DEEP-C: DEEP SEA TO COAST CONNECTIVITY IN THE EASTERN GULF OF MEXICO

Eric P. Chassignet, Deep-C Director

ADMINISTRATION

1) Contract Activity

Each of the Deep-C Consortium's 12 primary sub-agreements was established during the first quarter of Year 1. Deep-C requested and received approval from the Consortium for Ocean Leadership (COL) to enter into fixed-price sub-agreement with one subcontractor (SAIC) and for use of a modified Conflict of Interest form for the Naval Research Laboratory participants.

During the second quarter, all of the Consortium's sub agreements were executed (the last sub agreement was finalized on May 18, 2012) and all but one was amended to reflect the new GoMRI project year/timeline and reporting deadlines. Deep-C also established two additional sub-agreements (Valdosta State University and the University of North Florida). In light of Dr. Patricia Dixon's retirement, the Consortium requested and received approval from the Consortium for Ocean Leadership for a co-PI change at Florida State University.

During quarter 3, Deep-C requested and received approval to re-budget $18,950 in order to allow for new and modified capital equipment needs. There was no change in the overall project budget as a result. Approval to proceed with the early purchase of a coastal bottom drifter originally planned for year 2 was also requested and received. This required movement of approximately $15,000 from year 1 in the "Other Direct Costs" category into the "Equipment" category. Another notable change in the third quarter was an increase in travel funds needed so that scientific teams could participate in a rescheduled cruise. The original cruise was cancelled due to weather. So, approximately $9,000 was moved from "Other Direct Costs" to the "Travel" category to cover this unanticipated expense. Deep-C also received approval for a co-PI change on our University of South Florida sub-agreement in light of Dr. Ben Flower's passing. And approval for carryover of year 1 funds and continuation of funding in year 2 was requested and received.

In the final quarter of year 1, Deep-C requested and received approval to purchase an Atmospheric Pressure Interface Gas Chromatograph Triple-Quadrupole Mass Spectrometer equipped with a Liquid Chromatograph in lieu of a Field Ionization Gas Chromatograph Time-of-Flight Mass Spectrometer (in year 1) and a High Temperature Gas Chromatography system (in year 2). This request followed an extensive process to evaluate these combined products and their capabilities. This change positioned the Consortium to offer better analytical capabilities for both polar and nonpolar species and therefore produce more meaningful results. Deep-C was also approved to reallocate $114,096 from Year 1 budget to Woods Hole Oceanographic Institution sub-agreement to ensure scientific progress being made would not be interrupted. In Year 2, WHOI's budget will be reduced by $114,096. There was no change in the overall project budget as a result of these modifications.

Also during the fourth quarter, Ms. Tracy Ippolito from the FSU Center for Ocean-Atmospheric Prediction Studies was approved to fulfill the education and outreach responsibilities committed to by Dr. Roxanne Hughes. Approval was obtained to replace the Deep-C Research Experiences

for Undergraduates (REU) and Research Experiences for Teachers (RET) summer internships with a new Flexible Internship Program. There was no change in the overall project budget as a result of these modifications.

2) Risks and Impacts

Negotiations and subsequent delays in the execution of the prime agreement meant that many sub agreements were also delayed. *Corrective Actions:* Every effort was made to expedite the subcontracts so that work could begin. However, these delays resulted in underspent budgets at the end of year 1, and a need for a time extension to allow for a full three-year period for completion of scheduled deliverables.

Installation of the major instrument purchase for the High Magnetic Field Laboratory was delayed until the first quarter of 2013. However, Deep-C's research and milestones will be unaffected by the delay. *Corrective Actions:* Installation started on January 23rd was completed the following week.

The purchase of a replacement part for the biogeochemistry team's current oil extraction system could not be completed in 2012 due to delays on the side of the vendor (Buchi/Switzerland), and had to be shifted to 2013. This slowed down the processing of sediment samples retrieved in Q4 but had no impact on milestone completion.

