This is the cruise plan for the S-tag cruise that will be conducted in June 2005 to study and tag sperm whales in the northern Gulf of Mexico. It is conducted as part of the MMS-sponsored Sperm Whale Seismic Study under Cooperative Agreement Number 1435-01-02-CA-85186.

I. Cruise Logistics

A. Mobilization on 31 May-2 June 2005
   Departure planned for approximately 23:00 CDT on 2 June 2005
   Cruise dates: 3-30 June 2005
B. Port call: 19 June 2005
   Return planned for late afternoon of 30 June 2005
C. Port of departure: Galveston, TX
   Port call: Harbor Island, TX
   Port of return: Galveston, TX
D. Field Party Chief: Dr. Ann E. Jochens, TAMU
E. Ship: R/V Gyre, TAMU

II. Scope of Work for the Cruise

R/V Gyre will field a 28-day S-tag cruise in the northern Gulf of Mexico to tag sperm whales with either satellite-tracked radio tags (S-tags) or bioacoustic probe (B-probe). The cruise, called SWSS 2005 S-tag, will be at sea from 3-30 June 2005 with a port call on 19 June to exchange personnel in the visual and acoustic teams. Passive acoustics and visual surveys of sperm whales will be conducted to support tagging activities. The first cruise leg will be dedicated to S-tag deployment, and B-probe deployments will be carried out during the second leg. Additionally, 3-D passive acoustic tracking of sperm whales will be conducted during the first cruise leg. Oceanographic sampling for habitat characterization will take place during the entire cruise. Gyre will be staged out of Galveston, TX and the port call will take place at Harbor Island, near Port Aransas, TX. SWSS PIs who will participate in this survey are Ann Jochens, Dan Engelhaupt, Joel Ortega, and Aaron Thode. These PIs and their supporting teams, together with Deborah Epperson (both cruise legs), Carol Roden (first cruise leg), and Lee Benner (second cruise leg) of MMS, constitute a 23 person science party. Kyle Baker, from NOAA-Fisheries Protected Resources Division, will participate on the second leg of the cruise. It is presently planned that during the first cruise leg Gyre will survey the western Gulf of Mexico (north of 26°N from about 91°W to 96°W) in areas of water depth between 800m and 2000m. After the port call, the Gyre tentatively will head east along the 2000-m isobath to 88°W, and then head towards region of the Mississippi Canyon and off the Mississippi River Delta before turning back to Galveston.

A. Personnel

There will be a scientific team of 23 people: 15 men and 8 women. Participants and duties are:

Field Party Chief        Ann Jochens (also Oceanography team leader)
Oceanography             Alyson Azzara
Tagging crew  Joel Ortega (tagging, OSU team leader)
 Dan Engelhaupt (biopsy/genetic typing)
 Ladd Irvine (boat driver)
 Craig Hayslip (photographer)
 Andy Szabo (video)

TAMU Techs  Eddie Webb (Electronics Tech)
 Paul Clark (Electronics Tech)
 Bill Green (Deck Engineer)
 Marty Bohn (Deck Engineer)

1\textsuperscript{st} cruise leg (3-19 June)

Visual team  Lars Bejder (visual team coordinator)
 Rocio Cooley
 Glenn Gailey
 Rhoni Lahn
 Suzanne Yin

Acoustic team  Aaron Thode (passive acoustic 3-D tracking)
 Anurag Kumar (acoustic team coordinator)
 Sara Heimlich
 Deborah Epperson

Photo-ID team  Charlie Short
 Carol Roden

Fisheries echo sounder  Chris Wingard

2\textsuperscript{nd} cruise leg (19-30 June)

Visual team  Lars Bejder (visual team coordinator)
 Rocio Cooley
 Rhoni Lahn
 Suzanne Yin
 Kyle Baker
 Lee Benner

Acoustic team  Thomas Norris (acoustic team coordinator)
 Bill Burgess
 Sara Heimlich
 Deborah Epperson

Photo-ID team  Charlie Short
 Glenn Gailey
B. Location of Activities

A map of a tentative cruise track for leg one is shown in Figure 1. Gyre will leave Galveston, heading south until we reach the 1000-m isobath. Observations will begin after taking a CTD at 1000m water depth and deploying the passive acoustic hydrophone arrays. The ship will then move west and then south along the 1000-m isobath towards the Texas-Mexico border. High concentrations of satellite locations from whales tagged in 2002 and 2003 have been reported off Brownsville. All work will be in U.S. territorial or EEZ waters. Tagging efforts will be made where multiple sperm whales are located. The focus for leg one will be in the region west of about 95°W. However, if no groups of sperm whales are found or more than 10 tags are deployed in the westernmost part of the northern Gulf, the ship will start moving east, surveying in the deeper water area along the 2000-m isobath with a few zigzags in areas where records show previous concentrations of sperm whales. The ship will head towards Harbor Island, TX, with enough time to arrive at the dock on the morning of June 19.

