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General Introduction

R/V *Gyre* cruise 02G08 surveyed for whales along the middle continental slope (MCS) of the north central Gulf of Mexico from 94.7°W to 86.4°W (Figure 1A). The cruise left Galveston, TX, on July 19, 2002, and concluded in Gulfport, MS, on July 9, 2002. From 20 June - 8 July, five CTD stations were made, thirty-five T7 XBTs were dropped to profile temperature in the upper 760 m, and seven supplemental drops were made with T10 XBTs to collect additional data from the upper 200 m (Figure 1B). Ocean current velocity in the upper 300 m and upper 900 m was monitored continuously with hull-mounted 153 kHz ADCP and 38 kHz ADCP, respectively, and we pumped near surface water from ship's hull depth of 3.5 m through SeaBird temperature and conductivity sensors and a Turner Designs Model 10 fluorometer to log surface temperature, salinity, and chlorophyll fluorescence once per minute. Although the ship track was centered on the 900-1000 m isobath, our survey generally followed a zig-zag course between water depths from 575-820 m (zigs upslope) to 1125-1430 m (zags downslope).

We searched for sperm whales both acoustically and visually as we surveyed the MCS. We towed Ecologic and/or WHOI hydrophones round-the-clock, for over 400 hours while we surveyed the MCS, and we searched with BigEye binoculars for over 200 hours (generally from 06:30 - 19:30 CDT each day). Two rigid-hulled inflatable boats (RHIB) were used: RHIB-1 for tagging and RHIB-2 for support and photo-identification. Leg One of the survey began when we first reached the 900-1000 m isobath on the afternoon of 20 June and continued until the evening of 26 June, when we broke off to run to Gulfport MS to pick up a replacement alternator that was needed for RHIB-1. We departed Gulfport the evening of 27 June, and Leg Two surveyed along the MCS from the morning of 28 June through noon on 8 July. During the total of 18 days that we spent along the MCS, we encountered sperm whales either individually or in groups of 2-9 animals at seven locations. These animals were not encountered randomly in time or space, but instead most whales were heard/seen when the ship was between 89.9°W and 87.1°W. Figure 2 overlays on the 24-hour ship track the locations where whales were seen with BigEye binoculars during the daytime (06:30 - 19:30 CDT). Although most of the whales were seen in water depths of 900-1000 m, we heard/saw animals in water depths both shallower (to 700 m) and deeper (to 1300 m).

All S-tag, Photo-ID, and Biopsy/Genetic Typing activities were conducted in accordance with federal permits from the US National Marine Fisheries Service (NMFS) to Oregon State University (permit 365-1440-01), to Texas A&M University-Galveston (permit 821-1588-00), and to Dan Engelhaupt/University of Durham (permit 909-1465-01). Table 1 lists the 24 members of our scientific party.

Oceanographic Habitat

We designated a survey area based on depth zones in which most sperm whale sightings in the north central Gulf of Mexico had been made in the past (Ortega, unpublished) and on the tracks of a satellite-monitored sperm whale tagged in 2001 (Mate, unpublished). Within this area we conducted both a survey effort along pre-determined tracklines and more directed searches based on the sighting and tagging information, as well as Sea Surface Height (SSH) analyses. The latter were made available in near-real-time by Robert Leben to a University of Colorado Center for Astrodynamics Research website (http://www-ccar.colorado.edu/~realtime/gom-historical_ssh/). The SSH map for 9 June 2002 that we downloaded pre-cruise indicated that circulation over the middle continental slope should be cyclonic (counterclockwise) both west of about 92°W and east of about 89°W. That 9 June 2002 SSH analysis further indicated that we would likely encounter an anticyclonic (clockwise) warm slope eddy (WSE) between 92°W and 89°W that would separate these two regions of cyclonic circulation. We anticipated that this counterclockwise-clockwise-counterclockwise circulation triad would act like a series of counter-rotating gears to advect high salinity, low chlorophyll "blue" water onto the margin near 92°W, and to entrain low salinity, higher chlorophyll shelf water and transport this "green" water off margin near 89°W.

Subsequent SSH analyses for 17, 24, and 30 June that we received just before sailing, during the first week that we were at sea, and during the second week we were at sea, respectively, all showed this same general geometry. By comparing the SSH analyses for 9, 17, and 24 June, however, it appeared from a week-to-week temporal perspective that the more eastern of the two areas of cyclonic circulation was relaxing (becoming less negative in SSH anomaly). This relaxation of negative SSH anomaly in this cyclone to the east of 89°W was coincident with the NW movement of a second WSE that was originally (9 June) centered over the lower slope of the eastern slope of DeSoto Canyon, at 27°N and 86°W. By 24 June this eastern WSE looked to us to be interacting with and beginning to merge with the WSE that was originally sandwiched 92°W-89°W between the two areas of cyclonic circulation on the upper to middle slope. The merger of these two WSEs is suggested by the formation of a figure-eight area of local SSH high that is best seen by comparing the SSH analyses of 17 June (pre-cruise), 24 June (week 1), and 30 June (week 2).

Data from our flow-through system, XBT drops, and CTD stations generally confirm this picture. Figures 3-5 summarize flow-through temperature, salinity, and fluorescence. West of 94.5°W and east of 88.2°W, the surface salinity was < 36 and the water was visibly greenish in color. Chlorophyll concentrations in this "green" water averaged about 0.15 μg/L. Between 94.5°W and 88.2°W, surface salinity was generally > 36. Here, the water was azure blue in color and surface CHL concentrations averaged 0.1 μg/L or less. We found two exceptions to the general rule that high salinity, "blue" water characterized the region 94.5°W to 88.2°W. The first was on 25-26 June, as we explored the head of Mississippi Canyon near 28.1°N, 89.5°W. Here, as we drove up-canyon, salinity dropped from 36.4 to 35.9 and surface water color went from azure blue to visibly greenish-brown as surface CHL concentrations increased to 0.17 μg/L. The second was on 3-4 July, when we surveyed the Gulfport Valley region of the mid-slope near 28.9°N, 88.7°W. There, within 25 nautical miles of the Mississippi River delta, we entered surface water that was darker green in color, in which CHL concentrations reached 0.2 μg/L and in which salinity dropped to 34.4.

Between 88.2°W and 86.6°W, surface salinity generally ranged 32-35. A CTD cast in this region showed that the low salinity surface water was only about 5-10 m thick. This water was visibly green in color (CHL > 0.2 μg/L). Surface salinity as low as 27.5 and CHL concentrations > 0.4 μg/L were documented on 1 July in the Dorsey Canyon and Sounder Canyon area near 29.0°N, from 88.1°W to 87.8°W. We presume this low salinity water originated in the Mississippi River delta and was entrained into the off-margin confluence flow created between the weakening cyclone that the SSH analysis for 30 June indicated was centered near the shelf-slope break at 29°N and 88°W and the two WSEs that were merging over the middle and lower slope to the south. In general though, between 87.3°W and 87.1°W, the salinity was 32-34 and this increased to 34-35 to the east, between 87.1°W and 86.8°W. East of 86.6°W, salinity rose to > 36 and the water color changed from green back to azure blue.

From the five CTD stations done on this cruise, we know that the salinity increased to a maximum of about 36.6 between 50-150 m below the surface (Figure 6). However, none of the five CTDs showed the markedly higher salinity (i.e., salinity > 36.65 in this subsurface maximum) that is the diagnostic signature for Subtropical Underwater (SUW). Property-property plots of temperature versus salinity (TS plots) are a useful way to verify the absence of this SUW and to compare the individual CTDs (Figure 7). The absence of SUW is indirect but strong evidence that the mid-slope WSE(s) formed as shallow, warm filament(s) that squirt towards the continental margin as a Loop Current Eddy (LCE) transits westward in deep water. Were the WSE(s) still exchanging water with a deep water LCE, it (they) should have retained the characteristic subsurface high salinity that is diagnostic of the Caribbean origin of this SUW, for this salinity > 36.65 is the signature of the Loop Current and the LCEs that separate from it. In fact, a review of pre-cruise SSH analyses for the two months that preceded cruise 02G08 shows that the more western of the WSEs formed in late March 2002 as a filament of locally high SSH extending ENE from "Pelagic" Eddy (LCE-P). The magnitude of the SSH signal associated with this WSE (<20 cm) as well as with the eastern WSE (SSH < 20 cm) is additional evidence that both anticyclonic WSEs were secondary filaments shed from a deepwater LCE (SSH > 40 cm).

Figure 8 and Table 2 show that the depth of the 15°C isotherm generally ranged 200-250 m along most of the ship track from 94.7°W to 86.4°W. The 15°C isotherm was locally deepest (to 300 m) within the northern periphery of the mid-slope WSE between 91.0°W and 89.5°W. The shallowest 15°C depths (180-200m) were found near 94°W (XBTs 19, 20), from 91.5°W to 92.3°W (XBTs 28-30 and CTD 2), and east of 87.5°W (XBT 41).

In summary, whales were heard/seen both in green water and in blue water environments. Although some of the whales were encountered in the green water, low salinity, off-margin flow east of 88.1°W, the greatest number of acoustic and visual contacts with whales this cruise were in the region 90.3°W to 88.1°W. The oceanographic environment in this region 23-27 June and again 2-8 July was blue water, not green water. Specifically, surface salinity in the region 90.3°W to 88.1°W generally was > 36, and CHL was generally 0.1 μg/L or less. A quick, at-sea look at the 153 kHz ADCP record indicates that currents in this region 90.3°W to 88.1°W generally ran from W to E, or from WNW to ESE, following anticyclonically around the northern edge of the mid-slope warm slope eddy. Although our cruise track did not extend south far enough to reach the center of that WSE, we documented 15°C depths > 270 m in XBT drops made at the deeper (southernmost) zags downslope from the 1000 m isobath. Because most of our cruise track was restricted to water depths 575 - 1430 m, we do not know whether more whales were present offshore, in deeper water. However, from the time series of satellite position fixes on the 18 whales that were S-tagged during this cruise we will be able to estimate the frequency with which individuals may range seaward from the 900-1000 m isobath into very deep water.

Visual Survey and Monitoring

A visual observation station was established on the flying bridge consisting of three stand-mounted BigEye binoculars and a data entry station. A team of at least three observers maintained a continuous watch during daylight hours (06:30 - 19:30 CDT) while R/V *Gyre* transited/surveyed in water depths > 500 m. Two of the observers were on BigEye binoculars while the third person (data recorder) kept watch closer in with naked eye and with 7x50 binoculars. This third person also entered data into a laptop computer running Logger software. Logger is a data collection and depiction program written by Douglas Gillespie and made available by the International Fund for Animal Welfare.