RESEARCH

1) General progress update

A. Accomplishments

During its first year, the Deep-C Consortium members reached across institutional and disciplinary lines to establish strong research ties that allowed them to address the critical scientific questions developed in the proposal and necessary to enhance understanding of the connections between the deep sea, slope, and continental shelf. The trend was set by the Deep-C's leadership team during the "All Hands Kick-off" meeting November 1-2, 2011 in Tallahassee, Florida (agenda attached), during which time representatives from each of the 10 member institutions provided details of their planned scope of work for year 1. A major result of this meeting was the launching of a number of collaborative projects among partner institutions and with other GoMRI consortia (*Figure 1*). A second "All Hands" meeting was held in August 2012, with more than 120 researchers and students in attendance. The purpose of that meeting was to assess progress during the first 10 months and to plan for the balance of the

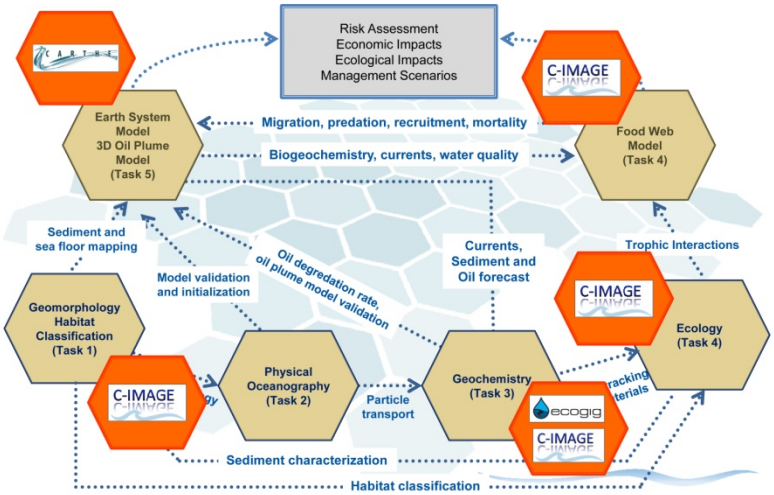

Figure 1. *Interaction between Deep-C tasks and other GoMRI consortia*

year. Between October 2011 and December 2012, Deep-C scientists participated in 13 cruises, 13 on-shore expeditions, and eight aerial flights.

The first year of the Deep-C Consortium also included a significant education and outreach component that resulted in more than 80 students (undergraduate, graduate, high school) participating in consortium-related research (*Figure 2).*

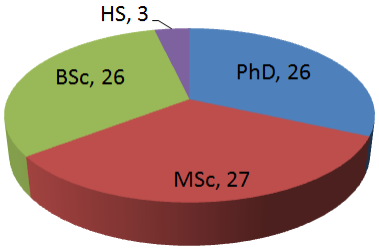

Figure 2. *Student participation in Deep-C*

Some of the major scientific accomplishments during the first project year (grouped by task) are outlined below.

Geomorphology

Members: Florida State University and the University of South Florida. Some of the team's first year highlights include:

- Incorporated bathymetry data from the NOAA R/V Okeanos cruise with historical data from the northeastern Gulf of Mexico.
- Completed seafloor mapping from shallow shelf to upper slope to assess bottom conditions and explore sedimentary processes and benthic habitats.
- An opportunistic camera survey of a small mound at 2,000m depth by the NOAA Ocean Explorer revealed gas bubbles, leading to discovery of an asphalt seep, the first reported in the northeastern Gulf.

Physical Oceanography

Members: Florida State University, SAIC, University of Miami Rosentiel School of Marine Science, and Woods Hole Oceanographic Institution. Some of the team's first year highlights include:

- Designed and deployed six deep-water moorings, two shallow-water moorings with ADCPs and CTD sensors; 36 Rafos floats onboard the R/V Pelican in May 2012 (to be recovered in May 2013).
- Processed recent and historical De Soto Canyon region data to validate a numerical model of wind-driven flows.
- Conducted six flights from NOAA P-3 in Hurricane Isaac across the Gulf (218 AXBTs, XCTDs, XCPs) in September in collaboration with NOAA HRD (includes four in-storm, and pre/post missions).
- Modeled Hurricane Ivan's response to thermocline current amplitudes, bottom temperatures, and strong upwelling events in the region.

