

Communicating Oil Spill Science

Using C-IMAGE for interdisciplinary education and outreach

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Abstract—The Center for the Integrated Modeling and Analysis of the Gulf Ecosystem I and II (C-IMAGE I and II) are two of fourteen centers funded by the Gulf of Mexico Research Initiative (GoMRI) investigating the short- and long-term impacts of submarine oil spills on the Gulf of Mexico Ecosystem. C-IMAGE researchers represent twenty institutions from six countries while having expertise in all oceanographic disciplines. Incorporating strong field, laboratory, and modeling components in C-IMAGE research allows opportunities for a variety of engaging education and outreach activities. Since 2011, C-IMAGE has produced seven podcasts, hosted eight Teachers At Sea which included Skype ship to-shore sessions, presented new discoveries to the public at localized venues, and broadened its reach using partnerships at Public Radio International (PRI), the Public Radio Exchange (PRX), GoMRI, and SeaGrant. This paper describes C-IMAGE's outreach efforts in detail while providing a look ahead to activities planned over the next three years.

Keywords—oil spill, education, media, teachers, Ixtoc, DWH

I. INTRODUCTION

Understanding the full ecological consequences of the Deepwater Horizon (DWH) event, determining best long-term mitigation strategies, and preparing for the next spill, requires a systems-level approach to the Gulf of Mexico ecosystem. Since no one institution has all the relevant expertise, the Center for Integrated Modeling and Analysis of the Gulf Ecosystem (C-IMAGE) involves 20 institutions, spanning a broad geographic range (seven US states and six nations) and academic expertise to synthesize oil spill science from diverse viewpoints. We develop and integrate empirically validated models of oil plume fate and ecotoxicology to improve prediction accuracy of contaminant distribution, composition, and ecosystem impacts of past Gulf of Mexico oil-well blowouts in order to predict the impacts of future ones.

C-IMAGE uses both DWH and the Ixtoc-I well blowouts to gain different perspectives on past oil spills; the Ixtoc-I blowout occurred in the southern Gulf of Mexico in 1979 spilling a comparable volume of oil to DWH into the Gulf of Mexico [1]. Our research allows for better retrospective assessments on the impacts of the DWH spills of oil, gas, and

dispersants. C-IMAGE's main goal is directed at improving the predictive tools for oil spills, which improves preparedness and response for any environmental disaster in the Gulf of Mexico or elsewhere. Our integrative approach provides decision-making tools to more accurately predict potential environmental consequences and ecosystem impacts of any future petroleum blowouts of varying composition and environmental toxicity.

C-IMAGE places high priority on public education using our researchers and students to interact with the public. In an effort to effectively communicate the research conducted by the C-IMAGE consortium, we provide an array of education and outreach activities targeting different audiences. To serve science educators, our mission is to enrich their classroom dialogue by providing teachers with hands-on field experiences. While our researchers are at sea, teachers contribute to the recovery and processing of sediment cores for chemical analysis, and collection of fishes for ongoing exposure studies. Ship-to-shore Skype communications during these cruises give their students a virtual sea-going experience because they are able to ask questions and witness oceanographic research in real time. We also provide teachers with professional development through GLOBE trainings, data collection and data visualization methods, which parallel how research is conducted at sea and in the laboratory [2]. For example, C-IMAGE scientists and GLOBE teachers/students collect and analyze atmospheric, hydrologic and sediment (or soil) data from respective environments over an extended time. With this hands-on approach, teachers and students learn science (i) is an organized process, (ii) takes multiple participants, (iii) identifies trends and (iv) eventually constructs models of systems.

To reach a broader audience both demographically and geographically, C-IMAGE produces a podcast series *The Loop* (<http://www.marine.usf.edu/c-image/education-and-outreach/download-our-podcasts>) featuring both national and international C-IMAGE researchers. These podcasts have been featured on the programs National Public Radio's series *Living on Earth* and WUSF's Florida Matters series.

To make our research more interactive with the public, C-IMAGE is creating a virtual tour of oil spill history. The Tour will include the facts of past spills such as location, depth, volume spilled, and impact, and incorporate information on the oil extraction process. The Tour focuses around questions of: what is known and unknown about oil spills, why are there large oil reservoirs in the Gulf and other areas of the world, and how the extraction process has changed over time? Using content developed for the Google Earth Tour, C-IMAGE will reformat and create additional material creating an interactive/touch screen version for use in various outreach partner locations.

