/04/2005	0638	27.0072	-95.0895	*	N	27.280	36.480	na
XBT2	06/04/2005	1030	27.1569	-95.1764	*	N	26.960	36.030	na
XBT3	06/04/2005	1813	27.5110	-95.2445	263	Y	27.018	35.434	955
XBT4	06/04/2005	2354	27.2160	-95.4866	213	Y	27.114	34.449	1223
XBT5	06/05/2005	1513	27.0821	-95.3361	193	Y	26.708	34.149	1260
XBT6	06/06/2005	0752	27.1150	-95.5761	177	Y	27.120	34.040	1260
XBT7	06/06/2005	2022	27.0733	-95.8008	190	N	27.501	34.206	870
XBT8	06/07/2005	0253	26.8380	-95.9126	177	Y	27.508	34.067	955
CTD2	06/07/2005	0525	27.7442	-95.7905	163	N	27.404	34.233	~1250
XBT9	06/07/2005	1747	26.7895	-95.6035	161	Y	27.418	34.098	na
XBT10	06/08/2005	1710	27.3475	-95.6348	213	Y	27.649	34.695	1013
XBT11	06/09/2005	1431	27.0324	-95.0954	210	Y	28.000	36.491	1412
XBT12	06/10/2005	2145	26.7597	-94.9900	222	Y	28.516	36.448	1595
XBT13	06/11/2005	0038	26.5284	-95.0281	239	Y	28.359	36.473	~1750
XBT14	06/11/2005	0418	26.4289	-95.3586	223	Y	28.193	36.446	1644
XBT15	06/11/2005	1430	26.4816	-95.7474	220	Y	27.064	35.450	1365
XBT16	06/12/2005	0322	26.6583	-95.6446	189	N	28.332	33.847	1414
XBT17	06/12/2005	0549	26.8614	-95.7333	156	N	28.018	34.190	1110
XBT18	06/12/2005	0820	27.0678	-95.8136	171	Y	27.843	34.108	911
CTD3	06/13/2005	0242	27.0099	-95.6263	150	Y	27.951	34.253	na
XBT19	06/15/2005	0133	27.2156	-95.5241	169	Y	28.565	34.252	1204
XBT20	06/15/2005	0434	27.0084	-95.3705	170	Y	28.534	34.183	1186
XBT21	06/15/2005	0533	26.9385	-95.3170	164	N	28.583	34.032	1517
XBT22	06/15/2005	1346	26.9688	-95.0821	197	Y	27.784	34.453	1461
XBT23	06/15/2005	2106	26.8527	-95.2189	196	Y	28.636	34.217	na
XBT24	06/16/2005	0250	27.1711	-94.9809	217	Y	28.841	34.244	na
XBT25	06/16/2005	0526	27.3759	-94.8723	245	Y	28.819	36.396	1122
XBT26	06/16/2005	0920	27.2555	-94.7334	250	Y	28.560	35.490	1165
XBT27	06/16/2005	1114	27.1047	-94.6615	247	N	28.765	35.557	1091
XBT28	06/16/2005	1309	26.9512	-94.5878	254	N	28.596	35.091	1206
XBT29	06/16/2005	1504	26.8177	-94.5232	261	Y	28.690	35.056	1211
XBT30	06/16/2005	1921	27.0294	-94.4302	247	Y	28.886	34.428	~1700
XBT31	06/16/2005	2327	27.2526	-94.2774	226	Y	29.276	34.462	1108
XBT32	06/17/2005	0743	26.8649	-94.7358	237	Y	29.046	36.531	1555
XBT33	06/17/2005	1024	26.7646	-94.9787	235	N	28.743	36.514	1389
XBT34	06/17/2005	1221	26.7183	-95.1647	244	N	28.814	36.511	1607
XBT35	06/17/2005	1428	26.6695	-95.3618	227	Y	28.757	36.521	1502
XBT36	06/17/2005	1631	26.6311	-95.5354	222	N	28.135	34.395	1497
XBT37	06/17/2005	1839	26.5897	-95.7049	204	Y	28.458	35.076	1369
XBT38	06/17/2005	2309	26.5165	-95.8154	200	Y	28.471	35.499	1280
XBT39	06/18/2005	0412	26.4871	-96.0435	210	N	28.493	35.413	1012
XBT40	06/18/2005	0602	26.6401	-96.0351	209	N	28.520	35.588	986
XBT41	06/18/2005	0752	26.8067	-96.0173	207	N	28.493	34.571	917
XBT42	06/18/2005	1002	26.8076	-95.8132	198	N	28.583	34.748	1248
XBT43	06/18/2005	1146	26.7888	-95.6530	203	N	28.574	34.529	1268

Table 3.2.10

CTD and XBT Stations on the 2005 S-tag Cruise
(continued)

Event	Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	15°C Isotherm Depth (m)	Chl Sample Taken?	Surf. Temp. (°C)	Surf. Salinity	Approx. Water Depth (m)
XBT44	06/18/2005	1339	26.7717	-95.4644	204	Y	28.748	35.409	1499
XBT45	06/18/2005	1749	26.9391	-95.3160	195	Y	28.832	35.465	1523
XBT46	06/19/2005	0108	26.9763	-95.3859	185	Y	29.165	34.227	1253
XBT47	06/19/2005	0425	27.1527	-95.7178	184	N	28.934	34.684	1020
XBT48	06/19/2005	0549	27.2573	-95.9085	193	N	28.837	34.433	575
XBT49	06/20/2005	0721	27.1859	-95.9950	202	N	29.139	34.703	564
XBT50	06/20/2005	0954	27.0849	-95.8097	183	N	29.028	34.867	892
XBT51	06/20/2005	1158	27.0331	-95.6284	182	N	28.832	34.367	1031
XBT52	06/20/2005	1523	26.9390	-95.3205	195	Y	28.681	36.124	1503
XBT53	06/20/2005	2051	26.7564	-95.7093	173	Y	29.063	35.928	1155
XBT54	06/21/2005	1300	26.9441	-95.5029	193	Y	28.516	36.284	1434
XBT55	06/22/2005	0738	26.6448	-95.8644	220	N	28.399	35.551	1315
XBT56	06/22/2005	1116	26.4962	-96.0456	216	N	28.601	36.546	1005
XBT57	06/22/2005	1336	26.3096	-96.0704	217	Y	28.868	34.524	866
XBT58	06/22/2005	1650	26.1359	-96.0965	240	N	28.970	36.572	847
XBT59	06/22/2005	2100	26.1538	-95.7240	256	Y	29.267	36.525	1240
XBT60	06/23/2005	0227	26.1878	-95.3564	261	Y	29.014	36.488	1677
XBT61	06/23/2005	1011	26.2233	-94.8601	265	N	28.783	35.773	1873
XBT62	06/23/2005	1343	26.1915	-94.5453	274	Y	29.001	34.945	deep
XBT63	06/23/2005	1731	26.1462	-94.2065	279	Y	29.241	35.365	deep
XBT64	06/23/2005	2221	26.1079	-93.8567	236	Y	29.147	35.848	deep
XBT65	06/24/2005	0312	26.4426	-93.8163	209	Y	28.903	34.507	1642
XBT66	06/24/2005	0704	26.7701	-93.8396	**	N	28.739	34.318	1500
XBT67	06/24/2005	0714	26.7794	-93.8399	211	N	28.765	34.290	1732
XBT68	06/24/2005	1106	27.1050	-93.8640	210	N	28.797	36.104	1022
XBT69	06/24/2005	2148	27.3321	-93.7612	209	Y	28.894	36.107	804
XBT70	06/25/2005	0312	26.4426	-93.8163	214	Y	28.828	35.961	808
XBT71	06/25/2005	0957	26.8791	-93.4471	176	N	28.850	35.825	1256
XBT72	06/25/2005	1913	27.5753	-93.0778	208	Y	28.961	36.270	511
XBT73	06/26/2005	0417	26.9513	-92.6792	233	Y	28.765	36.282	1420
XBT74	06/26/2005	0818	27.0919	-93.0136	219	N	28.757	36.278	1264
XBT75	06/26/2005	1224	27.2669	-93.3508	211	N	28.850	36.029	1193
XBT76	06/26/2005	1856	27.4858	-93.8840	215	Y	28.899	36.138	837
XBT77	06/27/2005	0827	27.5401	-94.2859	215	N	28.502	36.200	825
XBT78	06/28/2005	0704	27.3732	-94.8616	185	N	28.636	35.756	1049
XBT79	06/29/2005	0118	26.9843	-95.2095	200	Y	29.179	35.360	1430
XBT80	06/29/2005	0406	26.9760	-95.4480	191	Y	29.094	34.635	1190
XBT81	06/29/2005	0810	27.0857	-95.8121	197	N	28.921	35.390	874
XBT82	06/29/2005	1552	26.8323	-95.9852	215	N	28.828	34.938	968
CTD4	06/29/2005	2208	26.8225	-95.9052	208	N	29.147	34.771	~950

na = not available
* set to record to 200 m so no data at 15°C depth
**wire hit ship at 200 m; re-shoot as XBT67

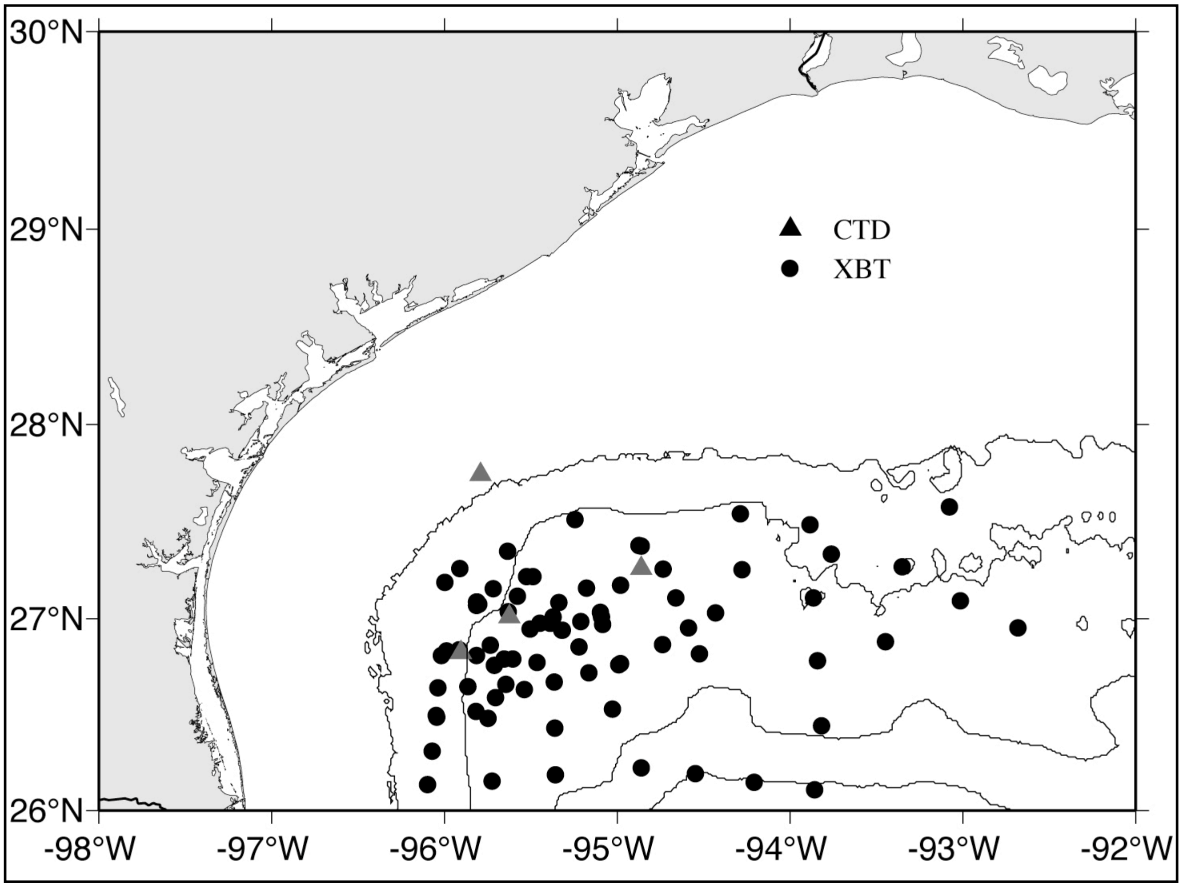

Figure 3.2.8. Locations of CTD and XBT stations on the 2005 S-tag cruise.