Biogeochemistry

Members: Florida State University, Eckerd College, Georgia Tech, University of South Florida, and Woods Hole Oceanographic Institution. Some of the highlights from this task group during the first year include:

- Radiocarbon analyses of sediments confirmed the "dirty blizzard" hypothesis that the oil spill resulted in the flocculation of material from the water column and the extraordinary rates of deposition on the sea floor in 2010.

- Examined pre-spill Mercury (Hg) stable isotope concentrations across different realms (sediments, atmosphere), taxa (fish, invertebrates), and habitats (inshore, offshore, seagrass beds, reefs) to quantify Hg accumulation in food webs.
- Generated a radiocarbon seafloor map depicting deposition of oil residues (see *Figure 4*).
- Characterization of current methane distributions and production zones in the water column of the Gulf.
- Isotopic analysis of faunal tissue collected at sites from Terrabone Bay, LA, to Apalachicola, FL, indicated that entry of fossil carbon into the food web decreased from west to east.

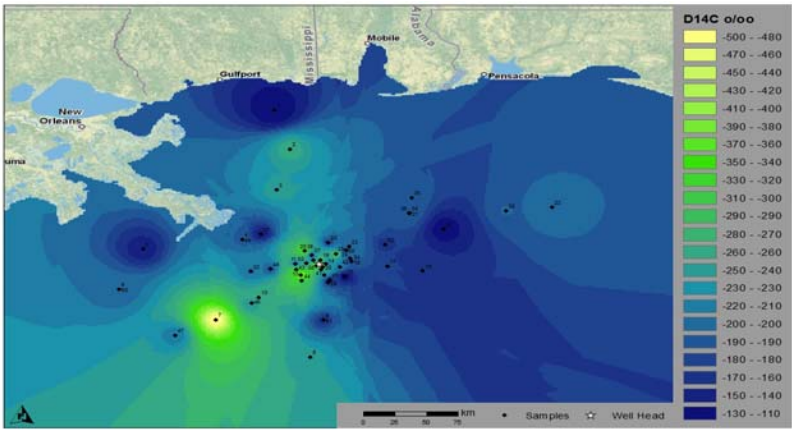

Figure 4: Brighter colors indicate more fossil (oil) carbon in the sediments

- Found that hydrocarbons from the Macondo well were rapidly oxidized and transferred into a carbon pool previously overlooked.
- Confirmation that Hurricane Isaac did not deliver oiled materials from the deep ocean, but rather deposited "dark" material that contained no oil and was coastal debris eroded during the storm.
- Verification that sheen samples collected in October and December 2012 contained drilling fluids indicating the oil was not leaking from the well, but likely from wreckage.
- Development of a FT-ICR MS principal component analysis for spill source identification primarily focusing on the non-volatile component of oil. The phenomenal resolution of this technique allows discrimination of as many as 15 peaks within 0.1 mass unit. Further, it enables determination of unique molecular formulas.

Ecology

Members: Florida State University, Georgia Tech, University of South Florida, University of West Florida, Valdosta State University, University of North Florida. Some of the highlights from this task group during the first year include:

- Described microbial communities reactivity to seasonal physical and biological processes using DNA analysis.
- Started database on pelagic phytoplankton.
- Sediment core time series revealed that PAH-levels levels had declined to background levels in sediments across the shelf.
- Analysis of 1,500 specimens, >70 species:
  - Catch rates and species richness of deepwater fishes decline with depth but unaffected by proximity to the blowout site.
  - Exposure to PAHs (from liver and bile samples) highest in proximity to the blow out site – but at low levels overall.
  - Species assigned to ecologically-relevant functional groups and analyzed for mercury levels to evaluate trophic structure and possible ecosystem-level effects.

- Initiated collaboration with C-IMAGE on ecosystem based trophic model (ATLANTIS).