Finally, C-IMAGE will host a series of Story Collider (<http://storycollider.org/>) events. Story Colliders are live shows featuring scientists telling a personal science story. The series will feature scientists telling stories about how science made a difference, affected them, or changed them on a personal and professional level. Story Collider staff will work with the scientists to refine stories prior to the event(s). The first event will be offered in Tampa, FL in February 2016 and in New Orleans, LA in February 2017. C-IMAGE will work with local NPR affiliates to promote these events.

II. THE C-IMAGE CONSORTIUM

A. Scientific Overview of C-IMAGE

C-IMAGE's main research objective is: to advance understanding of the processes and mechanisms involved in marine blowouts and their environmental consequences. Our consortium focuses both on extension of work started under the initial C-IMAGE I project (a GoMRI RFP-I consortium) and continues under the C-IMAGE II consortium (through GoMRI RFP-IV) that includes three new initiatives: (i) field work at the Ixtoc-I blowout site, (ii) establishment of a marine exposure facility at the Mote Aquaculture Park for fishes, and (iii) a Gulf-wide assessment of fish and sediment contamination to better understand and predict oil fate and impacts of DWH and other spills. C-IMAGE researchers conduct studies in six areas known as *tasks*: Task 1-near-to-far field modeling, Task 2-high pressure experimentation, Task 3-sedimentation of oil and its impacts, Task 4-impacts on the abundance, contamination and population dynamics of fishes, marine mammals and other marine life, Task 5-toxicology studies, and Task 6-ecosystem modeling. We focus on facilitating collaborative efforts between tasks to produce fundamental understanding of basic processes of marine blowouts and ecosystem impacts.

Near- and far-field modeling studies focus on the goal of refining our understanding of the dynamics of high pressure oil/gas/water jets, and the formation of plumes and other near-field dynamics. How much then, did deep dispersant injection contribute to formation of sub-surface plumes? C-IMAGE researchers are expanding high pressure-low temperature experimentation to include the use of dispersants to

understand the resulting particle size distributions measured with a novel endoscopic camera.

Previous C-IMAGE research documented a marine oiled snow sedimentation and flocculent accumulation (MOSSFA) event, wherein a substantial portion (4-10%) of the DWH oil reached the seabed [3]. Is a "MOSSFA-like" event the rule or the exception for marine blowouts? To test the hypothesis that oiled marine snow accumulation is a probable outcome, C-IMAGE is collecting and analyzing sediment cores from the Campeche region off Mexico, in the vicinity of the Ixtoc-I marine blowout (1979-1980).

Sampling of fishes in the vicinity of the DWH documented a decline in skin lesion frequency and in PAH metabolites in red snapper bile following the spill, however contaminant uptake and depuration varied among species [4]. Changes in fish community composition and declines in recruitment of several species including red snapper were also documented. This work continues to better understand the role DWH played in species and community dynamics, including marine mammals. Researchers are also conducting the first Gulf-wide toxicology assessment of continental shelf fishes ever undertaken, including Mexico.

An oil exposure test facility at the Mote Aquaculture Park is established to understand how contamination pathways (water, sediment, food) impact adult fishes. Two representative species (southern flounder and Florida pompano) are used to test chronic and acute exposures to a range of dispersant and oil concentrations. Existing and new methods to evaluate mutagenicity and genotoxicity in contaminated water and sediment exposures are being used.

Ecosystem models combine field-derived data and laboratory studies in quantitative frameworks to allow hind- and forecasting of the balance of tradeoffs in response actions to oil spills. Two ecosystem modeling frameworks are supported: one focusing on low trophic levels and modeling marine snow formation (ZOOSIM) and the other focused on high trophic levels (Atlantis). The ZOOSIM models are simulating formation and deposition of marine snow and the roles of biological interactions among low trophic levels. Atlantis includes an ecosystem services module and is used to understand the impacts of response efforts including the use of large fishery closed areas as happened during DWH.

III. OUTREACH OBJECTIVES

The C-IMAGE consortium allocates substantial resources –time and effort preparing and facilitating events – to educating the public in oil spill impact and recovery research. We focus our outreach efforts towards the specific aims of (i) inspiring interest in oil science, (ii) providing resources to the public, and (iii) informing all ages of the importance of our research. Our researchers and students consistently provide local outreach through community based presentations at brew

pubs or science festivals, while our teachers use their experiences at sea to connect with students hundreds of miles away. Both the geographic and scientific diversity of C-IMAGE partners are the two most critical characteristics to exploit to reach a large section of the public. Perhaps one of the more exciting opportunities afforded by C-IMAGE's geographic diversity is the ability for cross-cultural/lingual reach. C-IMAGE partners in Germany and Mexico have produced material in German and Spanish for global distribution. Slideshows and podcasts will be offered in multiple languages and Mexican teachers will be offered the next *Teacher at Sea* opportunity during the 2016 field season.