The visual team worked in two different modes. During surveys they collected data following a standard line transect protocol. Visual and acoustic monitoring teams operated independently during this time and only shared information on sperm whale detections once they had come abeam of the ship, at which stage the survey was broken so that the animals could be approached for tagging and photo-ID work. Locations of sperm whale sightings during survey plus directed searching are shown in Figure 2. Locations where pilot whales, false killer whales, and pygmy/dwarf sperm whales were sighted are shown in Figure 9. Locations where bottlenose, rough-toothed, pantropical spotted, and spinner dolphins were sighted are shown in Figure 10.

Once sperm whales had been sighted and the RHIBs were deployed, the visual team worked in a second operating mode. This involved spotting animals, fixing their positions using reticule measurements to determine range and bearings from the sum of relative bearing and ship's heading, and using this information to guide the small boat(s) to whale locations. The boats were guided by providing Latitude and Longitude values for the sightings or projected surfacing area from Logger, and/or by guiding the boats to the whales verbally. The locations of all first sightings and final submergences were recorded in Logger. In this tracking mode visual and acoustic teams worked closely together. The aim was to amalgamate all information on the location and behavior of whales (visual, acoustic data from the *Gyre*'s array and acoustic information from the RHIB boats' directional hydrophones) to form a view of the groups' movements and behavior. The visual team's final task was to suggest course and speed changes to the bridge to keep the *Gyre* in a position in which its visual coverage of whale aggregations (which typically spread over several miles) was optimal. We found that visual coverage and support could be provided most effectively when groups of whales were kept at a range of 1-4 km from the *Gyre*.

A digital video camera was mounted on a third pair of BigEyes and was used opportunistically, to collect accurate range and bearing for the video recordings and to document detailed animal movements and behavior.

Use of RHIB-2 in Support of Tagging and Photo-Identification

RHIB- 2 (the *Gyre*'s 14 foot Avon) was launched to support the RHIB-1 tag boat whenever sperm whales were sighted. RHIB-2 was crewed by two and sometimes three members of the scientific party who were experienced in driving small boats close to whales, tracking whales using a directional hydrophone, and taking identification photographs (visual-ID). RHIB-2 was equipped with a palmtop computer linked to a GPS that allowed the detailed track of the boat as well as the position of diving whales to be recorded accurately. Identification photographs were taken using a digital EOS 1D Canon Camera with a Sigma 100-300 mm telephoto lens. Ranges to whales were measured using Bushnell or Leica laser range finders.

The primary task of the RHIB-2 was to track whales acoustically to provide fine scale information on the location of submerged whales, thus allowing the tag boat (RHIB-1) to be close to whales when animals surfaced. This proved to be very effective, and allowed both RHIBs and the *Gyre* to stay close to groups of whales. Most of the time, the crew on the RHIB-2 also kept close to RHIB-1 to try to take identification photographs of whales once they were tagged. This was not very productive from a photo-ID perspective, however, as after whales were tagged they rarely fluked up, and when groups of 5 or more sperm whales were encountered it was not possible to acoustically track individual tagged whales through complete dive cycles. In reality, the most successful way of getting an identification photograph of a tagged whale was to take as many identification photographs as possible of as many different whales as possible instead of exclusively operating very close to RHIB-1. For example, during the flat-calm sea conditions on 3 July when RHIB-2 was not required to stay in close proximity to RHIB-1, four of the tagged whales were successfully photo-identified and tag attachments photos were taken. In addition, photo-ID images were taken from RHIB-1 using a conventional SLR, and these will be included in the fluke photos catalog in due course.

Although the number of photo-identification images obtained, 32, would be disappointing for a dedicated photo-ID cruise of this length, as explained above, photo-identification was a secondary goal of this S-tag cruise. During offshore photo-ID projects from small boats in other parts of the world, we would expect to average at least 10 identified animals a day. However, it is clear from this S-tag cruise experience that the use of one or more RHIBs with support from a visual team equipped with Big-Eye binoculars operating from an elevated platform on a mother vessel can be an effective way of collecting photo-ID material with Gulf of Mexico sperm whales. The broader perspective offered from an elevated viewing platform also may allow for a more systematic identification of animals in large aggregations.

This was the first occasion on which we had been able to use a digital camera to take sperm whale photo-identification images, and, as far as we know it is the first time this technology has been used with this species. The system proved excellent and offers many advantages over film, including the ability to take detailed sequences of each fluke up and to review photographic data and maintain the photo-catalogue at the end of each working day. We also had the opportunity to test beta versions of two new programs for automated photo-identification of sperm whales. One program, temporarily named “Phlukes”, assists the user in extracting the identifying contour of the fluke from the photograph. The other program, temporarily named “Match”, finds contours similar to those of the target image from a collection of contours previously extracted from a collection of photos. Both programs are written in Java and are being developed within “Europhlukes”, an EU-funded project under the direction of Reuben Huele that will set up a European database of cetacean images.

Each day’s photos were matched against a set of 2500 photos of sperm whale flukes in the NAMSC catalogue (North Atlantic and Mediterranean Sperm whale Catalogue). This was both to find possible matching photographs and also to test performance, ease of use, clarity of the interface, and logic of the data handling procedures. On a dedicated photo-ID project, such immediate information on the identity of individuals could be used to best direct subsequent days’ survey effort.

No matches of animals were found other than those among photos taken during this cruise. However, given the small number (36) of images from the Gulf of Mexico region that were archived in NAMSC before this present cruise, this is perhaps not surprising.

Despite the success of this cruise and of using the *Gyre* and two RHIBs as research platforms, several frustrations/limitations were found:

- It proved very difficult to stay with a group of whales at night due to the limited maneuverability and ship noise levels of the *Gyre*. This impaired tagging activities on several occasions when large groups seen late in the day were lost at night. Moreover, the *Gyre* was not in acoustic or visual contact with whales on some days when the weather was excellent.

- The low number of images obtained on this present cruise (just 32 fluke photos).

- Many of these shortcomings could be overcome by using another small independent vessel. This could provide a high level of support during tagging cruises by providing a quiet monitoring platform which would be much better able to find whales and track them through the night. It would also be able to monitor in other locations while the *Gyre* is at sea increasing the probability of finding whales. Such a vessel could also conduct longer-term acoustic monitoring, acoustic tracking and photo-identification/biopsy projects to provide more detailed information on how sperm whales use the habitat around oil-related structures and how they respond to acoustic sources such as seismic airguns and oilrigs.

Acoustic Monitoring, Detection and Tracking

R/V *Gyre* was outfitted with two acoustic monitoring arrays for this cruise: one built by Ecologic, and the other provided by the Woods Hole Oceanographic Institution (WHOI). Both arrays had similar hydrophone streamer sections consisting of 2 (Ecologic) or 3 (WHOI) hydrophone elements mounted about 3 m apart and housed in a ~10 m long polyurethane tube. The WHOI array was attached to a batfish depressor, which was intended to pull the hydrophone elements down and allow the WHOI array to monitor at greater depth than the Ecologic array. Unfortunately, the WHOI hydrophones/batfish combination was found to rattle at ship speeds ≥ 5 knots, and was generally noisier at lower speeds. Consequently, all monitoring was performed using the Ecologic hydrophone array, except during a series of trials to compare the two systems and a period of maintenance on the Ecologic array when the WHOI system was used as the primary monitoring array.

For most of the time the Ecologic hydrophone was deployed at the maximum cable length (approximately 400 m). With this amount of cable out, the hydrophone elements towed at an estimated depth of about 50 m. During surveys the vessel maintained a speed of 6 knots – which represented a good compromise between reducing noise and covering ground. A team of four acoustic monitoring personnel (monitors) provided 24 hour coverage for all of the time that the ship was seaward of the continental shelf. Two detection programs, “Rainbow Click” and ”Whistle” ran more or less continuously and their detection records were stored as computer files. Ishamael software was also run for long periods in real-time spectrogram mode. (Rainbow click, which automatically detects sperm whale clicks and calculates and displays their bearings, was written by Douglas Gillespie and made available by the International Fund for Animal Welfare. Whistle was written by Oliver Chappel and Doug Gillespies and was made available by Shell UK; it automatically detects and displays mid-high frequency tonal sounds. Ishmael was written by and made available by David Mellinger and provides a variety of acoustic detection, display functions.)

The monitors listened carefully to the hydrophones using stereo headphones for one minute every 15 minutes, and then scored and noted levels of noise and cetacean vocalizations in the Logger program. Monitors listened to a training program on the first day of the cruise and compared the way they scored sounds among themselves during the cruise to maintain a consistent scoring system. In addition, regular 20-second acoustic samples were recorded every two minutes and continuous recordings were made of interesting noises, including vocalizations from identified cetaceans, click trains from single animals over entire dives, and coda vocalizations from sperm whale social groups. During different phases of the cruise and depending on the requirements of tagging work, acoustic monitors either conducted standard survey monitoring, conducted searches for whales, or assisted in tracking groups and locating individuals for tagging and photo-ID.

The primary acoustic monitoring station was established in a dry lab aft of the computer room on the 01 deck. During days when groups of whales were being tracked for tagging and photo-ID, a second, open-air acoustic monitoring station was established on the flying bridge. This topside station facilitated the coordination of visual and acoustic information on whale locations during these periods. In addition, hand-held directional hydrophone units were carried in each of the RHIB boats. Acoustically equipped RHIBs proved to be a most effective method for fine-scale tracking during extended encounters with groups of whales. Monitoring could be performed away from the noise of the Gyre, and the vessels could respond and move speedily to quickly localize animals. The directional hydrophone that was designed and built for this project appeared to perform better than three older units that we had borrowed from various sources for use from the small boats.

Forty-seven hydrographic stations were occupied during our survey of the middle continental slope (Figure 1B), and sperm whales were detected acoustically at/near about 25% of these stations (Figure 11). In addition to monitoring for cetacean vocalizations, the presence of anthropogenic noise was noted. The *Gyre*'s own engine and prop sound masked many sources of anthropogenic noise, but seismic shots were a prominent part of the acoustic scene and were detected at a number of the stations. Opportunistic acoustic monitoring from the RHIBs close to Shell's Ursa platform and near several other rigs detected strong tonal sounds which may have resulted from drilling operations.