Table 3.2.11

Operation Times for the Fishery Echosounders

Start Date (d/m/y)	Start Time (UTC)	End Date (d/m/y)	End Time (UTC)	38-kHz On/Off	Elapsed Time 70-kHz (hours)	Elapsed Time 38-kHz (hours)
03/06/05	1242	03/06/05	2142	0	9.00	
03/06/05	2149	03/06/05	2155	0	0.10	
03/06/05	2157	03/06/05	2203	0	0.10	
03/06/05	2226	03/06/05	2246	0	0.33	
03/06/05	2307	04/06/05	0001	0	0.90	
04/06/05	0005	04/06/05	1604	1	15.98	15.98
04/06/05	1605	04/06/05	1742	0	1.62	
04/06/05	1747	05/06/05	0334	0	9.78	
05/06/05	0417	05/06/05	1524	1	11.12	11.12
05/06/05	1536	06/06/05	1315	1	21.65	21.65
06/06/05	1315	07/06/05	2317	0	34.03	
07/06/05	2317	08/06/05	1238	1	13.35	13.35
08/06/05	1238	09/06/05	0230	0	13.87	
09/06/05	0230	09/06/05	1318	1	10.80	10.80
09/06/05	1318	10/06/05	0127	0	12.15	
10/06/05	0129	10/06/05	1330	1	12.02	12.02
10/06/05	1330	12/06/05	0102	0	35.53	
12/06/05	0102	12/06/05	0122	1	0.33	0.33
12/06/05	0122	12/06/05	1914	0	17.87	
12/06/05	1914	13/06/05	0125	1	6.18	6.18
13/06/05	0125	13/06/05	0607	0	4.70	
14/06/05	1229	15/06/05	1616	0	27.78	
15/06/05	1616	15/06/05	2254	1	6.63	6.63
15/06/05	2254	16/06/05	1837	0	19.72	
16/06/05	1837	16/06/05	1944	1	1.12	1.12
16/06/05	1944	17/06/05	2257	0	27.22	
17/06/05	2257	18/06/05	0103	1	2.10	2.10
18/06/05	0104	18/06/05	2025	0	19.35	
18/06/05	2026	19/06/05	0013	1	3.78	3.78
19/06/05	0014	19/06/05	0454	0	4.67	
19/06/05	2235	21/06/05	1615	0	41.67	
21/06/05	1616	22/06/05	0051	1	8.58	8.58
22/06/05	0051	22/06/05	2150	0	20.98	
22/06/05	2151	23/06/05	0028	1	2.62	2.62
23/06/05	0029	27/06/05	1513	0	110.73	
27/06/05	1514	28/06/05	0043	1	9.48	9.48
28/06/05	0044	28/06/05	1806	0	17.37	
28/06/05	1807	29/06/05	0108	1	7.02	7.02
29/06/05	0109	29/06/05	2240	0	21.52	
Total					562.23	132.77

4 DATA COLLECTION ON MESOSCALE POPULATION STUDY CRUISES

Mesoscale Population Study (MPS) cruises were conducted in summers 2004 and 2005 aboard the quiet, 46' Hunter-class, motor-sailor, *Summer Breeze*, which was chartered from a Florida-based charter company. In both years, these summer cruises were conducted in 4 legs with durations of approximately 2 weeks each. This section summarizes the data collection activities for the MPS cruises conducted in summer 2004 (Section 4.1) and summer 2005 (Section 4.2).

4.1 Mesoscale Population Study Cruise of 2004

Introduction

The 2004 SWSS Mesoscale/PhotoID cruise surveyed for sperm whales in the northern Gulf of Mexico between 90.5°W and 84.5°W. This cruise started two days after the 2004 S-tag cruise (Section 3.1) had finished. This provided an extended temporal coverage of SWSS cruises during summer 2004, so that, overall, sperm whales were studied from 25 May to 11 August 2004. Table 4.1.1 illustrates the international make-up of the MPS science team.

The primary goal was to expand baseline information on population size, habitat use, social organization, movements and behavior of sperm whales and to help determine natural variability and potential responses to anthropogenic activities. Other integral tasks of the cruise were to determine distribution and movements of sperm whales in relation to natural changes in environmental conditions, investigate population structure and calving rate, and investigate residency of known individuals in the northern Gulf of Mexico. If and when opportunities presented themselves we planned to study behavioral reactions to acoustic emissions from platforms and seismic ships and to make opportunistic calibrated recordings of rig noise. These goals were achieved mainly by photo-identification and length measurements of individuals made during follows of groups extending over 10 to 60 hours, recordings of vocalizations and anthropogenic sounds, and collection biopsy samples. The primary study area was between 500 and 1500 m depth contours in the region of high oil/gas platform density and anthropogenic activity off the Mississippi River Delta and in the Mississippi Canyon.

Table 4.1.1

Science Team for the 2004 MPS Cruise

Participant	Nationality
Jonathan Gordon, Field Party Chief	United Kingdom
Nathalie Jaquet, Field Party Chief	Switzerland
Ricardo Antunes	Portugal
Steve Brown, Captain	USA
Raul Diaz Gamboa, Biopsy	Mexico
Thomas Gordon	United Kingdom
Chistoph Richter	Germany
Trudi Webster	New Zealand

The MPS cruise left St. Petersburg, FL, at 1500 EDT on 20 June 2004 and returned to St. Petersburg at 2100 EDT on 11 August 2004. The cruise closely followed the cruise plan, with three scheduled stops in Gulfport, MS, at the end of June, mid-July and late July (Table 4.1.2). We also made a 24-h stop in Pensacola, FL, on 8 August during inclement weather. Most of our visual and acoustic search effort occurred in water depths between 500 and 1500 m. While transiting to deeper water to-from port, we searched water depths ranging from 200 to 2100 m. Figure 4.1.1 shows the tracks of the research vessel during the four legs.

During Leg 1 (Figure 4.1.1a), we carried out a two and a half-day survey of the deep waters off Florida's northwest coast while transiting to the study area, surveyed through the DeSoto Canyon region, and spent the last three days of the leg in the Mississippi Canyon. During Leg 2 (Figure 4.1.1b), we concentrated our efforts in the area south of the Mississippi River Delta (MRD) and the Mississippi Canyon area. We also surveyed the most western part or our study, to as far west as 90.5°W. During Leg 3 (Figure 4.1.1c), we again concentrated our efforts in the MRD and Mississippi Canyon areas. We also spent 3 days surveying waters deeper than 1500 m, south of the MRD and Mississippi Canyon, when near real-time remote sensing information indicated that a Loop Current Eddy to the south of this part of the continental margin was entraining strong off-the-shelf flow into the deepwater area. During Leg 4 (Figure 4.1.1d), we spent two days in the Mississippi River Delta area, and then headed east, surveying towards DeSoto Canyon. After the port call in Pensacola, we headed south, again surveying the head of the DeSoto Canyon and the waters south of it as we made our way back toward St. Petersburg. Weather forecasts predicting the imminent arrival of Tropical Storm Bonnie and Hurricane Charley, forced us to curtail Leg 4 by one day. We headed directly for Tampa Bay arriving at 2100 CDT on 11 August. Although our course was a straight line, we surveyed acoustically until we arrived in waters shallower than 100 m.

When seaward of the continental shelf break, we routinely listened with the Ecologic towed stereo-hydrophone array for one minute every 15 minutes, noting sperm whale clicks, other cetacean vocalizations, and man-made noises; monitored sea-surface temperature (SST) continuously; and recorded environmental data every hour. Several times during each leg, we monitored basic oceanographic conditions to ~50 m below the surface with a vertically profiling conductivity-temperature-depth instrument (CTD).

Table 4.1.2

Summary of Dates and Port Calls for Each 2004 MPS Cruise Leg

Leg	Start date	Start Port	End date	End Port	Field Party Chief
1	20 June 2004	St. Petersburg	30 June 2004	Gulfport	Jonathan Gordon
2	2 July 2004	Gulfport	14 July 2004	Gulfport	Nathalie Jaquet
3	17 July 2004	Gulfport	29 July 2004	Gulfport	Nathalie Jaquet
4	1 August 2004	Gulfport	11 August 2004	St. Petersburg	Jonathan Gordon

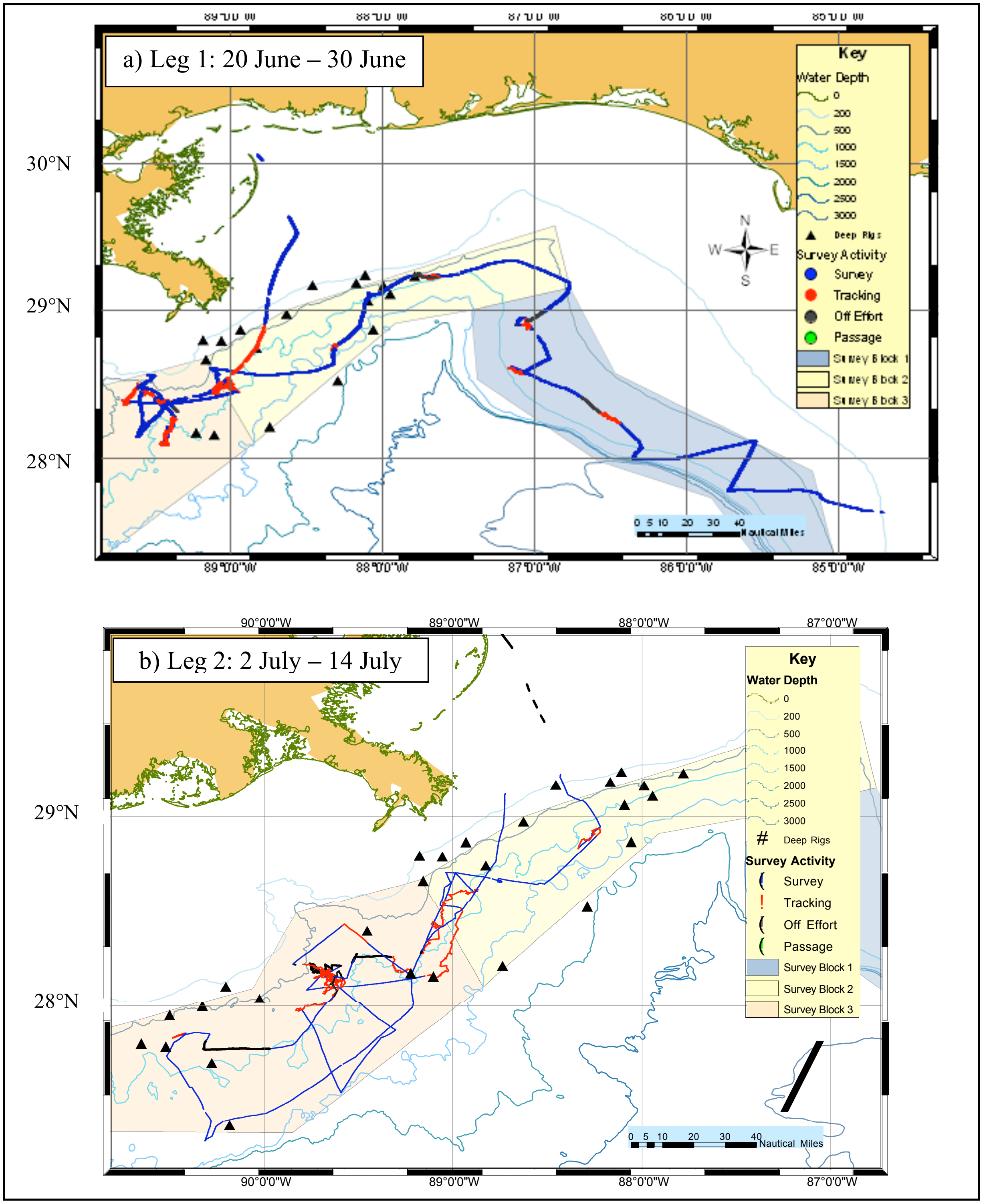

Figure 4.1.1. Cruise tracks for Legs 1-4 of the 2004 MPS cruise. Vessel track is colored by survey activity: blue during survey mode, red while tracking groups, black off effort and green when making passage.

