Testimony before the Committee on Transportation and Infrastructure, U.S. House of Representatives

RE: PREPARING THE UNITED STATES FOR potential IMPACTS FROM DRILLING ACTIVITIES IN CUBA and the Bahamas:

EARLY-WARNING, BIOLOGICAL AND PHYSICAL OCEANOGRAPHY BASELINES, IMPACTS RESEARCH, PREDICTIVE MODELING, and MITIGATION RESPONSE

SOUTH FLORIDA CUBA OIL SPILL CONSORTIUM

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1. INTRODUCTION & STATEMENT OF THE PROBLEM

Mr. Chairman and Honorable Members and Representatives of the Subcommittee on Coast Guard and Maritime Transportation, thank you for convening this hearing. It is my privilege to address the matter of oil drilling and production in the Cuban Exclusive Economic Zone and in Bahamian waters as well as the attendant likelihood of spilled oil or chronic oil releases reaching US coastal waters.

Based upon the current status of ocean science and pollution release studies in the semi-tropical waters in the southeastern US, the most direct answer is yes, a finite likelihood does exist for oil-bearing subsurface water, surface water, or both to reach US coastal waters. The operational detail of the science and the data on which the above is based is largely incomplete and, indeed, should be expanded as soon as practicable for more accurate predictive capability of impacts and effects.

Contrasting the Deepwater Horizon Spill and prospective Cuban spills

An oil spill in the Cuban exclusive economic zone, while having some features in common with the recent Deepwater Horizon spill, also has key distinguishing features which increase the potential peril. The location of drill sites is far more proximal (close beside or beneath) to the major, generally eastward, Gulfstream current system. In addition to the lateral entrapment (entrainment) of spilled oil into the Gulfstream flow, there is an additional possibility of entrapment by positive rising plume buoyancy. Both of these factors can help introduce spilled oil, associated drilling products, and chemical dispersants into the US Coastal Zone that can cause substantial damage to a number of vital interests of the US, including beaches, recreational and tourism industries, and marine and coastal ecosystems. Given proximity and currents, it is likely the initial impact of a drilling-related accident, especially (but not only) in the case of a Cuban spill, will be to the iconic Florida coral reef system, important fisheries and breeding grounds, location of threatened and endangered sea grass and coral, and habitat for rare and endangered species (birds, sea turtles, and marine mammals including manatees). The Florida Reef tract comprises up to 84% of the nation's coral reefs, is already under numerous environmental stresses, and ranges some 360 miles from the Dry Tortugas in the west to Martin County in the north. Florida has one of the most densely populated and highly developed coastlines in the United States. Coasts and ecosystems to the Carolinas and northward are also at risk and are of critical biological, ecological, economic, and human health importance. In the longer term, residual oil could impact possible desalination water supply activities along the US east coast and other coastal spatial planning activities. Florida's Coastal and Ocean economies contribute $587 billion to the State GDP. Nearly half of that activity 45% is from the atlantic coast counties that will be most immediately impacted by Cuba drilling. This represents 3.4 million jobs. Disruption to this economic engine be it through a spill or long-term chronic effects can have very serious consequences for our State's economy.

The components of the threat posed to Florida and other US waters consists primarily of spilled oil and releases of oil-bearing produced waters. These could occur during drilling and over much of the lifetime of the oil producing operations. Such discharges may be episodic and massive in size as in the case of the DWH event or chronic lingering events releasing smaller amounts of hydrocarbons at a time.

Some limitations Imposed by the Cuban Situation

At present there is no assurance of timely notification of the initiation of a spill or that proper treatment of produced waters will be accomplished. While satellite, aircraft, ship, and radar systems are useful in detecting ocean surface manifestations of an oil spill, subsurface oil releases are far more difficult to address without continuous access to the drilling sites or without a subsurface, remote sensing system for monitoring of drilling/production activities.
In addition, certain preventive and mitigation activities may be hindered by the location of the drilling sites.