During the second leg of the cruise (Figure 2), Gyre will leave Harbor Island and head southeast until we reach the 2000-m isobath. The ship will then move east, surveying the area along the 2000-m isobath and approaching any group of whales found for tagging. The focus of the cruise is to tag sperm whales in the western Gulf and the deep water Gulf. So, if enough sperm whale groups are found in the western or deep water regions, Gyre will remain in that region during leg 2. However, if no whales are encountered in those regions, then Gyre will head towards the region of the Mississippi Canyon and off the Mississippi River Delta, where high concentrations of whales have been consistently reported in previous years. The Mississippi Canyon and Mississippi River Delta portion will be included only if necessary to increase the chance of B-probe deployment.

C. Cruise Activities

The planned activities are sperm whale observations, tagging, and habitat characterization. The visual and acoustic sperm whale observations will assist in finding whales for deployment of satellite radio tags. Photo-identification (photo-ID), acoustic recordings, passive acoustic 3-D tracking, and genetic sampling will also be carried out during the cruise. All work with sperm whales will be conducted in accordance with the terms of permits issued by the U.S. National Marine Fisheries Service (now NOAA Fisheries) to Bruce Mate, Joel Ortega and Ladd Irvine of Oregon State University (permit 365-1440-01) and Dan Engelhaupt of the University of Durham (permit 909-1465-01). The habitat characterization consists of flow-through, near-surface thermosalinograph-fluorescence-chlorophyll sampling, ADCP measurements, echo sounder backscatter measurements, and CTD/XBT profiles, with supplementary remote sensing data.

The main task priority during this cruise is to tag sperm whales. Results from whales tagged in previous years suggest affinity of female whales for specific sites in the north central Gulf. 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, we are interested in tagging...
whales in areas different from previous years, specifically the western region and the deep waters in the central Gulf, to compare the movement patterns and the home range of sperm whales from different regions of the Gulf.

Our actual cruise track will depend upon availability of whales and physical oceanographic cues available to us before and during the cruise. The track of the cruise also will include consideration of recent sightings of sperm whales reported to MMS by marine mammal observers aboard seismic surveys in the northern Gulf, as well as sperm whale sightings recorded during the mesoscale survey on board the sailboat Summer Breeze. We will maintain frequent communication with the Summer Breeze to coordinate the track of both vessels and avoid interference by staying away from groups that the other team is working on. These recent sightings may help us to fine-tune our track lines, especially in the deep water region.

Tagging from RHIB-1
Joel Ortega will supervise tagging of sperm whales. The diesel-powered OSU rigid hull inflatable boat (RHIB-1) is the first choice for this tagging work. The re-engined R2 (RHIB-2), will be primarily dedicated to photo-ID and follow/recovery of the Bioacoustic probe (B-probe). It also will be a backup option for tagging work. Considering the possibility of the R2 being extensively used, we plan to take both 500-gallon gasoline storage tanks on this cruise to ensure we have adequate outboard engine fuel for the 28 days at sea.

Weather allowing, the tagging crew will depart the R/V Gyre when whales have been spotted visually or determined to be close by the acoustic survey team. Five people will be on the tagging boat: one to drive, one to tag, one to video tag attachments, one to biopsy, and one for photo-ID. The visual and acoustics teams will guide the tagging boat to the area where whales are or are expected to be surfacing. The acoustics team will provide bearings and estimated distance to underwater vocalizing whales to the visual team data recorder. The recorder will integrate information from both visual and acoustic teams and direct the tagging boat to locations where whales may come to the surface. Because the first approach of the boat is often the best, it will be important to time the approach well. This may entail waiting for a subsequent surfacing sequence if the initial approach seems unlikely to be productive. Tagging will be accomplished at short range using an air-pressurized applicator system. Video documentation of the tag itself will be important to help evaluate what type of placement and penetration is important for long-term tag survival. A skin biopsy will be taken immediately after tagging (most often during the same surfacing as the tagging occurs). The video documentation of the entire operation will emphasize methodologies and will be assembled for possible use at the ITM, for subsequent training and, possibly, educational programs.