When constructed in 1973, the *Gyre* was not specifically designed to be a quiet ship, so when towing Ecologic or WHOI arrays its engine noise and other ship noises limited our ability to hear whales unless animals were only a few km away. Nonetheless, most encounters with whales were initiated acoustically. It soon became evident, on days when the weather was favorable but whales had not been located by the *Gyre*, that the search effort could be increased dramatically by dispatching either one, or both, of the RHIBs to monitor acoustically ahead of or abeam of the *Gyre*, using directional hydrophones. When operated in this mode, the RHIBs greatly extended our effective acoustical swath. While this RHIBs-as-acoustic-spotter-boats scenario had not been anticipated before this cruise, by the midpoint of the cruise we were able to put together two omni-directional hydrophone systems using spare equipment that was on hand. Use of these omni-directional hydrophones, along with use of one of the directional hydrophones, allowed reasonably effective away-from-the-mother-ship monitoring from the RHIBs.

In summary, acoustic monitoring is an essential component of the SWSS fieldwork. Not only is it the most effective way of finding and following sperm whales, it also provides baseline information on the acoustic scene to provide the context in which sperm whale behavior can be understood. The *Gyre* is not an ideal acoustic platform. Some of the noise and maneuverability difficulties might be overcome by using more sophisticated acoustic systems such as two dimensional arrays and tracking software, beamforming arrays, and/or using longer cable lengths for the towed hydrophone arrays. However, serious consideration should be given to doing acoustic monitoring next year (summer 2003) from a second, motor-assisted sailing vessel that would supplement the acoustic monitoring that is done aboard R/V *Gyre*. Not only would the sailing vessel be inherently quieter than R/V *Gyre*, but because it would be a stand-alone platform it could stay with a group(s) of whales and/or continue and extend the survey for animals that may be tens to hundreds of miles away from the ship track of the oceanographic research vessel.

Satellite-Monitored Tagging

Eighteen whales were tagged during the course of the 3-week cruise (Figure 12). Tagging was done when/where groups of whales were encountered between the western edge of the Mississippi

Canyon (MC) and DeSoto Canyon (DC), with the majority of the tags applied south and southeast of the Mississippi Delta (MD). The air applicator system worked extremely well. Sixteen of the 18 tags were deployed completely; the other two were 40-50% deployed. In general, tags were placed within 6 inches of the mid-line along the whale's back between the middle of the base of the dorsal fin and 18" forward of the dorsal fin. This is an area that surfaces quite regularly and should provide good numbers of uplink messages during satellite passes when whales are at the surface. High-speed video, taken from a video with a fast shutter speed, of each tag application revealed the causes of the two tags deploying incompletely. This enabled appropriate adjustments in hardware and technique to be made in the field. Both of the two incompletely deployed tags were well placed on the whales backs, and both have good antenna orientation.

The Oregon State University diesel-powered rigid hulled inflatable boat (RHIB-1) with an extended bow pulpit worked well for close approaches to tag sperm whales. The added forward distance allowed closer approaches without whale responses. The added height allowed a better vertical orientation of the antenna. Most tags were applied to whales which were within 3 meters of the tagging platform. The *Gyre*'s crew did a masterful job of launching and retrieving the RHIB in an area of very limited deck space suitable for the crane's operation with a vessel weighing 3400 pounds. Bimini protection and an ample water supply were necessities as operations away from the ship lasted up to 12 hours/day.

We encountered whales only infrequently during the first week of the cruise. During this first week we also were hampered with swells large enough to prevent launching RHIB-1, because of risk of damage to its bow pulpit should either RHIB-1 or mother ship surge during over-the-side deployment of RHIB-1. During week 2, when we searched the eastern extremity of DeSoto Canyon, calm weather did not coincide with whale sightings. But during the third week of the cruise, we encountered good concentrations of whales. On calm weather days, we tagged up to 7 whales in a single day. Tags were applied in sea states up to Beaufort 4, winds up to 15 knots, and swells up to 3 feet. Beyond these conditions, tag application was impossible.

The tags are on a duty cycle which only allows them to transmit for 4 pre-selected hours every third day for the first 54 days. Starting 5 days before the D-tag cruise, the tags will start transmitting 4 hours/day on a daily basis to provide the WHOI group detailed information on whale locations for their cruise planning and throughout the one month cruise itself. During the D-tag cruise we expect one location/day on average. Following the D-tag cruise, satellite tags will transmit 4 hours/day every fourth day to extend their operational life and document longer-range seasonal movements.

Just before the end of the cruise, a 4-hour transmit cycle resulted in 17 locations of 12 tagged whales. This was very good. Argos orbits only last for maximum of 16 minutes overhead (10 minute average), while whales dive for 40 minutes and are at the surface for only about 10 minutes between dives. Thus, whales are only at the surface and available to transmit for 20% of the time on average and it is not unusual that many fully-functional tags will not be heard during any specific duty cycle.

Biopsy/Genetic Typing

Biopsy sampling during the satellite-tagging cruise exceeded all expectations. Skin and blubber samples from fifteen (possibly sixteen – pending genetic and photo identification of the sixteenth sample) of eighteen sperm whales outfitted with OSU satellite tags were obtained with sterilized darts. Although biopsy sampling and tagging operations were most successful on sperm whales occupying deepwater areas throughout the Mississippi River Canyon, we did manage to collect samples from whales in the DeSoto Canyon (Table 3). During tagging approaches, whales' sizes were estimated and a decision was made to proceed with tagging or switch to a biopsy-only approach for immature whales too small to tag. In all, a total of twenty-five skin samples were collected during the S-tag cruise. Given the amounts collected per biopsy, all tissue samples obtained are expected to provide more than ample material for all genetic applications.

As explained in the original proposal, the combination of satellite tagging and genetic techniques provides an in-depth examination of sperm whales found in the northern Gulf of Mexico. Molecular sexing, microsatellites, and mitochondrial DNA sequencing will provide a rich set of information that can be directly integrated with the movements of satellite tagged whales. We obtained a biopsy sample from multiple members of six groups (several of these sampled individuals have satellite tags to match). Degrees of relatedness will be tested between whales found within groups, allowing us to begin to answer questions such as how related and unrelated whales found within groups in the northern Gulf of Mexico maintain long-term close associations over space and time. In an ideal situation, one would attempt to sample all members that comprise a group. Given this year's primary focus on the satellite tagging effort, this was not possible. While our resulting genetic composition of groups may not portray an accurate representation of group structure for free-ranging sperm whales found in the Gulf of Mexico, the benefits of combining biopsy sampling and satellite tagging will supply numerous answers to previously unknown questions.

Table 1: R/V *Gyre* cruise 02G08 Science Teams

FPC (Field Party Chief):	Doug Biggs (TAMU College Station)
Electronics Technicians	Eddie Webb (TAMU College Station) Paul Clark (TAMU GERG)
Deck Engineers	Bill Green (TAMU Galveston) Mike Fredericks (TAMU GERG)
S-tag Team:	Bruce Mate (OSU Newport) * Mary Lou Mate (OSU Newport) Ladd Irvine (OSU Newport) Daniel Palacios (OSU Newport)
Visual Team	Nathalie Jaquet (TAMU Galveston) * Joel Ortega (TAMU Galveston) Christoph Richter (Canada) Will Rayment (New Zealand) Jamie McKee (SAIC) Erin LaBrecque (New Hampshire) Larry Glickman (Oregon)
Acoustic Team	Jonathan Gordon (Ecologic UK) * Sarah Tsoflias (MMS New Orleans) Ricardo Antunes (Madeira) Reuben Heule (Nederlands) Dan Lewer (OSU Newport)
Biopsy/Genetic Typing	Dan Engelhaupt (Durham Univ UK)
Flow Through Fluorescence/CHL	Alicia Salazar (TAMU College Station)
Videography **	Terry Ketler Productions, San Francisco

* Team Leader
** Complimentary Program, added at no cost to MMS since bunk space #24 was available

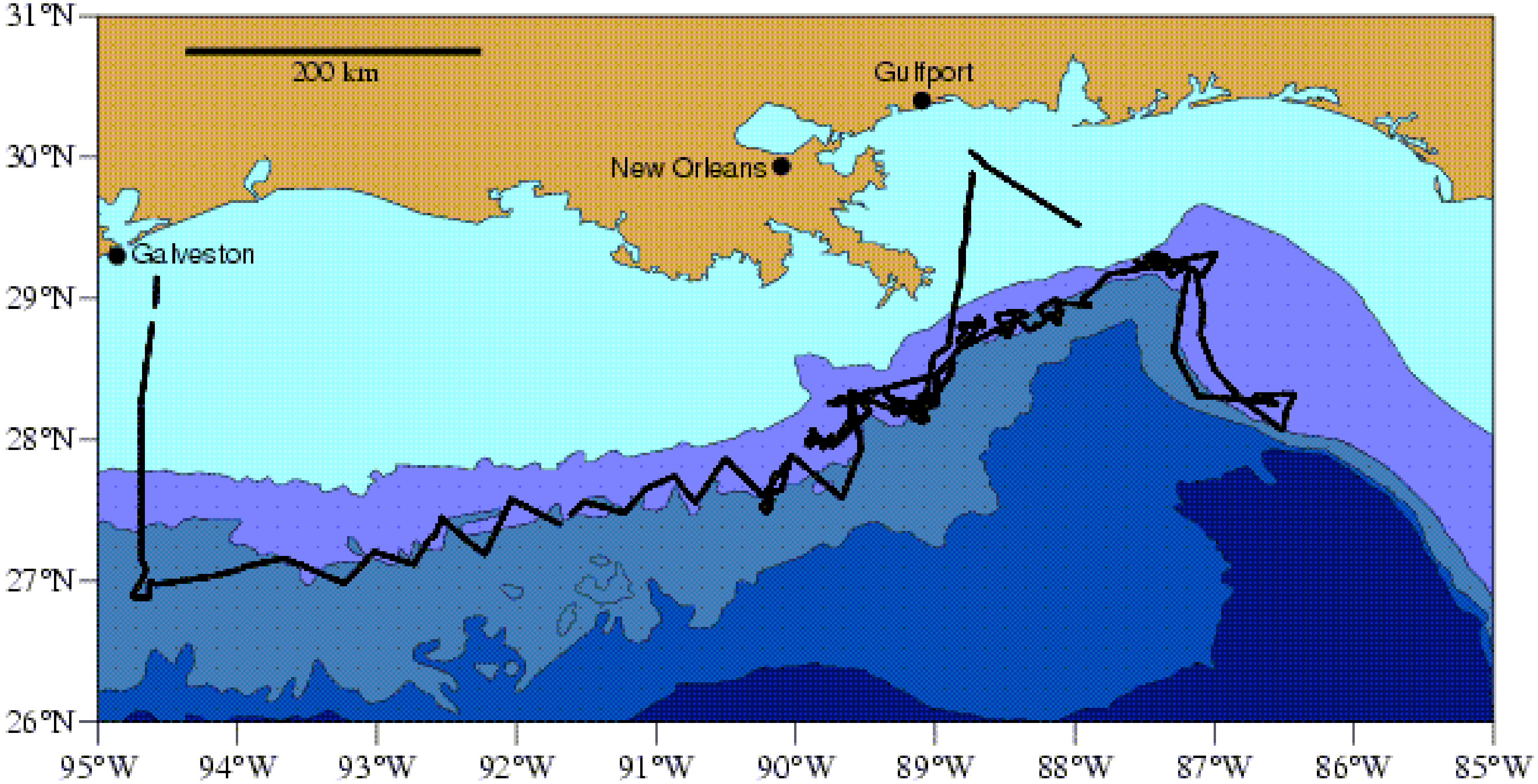
Table 2. Summary of hydrographic station, *R/V GYRE* cruise 02G08.