This section describes the various education and outreach activities currently underway in C-IMAGE.

A. Teacher at Sea, SENSE IT, GLOBE

C-IMAGE utilizes a robust field component by collecting water samples, sediment cores ("Mud") and fish samples ("Blood") throughout the Gulf of Mexico. In the three years of C-IMAGE I (2012-2014), the consortium hosted 24 cruises on Florida Institute of Oceanography's (FIO) fleet (R/V *Weatherbird II* and *Bellows*) translating to over 100 working days in the Gulf of Mexico. C-IMAGE hosted eight Florida teachers from four middle schools and four high schools. Teacher preparation for sea included training to become active members of the science party. On the inaugural *Mud & Blood* Expedition, our teacher, Patty Smukall, was trained by day in fish dissections by the chief scientist of the cruise and assisted the science party in documenting skin lesions and collecting muscle and bile samples muscle from three target species (Red Snapper, Golden Tilefish, and King Snake Eel) when analyzing oil exposure and recovery. In the evening, our teacher helped recover and process sediment cores for later analysis on shore.

The remaining seven teachers participated in our *Food Web* cruises. These expeditions traveled to the northern Gulf of Mexico to collect water, phytoplankton, zooplankton, and suspended matter to compare with the same samples collected along the West Florida Shelf. The northern Gulf of Mexico and West Florida Shelf regions were selected to assess how oil exposure impacted lower food web populations in impacted areas, compared to non-impacted areas. The science party trained teachers on CTD deployment, water sampling and collection from the rosette instrument, water filtration and sample processing. Teachers also participated in the collection and preservation of plankton samples using Bongo nets.

In the midst of sample collection and processing, our teachers participated in *Ship to Shore* classes with their students, college students and visitors to aquariums. Several members of the science party engaged in the learning from sea as guest speakers to the classes. To supplement live teaching sessions, the Teacher at Sea kept a daily blog with a description of daily activities. While teachers often gave a description of the scientific aspects of the expedition, students

also had many questions about the living arrangements on the vessel. How was the food? Where do you sleep? The combination of using video conferencing, still photos, and blogging helped to create the full seagoing picture for the land based students.

After teachers returned to the classroom, they translated their at sea experience to understandable inquiry based lessons about the science and technology associated with the specific objectives of the cruise, while learning about how this helps answer questions about larger ecosystem health of the Gulf.

"The students & I LOVED the video conferences today & we learned so much! What a wonderful glimpse you gave us of a working research vessel! Thanks for the amazing experience that you provided for my students." (Eileen Hayes, high school teacher, FL)

"This cruise was the best opportunity I have had to work with scientists & understand how science is utilized in the real world." Abby Madeiros, 6th & 7th grade teacher, FL)

"Scientists have systematically collected these samples over the past three years [and] have begun to create a historical database that will allow us to develop a clearer picture of how the Gulf behaves over time." (Elizabeth McCormack, 7th grade teacher, FL)

The SENSE IT program aims to make a direct connection between the scientific data collected and the sensor collecting these data. This NSF sponsored program uncovers the mystery of sensor development by providing participants with all the necessary materials to build an environmental sensor from the scratch, moving away from the mysterious "black-box" approach. This exercise has four associated modules: (i) Sensor development; (ii) Sensor deployment and data gathering; (iii) Water quality investigation; and (iv) Sharing data across observatories. These modules are formulated to be inserted into any standard STEM curriculum (courses in mathematics, chemistry, general science, physics, environmental science, and computer science). Students use a multimeter to measure sensor output and devise experiments to estimate the accuracy, repeatability and sensitivity of their devices. Currently, C-IMAGE focuses on teacher professional development by training teachers how to take the materials to their classroom where their students build the sensors, deploy their sensors in the field, and analyze environmental data. Direct connections are made between the sensors the teachers and students build with the sensors used in the scientific research enterprise and how specifically sensors are used to detect oil.

C-IMAGE achieves shore-based professional development for science educators through the SENSE IT and GLOBE learning programs. The Global Learning and Observations to Benefit the Environment Program (GLOBE) is a National Science Foundation and NASA sponsored education effort that gives students and educators of all ages the opportunities to engage in data collection and the scientific process. Involvement in the program fortifies understanding of surrounding natural systems including the atmosphere, biosphere, hydrosphere, and the sediment. What begins as a local event is transformed into a global exercise by connecting to other citizen scientists around the world that are taking analog measurements at their home locations.