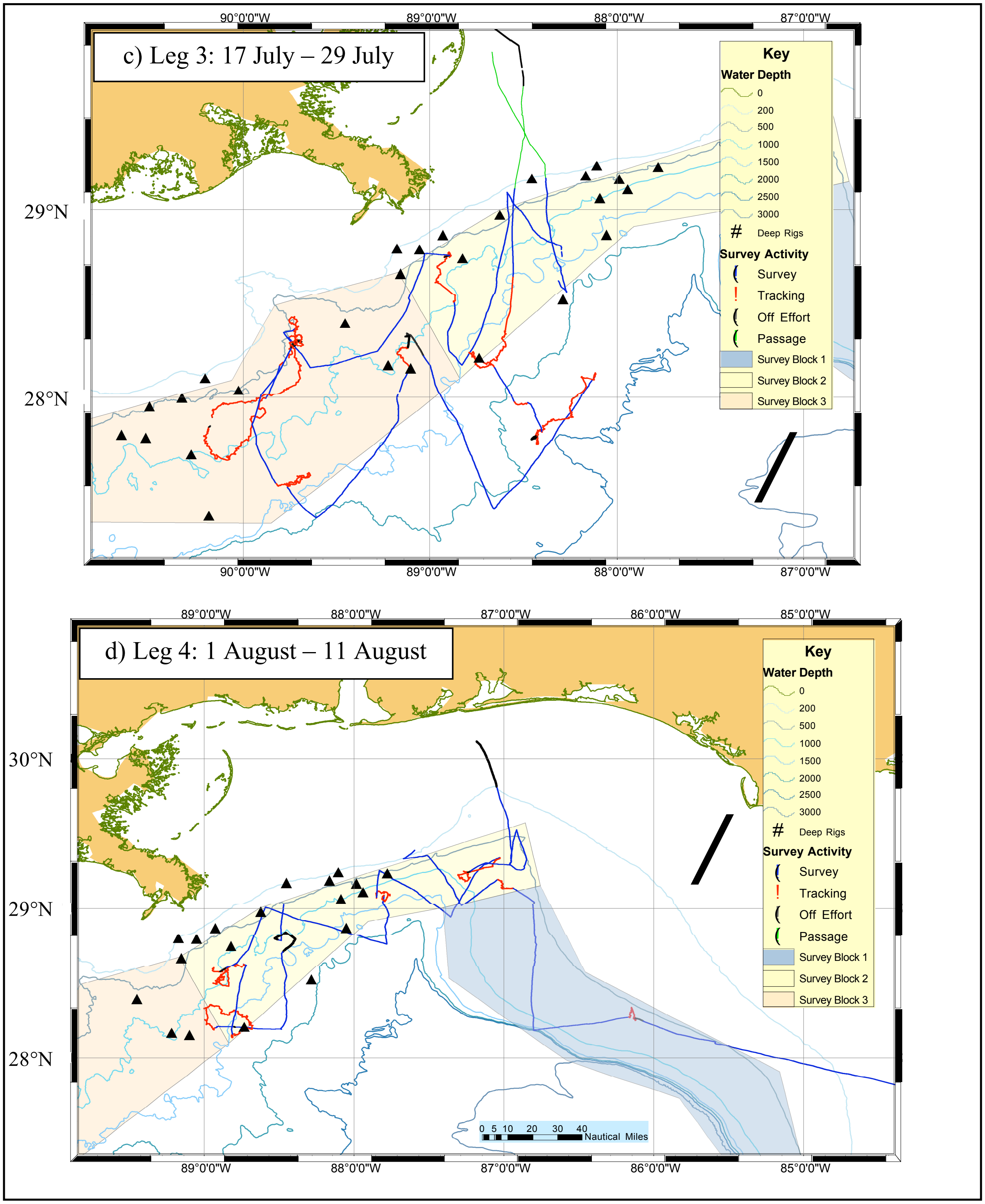

Figure 4.1.1. Cruise tracks for Legs 1-4 of the 2004 MPS cruise. (continued)

Permits

Photo-ID/Photogrammetry and Biopsy/Genetic Typing activities were conducted in accordance with federal permits from NMFS to Texas A&M University-Galveston (permit 821-1588-00), and to Dan Engelhaupt/University of Durham (permit 909-1465-02).

Research Vessel and Equipment

Vessel: Our previous experience, and that of other groups working on sperm whales in various locations around the world, has made us aware of the advantages of using modest sized motor sailing vessels for conducting certain types of research on individual marine mammals in offshore waters. These include the fact that they are quiet, easy to run by small teams, safe, maneuverable, independent and extremely cost effective. This can allow small teams to complete extended field seasons with time factored in for poor weather. As with any research vessel, there are very substantial advantages to having a platform that is dedicated and specially adapted to its task; however, for this first year, no such vessel was available and we had to charter a standard vessel and adapt it as well as we could. A suitable vessel, *Summer Breeze*, was available to charter from St. Petersburg Florida. *Summer Breeze* is a 46' Hunter sloop with a 76-HP engine and 7 berths.

Our first task was to adapt the vessel to our requirements and the first week of the charter was devoted to this while the last two days were dedicated to restoring it to its original state. The main tasks were to provide extra storage for food and equipment by adapting the heads, to provide an acoustic workstation in the saloon and fit hydrophones and acoustic equipment, to provide a mount for a directional hydrophone off the quarter, to fit a Global Star satellite telephone system, a navigation and communication computer and additional GPS receivers. To provide additional fuel capacity, 32 five-gallon jerry cans were stowed on deck. Lee cloths, new berths and extra fans were also provided.

The provision of clean electrical power and the elimination of electrical noise is often a problem on a small vessel. A pure sine wave inverter (Prosine 1800) was installed running directly off the vessel's house batteries. This provided clean AC power for laptop computers and for the acoustic work station. DC power was provided for preamplifiers and panel meters using a DC power supply. As the engine was run for much of the time its alternator charged the house batteries. Additional earthing and a suppressor served to eliminate electrical noise from the alternator.

Acoustic equipment: *Summer Breeze* carried essentially the same basic passive acoustic monitoring equipment as the R/V *Gyre*. The challenge was to house all this in a compact enclosure that could be closed up to protect the equipment if the vessel got into rough weather and to power it from the available power supply. Two stereo "Ecologic" towed hydrophones one with 100 and the other 200m of cable were carried and towed off each quarter. Having two matched hydrophones provided a spare in the event of loss or damage and also allowed them to be towed as "tandem" arrays to allow more accurate acoustic tracking using programs such as Rainbow Click and Ishmael. Rainbow Click is a computer program written by Douglas Gillespie with support from the International Fund for Animal Welfare to promote benign and non-invasive research. Ishmael is a multi-purpose bio-acoustic analysis tool written by David Mellinger. Each array contained a depth sensor. An acoustic work station was established on the saloon table. This consisted of two Magrec HP27ST preamplifiers rack mounted in a waterproof SKB instrument case, USB sound card (Creative Platinum), two panel meters to measure depth, a calibration tone generator and an audio switch to determine which hydrophone was being monitored, were fitted in the same case. As only one computer was available for acoustic analysis, an audio switch was used to switch between different elements to resolve left/right ambiguity when the hydrophones were deployed as tandem arrays. A feed from the main system was also available to the helm allowing the steering person to monitor the hydrophones on deck using headphones. In addition, the output from the hydrophones could be fed into the vessel's HiFi system providing general monitoring of underwater acoustic activity.

Two hand held directional hydrophones (originally made for use from rigid-hulled inflatable boats (RHIBs) on the Gyre) were available. In addition a more elaborate directional hydrophone within a streamlined pod was built following designs of directional hydrophones used from motor sailors by Hal Whitehead and colleagues. The advantage of this design is that it can stay mounted to the vessel. A mount for this was built from the main-sheet arch of "*Summer Breeze"*.

Operational Equipment: *Summer Breeze* has a "sugar scoop" stern with a swim platform and this provided very good access to the water and it proved straightforward to stop the boat and use a hand held directional hydrophone from this in calm conditions. The streamlined directional hydrophone was not used successfully. More time was needed to make an appropriate reflector to work within the streamlined housing as the hydrophone did not have any directional capability. It also proved impossible to make a sufficiently strong attachment as we were constrained to not make permanent alterations to the boat. For this project we were able to manage very well using just the hand held hydrophones but it would be sensible to continue to develop the fixed hydrophone to make tracking easier especially in poor weather conditions.

As we were able to track whales well using hand held directional hydrophones, and it was more straight forward keep all the tracking work on deck, tandem array techniques were little utilized. However, it will remain useful to be able to employ multiple hydrophone tracking methods on future projects, especially as software being developed by Aaron Thode, which should enhance these capabilities, becomes available.

Data Collection: Wherever possible data were collected directly to computers to minimize transcription errors and speed up later analysis. We relied on two programs for this. The Logger program ran continuously on the computer at the acoustic station in the saloon. Logger is a computer program written by Douglas Gillespie with support from the International Fund for Animal Welfare to promote benign and non-invasive research. It collected the vessel's track from GPS, information on search status and effort, hourly environmental data, non-sperm whale sightings and acoustic data into a coordinated relational database. Initial sperm whale sightings and fluke up positions were entered into Logger to generated a map of whale and boat movements and headings. All recordings from the towed hydrophones were made using the tape recorder within Logger with a 96-kHz sampling rate and on some occasions its automatic recording and buffering capabilities were used. In addition, data on hydrophone depth and surface water temperature was stored within the Logger database using programs written for this project by Ricardo Antunes. The second program "Encounter" ran on an HP 200 LX palmtop computer which was located on deck at the steering column. This was used to collect detailed data on sperm whale encounters including cluster sizes, headings, individual attributes, behavior and photographs taken. One of our first analysis tasks will be to integrate these two datasets within a single relational database.

Mast Climbing: Vessels of this type used for cetacean research usually have mast steps and access to a crow's nest on the mast. This provides an elevated vantage point both for improved visual searching and to allow images to be taken for length estimation. It was not possible to fit mast steps or a crows nest to this vessel. We hoped to be able to access the vessel's lower spreaders using a rock climbing harness and equipment, and a climbing rope was rigged on the mast. We attempted to use this on two occasions at sea but with a swaying boat it proved too risky to both equipment and personnel.