Station	Date	GMT	Latitude (°N)	Longitude (°W)	water depth (m)	15°C depth (m)
CTD-01	20-Jun	16:05	27.08	-94.68	1030	214
XBT-13 (T7)	21-Jun	1:52	27.03	-94.16	1780	194
XBT-14 (T7)		6:10	27.16	-93.67	1020	189
XBT-15 (T7)		10:10	26.98	-93.24	1325	209
XBT-16 (T7)		12:49	27.20	-93.03	1160	205
XBT-17 (T7)		15:32	27.12	-92.75	1360	207
XBT-18 (T7)		21:29	27.44	-92.53	920	218
XBT-19 (T7)	22-Jun	1:09	27.20	-92.25	1430	193
XBT-20 (T7)		6:21	27.57	-92.04	700	190
XBT-21 (T7)		10:37	27.40	-91.69	1000	194
CTD-02		13:55	27.55	-91.51	942	189
XBT-22 (T7)		16:50	27.48	-91.24	1275	223
XBT-23 (T7)		21:01	27.74	-90.88	925	245
XBT-24 (T7)		23:20	27.56	-90.72	955	272
XBT-25 (T7)	23-Jun	2:45	27.85	-90.52	660	258
XBT-26 (T7)		6:05	27.61	-90.24	1000	300
XBT-27 (T7)	24-Jun	0:39	27.88	-90.04	700	256
XBT-28 (T7)		4:42	27.60	-89.69	1125	283
XBT-29 (T7)		8:08	27.92	-89.53	1010	231
CTD-03	25-Jun	1:06	28.00	-89.87	680	247
XBT-30 (T7)	26-Jun	2:47	28.33	-89.60	840	212
XBT-31 (T7)		7:42	28.15	-89.16	760	208
XBT-32 (T7)	27-Jun	0:37	28.58	-89.01	575	224
CTD-04		1:56	28.66	-88.91	990	214
XBT-33 (T7)	28-Jun	19:40	29.27	-87.32	790	211
XBT-34 (T7)	29-Jun	2:55	29.01	-87.10	830	228
XBT-35 (T7)		5:34	28.75	-87.10	820	206
XBT-36 (T7)		8:08	28.50	-87.00	860	210
XBT-37 (T7)		10:42	28.29	-86.81	980	230
XBT-38 (T7)		13:54	28.07	-86.52	1180	231
XBT-39 (T7)		16:26	28.31	-86.43	715	225
XBT-40 (T7)	30-Jun	6:09	28.31	-87.11	1330	222
XBT-41 (T7)		9:32	28.62	-87.29	1150	186
XBT-42 (T7)		14:05	29.08	-87.21	1000	228
XBT-43 (T7)		15:24	29.21	-87.17	800	226
CTD-05		20:52	29.27	-87.44	870	201
XBT-44 (T7)	1-Jul	13:18	29.17	-87.77	1055	219
XBT-45 (T7)		16:03	28.99	-87.94	1425	221
XBT-46 (T7)	2-Jul	12:14	28.89	-88.17	1175	226
XBT-47 (T7)		21:48	28.80	-88.52	1100	239
XBT-48 (T10)	3-Jul	12:09	28.68	-88.62	1030	216
XBT-49 (T10)	4-Jul	5:49	28.48	-88.98	927	217
XBT-50 (T10)		7:58	28.26	-88.99	1210	216
XBT-51 (T10)		13:42	28.28	-89.28	813	222
XBT-52 (T10)	5-Jul	1:45	28.26	-89.70	775	218
XBT-53 (T10)		10:52	28.46	-88.99	970	215
XBT-54 (T10)	8-Jul	1:58	28.69	-88.96	790	211

Table 3. Biopsy/Genetic Typing tissue samples collected during S-tag fieldwork. Sample number code gives the date (yymmdd) followed by the consecutive number for multiple samples taken on any given day (01 to 08).

Sample #	Tag #	Group #	Approx. # Whales in Area	Latitude (N)	Longitude (W)
02062401		1	8	28º03.34	89º40.14
02062402	5660	1	8	28º00.70	89º41.76
02062403	5654	1	8	27º59.62	89º54.81
02062801	5648	2	8	29º12.47	87º10.70
02070101	5685	3	15-20	28º57.47	88º06.55
02070102	5650	3	15-20	28º57.37	88º06.53
02070103	5726	3	15-20	28º57.07	88º06.75
02070104	5725	3	15-20	28º54.18	88º05.93
02070105	5647	3	15-20	28º54.17	88º05.54
02070106		3	15-20	28º54.17	88º05.54
02070201	5678	4	8	28º51.96	88º29.74
02070202		4	8	28º53.04	88º28.66
02070301	5719	5	6-11	28º47.62	88º48.49
02070302	5709	5	6-11	28º42.30	88º45.84
02070303	5670	5	6-11	28º50.37	88º41.49
02070304	5720	5	6-11	28º51.02	88º40.40
02070305		5	6-11	28º51.02	88º40.40
02070306	5655	5	6-11	28º47.96	88º41.94
02070307	5701	5	6-11	28º48.30	88º41.89
02070308	5669	5	6-11	28º48.47	88º41.02
02070601		6	6-8	28º25.55	89º03.01
02070602		6	6-8	28º26.68	88º59.44
02070701		7	14-16	28º42.07	88º39.92
02070702		7	14-16	28º44.50	88º52.50
02070801		8	6	28º59.52	88º14.32

Figure 1A. S-Tag cruise trackline (from GDAS data)



Bold line indicates S-Tag cruise track.
Depth contours shown: 200m, 1000m, 2000m, and 3000m.

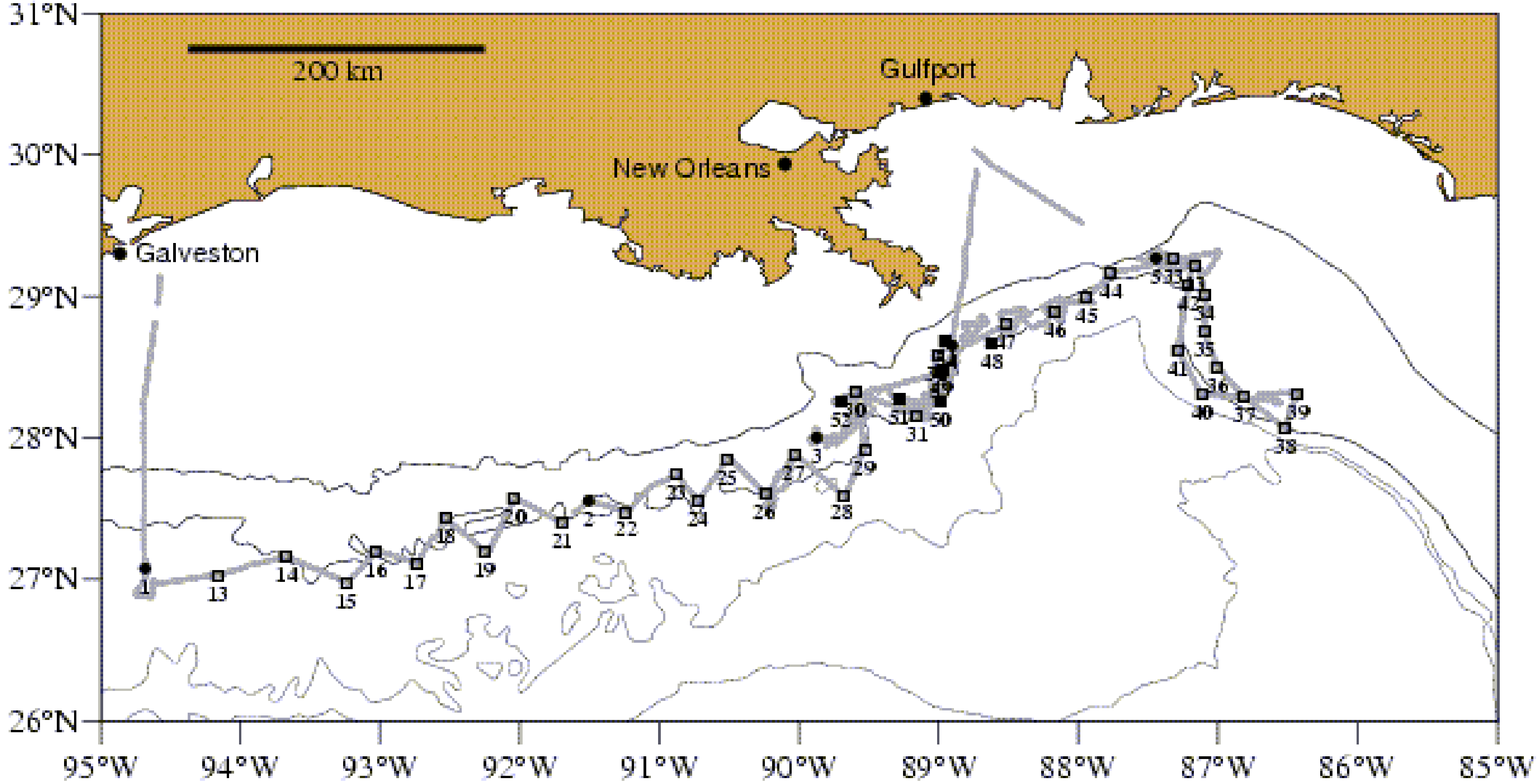
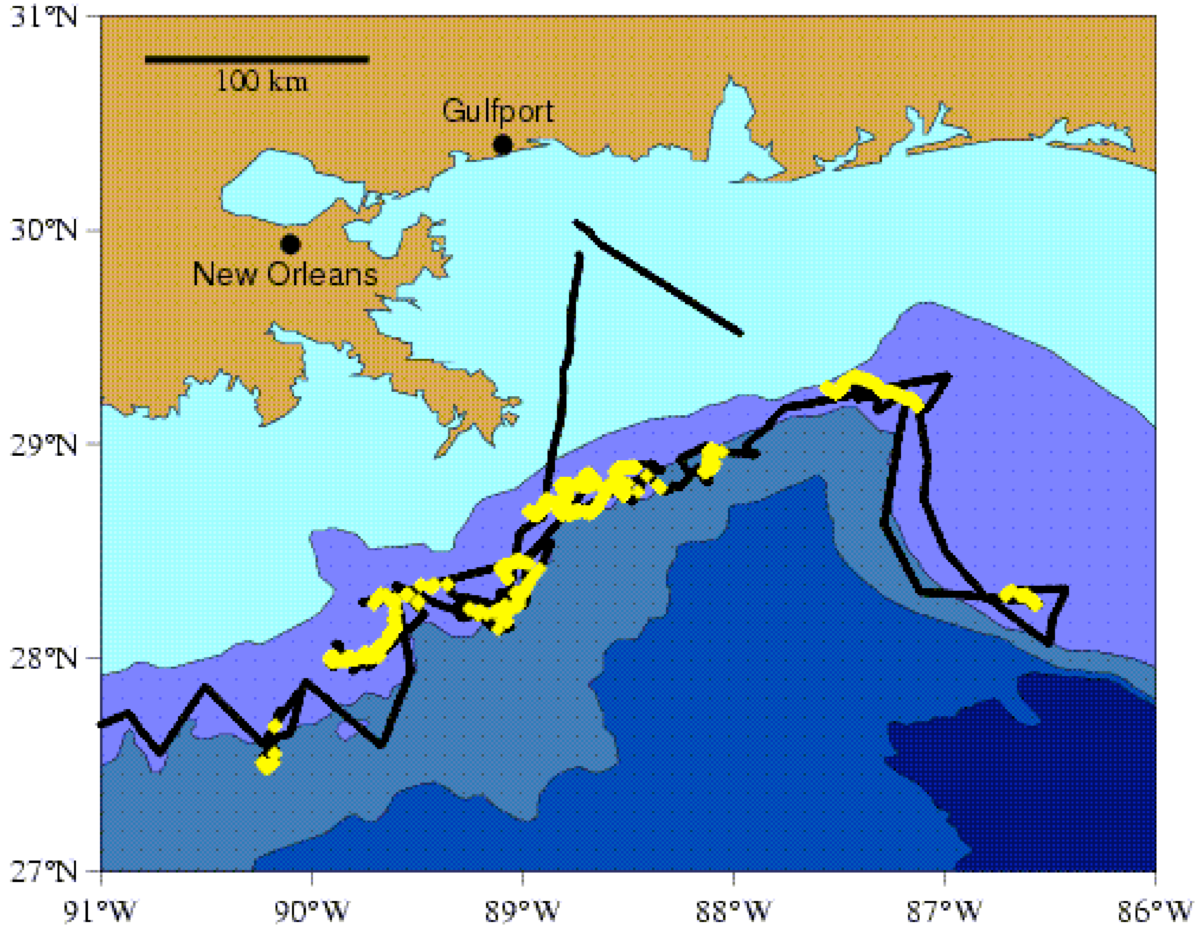