The United States has certain safeguards in the development of oil fields which may or may not be maintained in the Cuban drilling operations. For example steps have been taken in the US to ameliorate the toxicity and mercury levels in drilling fluids. Various mixtures of constituents are present when drilling fluids are released into the ocean. The fluid releases constitute another consideration in the impact of releases upon US coastal waters and may be largely unknown or unknown in detail by US responders. Indeed, in his State of the Union address given on January 23, 2012, the President of the United States indicated that he expected the companies that drill for oil and gas to disclose the chemicals they use and not put the health and safety of citizens at risk. How much disclosure may be expected from the various corporations anticipated to drill in Cuban waters? Developing preventative and mitigation methodologies may lack an opportunity for application. For example as shown in Figure three, underwater sound methods (applied to the Gulf of Mexico IXTOC oil spill, 1979) indicate the existence of a subsurface pool/plume of released oil was present in an area of many kilometers in extent about the spill site. A valuable study would be to seek if pumping this subsurface pool into oil carriers and out of the ocean is viable. The application of dispersants, while controversial, was done both proximally and distally from the spill site. Will that opportunity remain?

Multi-institution/agency Plan

Because of the broad potential and considerable threat to US coastal waters, a multi-agency, integrated plan is needed. This plan must be put in place now and become fully operational before any oil spill has actually occurred. For more than two years, members of the scientific community in South Florida have been visiting multiple agencies in Washington DC outlining key ocean resource imperilment and scientific concerns regarding nearby foreign oil drilling. Although, each agency visited has recognized the serious nature of the threat and the validity of both the resource and scientific concerns, there seems to be uncertainty as to how to implement a plan and action to address information gaps in order for the US to be best prepared to respond to and mitigate the next major oil spill emanating from Cuban waters. Such a plan would provide the opportunity for joint proactive action now, not awaiting a disaster to actually occur.

The US Coast Guard has operational leadership with regard to a Cuban oil spill and has developed an aggressive response plan focused upon oil spill transport, the use of dispersants, and the surface manifestations of an oil spill. While it is imperative to address these components of the spill, it is equally important to develop and implement a much expanded plan now to address other critical issues. The goal is to better understand current transport of both surface and subsurface oil whether concentrated or dispersed, establish a baseline of existing biological and physical conditions in order to both enable early detection against which impact can be measured, and study differential toxicity of oil compared to dispersed oil so that differential organism sensitivity can be accounted for and best mitigated. The plan can be developed in cooperation with the US Coast Guard and including additional Federal agencies and a partnership of South Florida institutions, both academic and federal, with many years of experience in studying local effects of Gulfstream transport and coastal interactions.

I want to make clear that the plan that is envisioned is not a "response plan". It should be implemented now before any actual spill takes place to provide sufficient time to gain requisite information and to generate a more effective response.

The following activities are suggested to better, and pro-actively, prepare the US to address the reality of nearby foreign (both Cuban and Bahamian) oil drilling and mitigate the consequences.

- Implement an oil spill early-warning monitoring system using acoustic, geophysical, satellite and other relevant methods.
- Baseline assessment of the status of coral reef and associated ecosystems in the likely spill path (Straits of Florida, SE/E Florida coast) to prioritize areas for spill response and to set restoration targets should a spill occur.
- Ocean observations for description of the physical oceanography and current movements to have more complete knowledge of the ocean hydrodynamic movements of the Gulf Stream and Loop Current, shallow to deep, from the Yucatan channel to the Southeast/East coast of Florida.
- Oil and dispersed oil toxicity characterization and toxicity studies to determine effects on a range of coral reef ecosystem and other organisms to develop risk assessments.

- Modeling for prediction of ocean dynamics for spill movement prediction over time and space both in the vertical and horizontal.
- Modeling for prediction of ecological /biological effects under various spill and response scenarios.
- Modeling to assess the potential impact of different observing strategies on baseline data collection, analysis of information, and data required for response and mitigation.