Survey Tracks and Monitoring

Even on large vessels, such as the Gyre, which are relatively noisy but provide good stable high sightings platforms and accommodate large visual teams, acoustic monitoring has proven to be the most effective method of finding sperm whales. On a small quiet vessel which is a poor sightings platform it becomes completely dominant. While searching for whales the hydrophones were monitored for 1 minute every 15 minutes while a standard 1-minute recording was made. If the vessel was under power the engine was eased back so that it was just ticking over, which greatly reduced noise. A significant source of electrical noise was the autopilot and during monitoring sessions the vessel was steered by hand. On some occasions, a single person would keep watch at night to allow the rest of the team to get a longer rest. In these cases Logger was set up to record automatically every 15 minutes and hydrophones were monitored by the helmsman at the wheel using headphones with data being entered into Logger as soon as the vessel was underway again.

We wished to achieve a representative coverage within the survey blocks designated beforehand with higher coverage within the blocks which were of greater interest because of their whale and oil platform densities. Our survey area was determined by the 500 and 1,500m depth contours. One practical way to achieve this is by laying down zigzag tracks with the turning angle between tracks being determined by the level of coverage required. While we planned to follow this approach it provide impractical for a number of reasons. On the first leg, the amount of fuel we carried constrained the extent to which we could use the engine. We didn't want to loose valuable field time by making a fuel run so we shaped our course to make best use of the available wind. The addition of extra jerry-jugs during the first port call in Gulfport took care of this problem. However, it was also impossible to predict in advance the amount of time we had available for survey as once whales were detected survey would cease and we would start tracking groups, often for 24 hours or more. Furthermore, to achieve even coverage of the study area, we would then lay down survey tracks in areas that had not been previously surveyed using the Show data module in Logger. On some occasions we would divert a track slightly to close with oil platforms or drills ships so that we could make opportunistic recordings of them. What was essential was that we did not choose courses directed to areas of known or suspected whale abundance. This might occur if we tried to locate a tagged whale based on its latest locations, for example. Any such tracks (which we called hunches) were specifically noted as such in Logger. These compromises as far as following pre-determined tracks should not present special analysis problems for a photo-id study such as this one, as the tracks (Figure 4.1.1) indicate that the overall area was covered quite well.

Table 4.1.3 summarizes the effort in survey and tracking mode over the study season. It can be seen that almost as much time was spent tracking whales as was spent surveying for them.

Table 4.1.3

Summary of MPS Research Effort During 2004

Description	Hours of Effort	Nautical Miles Covered
Survey	437	2,194
Directed "Hunch" Survey	26	112
Tracking Photo-ID	350	1,029
Regular Acoustic Monitoring (1877 Stations)	600	2,645

Acoustic Monitoring: Overall, some 1876 standard monitoring stations were completed with 1511 being performed while the vessel was on survey mode, and sperm whales were detected on 174 (11%) of these. As the vessel would enter tracking mode as soon as the whales were detected this number under-represents the proportion of random stations at which a whale would be detectable. A better way to analyze these data will be to consider discovery times (=survey time between different encounters with sperm whales) in different areas.

Dolphins were detected at 200 out of 1511 (13%) stations on survey mode. As survey activity was not affected by dolphin detections this percentage probably does closely reflect the general probability of hearing dolphins in these waters.

Seismic surveys were heard on only 79 (5%) of all monitoring sessions and these were all in the westerly portions of the study area. This is lower than detection rates in previous seasons, for example seismic was heard at 30% of all stations in 2003. This probably accurately reflects the fact that fewer seismic surveys were being conducted in our study area than in previous seasons and we only saw one seismic vessel during our cruises. Of course this also restricted the extent to which we were able to make opportunistic observations of sperm whale responses and movements in the presence of seismic vessels.

Sightings of Other Species of Cetaceans

A modest motor sailing vessel is not an ideal sightings platform, and our team was a small one with many other priorities. In addition, we were well aware that other teams operating from much better visual platforms are continuing visual survey programs in this area. For these reasons we decided not to put a large effort into visual survey during daylight hours. Consequently, few sightings of cetaceans other than sperm whales were made (Table 4.1.4).

Photo-identification, Photogrammetry and Behavioral Observations

The use of the motor-sailing vessel R/V *Summer Breeze* proved to be efficient for photo-identification, photogrammetry and behavioral observations. As the vessel was relatively quiet, it was easy to detect whales acoustically; and because we were able to use a directional hydrophone from the stern of the vessel, we had no problems in tracking whales at night. As there was no need to launch an independent small boat, we were usually able to start working with a group at first light, indeed many of our identification photographs were taken before 8 am. We could thus take full advantage of the light, and were able to work visually with the whales for approximately 13 hours per day, weather permitting.

Table 4.1.4

Sightings of Species Other Than Sperm Whales in Waters Greater Than 500-m Depth

Species	Number of Sightings	Group Size	Date (m/d/y)	Latitude (°N)	Longitude (°W)
Bottlenose Dolphin (*Tursiops truncatus*)	1	5	07/29/2004	29.5144	-88.5074
Pygmy or dwarf sperm whales (*Kogia sp*)	1	2	07/20/2004	28.1628	-89.5934
Melon-headed whale (*Peponocephala electra*)	1	30	07/08/2004	28.1200	-89.5712
Pantropical Spotted Dolphin (*Stenella attenuata*)	7	35 mean			
Sighting 1		12	06/23/2004	28.8918	-87.1082
Sighting 2		50	06/24/2004	29.3155	-87.2537
Sighting 3		3	07/08/2004	28.1523	-89.6173
Sighting 4		100	07/09/2004	27.5003	-90.3396
Sighting 5		20	07/26/2004	28.1282	-88.1162
Sighting 6		15	08/10/2004	28.2786	-86.1327
Sighting 7		45	08/10/2004	28.2540	-86.1215
Short-finned Pilot Whale (*Globicephala macrorhynchus*)	2	10 mean			
Sighting 1		15	07/05/2004	28.1798	-89.6682
Sighting 2		5	07/08/2004	28.1678	-89.6860
Rough Toothed Dolphin (*Steno bredanensis*)	1	12	06/22/2004	27.9874	-86.2284
Clymene Dolphin (*Stenella clymene*)	1	8	06/24/2004	29.2153	-87.6458
Cuvier's Beaked Whale (*Ziphius cavirostris*)	1	1	07/27/2004	27.8247	-88.3872
Unidentified dolphin	3	27 mean			
Sighting 1		50	06/24/2004	29.3317	-87.1528
Sighting 2		20	06/24/2004	29.2136	-87.6441
Sighting 3		10	06/29/2004	28.4657	-89.0692

When whales were seen, they were approached slowly from behind their orientation, to within a distance of 50 to 70 m. At the beginning of a deep dive, sperm whales usually lift their tail flukes above the surface, allowing for an identification photograph to be taken with a Canon EOS D1 digital camera and 100-300 mm Sigma lens (f4). For the purpose of photogrammetry (size measurement), ranges to whales were measured with a Bushnell 1000 Yard Pro laser range finder. Once the whale fluked-up, the vessel was quickly positioned in the slick ("foot-print" left by the whale at the location it dove) to check for possible defecation. The engine was then switched off and we recorded the time of the whale's first click as well as the first several minutes of its vocalization. The exact time the individual was first seen (± 5 sec); time the whale fluked-up (±5 sec); size of the whale cluster; presence/absence and behavior of calves; behavior of the individual, its heading, whether it had a callus or not; and whether there was defecation in the slick were all recorded onto an HP 200 XL palmtop computer in a water-proof housing, linked to a Garmin 12LX GPS.

Photo-Identification: During the 4 legs, we spent 37 days in waters deeper than 200 m (i.e., excluding the days transiting to and from port in shallow waters). Of these 37 days at sea, 32 days were spent in visual contact with sperm whales, and during one day (July 18) we had numerous acoustic contacts but could not track the whales due to strong winds (>30 knots) and heavy rain. Therefore, during the entire cruise, only four days (two on Leg 1, one on Leg 2 and one on Leg 4) were spent without visual or acoustic contact with whales.

As in previous years, we found a strong segregation between groups of bachelor males and groups of female/immature whales. Most of the bachelor groups were found in the DeSoto Canyon area, while all of the groups of female/immature were found between approximately 90°W and 88°W. We did not find large aggregations of whales (15-25 individuals), as we had in the Mississippi River Delta area on June 17 and 18, 2003. All groups of female/immature sperm whales that we encountered consisted of approximately 8 to 12 individuals.

Fifteen groups of female/immature whales were followed during this cruise; seven groups for 10 to 24 hours; seven for 24 to 48 hours; and one for about 60 hours. On nine days, we encountered either lone whales or small groups of what appeared to be bachelor males. Two of the lone whales occurred in the Mississippi River Delta area and all the others in the DeSoto Canyon area and along the Florida coast. None of the lone whales appeared to be large enough to be breeding males; however, they appeared to be larger than females. Analyses of their click interpulse intervals as well as photogrammetry will give us more accurate estimates of their sizes. Over one-half of the groups of female/immature sperm whales had at least one calf with them, and on two occasions we saw very young calves that were still unable to swim effectively. One "older calf" conveniently stretched itself alongside the research vessel, and we were able to measure it relative to marked areas on deck. We were surprised to find that it was only about 3.3 meters in length, while the literature states that calves are born at about 4 meters.

A total of 302 identification photographs were taken during this cruise. Table 4.1.5 shows the number of identification photographs taken on each leg, as well as the cumulative number of different individuals identified each day. To date only the matching within each day has been performed, and thus the total of different individuals identified during each leg will be slightly less than the number provided in the last column of Table 4.1.5. As some groups were followed on more than one occasion, the total of different individuals identified during this 2004 mesoscale population study cruise is expected to be slightly less than 147. Matching of these 302 identification photographs will be carried out during the next several months, and exact numbers cannot yet be specified.

Only preliminary matching of sperm whale individuals within the SWSS collection has been performed at this time. Preliminary results indicate that one group of sperm whales was seen on two occasions, on July 28 and August 3, both times off the Mississippi River Delta. Otherwise, there presently appear to have been no re-sightings of groups between non-adjacent days. At least 11 individuals identified this year had been previously identified in 2002/2003. Five of these individuals were identified together in 2002, re-identified together in 2003 and once more re-identified together during this cruise. Therefore, these individuals seem to have stayed together, as would be expected for mixed group members.

Table 4.1.5

Number of Identification Photographs Taken During Each Leg and Cumulative Number of Different Individuals Identified Each Day
(Note the cumulative number is a simple summation over the leg dates of the different individuals identified for each day, with no correction for individuals that may have been identified on more than one day during the leg.)

Leg	Number of photo-ID sequences	Cumulative number of different individuals identified each day
1	36	24
2	92	48
3	135	58
4	39	17
Cruise Total	302	147

At the end of 2003, the "GulfCet-SWSS" sperm whale catalog for the Gulf of Mexico, which has images collected over nine years between 1994 and 2003 by GulfCet, SWAMP, and SWSS cruises, contained 123 individuals represented by good quality photo-identification photographs. This cruise on which photo-ID has been one of several research priorities has made a significant contribution to the catalog, as 302 identification photographs were taken, probably representing about 100 different individuals. Our previous estimates suggest that the population of the northern Gulf of Mexico is roughly 300 individuals, and thus we may now have identified well over one-half of the population. However, new population estimates and discovery curves will now be re-calculated, taking into account this wealth of new data. As the size and quality of the catalog increases, so does its utility as a tool for providing reliable answers to management questions on population size, movements and demographics.