Tags will be initiated before the cruise to put them into synchrony with the satellite passes and the duty cycle calendar. Based on the results from tagging conducted in the last three years, OSU had an average of 1+ good locations per day with a 4-hour transmission schedule. Under this schedule, the battery supply was used up in 137 days in 2001. With a reduced duty cycle, some tags transmitted for more than 10 months in 2002. To increase the likelihood of a year-round picture of movements, tags deployed in 2005 will have a 4-hour per day transmission schedule and will transmit one out of every four days until the batteries are exhausted.
On the second leg of the cruise, when multiple whales are found early in the day, during good weather, a B-probe will be deployed on single whale. The B-probe is attached to the whale with suction cups to record acoustic data and time-depth profiles for 2-4 hours. It must then be recovered and data downloaded to a computer before a new deployment. Deployment of the B-probe, made possible through a cooperative agreement with ONR, will help us calibrate vocalization strength, flow noise and pressure effects on an acoustic sensor, which may be incorporated into a future version of the S-tag. B-probes only will be applied when there will be sufficient daylight remaining to assure that the tag release and recovery will occur well before the small boat (RHIB-2) is required to return to Gyre for the evening. Our goal is to complete a minimum of 2 B-probe deployments and dedicate at least 2 days with whales for this purpose.

**Acoustic Monitoring**

Anurag Kumar and Thomas Norris will coordinate the acoustic team on the first and second cruise legs respectively. A pair of 2-element towed hydrophone arrays that were fabricated in 2003 by Ecologic and a 6-element towed array that was fabricated by Aaron Thode in 2004 (see 3-D passive acoustic tracking section) are available for acoustic monitoring. We plan to deploy one Ecologic array off the Gyre’s port side and the Thode array on the starboard side. By lining up a single hydrophone from each array so that they are the same distance from the stern of the vessel, it is possible to resolve the left/right sound direction ambiguity inherent in using a single line-array. The second Ecologic array will serve as backup in case of failure of the main Ecologic array. Hydrophone systems, deployment methods, and survey speed will be based on previous experience gathered during SWSS cruises conducted over the last two years.

The towed arrays will be monitored 24 hours/day both aurally and visually using the Integrated System for Holistic Multi-channel Acoustic Exploration and Localization (ISHMAEL) software package. Location of acoustically active sperm whales will be estimated using bearing angle information determined by ISHMAEL and plotted using the program WhaleTrack-2 (WT2) developed by Glenn Gailey. Acoustic data will be recorded using Ishamel as described below. Ancillary data (lat, long, ships heading and speed, comments, etc.) can be recorded in WT2 using user-definable fields. These data are saved as an MS Access file. Acoustic effort will be recorded and summarized each day for inclusion into the final cruise report.

An organized shift system will be established to provide round the clock coverage and to achieve sufficient overlap between watches to ensure continuity. While surveying and searching for whales, the monitoring team will listen carefully for 1 minute every 15 minutes and enter their assessment of water noise and cetacean vocalizations in a pre-prepared form in WT2. When sperm whales are detected during daylight hours, the estimated location will be communicated to the visual team either by radio or through WT2. If a group (2+) of sperm whales is detected at night, the vessel will be diverted and the acoustic monitor will try to keep the vessel in the vicinity of the whales.

Acoustic recordings will be made whenever codas (stereotyped patterns of clicks produced by socializing whales) are heard during monitoring. Recordings will be done using the manual recording function available in ISHMAEL. Sperm whales have been reported to have coda dialects that vary between groups and regions, and analysis of coda vocalizations should provide a perspective on sperm whale spatial and social structure in this region to complement that
provided by genetics. Other sounds of interest, including creaks, will also be recorded as encountered.

**Visual Monitoring**
Lars Bejder will coordinate the visual observation team on both cruise legs. During survey/search mode, three observers will be on watch, on the Gyre’s flying bridge, during daylight hours. Two observers will use “big-eye” 25 x 150 binoculars, while a third observer will keep watch with 7x50 binoculars and enter data into a computer. The observers on the big-eye binoculars will search a 100° swath, from 90° on their side, to 10° past the bow on the opposite side. Six observers will rotate between positions every 30 minutes to avoid fatigue and ensure continuity of whale tracking. Data on search effort, sightings, and environmental conditions will be recorded with the computer program WhaleTrack-2 (WT2). Distance to each sighting will be estimated using reticles etched into the right eyepiece of the binoculars and bearings will be measured with the aid of a graduated scale at the base of the binoculars. Location of the whales will be estimated from the distance and bearing data using the function available in WT2.

Once a group of sperm whales is detected, the visual team will work in coordination with the acoustic team to maximize S-tagging and photo-ID efficiency. This will involve estimating the location of the surfacing whales and tagging boat and the distance between them with the aid of the computer program WT2. Location of whale sightings and acoustic detections will be plotted and recorded using the computer program WT2. The visual data will be communicated by VHF radio to the tagging and photo-ID boats to direct them into areas where whales have been sighted or where they are likely to surface.