During teacher professional development trainings using GLOBE environmental science protocols and data visualization methods, teachers engage in science parallel to many of the same parameters used for C-IMAGE system recovery science. For example, both C-IMAGE researchers and GLOBE teachers collect and analyze hydrologic data to characterize Gulf water or a body of water near schools by measuring oxygen, salinity, temperature, and nutrients. This data is collected on repeated temporal and spatial scales and used to construct time series of changes or consistencies over time in an ecosystem. Similarly, C-IMAGE scientists collect and characterize sediment cores from the Gulf, while C-IMAGE teachers collect local soil samples and characterize using similar composition, grain size analysis, and some chemistry parameters used by C-IMAGE geochemists. In this way, teachers are able to parallel environmental monitoring, sampling protocols and representation of data within their respective environments from the same locations over an extended time. This provides a foundation to engage teachers and their students in ongoing C-IMAGE research following environmental changes in the Gulf and in their water, soil and atmospheric data.

During the first three years of the program, 330 teachers participated in C-IMAGE professional education workshops with over 5,000 students impacted throughout Florida. During C-IMAGE I we partnered with two other GoMRI-funded consortia, DEEP-C and CARTHE, to share professional development events with teachers in their regions of the state.

B. Media Outreach and Online Presence

Several events and campaigns create a virtual presence for C-IMAGE. To sustain our outreach goals of (i) inspiring interest in oil science, (ii) providing resources to the public, and (iii) informing all ages of the importance of our research, we use social media and web-based outreach. We have a variety of target audiences of varying age ranges and countries of origin. Engaging viewers in the 18-45 age range is accomplished primarily through our webpage and social media outlets. We strive to connect the public with the human and personal side of oil spill research by regularly informing the public on new consortium initiatives, publications, and research progress. The aim of our web presence is to give a

face to our researchers to facilitate engagement from the public in our research results and updates. We are strongly committed to take steps to better articulate or translate the scientific research in an effort to not only educate, but also continue to deserve the public's trust in the scientific enterprise as a whole.

The specific avenues we use include (i) social media presence via twitter and Facebook, (ii) *The Loop* radio series, and (iii) *C-IMAGE Spotlight* video series.

To reach out to those using web based news and entertainment, we keep a broad audience in mind when sharing news stories and content. Our goal for public outreach-particularly when sharing content on social media streams - is to pique interest in oil spill science and inform how our studies improve understanding of oil spills and their impact. When focusing on the web presence and social media aspects, our objective is to generate shares and comments from our viewers with the potential to reach other interested users outside of our own network. Sharing blog articles highlighting researchers' interest, posting photos from research expeditions, and updating followers on our international partners have given us strong interactions with large audiences through this virtual venue.

The type of content we share is closely aligned with our scientific timelines; summer is more field oriented, while we focus on meetings, analyses and syntheses in the fall and early spring. In particular, our *Mud and Blood* cruises generate a strong following from fellow researchers and fans who comment, share or retweet our photos or cruise updates. Summer 2015 marked our busiest field season to date: three cruises traveling to the northern and southern Gulf of Mexico totaling 52 days at sea. Each of our three expeditions has an appointed outreach lead responsible for daily expedition updates ("photo of the day") for our webpage and social media, audio and video interviews of C-IMAGE researchers, and photography and audio recordings of field operations. These outreach leads provide quality content to keep the public informed as to what is happening during a research expedition. The research conducted in the southern Gulf of Mexico focuses on the Ixtoc-1 (1979) well blowout to understand the changes in oil degradation over three decades in sediments and fishes. Data collected will allow scientists to predict the long term effects of DwH and of future oil disasters. During our summer expedition updates, we observed an increase in following of 5% on Facebook, and 12.5% on Twitter (Facebook likes and Twitter followers).

The Loop is a podcast series produced in partnership with Mind Open Media reporters Ari Daniel Shapiro and David Levin, and WUSF-Tampa Bay's NPR radio station. This series of six podcasts explains the goals of our research, from oil's impacts on sediments, to modelling an ecosystem. David Levin was able to board the RV *Justo Sierra* to collect audio and visual material that will be used for the production of podcasts and audio/video slideshows featuring the

research expedition. WUSF has also produced a radio piece on *Florida Matters* with Chief-PI Dr. Steve Murawski, Chief Scientist Dr. David Hollander, and research associate Dr. Isabel Romero, which was broadcasted on WUSF-89.7 FM.