Implementation of the plan would involve the following elements:

1. Inviting and integrating other Federal agencies, in addition to the Coast Guard, into a Cuban oil drilling/production effort for response to a Cuban oil spill.
2. Establishment of a partnership between the US Coast Guard and a consortium of South Florida institutions having the in-depth experience, local knowledge, data, and expertise to be most effective in our unique oceanic and coastal environments. These institutions include, presently, Florida International University, NOVA Southeastern University, the University of Miami, NOAA's South Florida regional science laboratories and centers (AOML, NHC, and SEFC), and private industry. Other partners could eventually include SECOORA, IOOS, FLCOOS and other Universities and Institutes.
3. Jointly planning a system for gathering operational data and concurrently for gathering research data with quick payoff for operational activities, e.g. real-time current information for transport calculations and modeling.
4. Jointly planning and implementing a system to gather data which will be of use in longer term damage and impact issues such as oil characterization (both at well site proximity and US coastal water locations), eco-toxicological impacts, coral reef, inlet and port, spatial coastal planning impacts.
5. Evaluating the use and need for, and implementing as necessary, a non-intrusive monitoring system utilizing water borne and bottom borne energies originating at the Cuban oil operation sites.
6. Utilizing/developing systems and platforms, including optical, acoustical, and sampling systems, both manned and autonomous, capable of detecting, mapping, and sampling subsurface oil.

My testimony presents a suggested plan and scientific consortium team for research and related activities to address gaps in information and to better address our US response to foreign oil drilling and spills. This research is central to understanding and responding to any release affecting US waters. However, the immediate proximity of imminent drilling in Cuba and the Bahamas outside the oversight or control of US regulators or responders makes this preparation an extremely urgent priority.

2. ADDRESSING INFORMATION GAPS TO BEST PREPARE FOR AND MITIGATE EFFECTS OF CUBAN OR OTHER PROXIMAL OIL SPILLS

There are several features to consider in dealing with potential releases or spills of oil in the Cuban Exclusive economic Zone: the nature of the oil sources, the spatial and temporal distribution of the oil in the immediate vicinity of the spill site, entrainment of the oil into ocean currents, transport of the oil by winds and ocean currents, detrainment of the transported oil, both surface and subsurface, into the US coastal zone. These may help answer the following questions.

(A) What might the near-field dispersed pattern of spilled or released Cuban oil?

To help understand the prospective dispersal pattern of spilled or released Cuban oil, it is noted that drilling in the Cuban Exclusive economic Zone will likely occur over a range of water depths ranging from a few hundred meters to more than a thousand meters. If the spill originates with a drilling well then such a spill may initiate near the ocean bottom and disperse/rise vertically through the ocean water column to the ocean's surface. Thereafter spilled oil may disperse over the ocean's surface under the influence of winds, waves, and oceanic currents. The subsurface oil may rise as a plume with multiple plumes at multiple depths possible. Thereafter, the oil plumes will move laterally and vertically under the influence of sub-ocean surface currents. There could also be a near-ocean-bottom plume which would move very slowly.

In contrast to the Deepwater Horizon oil spill, the sites at which Cuban oil drilling will occur are much more likely to be impacted almost immediately by the major current system north of Cuba, namely the Loop current/Gulfstream. At the time of origin of an oil spill the current, depending on the specific drilling site location, may be north of the spill, south of the spill or over the spill. Depending on the duration of the spill, it may be possible for a spill site to be, at various times, north of the current, south of the current or under the current. This circumstance adds substantial variability in the transport of the oil and affects potential impacts to the US coastal zone.

Further complicating the spilled oil transport circumstance is the possible presence of eddies at the "boundaries" of the main current core flow. Depending on the spatial location and depth of the oil source, spilled oil might have to traverse boundary eddy fields before entrainment into the main Gulfstream flow.

(B) How might the water-dispersed Cuban oil be transported to U.S. waters?

Again in contrast to the Deepwater Horizon spill, in the case of a Cuban spill, released oil could rise as a plume and encounter the Gulfstream flowing directly overhead. In this case, potentially far greater entrainment of the oil into the main body of the current, being driven by the positive buoyancy of the plume into the current, could potentially occur. This is in addition to the lateral entrainment of the oil into the Gulfstream current as projected in the Deepwater Horizon spill. The entrained oil will subsequently move with, the primary currents and winds.