**Photo-ID and Photogrammetry from RHIB-2**
During good weather, Charlie Short will lead a Photo-ID team from a second rigid-hull inflatable boat (RHIB-2). The main objective of the photo-ID effort during S-tag is to obtain information from tagged whales. For this purpose, the photo-ID boat will work in close coordination with the tagging boat. A secondary function, if necessary, will be to extend the region being observed acoustically by using a directional hydrophone about 3 miles abeam of Gyre to assist in locating whales. After a whale has been tagged, the tagging boat will move on to look for other whales, leaving to the second boat the responsibility of getting pictures of the tagged whale. When B-probe is deployed, RHIB-2 will coordinate with the visual team to keep the tagged whale within VHF radio range until the probe comes off and is recovered.

**Genetic Sampling**
Dan Engelhaupt will conduct genetic biopsy sampling in coordination with satellite tagging of sperm whales. Working aboard RHIB-1, he will biopsy sample satellite tagged whales immediately after a tag is attached. A small plug of tissue (6 mm x 40 mm) is taken from the underside of the flukes or behind/below the dorsal hump by a crossbow-propelled dart with a sterilized coring tip. The dart is free-floating and will be retrieved immediately after sampling. Biopsy samples then are put on ice until they can be sectioned and preserved properly aboard the R/V Gyre. Additional biopsies beyond those taken from tagged whales may be possible at times when whales are deemed too small to tag or tagging is not otherwise feasible. Up to 500 biopsy samples from sperm whales in the Gulf of Mexico can be collected under the National Marine
Fisheries Service Marine Mammal Protection Act/Endangered Species Act permit number 909-1465-01 held by Dan Engelhaupt.

An additional component of this study is to describe the behavioral responses to biopsy sampling and record any tag effects observed on previously tagged whales. Detailed data sheets and digital video will be used to record this information. Our previous findings show that approximately 70% of whales show no reaction to the dart making contact.

**Habitat Characterization**

Habitat characterization work will be coordinated by Ann Jochens to supplement rather than to compete for ship time with the tagging and acoustic survey efforts. Accordingly, most of the hydrographic data collection will be carried out while the vessel is underway. Four activities are planned for habitat characterization: 1) continuous collection of near-surface observations of temperature, salinity, and fluorescence from the flow-through system (data logged once per minute), 2) except when turned off for other acoustic work, continuous collection of ADCP data from a 38kHz phased array instrument (data binned every 5 minutes), 3) operation of a Simrad-60 fishery echosounder system that will log backscatter continuously from a 70 kHz fishery echosounder transducer and intermittently from a 38 kHz fishery echosounder transducer, and 4) collection of approximately 6-8 CTD and 84 XBT profiles. We will have 7 cases of Deep Blue XBTs aboard and so can drop these with 20 n mile spacing as we survey the 1000-m and/or 2000-m isobaths from 93°W to 84°W. Additionally, the remote sensing activity of the study will provide ocean color and SSH images for cruise planning and operation. Details of the data collection systems follow.

Continuous flow-through sampling will use water from an in-line flow that is pumped from the ship's hull depth of 3.5 m to laboratory sensors. The sensors will measure sea surface temperature, conductivity/salinity, and fluorescence. Data from the thermosalinograph-fluorometer are binned in 1-minute intervals giving about 0.25 km horizontal resolution of 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 will be collected during S-tag 05 to compare/contrast with the April 2005 calibration sampling.

A 38kHz ADCP phased-array instrument will be installed on the Gyre to collect upper water current velocity and backscatter data. 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 R/V Gyre will be outfitted with a Simrad-60 fishery echosounder system that will allow us to log backscatter from 70 kHz and 38 kHz fishery echosounder transducers. We plan to install the 70 kHz transducer in the "moonpool" trunk mount that on previous cruises housed a 153 kHz narrowband ADCP. This 70 kHz echosounder will be run continuously throughout the cruise. We plan to mount the 38 kHz transducer on a transducer-mounting pole that can be swung over-the-side for use as opportunity allows, during times when Aaron Thode judges that the 38 kHz
sound will not interfere with close-in follows of diving whales. These would be times when the
vessel is at low speeds and searching for acoustic contacts with whales, or when we have distant
contacts with animals. Use of the 38 kHz fishery echosounder at these times will require the 38
kHz phased array ADCP be turned off.