Resightings of Satellite Tagged Whales: Nine of the groups encountered while working in the Mississippi Canyon area or Mississippi River Delta area contained one or two tagged whales. Preliminary analyses suggest that we saw 12 different tagged whales. For most of the tagged whales, we obtained good photographs of the tag as well as the attachment area, for the majority of them we also obtained good identification photographs. Unfortunately, it may not always be easy to link an identification photograph to a tag number as the colors of the tags were difficult to distinguish even when we approached the whales to within approximately 40 meters. We found it particularly difficult to distinguish between white and yellow, and blue and black tag bands. All tagged whales were found in waters <1000 meters in the Mississippi Canyon and Mississippi River Delta areas.

Length Measurements: To estimate sperm whale total length, roughly 200 identification photographs were taken in conjunction with a measurement of the distance to the fluke using a Bushnell Yardage 1000 laser range finder. This method allows for accurate calculation of fluke width. Using a polynomial regression derived from whaling data, total length will be calculated for all of these encounters.

Sperm whale size can also be estimated acoustically by measuring interpulse intervals within sperm whale clicks. Recordings for this must be made soon after a whale flukes so that clicks can be reliably linked to particular identified individuals. We had found making such recordings challenging working from RHIBs but on "Summer Breeze", with the towed hydrophones continuously deployed, useful recordings were made at the beginning of the dives of most identified individuals.

Behavioral Observations: Generally, sperm whale groups exhibit two broad types of behavior: 1) foraging behavior is characterized by individuals forming small clusters of one or two whales on average, deep-diving about every 50 minutes, and emitting usual clicks, 2) socializing behavior is characterized by individuals forming large clusters (>5 individuals on average), not fluking up, the emission of codas, and activities that can be seen at the surface such as breaches and head-outs. As groups were followed closely for 10 to 60 hours, we were able to record in detail the amount of time that each group spent in each behavior, as well as time of the day of the socializing period. Most of the groups that we encountered spent considerable time in socializing behavior (up to one-half of daylight hours). However, several groups on Leg 3 and the two groups that we encountered on Leg 4 did not socialize at all. Post-cruise data analyses will tell us whether aspects of oceanography or feeding success (as indicated by defecations) were different for these groups than for others.

During three days on Leg 2 (July 10, 12, and 13), individuals that appeared to be foraging (as indicated by being in small clusters and spread out over a couple of miles, as well as the production of usual clicks) did not fluke-up. They tended to remain at the surface for about ten minutes, then shallow dive for about 40 minutes before resurfacing again. About two minutes after they shallow-dived they would begin to emit usual clicks. We had never observed such behavior before, and wondered whether these whales were feeding on shallower prey during these days. On each of these days, the water was very green and very murky (especially on July 12-13), more so than what was observed at other times of the cruise.

Indicators of Feeding Success: The capability of being able to stand at the relatively stable bow of the vessel, about 2 meters higher than on a RHIB, allowed us to check slicks for defecation and thus to get an indication of feeding success. For this purpose, the vessel was quickly positioned in the slick of the whale after most fluke-ups. However, in very green/brown murky water, defecations could not be seen reliably, and data will not be used for feeding success analyses for such conditions. On rare occasions, squid beaks can be found in the defecation, and on July 4, three squid beaks were collected. Squid species can be identified from squid beaks, and thus this finding represents a first step in our understanding of sperm whale diet in the Gulf of Mexico. On one occasion we also collected an arm of a squid in the wake of a whale; this arm had probably been regurgitated by the whale.

Skin Samples: Despite being of low priority in the proposal, a total of six biopsy samples were taken during the cruise (Table 4.1.6), each with an associated identification photograph. Biopsy sampling occurred only during the last three legs as the only person allowed by permit to take biopsy samples (Raul Diaz-Gamboa) was not on board during Leg 1. A large number of biopsies have been taken over the last few years in the Mississippi River Delta and Canyon area and a few of these samples have an associated photo-identification. To avoid duplication of samples, we only took biopsies when we believed that the target individual had probably not been biopsied before, or when we saw a tagged whale for which there was no associated biopsy sample. As most of the effort during previous years has targeted groups of female/immature whales, few lone males are likely to have been biopsied and thus our effort was concentrated on probable males.

No special effort was deployed to collect sloughed skin. However, on five occasions, we easily collected large sloughed skin samples usually from identified whales. Furthermore, on August 9, when attempting to biopsy an identified lone male, the dart missed but collected a sample of sloughed skin. Sloughed skin can be used both for genetic and stable isotope analyses. Stable isotope techniques are useful for indicating the trophic levels of individuals, differences in diet between sexes and areas, etc., and thus could give us more information on sperm whale diet in the northern Gulf of Mexico.

Table 4.1.6

Biopsy Samples and Their Locations

Biopsy Sample Number	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Region*	Comments	Photo-ID Number
B1	03/07/2004	16:14:27	28.930150	88.223333	MRD	Lone whale, likely male	#736
B2	06/07/2004	14:25:07	28.095233	89.678100	MC	Individual who left the group for half of the day (male?)	#1242
B3	10/07/2004	16:51:44	28.205733	89.312333	MC	Yellow/red tag (1390); left side	PM04aGM 0028
B4	22/07/2004	15:20:28	27.738617	90.192433	MC	Part of group not seen before	#2538
B5	05/08/2004	19:18:48	29.099367	87.855633	DSC	Lone male	#5251
B6	06/08/2004	17:38:39	29.227033	87.242283	DSC	Lone male	#5424

*MRD = Mississippi River Delta region; MC = Mississippi Canyon region; DSC = DeSoto Canyon region

Small Scale Movements: From the present research platform, we found it straightforward to track groups of whales after dark and to stay within acoustic contact to them all night. Therefore, we obtained detailed small-scale movements of groups for up to 60 hours at a time. In total, eight groups were followed for two to three days each.

Coda Recordings

Codas are vocalizations consisting of sperm whale clicks repeated in stereotyped patterns. They are usually heard from groups of whales socializing at the surface. Recent work suggests that analysis of coda repertoires can reveal information on the cultural organization of sperm whale populations, indicating how individuals and groups interact and exchange information. This can provide information on individual interactions and "cultural" population structure at a relatively short temporal scale that will often be important for management. For example, groups that share similar coda repertoires are likely to interact frequently, may have had similar experience of exposure to natural and anthropogenic activities and may show similar learned responses to such activities. Codas do not propagate as far as regular sperm whale clicks, and for this reason good recordings of codas have been difficult to collect from larger vessels such as the *Gyre*; in addition, it was difficult to allocate coda recordings to particular groups. On this cruise however, the boat would either heave to or sail slowly close to socializing groups and as a consequence extensive coda recordings were made from most of the groups encountered.

Calibrated Recordings of Rig Noise

Recordings were made close to rigs and drill ships on an opportunistic basis using a calibrated hydrophone and amplifier (Table 4.1.7). If we were in the vicinity of a rig or drill ship, were not with whales and weather conditions were favorable the structure would be approached, usually to a range of 500-1000m so that recordings could be made using both our towed hydrophones and a calibrate system used only for this purpose. We always attempted to raise the rig or drill ship on VHF radio so that we could explain our activities and request information about the rig or ship's current activities. We were not always successful in establishing contact but when we did personnel were usually co-operative and helpful. The calibrated system consisted of a Reson TC4033 hydrophone and a Reson VP200 Voltage preamp being captured by a National Instruments digital acquisition card (DAQ AI-16E-4) in a laptop computer. The Reson hydrophone was individually calibrated by the manufacturer and provided with its own calibration chart. The voltage amplifier and sound card are manufactured as measurement instruments and the sensitivity of this part of the chain will also be measured in lab. Recordings were made using the Ishmael acoustic analysis and recording program. At the same time recordings from the towed hydrophones were made using Logger with 1-kHz and 10-kHz calibration tones being recorded during each session. While recordings were being made the vessel's location was logged every 10 seconds and the range to the structure was also regularly measured using laser range finding binoculars and noted.

It is evident from monitoring close to rigs and drill ships during this and previous seasons that their noise output is highly variable, depending no doubt on the activities in which they are involved in. Fully capturing this variability would require a significant dedicated long-term characterization effort. However, the opportunistic recordings we were able to make this summer represent an alternative approach to collecting some of these data at low cost.

Habitat Data

On most evenings, a CTD cast was made using a Seabird CTD. The CTD was lowered and retrieved by hand to a depth of approximately 50 meters. Table 4.1.8 gives the location of each of the 23 CTD casts. Sea surface temperature was recorded continuously using a 4-20mA temperature sensor (Omni-Instruments) mounted through a skin fitting on the boat whose output was displayed using a Asahi Keiko panel meter. The RS232 output from the panel meter was read and values were stored it the Logger Database using a program specially written for the project by Ricardo Antunes. Temperature was typically logged every minute and some 92,000 readings were made during the project.

A description of water color was recorded every hour. Whales were heard/seen both in green water and in blue water environments, and in all depths from 500 to 2000 meters. As our survey track was determined without integrating knowledge on either sea surface height (except for three days during Leg 3) or bathymetry, and as we attempted to survey all water depths between 500 and 1500 meters as well as different sea surface heights, we should have a relatively unbiased picture of sperm whale habitat in the northern Gulf during June-August 2004.

Concluding Statements

The *R/V Summer Breeze* cruise was the first SWSS cruise to use a motor-sailing vessel to study sperm whales in the Gulf of Mexico. Such vessels have been used widely to study sperm whales in other areas of the world, and we are pleased to find that it was just as efficient and productive in the Gulf of Mexico as elsewhere. The use of such a vessel allowed us to collect a large amount of identification photographs (302 in total), as well as good quality coda recordings, recordings of vocalizations during the 1st few minutes of a dive for length measurement analyses, long-term follows, and defecation rates. Such information on the biology of the species cannot be reliably and consistently gathered from a large vessel.

The success of this cruise was aided by good weather enjoyed for most of the field season. Although we were working from a much smaller vessel than the R/V *Gyre*, we were less constrained by weather than is the case when poor weather constrains our ability to launch RHIBs from a larger vessel. Thus, *Summer Breeze* provided a more stable and capable working platform than a RHIB in poor weather conditions.