(C) How will oil make its way from the passing Gulfstream to the Florida Coastal Zone?

Assuming that the Gulfstream, other ambient currents, and winds result in the transport of both surface and sub-surface oil into the vicinity of South and Eastern Florida, what mechanisms may exist for the detrainment of the oil from the Gulfstream and environs to the Florida coastal zone? Note that I am using the word coastal zone rather than shore because the potential impact area for Florida includes many Florida resources, besides beaches, such as coral reefs and fisheries. There is also the question of impacts of oil entering into inlets, bays, ports and so on. We consider the detrainment process to affect both the surface oil and the subsurface oil. As I understand it, the US Coast Guard response is focused upon the surface manifestation of the Cuban oil. In this plan dispersants are contemplated which should gather the oil into droplets which would then sink with time.

In studies done in the Florida Area Coastal Environment(FACE) program carried out by the Atlantic Oceanographic and Meteorological Laboratory (AOML) a component of the National Oceanic and Atmospheric Administration (NOAA) measurements were carried out on the nutrient concentrations present in the coastal water. Recent measurements in that program suggest that cold, nutrient rich, water make their way over the coastal bottom from the deeper portion of the Gulfstream (and perhaps underlying waters) onto the shallow Florida shelf in the area ranging from southern Miami-Dade County north. If spilled oil is caught up or entrained in the body of the Gulfstream, it is possible that oil-containing water could be brought up to the Florida shelf as well during these cold-water "upwelling" events. These cold water features can extend many kilometers, occur in the bottom portion of the water column (and thereby have a clear possibility to impact coral reefs and bottom dwelling fish) and ocean at an unknown rate, but might occur ocean at a frequency comparable to western boundary eddys, e.g. about every two to three weeks or so.

2.1. Some Plan Elements

At this time the programmatic solution to the Cuban-Oil Drilling activity is seen to be complex and will require collaboration by a number of entities to fully develop. There is little doubt that significant resources, financial and otherwise will be required. The items in 2.1, 2.2, 2.3, 2.4 and 2.5 below are thoughts that will be considered in the development of the major U.S. plan. They are suggestions and are not intended to be prescriptive and not complete enough to form a programmatic solution to this broad and immediate problem.

Monitoring For Early Warning: To receive the earliest possible warning of drilling operations and any spills of drilling fluids, oil, and produced waters, monitoring is essential. Within the 12 nautical miles limit of the Territorial Waters of Cuba non-intrusive monitoring (no instrumentation placement or ship entries into) would rely on remote sensing measurements using electromagnetic and underwater sound systems as well as satellite imagery. Outside the territorial limit, instrumentation via placement and ships would be utilized.

Acoustic & Geophysical: Cuban oil drilling "system", i.e. drill rigs, machinery, shaft/pumping operations, service ships, etc. will generate radiated energy that can be detectable in non-Cuban-controlled waters. Characterization of the source and signal loss of such underwater sound and in the ocean bottom (seismic energy) is critical. Ambient "noise field" measurements can provide "background" measurements to evaluate and tune detection abilities. As a precursor source levels and frequency content or distribution of the radiated underwater sound and bottom sound energies will be measured and modeled for a group of existing drilling and production platforms in US waters and other available waters.

More extensive data on oceanic temperature, salinity, and density profiles over multiple years and high special distribution will improve the accuracy of transmission loss predictions, helping identify the transport and vertical distribution of sub-ocean surface oil, oil and dispersants, and related pollutants.

Remote Sensing (Satellite and Airborne Systems): Existing satellite systems (altimetry, infrared, microwave, and visible (hyperspectral) range sensors) will be significant contributors to detecting ship and drill rig activities. This data will be corroborate/compliment underwater sound data for anomaly detection as well as insight into the effects of frontal systems and other ocean phenomena on surface oil and drilling fluid transport.