Figure 1B. Location of CTD (circles), T7 XBT (empty squares), and T10 XBT (filled squares) stations during the cruise S-Tag. Gray line indicates S-Tag cruise track. Depth contours shown: 200m, 1000m, 2000m, and 3000m.

Figure 2. Location of sperm whale sightings



Bold line indicates S-Tag cruise track.
Depth contours shown: 200m, 1000m, 2000m, and 3000m.

Figure 3. Sea surface temperature measured along cruise track line

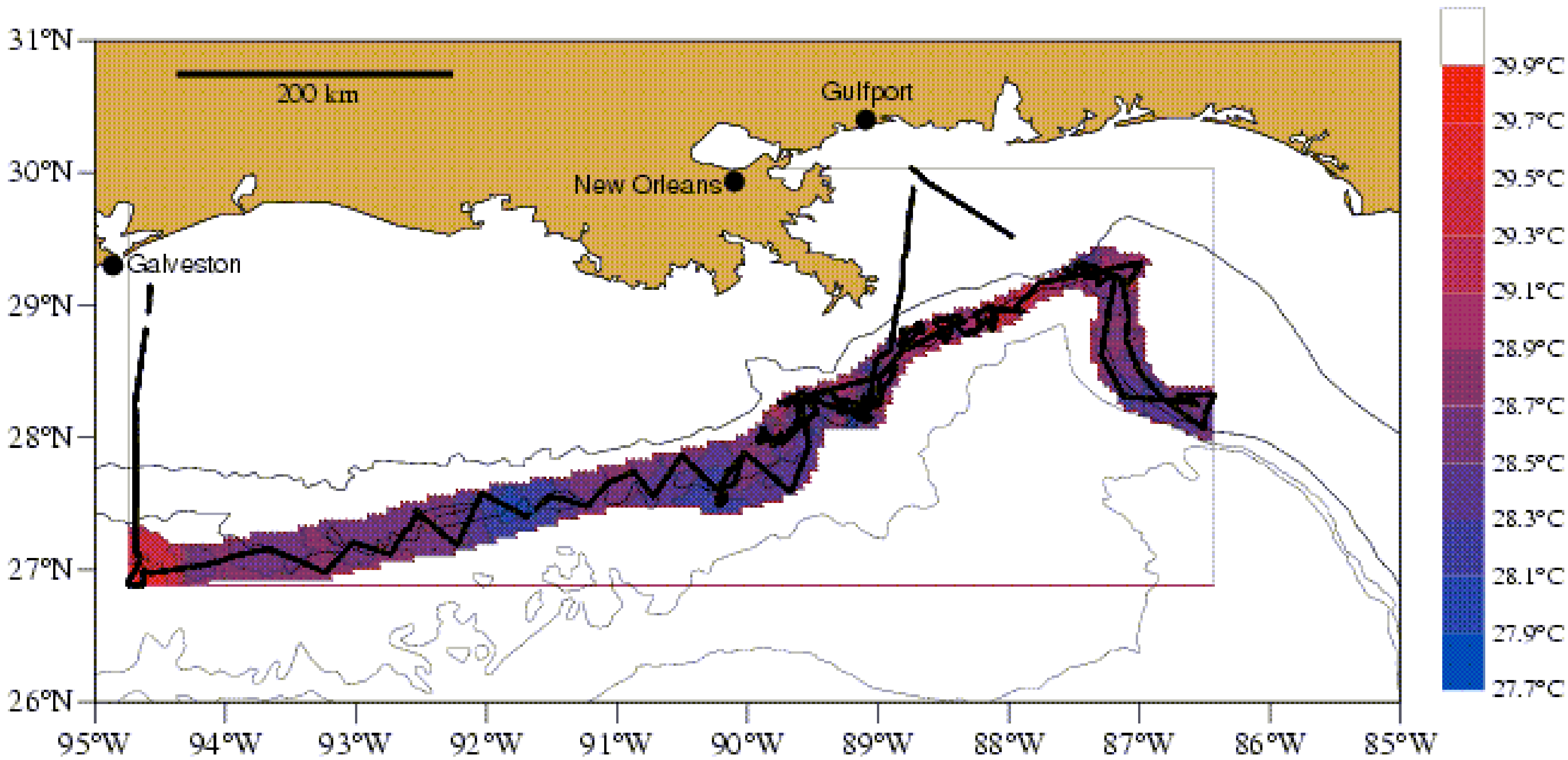


Figure 4. Sea surface salinity measured along cruise track line

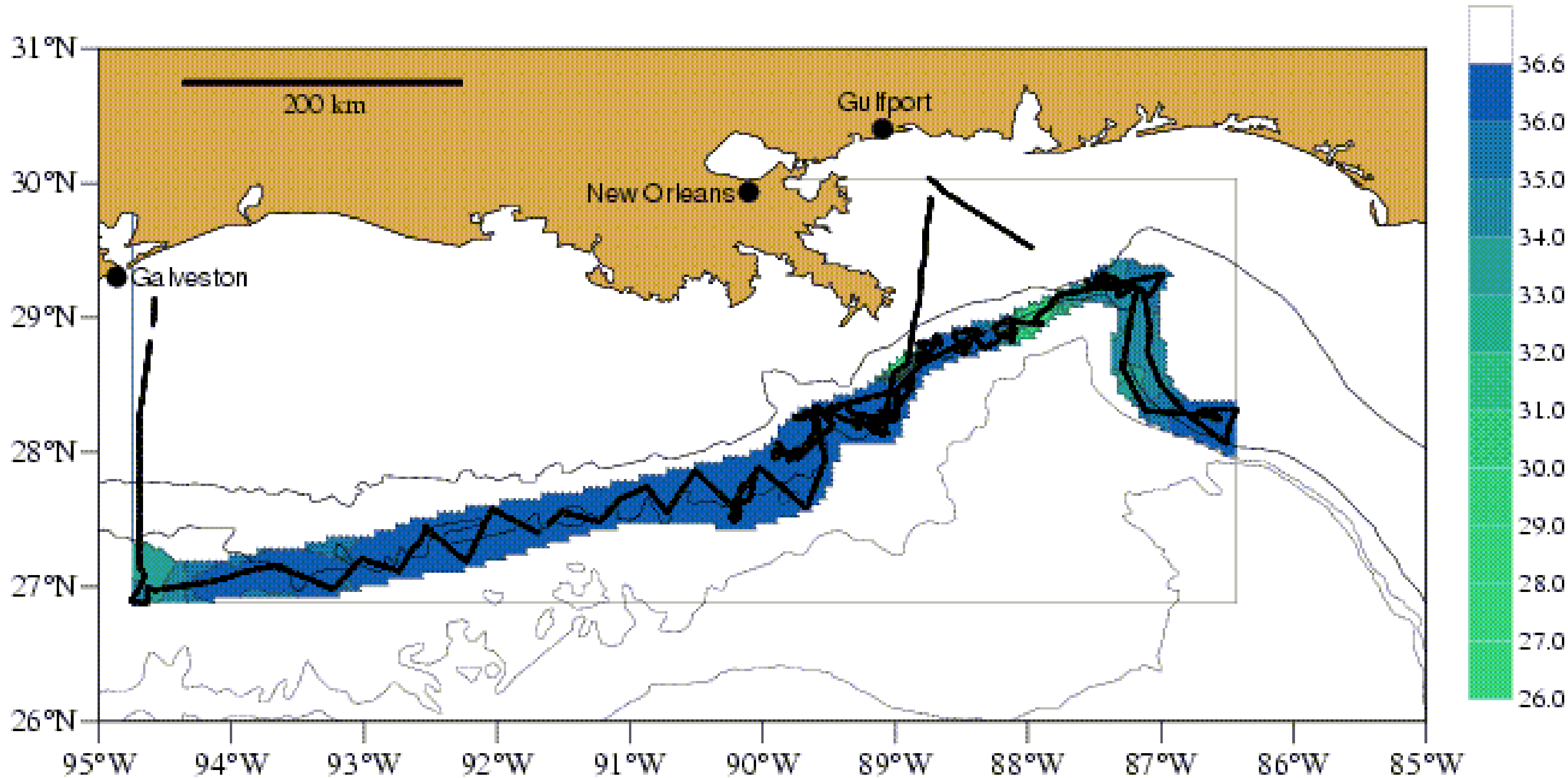


Figure 5. Sea surface fluorescence (millivolts, log-transformed) measured along cruise track line