Table 4.1.7

Summary of Occasions on Which Calibrated Recordings Were Made of Production Platforms and Drill Ships

Date	Approx. Time	Rig Name	Notes
25/06/2004	18:00	Petronius	Could not make radio contact
28/06/2004	18:00	Medusa	Could not make radio contact
28/06/2004	19:50	Ocean Lexington	Not drilling, reported had been using vibrator
29/06/2004	12:30	Matterhorn	
04/07/2004	19:30	Ursa	Made contact by radio requested 500m exclusion zone, not drilling
25/07/2004	11:00	Ursa	Made contact, not drilling
02/08/2004	14:00	Discovery Enterprise Drill Ship	Concreting casings, not drilling
02/08/2004	19:30	Devil's Tower	Spoke by radio. Exchanged information on cetacean sightings
05/08/2004	13:00	Petronius	Heavy Weather

Table 4.1.8

Locations of CTD Casts That Reached 50 m or More

Date	Time	Latitude (°N)	Longitude (°W)	CTD Number
Leg 1				
23 June 2004	16:00	28.8924	87.1103	1
25 June 2004	20:50	28.4997	89.0721	2
Leg 2				
3 July 2004	16:58	28.9166	88.2213	3
4 July 2004	18:54	28.1482	89.1169	4
6 July 2004	19:15	28.1089	89.6108	5
7 July 2004	20:00	28.0548	89.6357	6
10 July 2004	18:20	28.2536	89.3166	7
11 July 2004	17:20	28.2186	89.8129	8
12 July 2004	19:15	28.5899	88.9972	9
Leg 3				
19 July 2004	18:30	28.7478	88.9219	10
20 July 2004	18:34	28.2919	89.7365	11
22 July 2004	19:00	27.8366	90.1798	12
23 July 2004	18:45	28.2665	89.7432	13
24 July 2004	18:45	27.5221	89.7593	14
25 July 2004	11:10	28.1484	89.1076	15
26 July 2004	19:20	28.0923	88.1241	16
27 July 2004	18:40	27.8155	88.4168	17
28 July 2004	18:47	28.3476	88.5994	18
Leg 4				
2 Aug 2004	17:35	28.2078	88.8011	19
3 Aug 2004	19:20	28.1394	88.8150	20
5 Aug 2004	19:25	29.0954	87.8562	21
6 Aug 2004	19:10	29.2354	87.2513	22
9 Aug 2004	18:45	29.0392	86.8005	23

4.2 Mesoscale Population Study Cruise of 2005

Introduction

Our primary goal during the second summer of MPS cruises was to survey for sperm whales along the shelf edge of the northern Gulf of Mexico approximately between longitude 91°W and 86°W, with a particular emphasis on the survey blocks that included the Mississippi Canyon and Mississippi River Delta outflow regions. These are the areas that had the highest sperm whale encounter rates in previous years. This was particularly the case for mixed groups, which comprise females and immature animals. Because our survey vessel, the same 46' motor-sailor that we had chartered in summer 2004, was based in St. Petersburg, Florida, a passage had to be made along the western Florida coast to and from our main study areas. We aimed to survey between the 500 and 1500-m depth contours in this eastern area but with a lower level of effort. Within our main survey area we expected, based on experience from previous years, to encounter mainly large mixed groups in the Canyon and Delta outflow regions and maturing males in small and dispersed groups to the east and in the DeSoto Canyon and Florida coast regions. The primary data to be collected on this project were photo-id images, along with visual and acoustic measures of length, acoustic recordings and where possible, biopsy samples. The photo-id data are useful for revealing a variety of basic biological data for this population, including population size, range of movements, residence patterns, and social organization.

The cruise was conducted in four legs, described below. The science team members for each leg are shown in Table 4.2.1. Jonathan Gordon and Christoph Richter were the Field Party Chiefs for Legs 1 and 4 and Legs 2 and 3, respectively. Figure 4.2.1 summarizes the planned survey blocks and the actual tracks over the four legs.

Table 4.2.1

Science Team for the SWSS 2005 MPS Cruise

Participant	Function	Participation in legs
Jonathan Gordon	Party chief, legs 1+4	1 and 4
Christoph Richter	Party chief, legs 2+3	1-3
Pip Bauerlein	Skipper	1-4
Ricardo Antunes	Acoustics	1-4
Sierra Deutsch	Observer	1-4
Raul Diaz-Gamboa	Biopsy	2-4
Sam DuFresne	Observer	1-4
Thomas Gordon	Logistics	1-4

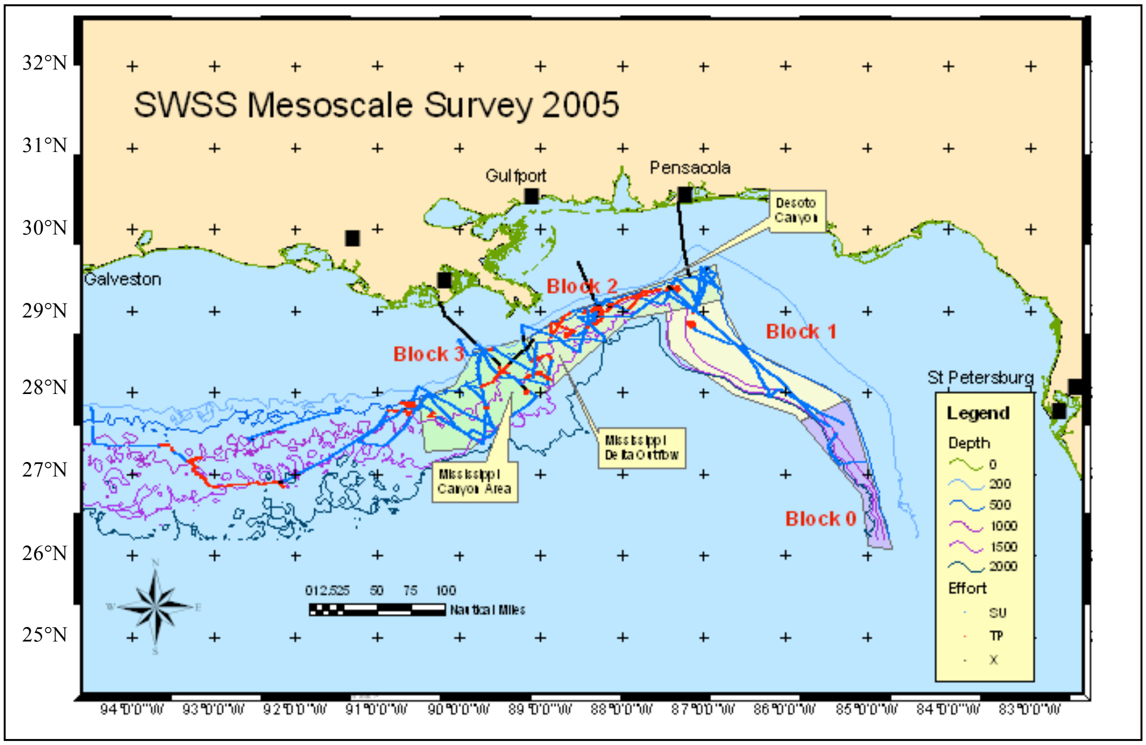

Figure 4.2.1. Cruise tracks for the 2005 MPS cruise. The predetermined survey blocks (Blocks 0 to 3) are overlaid by the actual track of the *Summer Breeze* (thick colored lines: blue is survey mode [regular acoustic monitoring] (SU); red is tracking and photo-ID mode (TP); black is off-effort or on-transit (X)). Depth contours are shown with thin colored lines.

The charter of the vessel began on 4 June but work to assemble and check equipment stored in Galveston, Texas, had been underway for several weeks beforehand. Equipment was driven to St. Petersburg in a rented truck by two of the team. Most of the rest of the team assembled in St. Petersburg on 3 June. Mobilization, which essentially involved adapting a standard inshore charter yacht to be a viable offshore research vessel, was extensive and took nine days of intense work. Preparations were hampered somewhat by the fact that some of the key personnel arrived late because of delays in receiving visas and by a few days of torrential rain and stormy weather from "Arlene", the first hurricane of the season, which passed offshore. Mobilization work included establishing an acoustic monitoring and science work station, fitting two towed and one directional hydrophones, fitting a through-hull temperature sensor system, fitting a satellite communications system and a navigation computer, fitting a man-overboard alarm system, converting two heads to food storage, adapting the vessel's accommodation to provide seven reasonable sea berths, and augmenting the vessel's fuel supplies with 32 jerry cans on deck.

Summer Breeze left St. Petersburg on 13 June and monitoring work began on 14 June, when we reached deep water. The first leg consisted of surveys along the Florida Shelf edge, into the DeSoto Canyon and along the northern edge of the Gulf of Mexico as far as the Mississippi Delta Region. During this leg, whales seemed generally to be less abundant than in previous years. No large mixed groups were encountered and maturing males seemed to be distributed further to the west than in other years. Many of the whales that we did see appeared not to be feeding during the day, thus were not fluking and could not be photo-identified. The vessel made its first port call in Gulfport, Mississippi, on 20 June, a day earlier than planned, in part because one of the team had developed a worrying ear infection but also to allow time to attend to a number of mechanical problems which had developed on the boat. We also used this time to build a mount for a new directional hydrophone. Figure 4.2.2 shows the tracks of Leg 1.

The second leg began on 23 June and continued the survey to the west. No whales were encountered in the Mississippi Canyon (previously an area with a high encounter rate) and most encounters were with small groups (≤ 4 animals) towards the western end of our survey blocks. Work was hampered by poor weather due to frequent thunder squalls and persistent high winds. Leg 2 was curtailed on 29 June when one of the team developed a serious eye infection. The boat returned to Gulfport; the ill team member attended hospital and was then required to recover at her family home.

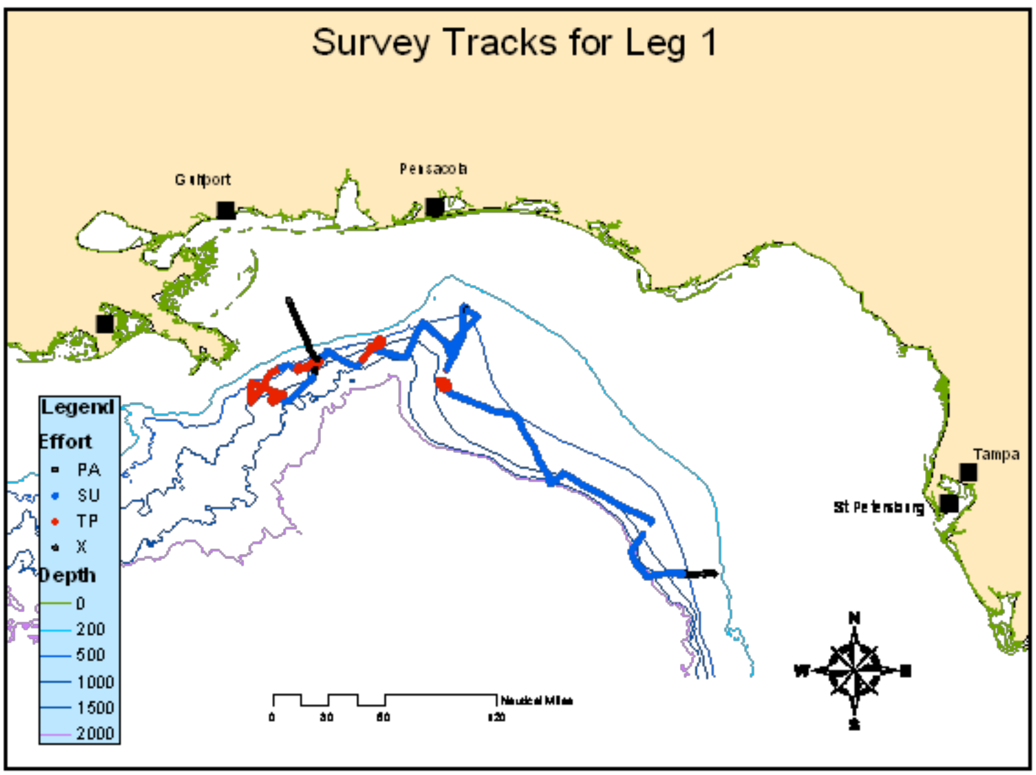

Figure 4.2.2. Track for Leg 1 of the MPS cruise from 13 – 20 June 2005. Green line: survey mode (regular acoustic monitoring); red line: tracking and photo-ID mode (TP), black line: off effort or transiting. Depth contours are shown (thin colored lines).

A reduced team left Gulfport after this emergency port call to continue the survey on 2 July. The team soon picked up a loose aggregation of four whales and tracked them over 33 hours as they moved some 60 miles roughly following the 1000m contour into the DeSoto Canyon region. However, tropical storm Cindy then intervened, forcing a port call to Pensacola, Florida. Immediately after this storm passed, hurricane Dennis began moving up the eastern Gulf, with Pensacola directly on its track. Due to the lack of shelter in Pensacola, the team decided to move the boat to the west as quickly as possible and took shelter at Morgan City, Louisiana, on 9 July. This also provided an opportunity for the team member with the infected eye, now recovered, to rejoin the vessel.