Modeling

Members: Florida State University, Naval Research Laboratory at Stennis Space Center, Norwegian Meteorological Institute, Tendral LLC, University of Miami Rosenstiel School of Marine Science, and University of South Florida. Some of the highlights from this task group during year 1 include:

- Configured the coupled ocean-atmosphere-wave COAMPS system with a 3 km ocean and 6 km atmosphere and wave forecast components.
- Coupled the NCOM Gulf of Mexico model to the COSINE-13 ecosystem and provided real-time runs to support Deep-C field work.
- Validated a multi-decadal simulation of the 1/25° HYCOM Gulf of Mexico.
- Implemented and tested a Florida shelf circulation and wave model, now available to the public via daily, automated nowcast/ forecasts.
- Found energetic deep currents throughout the Gulf are generated by the Loop Current and associated cyclonic/anticyclonic eddies.
- Showed interaction of the Mississippi River plume with the currents in the northeastern Gulf under flood conditions depends on the status of Loop Current system intrusions.
- Developed an open source oil drift code and made first oil drift test simulations with ocean forcing.
- Developed a non-hydrostatic 3D Fast Plume Model to handle plume dynamics in case of subsea blowout.

B. Obstacles

- One of the elements missing from the Deep-C body of work in year 1 was sampling mesopelagic fish fauna. This is critical to our understanding of trophic interactions and benthic pelagic coupling relative to the oil spill, especially involving the deep scattering layer. What is needed is a ship with the capabilities to conduct research in this zone using midwater trawls with appropriate mesh size for their capture. *Corrective measures:* We are encouraged by discussions with FIO to obtain a Tucker trawl and adapt the R/V Weatherbird II to sample mesopelagic fishes.
- Characterizing differences between pre- and post-spill samples of sediments and organismal tissues is critical to our understanding of the effects of the oil spill. Currently, there exists no centralized catalog system identifying where repositories of pre- and post-spill samples exist or their availability for conducting specific analyses (e.g., analyses of total Hg concentration, Hg species quantification, C N and S or Hg stable isotopes analyses). While Deep-C researchers are investigating the availability of samples held by members of various GOMRI consortia and by collaborators within the National Marine Fisheries Service , we recognize that the best repositories likely will be found within other agencies of the federal government and within BP since these collections were made long before any of the consortia existed. *Corrective measures:* We encourage GOMRI to provide a mechanism by which consortia members could gain access to samples held by the federal government or by BP, either as a common repository for samples ore metadata identifying availability of samples across entities.

- The unexpected death of co-PI Benjamin Flower was a significant loss to the scientific community and specifically to his graduate students and postdoctoral associate involved with him in assessing the impact of the DwH disaster since the early days via rapid response funds from BP and the National Science Foundation, and as part of the Deep-C team. *Corrective measure:* David Hollander has stepped up to serve as research supervisor for USF's post-doctoral fellow and graduate student working on Deep-C projects, in addition to his other commitments on this project.
- The current manual techniques employed to extract hydrocarbons from the sediments are extremely time consuming and present a significant bottleneck to ongoing research. *Corrective measures:* Geochemists at Florida State University successfully obtained internal funding from the FSU Equipment and Infrastructure Enhancement Grant (EIEG) to purchase accelerated oil extraction instruments that work more efficiently. We also requested and received GOMRI approval to reallocate funds to supplement this EIEG grant. Purchase of these instruments will position us to offer better analytical capabilities and therefore produce more timely and meaningful results.
- Collection of samples when unexpected events occur (eg, recent appearance of oil sheens at the DwH site) is limited by ability to respond rapidly. *Corrective measures:* We are investigating the use of ships of opportunity to allow for rapid deployment to event sites with NOAA, BP, and other entities.
- Limited availability of large ships (+200-ft) restricts our ability to conduct field work in a number of areas (e.g., specific types of sediment core sampling. *Corrective measures:* We are encouraged by recent discussions facilitated by GoMRI to develop cooperative relationships (and funding vehicles) with NOAA, NASA, and NSF to provide GOMRI-funded projects with greater access to larger, more sea-worthy ships. This benefits the research by enhancing research opportunities and the ship owners by enhancing subscriptions, while encouraging greater fiscal responsibility among consortia.
- GOMRI data management requirements are more complex than we anticipated and appear to present stumbling blocks across consortia. *Corrective measures:* we encourage GOMRI to provide hands-on problem solving working groups to better define what can be implemented in a realistic timeline.