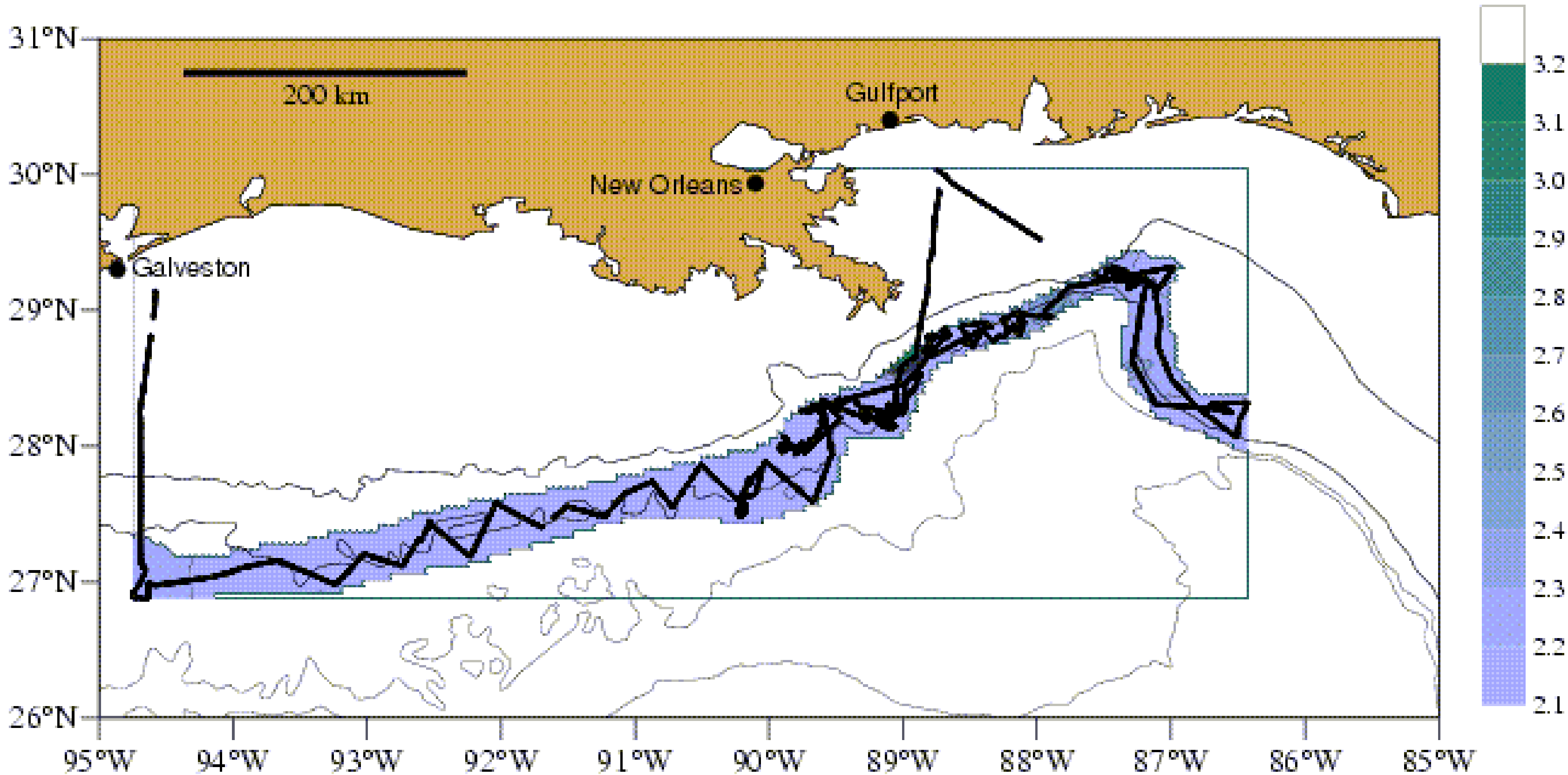
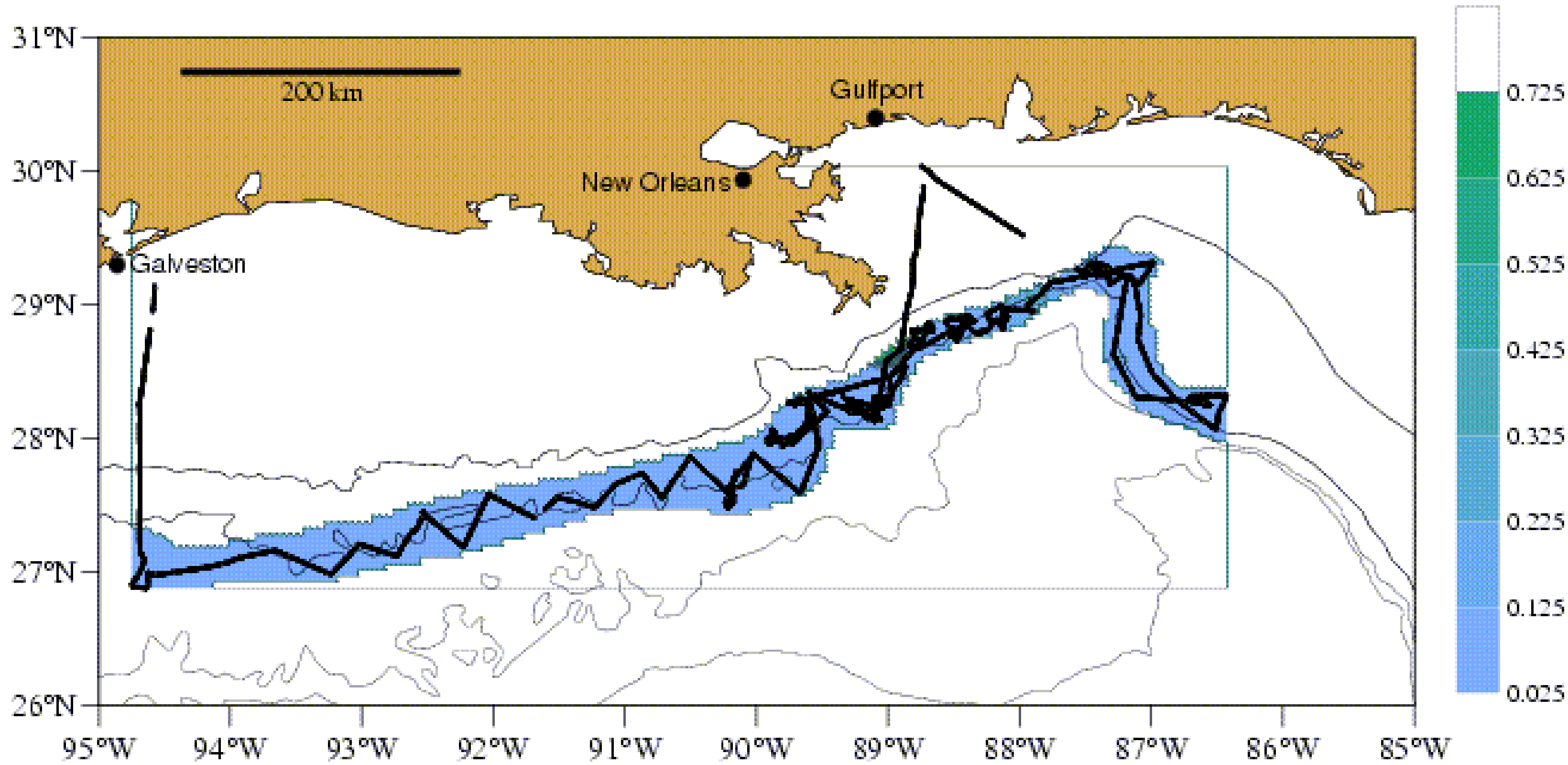


Figure 5B. Sea surface chlorophyll concentration (mg/m^3, log-transformed) measured along cruise track line



Gray line indicates S-Tag cruise track. Depth contours shown: 200m, 1000m, 2000m, and 3000m.

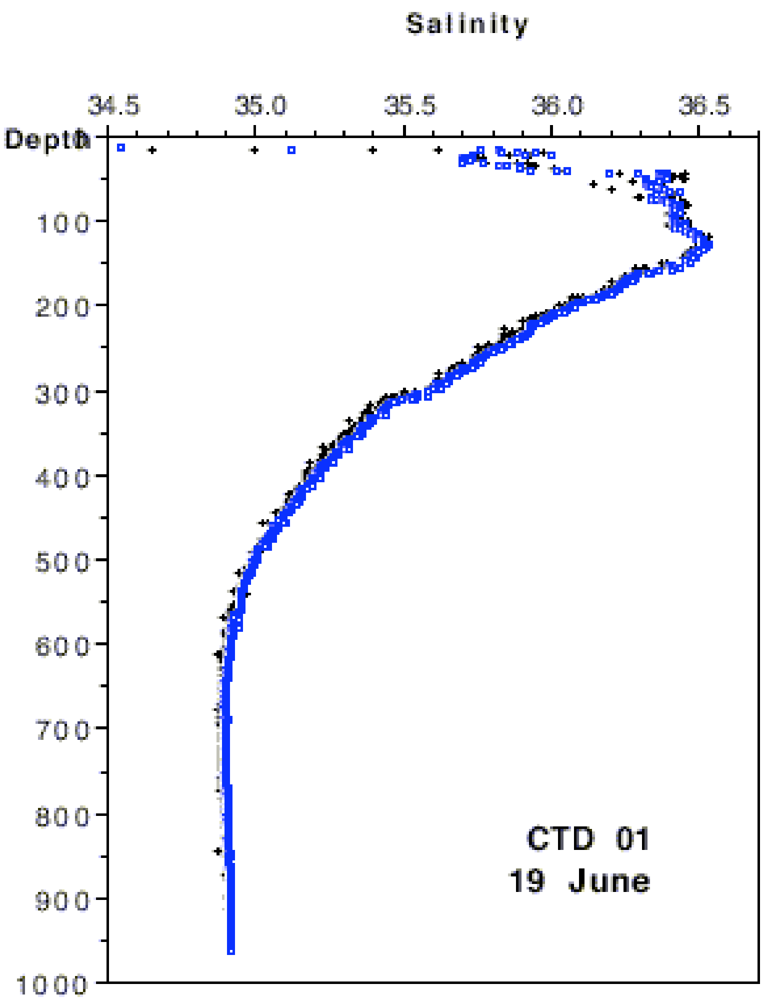


Figure 6. Salinity in the upper 800 m at CTD number 1.