Summer Breeze put to sea again on 12 July, reaching deep water and resuming monitoring on 13 July. Just after midnight, a major electrical fault developed in the vessel's engine resulting in the starter motor, alternator and all of the engine's wiring burning out. With no propulsion, major repairs required and hurricane Emily now threatening, the boat sailed slowly towards Galveston, where TAMUG could provide support. *Summer Breeze* eventually arrived at the TAMUG Small Boat Basin late on 15 July. Figure 4.2.3 shows the tracks during Legs 2 and 3.

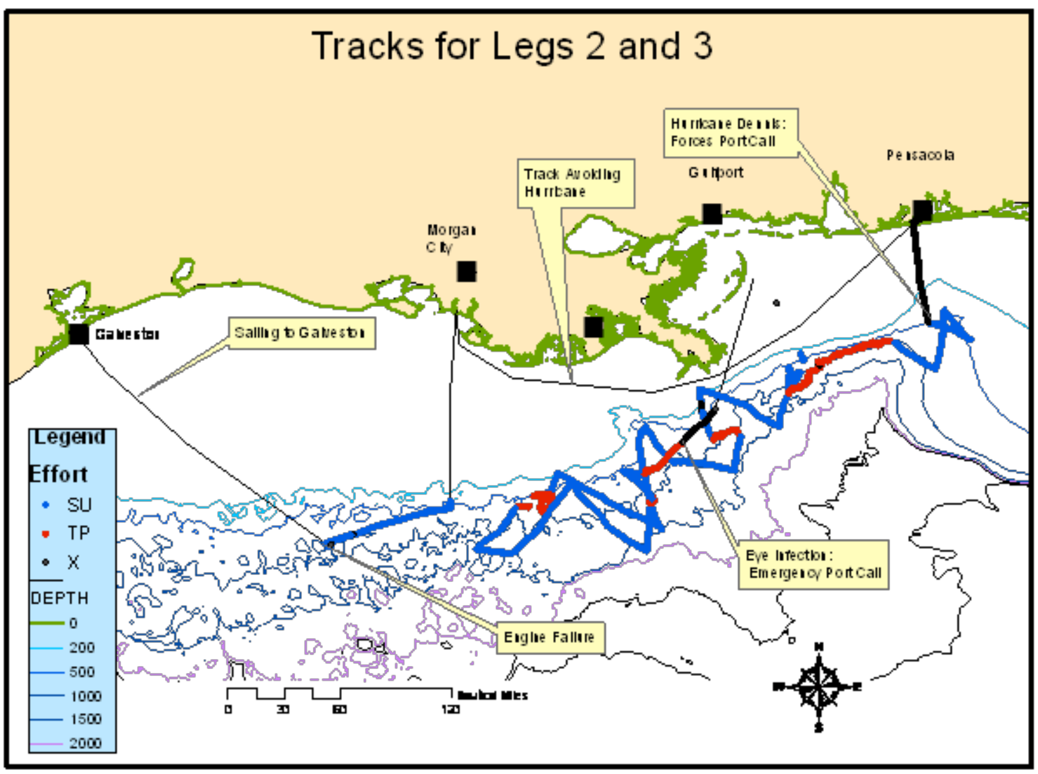

Figure 4.2.3. Tracks for Legs 2 and 3 of the MPS cruise from 23 June – 15 July 2005. Green line: survey mode (regular acoustic monitoring); red line: tracking and photo-ID mode; black line: off-effort or transiting. Depth contours are shown (thin colored lines).

Repairs to the engine took over a week to complete but it was possible to rearrange travel to bring the start of the final leg forward by a few days and *Summer Breeze* left Galveston on 23 July. Figure 4.2.4 shows the track of Leg 4. The boat was once again operating with a reduced team as the biopsy collector had an injured foot which had become infected and required shore rest. Although Galveston was well to the west of the planned survey areas, it was decided to survey from there, in part to cover a gap between the areas surveyed by the S-tag and MPS projects but also to further investigate the apparently anomalous patterns of sperm whale distribution this year. With generally good weather conditions and whales encountered on most days, this final leg was especially productive. One large mixed group was encountered and followed for two days. It was well to the west of our designated survey area. In the main study area, only maturing males were encountered. A brief port stop was made at Port Fourchon, LA, to pick up the team member whose injured foot had recovered and to take on fuel and fresh provisions. On 30 July, a loose grouping of three whales was tracked as they crossed the track of an active seismic survey vessel. This should provide interesting opportunistic observations of such interactions.

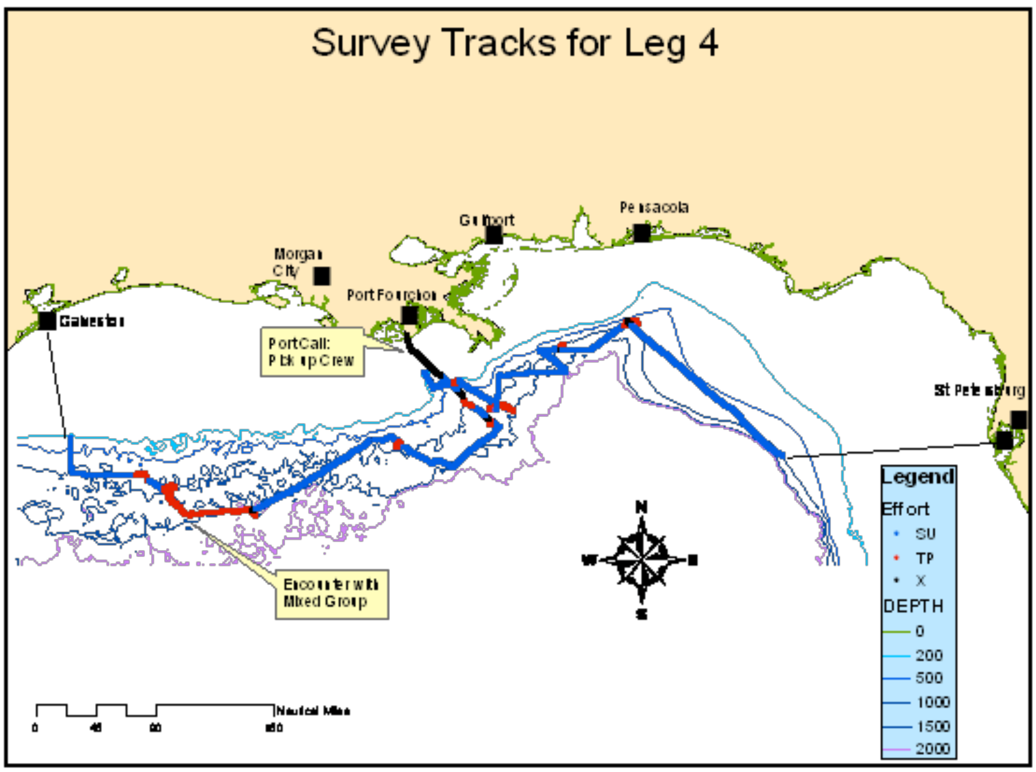

Figure 4.2.4. Track for Leg 4 of the MPS cruise from 23 July – 3 August 2005. Green line: survey mode (regular acoustic monitoring); red line: tracking and photo-ID mode, black line: off effort or transiting. Depth contours are shown (thin colored lines).

No sperm whales were encountered during the passage along the Florida coast during the final return leg though monitoring was also affected by torrential rain and thunderstorms. Hydrophones were recovered and surveying ended in the evening of 2 August. The vessel arrived back in St. Petersburg on the evening of 3 August. Three days were spent removing our equipment from the boat, refitting its normal charter inventory, cleaning and tidying up. Research equipment was driven back to Galveston in a rented truck by two of the team members and the rest of the team members dispersed. Information on all legs and port calls is summarized in Table 4.2.2.

Table 4.2.2

Summary of Legs and Port Calls for the 2005 MPS Cruise

Leg	Start		End		Field	Comments
	Date	**Port**	**Date**	**Port**	**Party Chief**	
	1 June	Galveston, TX	12 June	St. Petersburg, FL		mobilization
1	13 June	St. Petersburg, FL	20 June	Gulfport, MS	Gordon	
2a	23 June	Gulfport, MS	29 June	Gulfport, MS	Richter	medical
2b	2 July	Gulfport, MS	5 July	Pensacola, FL	Richter	tropical storm Cindy
3a	7 July	Pensacola, FL	9 July	Morgan City, LA	Richter	hurricane Dennis
3b	12 July	Morgan City, LA	15 July	Galveston, TX	Richter	engine breakdown
4a	23 July	Galveston, TX	30 July	Fourchon, LA	Gordon	team member pick-up
4b	30 July	Fourchon, LA	3 August	St. Petersburg, FL	Gordon	
	3 August	St. Petersburg, FL	8 August	Galveston, TX		demobilization

Accomplishments

During the 2005 MPS cruise on the *Summer Breeze*, we completed 333 hours in survey mode during which we covered 1969 nautical miles. This included 1262 regular one-minute acoustic monitoring stations. In addition, 311 hours were spent in tracking and photo-ID mode, covering 680 nautical miles.

June and July 2005 were record-setting months for hurricanes, with seven tropical storms in all. This project was affected by four of them. Nevertheless, because the vessel was able to be on the water over a span of approximately 6 weeks, overall results and success with sperm whale encounters was satisfactory, and new data on sperm whale age and sex distribution, sounds, behavioral patterns, and photo-identifications were gathered. This information is outlined in more detail below. Probably the most significant finding from this season will prove to be the provision of evidence of an apparent shift in the distribution of different components of the population.

Permits

The behavioral/photo-identification part of this project was conducted under NMFS Scientific Research Permit To Take Marine Mammals, Amendment No. 1, Permit No. 821-1588-01 (Principal Investigator Dr. Randall W. Davis; Co-Investigator Dr. Bernd Würsig). Biopsy sampling was conducted under NMFS Permit No. 909-1726-00 (Principal Investigator Dan Engelhaupt of the University of Durham.).

<u>Vessel</u>
The research platform used for this leg of the survey was the *Summer Breeze,* which had also been used last year. It was chartered from Sunsail in St. Petersburg, Florida. *Summer Breeze* is a 46’ sloop with a 76-HP engine and 7 berths (Figure 4.2.5).

Summer Breeze was modified to provide extra storage for food and equipment by adapting the heads and providing lee cloths and additional fans to improve its accommodation. An acoustic work station (see below for details) was set up in the main cabin. Communication and navigation was improved by adding a Global Star satellite telephone system, a dedicated navigation and communication computer, and additional GPS receivers. In addition, a man-overboard alarm system was fitted to enhance team safety. Finally, to provide additional fuel capacity, 34 five-gallon jerry cans were lashed on deck.

The provision of clean electrical power and the elimination of electrical noise is often a problem on a small vessel. A pure sine wave inverter (Prosine 1800) was installed running directly off the vessel’s house batteries. This provided clean AC power for computers and for the acoustic work station. A separate DC power supply served preamplifiers and panel meters.

Figure 4.2.5. The *Summer Breeze,* a 46’ sloop, served as the research vessel for the 2005 MPS cruise. To extend the reach of the vessel, 34 red and yellow jerry cans were lashed to the deck. One of the towed hydrophones can be seen coiled up at the port stern. (Photo: Bill Lang)

Acoustic

Two stereo "Ecologic" towed hydrophone arrays, one with 100m and the other with 200m of cable, were carried and were towed off each quarter. Having two matched hydrophones provided a spare in the event of loss or damage, and also allowed them to be towed as "tandem" arrays to allow more accurate acoustic tracking using programs such as Rainbow Click[1]. Each array contained a depth sensor.