C. Collaborations

Networking and cooperation with organizations outside of Deep-C resulted in numerous collaborations that extended our reach, enhanced our efforts, and accelerated our progress. During the first year, the most notable included:

- The *University of Southern Mississippi* by exchanging model and observational data for the Gulf of Mexico to inform ocean color product development.
- The *Russian Hydrometeorological Institute (RosHydromet)* which is working on oil in ice simulations.
- *"On Wings of Care"* (a nonprofit charitable organization dedicated to the protection and preservation of wildlife, wild habitat, and natural ecosystem) to conduct aerial overflights of natural and anthropogenic oil seeps Gulf of Mexico.
- *Scripps Institution of Oceanography*, established by Woods Hole Oceanographic Institution Deep-C members with Professor Lihini Aluwihare. The project addresses a chemical means to

cleave oxygen from oxidized hydrocarbons to identify the hydrocarbon skeletons that have been oxidized, providing insight into the processes that caused the Macondo well oil to oxidize

- Two recently BOEM-funded studies: *"Weathering and Advection Model for Oil Spill Tracking (WAMOST)"* which will involve extensive analysis of ocean model data and development of new techniques of coupling ocean models to oil spill models; and *"Data Assimilative Ocean Hindcast for Oil Spill Risk Analysis in the Gulf of Mexico"* which will deliver a HYbrid Coordinate Ocean Model (HYCOM)-based data assimilative modeling framework that can be used to accurately hindcast ocean currents and other state variable needed for oil spill risk analysis in the Gulf of Mexico.
- *SINTEF*, Norway, through a BOEM-funded project involving the analysis of model flow fields and development of new surface oil drift methods.
- *BOEM* for industry geophysical data and on the BOEM-funded Lagrangian deep circulation study.
- *NOAA NESDIS* satellite observation group for satellite remote sensing of natural and anthropogenic oil releases.
- *National Marine Fisheries Service* and *Florida Fish and Wildlife Research Institute* for the provision of samples of fauna throughout the foodweb from before and after the spill
- *U.S. Coast Guard Academy* working towards chemometric methods to disentangle GCxGC chromatograms of weathered oils.
- *NOAA Ocean Exploration RV Okeanus Explorer* expedition in the Gulf. The data set of seafloor bathymetry collected is very useful to Deep-C researchers.
- *University of West Florida, Savanna State University, Seattle Aquarium,* and *Texas A&M*, on fish taxonomy, systematics, and phylogenetics.
- *Savannah State University, Florida State University, Sweetbriar College*, for fish life histories.
- *University of North Florida*, on fish toxicology and reproductive endocrinology.
- *University of Toronto,* on feeding biomechanics of deepsea sharks.
- *University of Western Australia* and *University of British Columbia,* on fish brain and visual physiology.
- *Florida International University, Florida State University, University of West Florida,* on fish trophic ecology.

Relationships with experts in the field of hydrocarbon research were also of great value during our first year including:

- *Dr. Peter Berg, University of Virginia,* to evaluate benthic oxygen flux associated with the oil spill.
- *Dr. Terry Snell, Georgia Tech,* to link biodegradation with toxicity of Macondo oil.
- *Dr. Steve Rowland, University of Plymouth, UK,* to study samples to study molecular weight petroleum hydrocarbons and their fate.
- *Dr. David Valentine, UCSB*, to exchange samples and studying the oxidation of hydrocarbons.
- *Dr. Jorge Zavala, UNAM, Mexico*, on oil spill models.