C-IMAGE Spotlight is a video series published on the C-IMAGE YouTube channel. The purpose of this video series is for C-IMAGE researchers to share their findings, goals, and hopes for the project through a visual media rather than the traditional journal publication. Researchers from Georgia Tech, Texas A&M-Corpus Christi, University of Western Australia, USF-College of Marine Science, and Wageningen UR in the Netherlands answered questions from the goals of their research to their least favorite parts of their jobs.

C. Community Involvement

St. Petersburg, FL is the headquarters of C-IMAGE and is home to seven government, academic, or private companies with an inherent interest in ocean health and technology. Because of this, marine science activities hosted or sponsored by these agencies are frequent and well attended. Historically, our consortium has participated in some larger community events that already have a large following such as the *St. Petersburg Science Festival* and the *Guy Harvey Fisheries Symposium*. C-IMAGE has leveraged similar relationships at our partner locations and has participated in large events like the *Night of Science Festival* in Hamburg, Germany where C-IMAGE research was presented in both English and German.

Conversely, C-IMAGE researchers and students have moved to smaller, more focused venues where one-on-one discussions can develop organically in a more social and relaxed setting. Participation in Pint of Science, League of Women's Voters seminars, press conferences, environmental film festivals and Florida Institute of Oceanography-Media Day are several examples of how our researchers share their thoughts in the community. C-IMAGE has an estimated reach of 5,000 citizens in the Tampa Bay Area and we look to improve engaging the communities of our partners, both local and abroad. Our next phase of community outreach includes involvement of the education & outreach networks at our partner institutions. C-IMAGE scientists and students at our partners like Penn State University, Texas A&M-Corpus Christi, and Universidad Nacional Autónoma de México provides us with a larger audience to voice the oil spill science conducted by C-IMAGE.

D. SeaGrant Partnership

The GoMRI provides support to Sea Grant programs in the four Gulf of Mexico regions (Florida, Mississippi-Alabama, Louisiana, and Texas) to increase the use of the oil spill science coming out of GoMRI funded programs. This partnership is intended to use Sea Grant's wide-ranging audience to understand what people really want and need to know about their Gulf. Each discipline of oceanography is assigned a Sea Grant Extension Specialist whose priority it is to share oil spill research results to audiences through bulletins, fact sheets, and science seminars given by GoMRI

funded scientists. C-IMAGE works closely with the extension specialists by providing access to the peer reviewed science in an appropriate form for the targeted stakeholder groups.

IV. FUTURE ACTIVITIES AND CONCLUSIONS

Communicating oil spill science worldwide is a crucial first step to meet C-IMAGE's overall objectives of providing the public with thought-provoking questions and answers about the anthropogenic impacts on the health of our ocean ecosystems. We provide hands-on exhibits to younger audiences through events like Science Festivals and Ocean's Day while also targeting their teachers through proven Professional Development programs like GLOBE and Teachers at Sea, and establishing a web presence through social media outlets. Additional person-to-person communications are used to reach a more mature crowd through our events at smaller local venues, like brew pubs or non-profit group meetings. We will expand this effort to more of our partner locations to target people that may not have familiarity with the Gulf of Mexico, but may have experience with the impacts of oil exploration and extraction in a different environment. A new component of these more personal outreach efforts will be the *Story Collider* series. *Story Collider* brings personal stories about the scientific experience from individuals to the public in venues like theaters, pubs, libraries, etc. The intent is to engage the listener by humanizing the scientific process, restoring trust in the world's experts. These stories will be recorded and converted to podcasts for wider dissemination.

Another new initiative C-IMAGE will offer in the future is a historical perspective on oil spills by developing an electronic tour of past oil spills. Our research focuses on looking at the 35 years following the Ixtoc-1 blowout, shedding light on how the northern Gulf may recover in the coming decades. Oil disasters are bound to happen again and by giving the public a global and historical lesson on the role of hydrocarbons in the environment and the geology behind their distribution will help them better understand why some areas are more at risk for exploitation than others.

The expansion of the C-IMAGE consortium over the last year not only adds scientific expertise, but also amplifies our education capabilities by taking advantage of mature and established programs at our partner locations. This creates an opportunity for C-IMAGE to consistently be in the spotlight and to merge oil spill science with other earth and ocean science concepts.

ACKNOWLEDGMENTS

This research is made possible by a grant from BP/The Gulf of Mexico Research Initiative through the C-IMAGE Consortium.

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