New polarmetric Synthetic Aperture Radar (SAR) can allow effective discrimination of oil spills and for tracking spills. Fusion of multiple daily remote sensing products of ultra-high resolution (centimeters), high resolution (meters), and medium resolution (250 m to several km pixels) imagery over synoptic scales should be assembled from complementary optical, infrared, and synthetic aperture radar satellites. Aircraft will provide ultra-high spatial resolution (centimeters to tens of meters) and high quality observations around the site of a spill using hyperspectral and multi-spectral optical sensors, calibrated infrared radiometers and X-band SARs. These will help in characterizing and mapping of an oil spill (simultaneous aerial mapping with SARs and optical and thermal instruments and were never utilized during the Deep water Horizon event.

2.2. Ocean and Environmental Baseline Assessments

Ocean Observations: In an oil spill off the north coast of Cuba, currents will likely transport spilled oil in a northeasterly direction. Oil and related pollutants spilled in the Cuban EEZ could reach Florida and the eastern US in a far shorter period of time than that from the Deepwater Horizon (DWH) oil spill. Natural processes to degrade spilled oil and released drilling fluid means oil reaching US waters will have far time than oil from the DWH.

There are complex phenomena associated with current transport north of Cuba including the ambient ocean currents of the US and the Cuban EEZ. The Gulf Stream passes between Florida and Cuba. The Gulf of Mexico is linked with the Atlantic Ocean through the Strait of Florida and to the Caribbean Sea through the Yucatan Channel. The Gulf Stream forms the "loop current" in the Gulf of Mexico for portions of the year. These interact with sea floor bathymetry, coastal topography, seasonality, meteorology, and episodic (hurricane and other storm) influences.

More extensive (in space and time) oceanographic measurements north of Cuba, between Cuba and Florida, and in the Bahamas are critical to provide real-time field data for input into coastal ocean circulation models for the region. Full or partial water column measurements can be made utilizing Acoustic Doppler Current Profiler (ADCP), conductivity-temperature-pressure, acoustical, and hydro-chemical instruments from several platforms including: fixed installations on the ocean bottom and on submerged and/or surface buoys. Data recorded at the instrument site and via real-time data transmission will be needed. Broad area, high resolution surface ocean currents and fronts can be observed using radar instruments on shore, as well as, from space. Sea gliders and autonomous underwater vehicles, or their hybrids, can complement the acoustic and electromagnetic remote sensing tools. Some consideration of transport via deeper westward/southward going currents through the Yucatan Straits could also be envisioned.

Obtaining water samples for analysis or by in situ sensing is a key feature of the observing / monitoring system. Water sampling addresses multiple requirements: (a) prospective oil and/or drilling fluid releases and transport into the US exclusive economic zone, (b) establish arrival of releases at environmental assets of environmental and economic importance, e.g. coral reefs.

Biological Baseline: The environmental and economic impact of an oil spill in foreign waters reaching the US would be devastating with significant impacts to the entire iconic Florida Reef Track coral reef ecosystem, including to fishes and other key organisms that spend portions of their life cycles in foreign and US waters. US Reef ecosystem degradation would have major economic and ecologic ramifications The annual economic value of Florida coral reefs is over $6 billion resulting in over 70,000 jobs in South Florida alone (Hazen & Sawyer, 2000). Substantial economies exist from coastal zone industries and tourism activities of a large portion of the US east coast regarding the value of fishing and tourism. These environmental and economic effects are potentially an order of magnitude greater than that realized from the Deepwater Horizon spill.

Effective evaluation of post-oil spill impacts requires comprehensive knowledge of existing ecosystems. The limited pre-existing information on the baseline status of Gulf of Mexico ecosystems hampered the prioritization of most effective and least harmful response actions, compromised proper assessment of Deep Water Horizon spill impacts and constrained setting appropriate targets for restoration. It is critical to obtain baseline information for the marine ecosystem between northern Cuba and the Florida reef track and Florida Bay to avoid these pitfalls in the event of a Cuban oil spill.

Only about 50% of the Florida Reef Tract coral reef resources have been mapped. Most existing maps are old, based primarily on aerial photographs, and consequently are less than adequate for best spill response. Remote sensing coupled with *in situ* groundtruthing and assessment could update and provide more complete habitat layers to accurately locate and describe what currently exists. Additional bathymetry measurements are needed throughout the Keys and to the north to provide the underwater topographic template for biological mapping.