Other collaborations allowed us to maximize resources and develop a robust data management system at a remarkable pace. The Deep-C Data Center worked with the *Biological and Chemical Oceanography Data Management Office* (BCO-DMO) and *Woods Hole Oceanographic Institution* to provide for shared vocabularies and with the *Rolling Deck to Repository, LDEO, Columbia University* leveraging database and metadata schemas developed by the R2R to aid management of research cruise data. The Data Center team also worked with the *National Geophysical Data Center (NGDC)* to secure access to historical geologic and geomorphologic data sets in the northeastern Gulf of Mexico.

Collaborations with other GoMRI-funded consortia encouraged the development of innovative and groundbreaking strategies in our shared areas of interest and accelerated the pace of research, to the benefit of all parties concerned and to GoMRI overall. Projects funded last year by BP-FIO enhanced collaborative opportunities within and among the RFP III consortia, including shared cruises, shared collections of water samples, sediments, microbial communities, particularly providing access to samples collected from the Macondo well in December 2010 and September 2011.

- *Deep-C and CARTHE:* Almost immediately after the consortia were funded, a collaborative effort started between Deep-C and the CARTHE Consortium members on Uncertainty Quantification (UQ) aspects (A. Srinivasan, M. Iskandarani). The focus of this effort centers on the development of a plume model for subsurface blowouts to verify and validate the fast plume model against high fidelity simulations of the subsurface plume. It also includes exploring the use of polynomial chaos-based UQ techniques to quantify uncertainty in model simulation.
- *Deep-C and C-IMAGE:* Collaboration with members of the C-IMAGE Consortium, particularly in the areas of geochemistry and ecological studies, proved extremely fruitful. Over the course of the year, Deep-C members from Georgia Tech and C-IMAGE members at the University of South Florida met frequently and participated in joint cruises that enhanced sample collection (600+) for analysis of the ecological impacts on microbial communities in deep sea sediments within a few months of the Deepwater Horizon discharge and provided input on food web development at the base of the food chain, and work on organic geochemical, 14C- chemical tracing, microbial community structure, short-lived radio-isotope chronology, metal chemistry, sediment toxicity and detailed chemical analyses of polar organic compounds. Our joint efforts have also enabled us to link the occurrence of fish disease with the abundance and distribution of petroleum hydrocarbons in outer-shelf and slope sediments and on FT-ICR-MS, and core lipid and microbiological analysis. Initial collaborations between Deep-C members at Florida State University and C-IMAGE members at the University of South Florida have started for development of the Atlantis food web model.
- *Deep-C and ECOGIG:* Joint cruises allowed Deep-C and ECOGIG scientists to observe and collect natural oil slick samples and to study benthic habitats and natural hydrocarbon seeps through exploration and limited multi-core sampling. Sediments collected were frozen and brought back to Florida State University for analysis; subsamples were sent to Georgia Tech. Most recently, the collaboration between Deep-C colleagues at WHOI and at Florida State University (a member of both consortia) involved a rapid response to collect samples from sheens that appeared above the sea surface of the wellhead from October to December 2012 and analyzed them for olefins (or alkenes) present in oil that has a Macondo well signature.

Researchers provided a memorandum to the US Coast Guard and BP informing them that sheen samples collected in 2012 contained drilling fluids indicating the oil was not leaking from the well, but likely from wreckage.

2) Results to date and scientific highlights

Theme 1: Physical distribution, dispersion, and dilution of petroleum (oil and gas), its constituents, and associated contaminants (e.g., dispersants) under the action of physical oceanographic processes, air sea interactions, and tropical storms. Our goal is to determine the effect of seasonal currents and episodic oceanographic or atmospheric drivers on the transport of oil and hydrocarbon gases from the source region to sea floor and pelagic environments in the northeastern Gulf. To do this, we need to understand how these processes are influenced by sea floor geomorphology, with an emphasis on how topographical features influence deep sea to shelf connectivity. In this first year, we started developing a basemap, incorporating bathymetry data from the NOAA R/V Okeanos cruise (especially centered on the De Soto Canyon) with historical data from the northeastern Gulf of Mexico. We also completed mapping the region from the shallow shelf to upper slope to assess bottom conditions and explore sedimentary processes and benthic habitats. We then processed recent and historical oceanographic data from the region to validate a numerical model of wind-driven flows. Current data is being collected from surface to 400 m using moorings with ADCPs and CTD sensors (to be retrieved in May 2013). During an opportunistic extreme event (Hurricane Ivan) we conducted aerial deployments to collect pre, during, and post event data from AXBTs, XCTDs, XCPs in collaboration with NOAA, which allowed us to model hurricane response to thermocline current amplitudes, bottom temperatures, and strong upwelling events in the region.