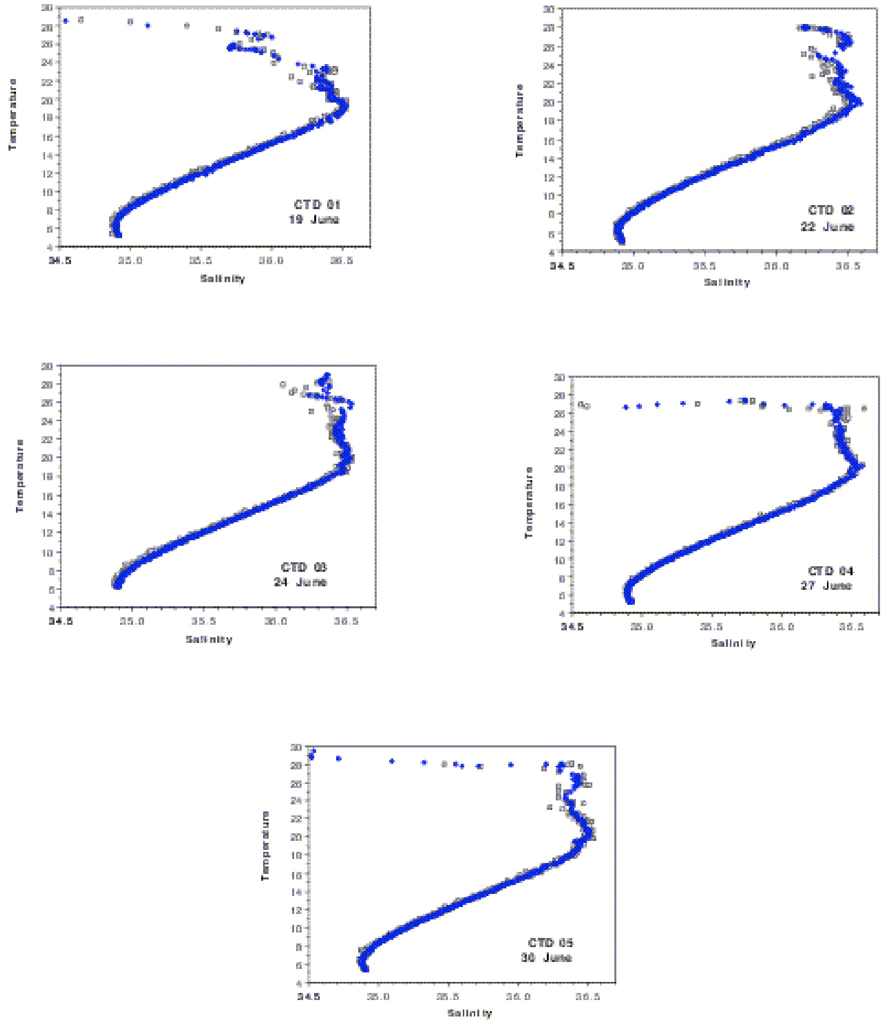
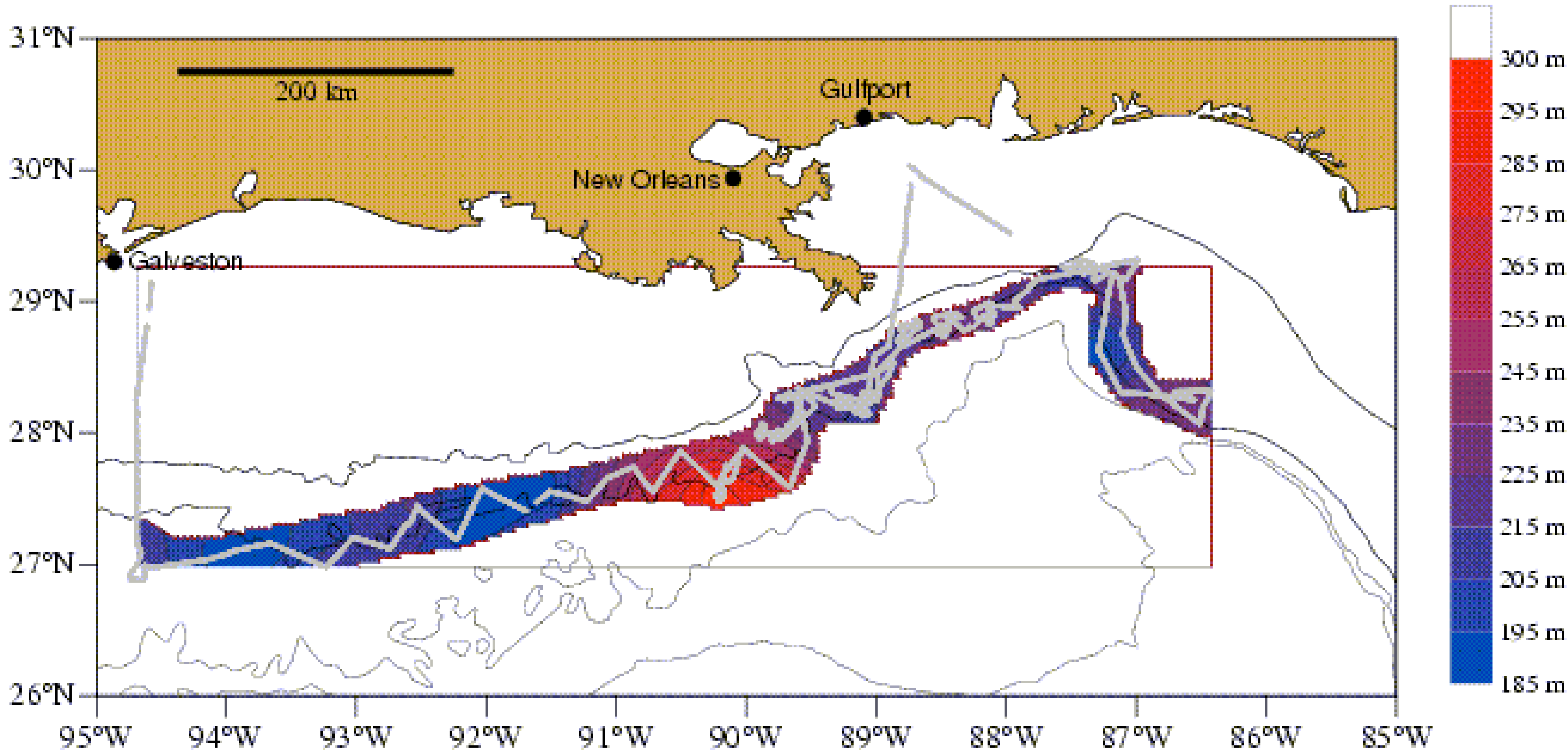


Figure 7. Temperature-Salinity plots for CTDs 1-5 from R/V *Gyre* cruise 02G08.

Figure 8. Depth of the 15°C isotherm measured along cruise track line



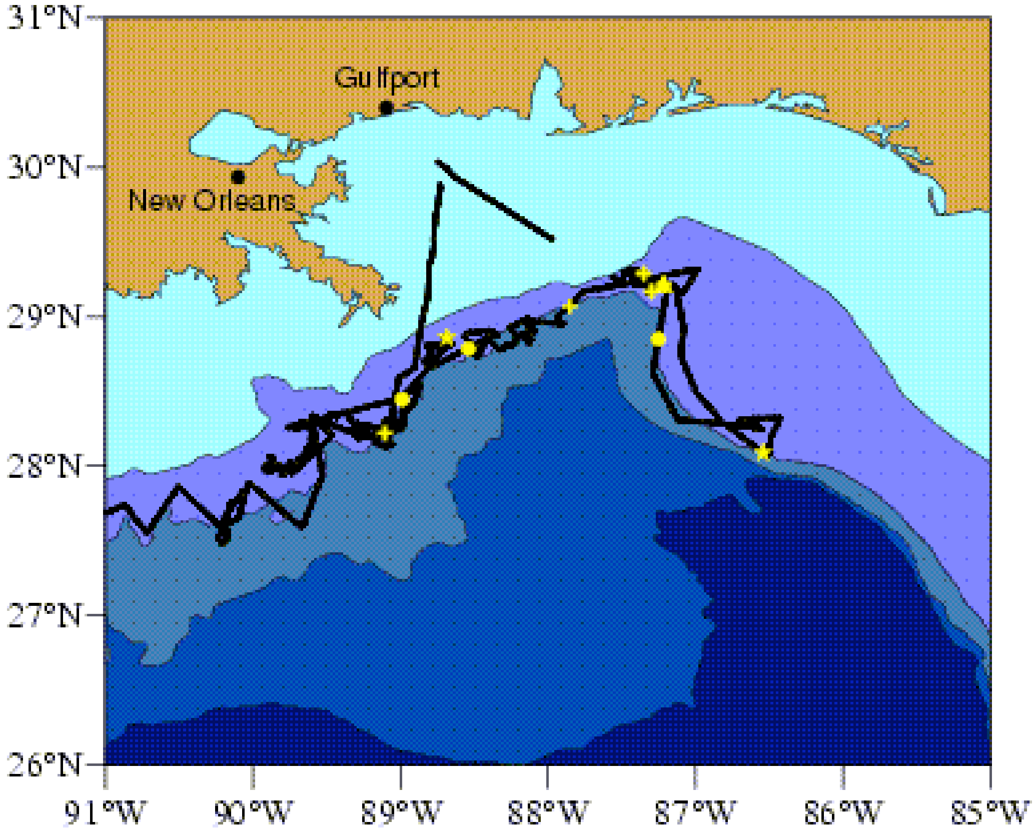


Figure 9. Location of bottlenose dolphins (crosses), rough-toothed dolphins (stars), pantropical spotted dolphins (circles), and spinner dolphins (triangles) sightings.