Quantitative study at selected sites key fish, invertebrates, plants and plankton at fixed and randomly locations will be utilized to best quantify the resources. Knowledge of present resource status and understanding of trajectories in such populations and communities is critical for the development of meaningful experimental and modeling approaches that evaluate oil-related impacts.

Community diversity and resilience of the Florida reef ecosystem is critically dependent on successful recruitment of reproductive propagules, and the movements of adult organisms. There is close proximity of Cuban and Florida coral reefs. Surface current-based oceanographic models for biological connectivity requires testing for predictive ecological models of foreign oil spill impacts on Florida reefs.

2.3. Toxic Effects

There are large gaps in our understanding of detailed, synergistic, short, and long term effects of oil spills and spill treatments on tropical coral reefs, seagrass, pelagic and benthic ecosystems. Oil spills are known to be detrimental to coral reef ecosystems but the degree of severity varies with hydrocarbon type, dosage, organism, and cleanup or mitigation methods. In summary:

- *"Spill impacts vary in severity with the specific conditions at a given spill, including oil type and quantity, species composition, and the nature of oil exposure….*
- *Longer exposure to lower levels of oil may kill corals as well as shorter exposure to higher concentrations….*

*Evaluation of oil toxicity is not an easy task, since each spill presents a unique set of physical, chemical, and biological conditions. … "Oil" includes substances that are chemically very different, ranging from highly toxic and volatile refined products, to less acutely toxic but persistent, heavier fuel oils. Different species and life stages within a species have varying sensitivities and thus may respond very differently to oil exposure. … How corals are exposed to oil bears directly on how serious the impact will be… " (*NOAA (Oil Spills in Coral Reefs: Planning and Response Considerations, 2nd edition NOAA Office of Response and Restoration, 2010).

Without more knowledge, it is impossible to be well prepared for a spill and, importantly, to best plan for and implement effective mitigation efforts, determine damages caused by a spill, and set restoration targets after a spill.

The US Coast Guard response appears focused upon the surface manifestation of the Cuban oil and in the use of dispersants. In Deepwater Horizon, millions of gallons of dispersants were also used at the deep source.

It is well known that dispersed oil can have differential toxic effects to various components of coral reef ecosystems. Therefore, more complete toxicity evaluation is needed for the interaction of the chemical evolution of oil and dispersed oil with the responses of keystone reef organisms, encompassing bacteria, macroalgae, invertebrates (e.g., corals, ocotocorals, sponges) and fishes. Species of focus must cover a broad-range of life-history and ecological traits, including sessile and mobile organisms. Studies should focus on the diversity of oil degradation products (which vary greatly in toxicity) that are likely to impact reef and associated ecosystems.

Understanding, quantification, and thresholds for cellular to community impacts of variable severity acting alone or in concert with other stressors (including those that may accompany climate change) can be accomplished using:

- Dose-response laboratory and microcosm experiments, field assessments, and modeling
- Histological, cellular, molecular, biomarker, skeletal growth, and population and community-level parameters as health indicators.

Evaluation of historical effects of past oil spills as a guide to predicting future impacts can be also be assessed through annual growth and skeletal chemical records of corals that were been previously impacted by a major prior spill, IXTOC, in the 1970's that had significant reef impact. Such information will be useful to evaluate effects to still living corals from the past oil spill and to provide important predictive information for gauging effects of subsequent spills.

2.4. Predictive Modeling of Spill Interactions & Impacts

Physical Oceanographic: Modeling of ambient currents north of Cuba and at the western (Cuba and the Yucatan) and the eastern end (Florida Straits) passages is fundamental to understanding of the transport of released drilling fluids and spilled oil. Challenging aspects of this modeling are the requirements for water column current modeling in a wide range of spatial and temporal scales and modeling of currents linking major flows, e.g. the Gulf Stream, to currents between the Gulf Stream and coasts. Outstanding modeling capabilities of the flows in the Gulfstream Florida Cuba environment, with several years of data and experience resides within the institutions of the scientific consortium mentioned in this document.