Theme 2: Chemical evolution and biological degradation of the petroleum/dispersant systems and subsequent interaction with coastal, open-ocean, and deep-water ecosystems. Our goal is to assess the influence of oil and gas on water column and sediment biogeochemical processes and the distribution of substances that affect biological productivity, particularly as it relates to the distribution of radiocarbons, mercury, and methane, as well as their uptake in biological systems. We conducted intensive geochemical analyses that produced a number of significant results. We found that hydrocarbons from the Macondo well were rapidly oxidized and transferred into a carbon pool previously overlooked. We also developed procedures for identifying spill source primarily focusing on the non-volatile component of oil. The phenomenal resolution of this technique allows discrimination of as many as 15 peaks within 0.1 mass unit and allows us to determine the unique molecular formulas of these constituents. We successfully characterized current methane distributions and production zones in the water column and developed a seafloor map depicting the distribution of radiocarbon residues. We produced irrefutable evidence that the oil spill resulted in the flocculation of material from the water column and the extraordinary rates of deposition on the sea floor in 2010 (“dirty blizzard hypothesis”). Related to studies of how pollutants enter the food web, we conducted isotopic analyses of faunal tissue across coastal sites and found that entry of fossil carbon into the food web decreased from west to east. Our intent is to track movement of other pollutants (particularly, mercury) through food webs. Here, we have examined pre-spill Mercury (Hg) stable isotope concentrations across different realms (sediments, atmosphere), taxa (fish, invertebrates), and habitats (inshore, offshore, seagrass beds, reefs) and are actively identifying sources of similar post-spill samples for comparison. Several stochastic events required a rapid

response to collect time-sensitive data. The first was Hurricane Isaac, which deposited dark material on Gulf beaches that many residents thought was oil. Analyses indicated that the material contained no oil but rather was coastal debris uncovered by wave action during the storm. The second event was an oily sheen that appeared around the Maconda well site. The question presented was "where did the sheens originate?" and it was found they contained drilling fluids indicating the oil was not leaking from the well, but likely from wreckage.

Theme 3: Environmental effects of the petroleum/dispersant system on the sea floor, water column, coastal waters, beach sediments, wetlands, marshes, and organisms; and the science of ecosystem recovery. Our goals are to define and quantify the diversity of biological responses to the dynamic physical and chemical properties of the environment and to assay the impact of discharged and background hydrocarbons on community structure and function to inform the development food web models. The studies conducted in year 1 occurred across trophic levels that included pelagic phytoplankton, pelagic and benthic microbial communities, and benthic invertebrate and fish assemblages, from both organismal and ecological approaches, including the development of taxonomic databases across groups. For microbial communities, we conducted incubation experiments to characterize microbial populations that degrade oil from De Soto Canyon and the West Florida Shelf and we described reactivity to seasonal physical and biological processes using DNA analysis. Accompanying sediment core time series revealed that PAH-levels levels had declined to background levels in sediments across the shelf. For the macrofaunal component, we analyzed over 1,500 specimens, >70 species and found that catch rates and species richness of deepwater fishes declined with depth but appeared unaffected by proximity to the blowout site. We also found that exposure to PAHs (from liver and bile samples) highest in proximity to the blow out site – but at low levels overall. We assigned fish species already in taxonomic databases to ecologically-relevant functional groups and analyzed for mercury levels to evaluate trophic structure and possible ecosystem-level effects. And we collaborated with C-IMAGE on an ecosystem based food web model (ATLANTIS) where data from all trophic levels indicated above will be assimilated to evaluate species interactions.