The acoustic work station was housed in a waterproof SKB instrument case. It consisted of a laptop computer and two Magrec HP27ST preamplifiers, which were interfaced via a USB sound card (M Audio). Two panel meters measured depth of the hydrophone arrays. As only one computer was available for acoustic analysis, an audio switch was used to select between the arrays when the hydrophones were deployed as tandem arrays to resolve left/right ambiguity. A calibration tone generator was also mounted in the instrument case to allow for calibration of the system.

A feed from the main system in the acoustic work station was available at the helm allowing monitoring of the hydrophones on deck using headphones. In addition, the output from the hydrophones could be fed into the vessel's HiFi system providing general monitoring of underwater acoustic activity.

Two hand held directional hydrophones mounted on long fiberglass poles were used when tracking sperm whales at close range. In addition, a more elaborate directional hydrophone within a streamlined pod was built following designs for directional hydrophones used from motor sailors by Hal Whitehead and colleagues. The advantage of this design is that it can stay mounted to the vessel. A mount for this was attached to the main-sheet arch of *Summer Breeze.*

Operation: The towed hydrophone systems worked well. The 100-m hydrophone was used continuously whenever the vessel was in water deeper than 200 m. The second hydrophone was occasionally deployed to assist with tracking whales. Hand held directional hydrophones were normally used by stopping the boat and deploying them from the swim platform at the stern of the boat. With such good access to the water this proved feasible in calm conditions. The streamlined directional hydrophone was not completely successful. Sufficient tests were done to demonstrate that it could be monitored underway and provided reliable bearings to whales being tracked. However, it proved impossible to make a sufficiently strong but temporary attachment on a vessel that was only available for a short term charter.

Data collection: Wherever possible data were collected directly to computers to minimize transcription errors and speed up later analysis. The Logger[2] program ran continuously on the computer at the acoustic work station. It collected the vessel's track from GPS, information on search status and effort, hourly environmental data, non-sperm whale sightings, acoustic data, and information on encounters with sperm whale groups and individuals. All data were stored in a coordinated relational database. All recordings from the towed hydrophones were made at a 96kHz sampling rate using the tape recorder within Logger. On some occasions Logger's

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[1] Rainbow Click is a computer program written by Douglas Gillespie with support from the International Fund for Animal Welfare to promote benign and non-invasive research.

[2] Logger is a computer program written by Douglas Gillespie with support from the International Fund for Animal Welfare to promote benign and non-invasive research.

automatic recording and buffering capabilities were used. In addition, data on hydrophone depth and surface water temperature were stored within the Logger database using programs written for this project by Ricardo Antunes. A new feature in Logger is the ability to open forms and control some functions using external buttons. We installed a system of wireless remote control buttons to be able to open key forms and initiate tape recordings from deck which made it easier to record data on a computer below decks. Occasionally, for example when working with larger schools of sperm whales, notes were also made on paper forms. This information was transcribed into Logger immediately after these encounters ended.

Photo-ID and Photogrammetry

The primary data collected on this project were photographs and observations to characterize individual animals, in particular images to allow animals to be identified. To collect these, animals were carefully approached from astern to allow sequences of photographs of the fluke up to be taken as close to perpendicular as possible. We used two digital SLR cameras (Canon 1D and 1D-MarkII), equipped with Sigma 100-300 mm lenses. Observers also looked carefully at the whale's dorsal fin using stabilized 12X binoculars (Fujinon) to determine whether or not it carried a callus (calluses are more common on mature females). Ranges to whales were measured using laser range finders. These distances served two purposes. Firstly, relaying this information to the helm helped with maneuvering. A range of between 40-50 meters is ideal for photo-identification. Secondly, the exact range to the whale when it fluked can be used to estimate fluke width, and consequently body length of the whale. Along with the distance to the fluke, we also recorded an estimate of the relative angle between us and the fluke, since this measure influences the quality of the estimates of fluke width.

Some 180 photographic sequences were taken of fluke ups for photo-identification. Of these, 31 were taken on Leg 1, 37 on the middle legs and 112 on the final leg. This distribution reflects both the poor weather and other problems encountered in the middle of the cruise. It also points to the general lack of large mixed groups within our study area and the fact that the whales encountered during the first and middle legs often were not feeding and thus not fluking up. Some individuals bore such obvious marks that we are confident that several animals have already been identified in previous years.

Acoustic Monitoring

Hydrophones were monitored every 15 minutes for one minute when the vessel was offshore and in survey mode. This year we experienced some electrical noise on the system (emanating from the alternator) which we were unable to fully eliminate. We believe that this must relate to changes made to the boat between the two seasons but we were never able to isolate the cause. To facilitate monitoring, the engine would be turned off on every second monitoring station. A total of 1262 standard one minute monitoring stations were completed. Dolphins were detected at 19% of these (compared to 13% in 2004). Seismic airguns could be heard at 28% of these. This compares with detection rates for seismic of 5% and 30% in 2004 and 2003 respectively. Sperm whales were detected at 8% of stations compared to 11% in 2004. However, as the vessel would come off survey mode and start tracking soon after whales are detected, these are much lower than detection rates one would expect for a non-closing survey mode.

Coda Recordings

Codas, stereotyped patterns of clicks believed to be used for communication and most often heard from socializing whales, can be analyzed to reveal the cultural organizational structure of sperm whale populations. This year we continued to add to our repertoire of recordings from mixed groups and were particularly excited to obtain substantial recordings from groups of maturing males, which have previously been poorly sampled. Table 4.2.3 summarizes dedicated coda recordings.

Tissue Collection

Biopsy samples were collected for Dr. Dan Engelhaupt. Only one of the team, Raul Diaz-Gamboa, was permitted for this work. Diaz was not available for the first leg and was injured for the first part of the final leg, consequently only two samples were collected from individuals believed to be males. The biopsy samples were stored in 20% DMSO solution to preserve the tissues. In addition, three sloughed skin samples were collected. Table 4.2.4 gives the locations of the tissue samples.

Table 4.2.3

Summary of Dedicated Coda Recordings

Date (d/m/y)	Number of Recordings Made	Minutes of Recording
17/06/2005	8	31.6
18/06/2005	3	11.2
19/06/2005	8	66.6
03/07/2005	11	47.8
04/07/2005	5	27.2
25/07/2005	7	46.2
26/07/2005	3	20.5
01/08/2005	7	81.1

Table 4.2.4

Locations of Tissue Sample Collection

Biopsy Sample Number	Date (m/d/y)	Latitude (°N)	Longitude (°W)
05073001	07/30/2005	28.2104	-89.0015
05080102	08/01/2005	29.2413	-87.3053

Other Sightings

The small team on this project had a heavy workload to maintain round the clock monitoring. While the small research vessel used was quiet and excellent for acoustic monitoring it lacked a good visual observation platform. Thus an effective visual monitoring watch was not maintained when sperm whales were not being tracked. Nonetheless, a number of sightings of species other than sperm whales were made in offshore waters; these are summarized in Table 4.2.5. Two highlights were an encounter with a Bryde's whale on the continental shelf south of Pensacola and an encounter with false killer whales offshore from the Florida coast.

Rig Recordings

A number of opportunistic recordings of noise fields close to oil platforms and drill ships were made. Both the vessel's primary towed hydrophones and a calibrated recording setup were used. Recordings are summarized in Table 4.2.6.

Table 4.2.5

Sightings of Species Other Than Sperm Whales During the 2005 MPS Cruise

Date (m/d/y)	Time (UTC)	Species	Estimated Group Size	Latitude °N	Longitude °W
06/15/05	1910	Pantropical spotted dolphins	25	28.0565	-86.2254
06/15/05	2037	Unidentified dolphin	10	28.1535	-86.2913
06/15/05	2210	Pantropical spotted dolphins	50	28.2820	-86.3450
06/16/05	1626	Kogia species	1	29.0025	-87.1074
06/16/05	1841	Kogia species	1	29.1668	-87.0249
06/17/05	1325	Pantropical spotted dolphins	2	29.0932	-87.5456
06/17/05	1340	Melon-headed whale	200	29.1012	-87.5674
06/19/05	0114	Pantropical spotted dolphins	20	28.7635	-88.6207
06/19/05	1305	Risso's dolphin	6	28.9864	-88.4402
06/19/05	1854	Pygmy Killer Whale	12	28.9887	-88.3981
06/19/05	1949	Risso's dolphin	6	28.9987	-88.3568
06/19/05	2254	Short-snouted spinner	15	29.0614	-88.2765
06/25/05	1245	Pantropical spotted dolphins	30	28.1161	-88.9061
06/27/05	1807	Short-snouted spinner	8	27.7987	-90.5462
06/28/05	1939	Melon-headed whale	15	27.9655	-90.3579
07/03/05	1050	Unidentified dolphin	50	28.8631	-88.4214
07/04/05	1508	Pilot whale	20	29.2398	-87.6502
07/04/05	1844	Unidentified dolphin	7	29.2527	-87.5555
07/06/05	1800	Bryde's whale	1	29.67	-87.22
07/13/05	1552	Bottlenose dolphin	8	27.7401	-91.5214
07/25/05	2151	Melon-headed whale	80	26.8406	-92.9924
07/30/05	1103	Melon-headed whale	30	28.1644	-88.8874
08/02/05	1600	False killer whale	18	28.2296	-86.1789
08/02/05	2227	Pantropical spotted dolphins	20	27.6618	-85.5828

Habitat Characterization

Surface water temperature was logged every minute at a water depth of approximately 1 m. These data were recorded in Logger through an interface program written by Ricardo Antunes and over 24,000 measurements were recorded. In addition, whenever time allowed, usually at the end of the day, a CTD cast to a depth of approximately 50 m was completed using a hand deployed Seabird SeaCat CTD. Table 4.2.7 summarizes the CTD casts.

Table 4.2.6

Recordings of Rig Noise Made During the 2005 MPS Cruise

Date	Time (UTC)	Rig Name
14 July 2005	02:18	Ocean Victory
27 July 2005	17:00	Ocean Saratoga
27 July 2005	17:40	Brutus
27 July 2005	19:00	Genesis
28 July 2005	02:26	Ocean America
27 July 2005	06:17	TranOcean

Table 4.2.7

Locations of CTD Casts on 2005 MPS Cruise

Date (m/d/y)	Time (UTC)	Latitude (°N)	Longitude (°W)	CTD #
06/16/2005	15:31:39	28.9417	-87.1349	1
06/17/2005	17:04:40	29.1558	-87.7920	2
06/18/2005	17:16:33	28.7999	-88.4239	3
06/19/2005	16:19:40	28.9989	-88.4331	4
06/24/2005	16:32:30	28.5475	-88.6289	5
06/27/2005	16:18:24	27.8417	-88.6289	6
07/03/2005	17:42:06	28.9849	-88.2332	7
07/13/2005	16:03:25	27.7371	-91.5421	8
07/24/2005	17:56:35	27.2901	-93.5184	9
07/25/2005	18:12:25	26.9316	-93.0966	10
07/26/2005	17:40:06	26.8848	-92.3699	11
07/27/2005	16:57:17	27.7929	-90.6901	12
07/30/2005	17:19:14	28.2376	-88.9914	13
07/31/2005	17:46:44	28.9034	-88.5012	14
08/01/2005	17:43:48	29.2697	-87.3594	15
08/02/2005	17:57:39	28.0733	-85.9902	16

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.