A set of high-resolution, non-hydrostatic models can be imbedded at critical locations in an existing coastal circulation nowcast/forecast model for the Yucatan Chanel, Gulf of Mexico, Straits of Florida, and South Atlantic Bight. Advantage can be taken of existing models and in expanding modeling efforts.

Ecological: Responses of the ecosystems to the many different aspects and effects of oil and dispersed oil remain are unclear. Yet without such information, it is impossible to best organize the best response.

Experimental exposure results, reef connectivity dynamics, trophic relationships, and past effects can be used to construct ecological models to predict ecosystem responses to oil and dispersed oil spill scenarios. Detailed results obtained from empirical work will provide scaled information (across several levels) of oil and climate change impacts on tissue, cellular, organismal, and population levels. This information will mathematically explicit by a series of dynamical equations that recreate the cascade of impacts. The result will be a master ecological model for numerical experimentation with different pollution scenarios. Depending on the information available, models will be based on Leslie-matrices, will measure life-history event likelihood using Markov chains, and/or will employ ordinary differential equations. Choice of model will depend on availability of data and life-history information of the organisms (i.e. stage or size-explicit life tables versus only general survivability information). The overall model will be parameterized using experimental and connectivity results and will be verified by hindcasting against known trajectories (experiments). If concordance can be achieved, such models can then be used for forecasting.

2.5. Mitigation

Several models and strategies can be developed specifically to enhance the ability of the US Coast Guard, and other agencies to understand where a spill is going in space and time and what are likely ecological and environmental effects. This information allows planning of best response and mitigation of a spill related to Cuban oil drilling activities.

Models will be appropriately developed or coded in Matlab as a series of inter-linking functions fronted by user-friendly, graphical user interfaces (GUI). Output would be designed for use by resource managers to investigate the potential impacts of various levels of oil/dispersant pollution future. Dynamics among reef organisms will be evaluated by utilizing population growth rates of various organisms to allow exploration of ecological cascades, keystone effects, and multi-species effects. Models will provide explicit parameterization of oil, dispersant and climate change. Sub-models will be combined to an overall, compartmentalized, master model Various levels of stressors (pollution and/or climate change) and empirically determined connectivity dynamics can be set to predict changes in populations and communities resulting from various oil-drilling and spill accident scenarios.

ECOSIM-style models can be developed to incorporate Fisheries and Fisheries management tools and that may act synergistically with oil impacts. This will require data from the empirical studies.

The overall purpose should be is to utilize in-situ and remote sensing observations, knowledge of effects, oceanographic and bio-physical numerical modeling, and data assimilation to trace oil spills, understand effects, and mitigate their impact on sensitive ecosystems.

3. CONSORTIUM SCIENCE TEAM

Current South Florida institutions have the in-depth experience, local knowledge, and data to be most effective in our unique oceanic and coastal environments. These institutions include Florida International University, NOVA Southeastern University, the University of Miami, NOAA's South Florida regional science laboratories and centers (AOML, NHC, and SEFC), and private industry. Other partners could eventually include SECOORA, IOOS, and FLCOOS.

4. FIGURES

Four Figures are attached to the back of this testimony. These figures were provided by members of the Consortium mentioned earlier of from certain news papers or journals.

The first Figure shows the extant oil tracts and leases for Cuba and the Bahamas. This figure come from the named newspaper and is ascribed therein to Jorge Pinon.

The second and third Figures come from Dr. Richard Dodge at NOVA Southeastern University. Both these figures provide a depiction of the Loop Current/Gulfstream.

The fourth Figure comes from a NOAA Technical document and was developed by the writer.

The fifth Figure comes from Dr. Richard Dodge and shows the geographic area of the Deepwater Horizon spill at a particular time. Note that the expected form of the geographic distribution of any prospective Cuban oil spill will likely be different from the DHW distribution.

I thank you for your invitation to speak and for your attention.