Theme 4: Technology developments for improved response, mitigation, detection, characterization, and remediation associated with oil spills and gas releases. Prediction of the fate of oils, such as those released during the DwH oil spill, and their impact on the environment not only requires detailed knowledge of the Gulf 3D circulation, but also knowledge of the surface winds, waves, sediments, and biogeochemistry. Our goal for this theme is to develop a comprehensive model with the capability to forecast the pathways along which such exchanges occur and predict the level of risk associated with specific outcomes. Our approach is to have two teams of experts, with the first team focusing on the provision of historical and newly acquired field data in the northeastern Gulf of Mexico to the second team, which will then focus on the Earth System Model prediction system development and validation. During Year 1, our teams accomplished several key tasks. We configured the coupled ocean-atmosphere-wave COAMPS system with a 3 km ocean and 6 km atmosphere and wave forecast components. We also coupled the NCOM Gulf of Mexico model to the COSINE-13 ecosystem and provided real-time runs to support Deep-C field work and validated a multi-decadal simulation of the 1/25° HYCOM Gulf of Mexico. We implemented and tested a Florida shelf circulation and wave model, now available to the public via daily, automated nowcast/ forecasts. And finally, we developed an open source oil drift code and made first oil drift test simulations with ocean forcing and a non-hydrostatic 3D Fast Plume Model to handle plume dynamics in case of subsea

blowout. Key findings in this theme during the first year include: 1) energetic deep currents throughout the Gulf are generated by the Loop Current and associated cyclonic/anticyclonic eddies, and 2) interaction of the Mississippi River plume with the currents in the northeastern Gulf under flood conditions depends on the status of Loop Current system intrusions.

3) Other products or deliverables

Deep-C Data Management

- Deep-C Data Management Plan: http://deep-c.org/images/documents/Deep-C_DataMgmtPlan.pdf
- Deep-C Data Center Web Portal: http://deep-c.org/data
- The Deep-C Atlas - http://viewer.coaps.fsu.edu/DeepCProject/mapviewer
- Deep-C Data Center Tabular Interface - http://deep-c.org/data/tabular
- Deep-C Virtual Library - http://deep-c.org/library/

Other Data, Maps and Imagery

- Radiocarbon map (see page 4 of this report)
- Center for Environmental Diagnostics and Bioremediation (CEDB) Gulf of Mexico Research Initiative Parameters and Cruise Data - http://uwf.edu/cedb/gom-parameters-cruise-data.cfm

Models

- Fast Plume Model
- Gulf of Mexico Interaction of Oil Spill website - http://kilden.met.no
  (user name = deepc password = oilspill2013)

Education & Outreach

- Deep-C website: www.deep-c.org
- Voices from the Field Blog: http://deepcconsortium.blogspot.com/
- Deep-C brochure: http://deep-c.org/images/documents/Deep-CBrochure_web_10-12.pdf
- Deep-C poster: http://deep-c.org/images/documents/DeepCPoster2012_11x17.pdf
- Deep-C Facebook page: http://www.facebook.com/deep.c.consortium
- Deep-C Twitter account: https://twitter.com/DeepCConsortium
- Deep-C YouTube Channel: http://www.youtube.com/DeepCConsortium
- Deep-C Photo Gallery: https://picasaweb.google.com/112164058289504852022
- Fluid Demo Kit for Teachers: http://deep-c.org/images/documents/fluid-dems-for-middle-hs-teachers.pdf

4) Please enter the total number of each item reported for this report year:

		Total for Report Year
a.	Cruises & Expeditions	25
b.	Workshops and meetings organized	30
c.	Peer-reviewed publications *(published + accepted)*	15
d.	Presentations and Posters	124
e.	Quotes/Interviews/Features/Articles	68
f.	Data *(DSF submitted)*	5

g.	Consortium participants	108
h.	Student and post-doctoral participants	78
i.	Scientific partnerships and collaborators	68
j.	Outreach Products and Activities	104
k.	Images *https://picasaweb.google.com/112164058289504852022*	~400
l.	Leveraged (non-GoMRI) funding	$53,789,001