Approximately 6-8 CTD casts will be made to approximately 1000 m using a SeaBird SeaCat
CTD. CTDs will be taken on each leg before the hydrophone arrays are deployed. Thereafter,
CTDs will be taken as opportunity arises in frontal regions and in the cyclonic and anticyclonic
eddies. XBT sampling will occur as opportunity allows during the whale surveys. Up to 84
XBTs will be deployed. We anticipate deployment of XBTs along the 1000-m and 2000-m
isobaths off Texas, along the 1000-m and 2000-m isobaths during the transit east, and in features
near the Delta.

3-D Passive Acoustic Sperm Whale Tracking
Aaron Thode will use a specially fabricated hydrophone array to conduct 3-D passive acoustic
tracking of individual whales. The six-element array, which is now 800 m long, consists of two
three-element subarrays separated by 400 m. Each subarray has a pressure transducer to record
hydrophone depths. The array will be deployed from the starboard winch, while the Ecologic
array is deployed from the port winch. The array can withstand tow speeds of 10 knots, so it is
not expected that the array would need to be recovered except for repairs or possibly small boat
operations.

The array will be recording whenever sperm whales or dolphins are present. Thode will provide
a hard-disk multi-track recording system that will sample four channels from his array and two
channels from the Ecologic array. He will have eleven 200 Gb hard disks to record this data. The
output of the acoustic recorder can be fed into the computer systems devised by the S-tag
acoustics team, so the array can be used for real-time tracking and left/right ambiguity resolution.
Thode will also provide two laptops that he will use to sample the pressure transducer outputs.

During the day when active tagging work is proceeding, Thode will be recording but will have
no control over the motion of the vessel. During evenings when whales are present, Thode will
have the authority to direct ship motion to optimize the array position for recording 3-D tracks of
the animals. This position consists of a slow 1-2 kt tow speed that will slowly pass to one side of
a group of animals over a 30 to 60 minute period. The vessel may have to readjust its position
after this time to pass through the animals again. Thode may also attempt to attach an
autonomous acoustic recorder to the end of the array to test the performance of a larger-aperture
array.

It is expected that this optimized 3-D recording will take place whenever a new group of animals
is encountered during the night or in the evening after a tagging session has ended.

Opportunistic seismic airgun recording
If the opportunity arises and will not interfere with the tagging operations, an opportunistic
airgun calibration measurement might be conducted. This would be done by converting the
towed 3-D tracking array into a vertical array. The resulting data would have some ship and flow
noise contamination, but would otherwise be fully calibrated and recorded with 24-bit precision.
Whenever a seismic airgun survey is encountered within 20 km range and no sperm whale tagging activity is planned, the Gyre would position itself so that the seismic vessel closest point of approach (CPA) is the minimum range permitted by agreement between Captain Dyer and the seismic vessel, and so that Gyre is riding the swell. The Gyre would then lower ship speed to 2-3 kts, the optimum speed for minimizing cavitation noise from the propeller. The swell should be arriving from behind the ship. At these speeds the towed array would sink substantially. The forward subarray would sink to about 60 m depth and the rear subarray would sink to about 112 m depth. Ocean conditions may permit the ship to slow further and the array to sink deeper, possibly all the way to the vertical. The depths of the hydrophones would be logged automatically, the inclination of the array cable would be recorded, the ADCP profiler would measure potential cross- currents, and the bottom bathymetry would be profiled. Thus the location of the hydrophones relative to the Gyre should be fixed to within a few meters. Once the seismic tow vessel passes CPA, the Gyre will gradually accelerate up to 6 knots, shallowing the hydrophone depths to less than 20 meters, thus giving an opportunity for measuring the sound field in a surface duct, if one exists.

There would be Gyre cavitation noise and flow noise on the hydrophone, but it is expected that the signal to noise ratio of the arriving airgun pulses would be substantially greater than the noise floor over a large frequency band. If the data quality is sufficiently clean, then one would have obtained a series of measurements of airgun sounds at a variety of depths and ranges, along with knowledge of the bottom bathymetry profile and currents. If (through the IAGC) the GPS track, airgun configuration, and tow depth can be obtained from the organization running the seismic vessel, then it might be possible to invert for the airgun source signature and propagation environment using standard geophysical inversion techniques that have been implemented in the underwater acoustic and seismic communities.
Figure 1. Tentative cruise track for leg 1 of SWSS Gyre, S-tag 2005 cruise (thick line). Contour lines represent the 200, 1000, 2000, and 3000 m isobaths.
Figure 2. Tentative cruise track for leg 2 of SWSS Gyre, S-tag 2005 cruise (thick line). Contour lines represent the 200, 1000, 2000, and 3000 m isobaths.