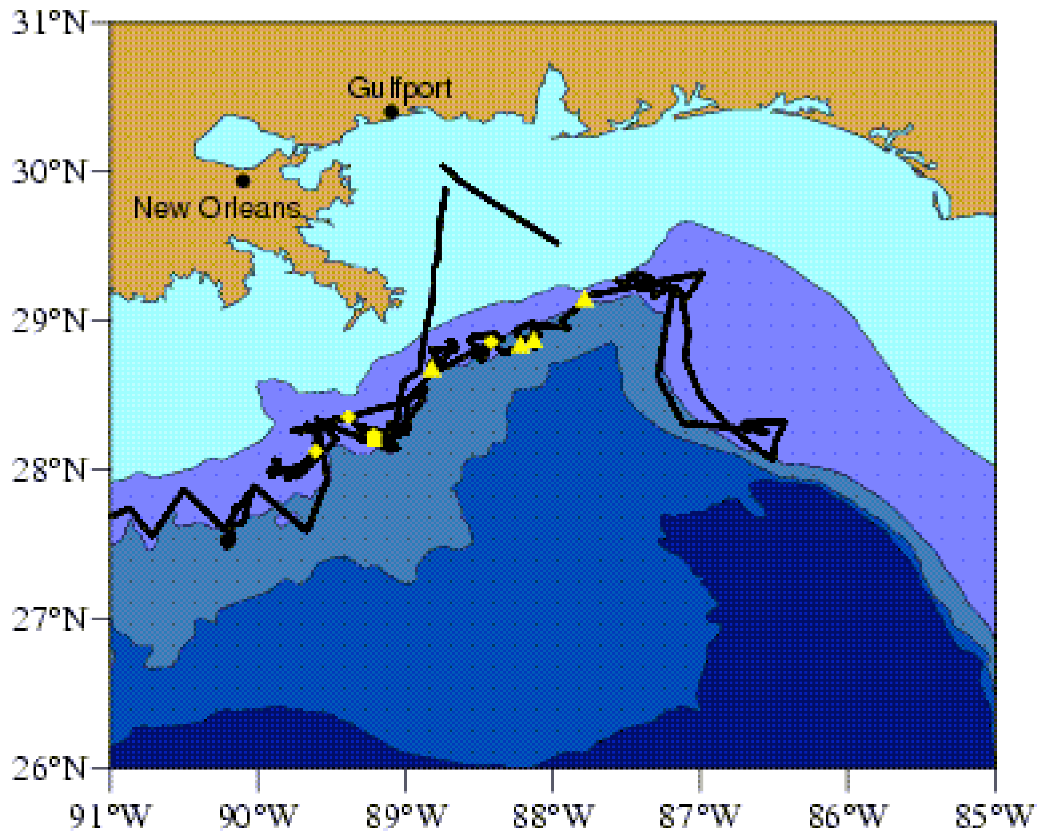
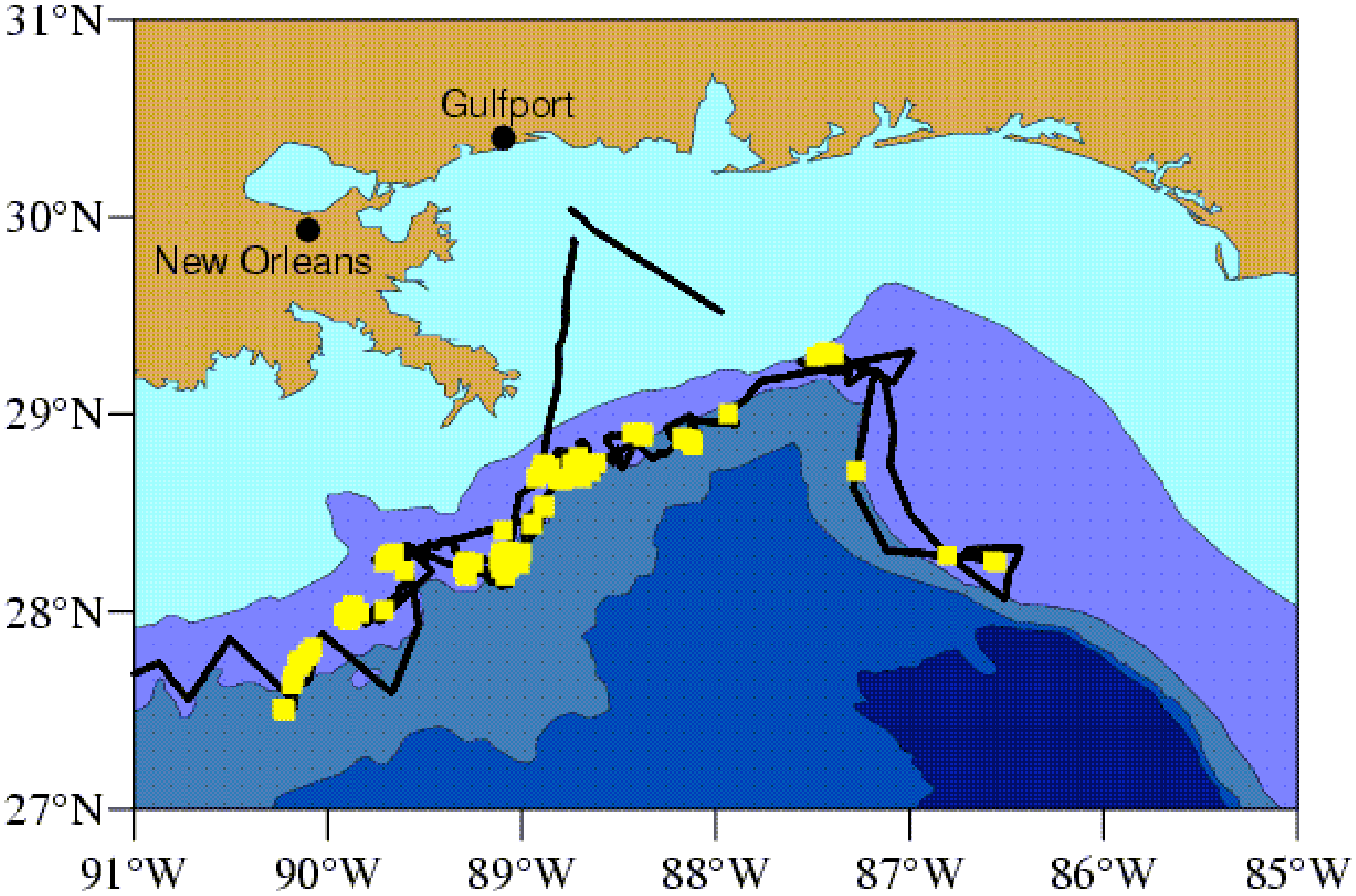


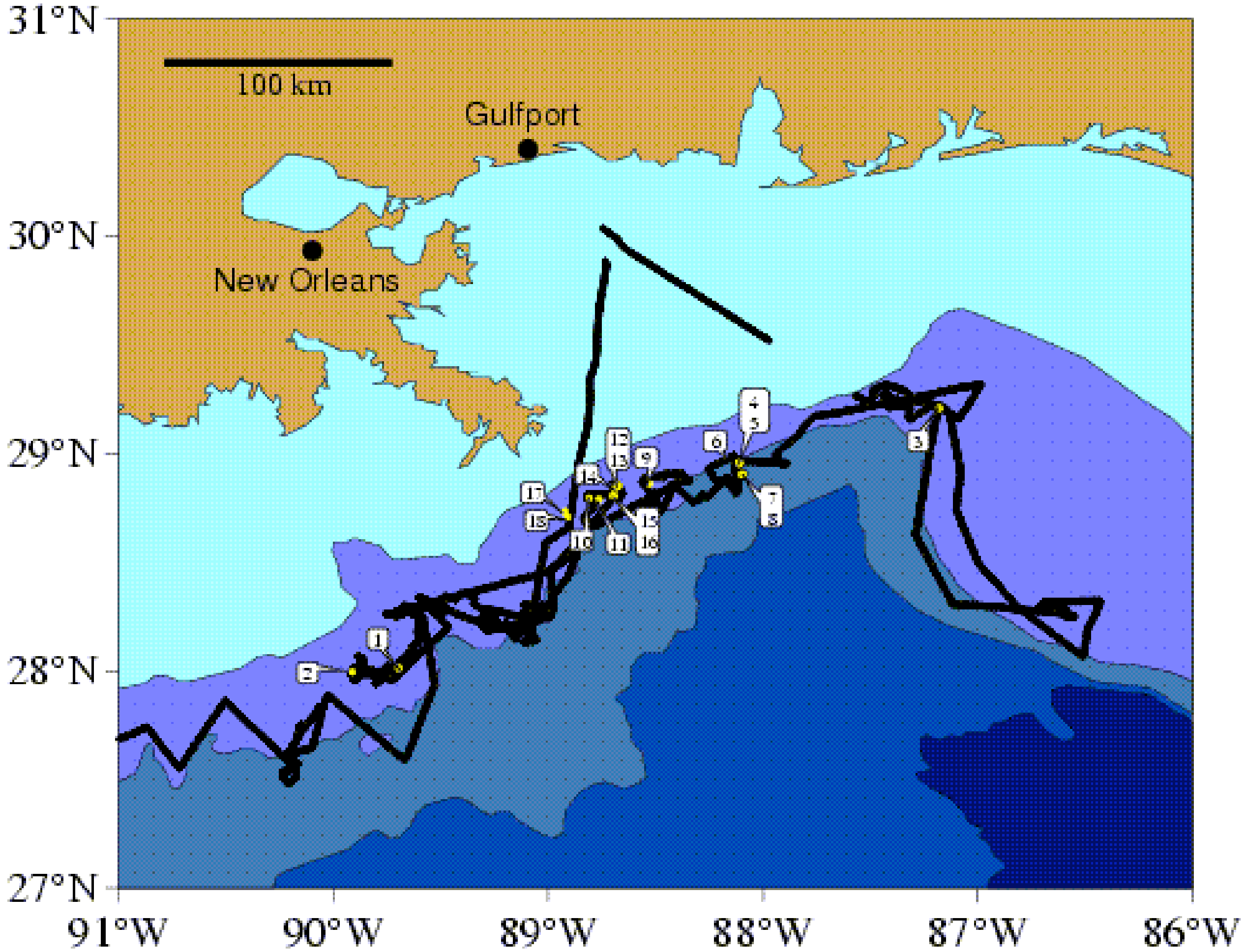
Figure 10. Location of pilot whales (diamonds), false killer whales (square), and pygmy/dwarf sperm whale (triangles) sightings.

Figure 11. Location of sperm whale acoustic contacts



Bold line indicates cruise trackline. Depth contours shown: 200m, 1000m, 2000m, and 3000m.

Figure 12. Locations where sperm whales were tagged



Depth contours shown: 200m, 1000m, 2000m, and 3000m.