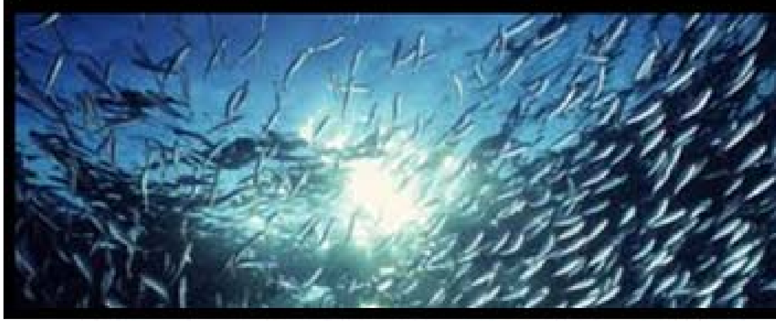
Environmental Impact Assessment for Exploratory Drilling in the Bain, Cooper, Donaldson and Eneas Blocks, Offshore The Bahamas

BAHAMAS PETROLEUM COMPANY PLC.



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Project: Exploratory Drilling Program

Proponent: Bahamas Offshore Petroleum Limited (“Bahamas Petroleum Company”)

Location: Bain, Cooper, Donaldson and Eneas License Blocks (“the Blocks”)

Project Description and Schedule

The Blocks, shown in Figure ES-1, are located offshore The Bahamas, southwest of Andros Island adjacent to the marine border with Cuba. Bahamas Petroleum Company has not finalized the well locations, but the wells will only be located in deepwater (>300 m) portions of the Blocks. The proposed location of the first well (Figure ES-2) is in the Donaldson Block, approximately 80 miles (~130 km) from Andros Island and 25 miles (~40 km) from the nearest Cuban islands in water depths of approximately 1,650 ft. (~500 m).

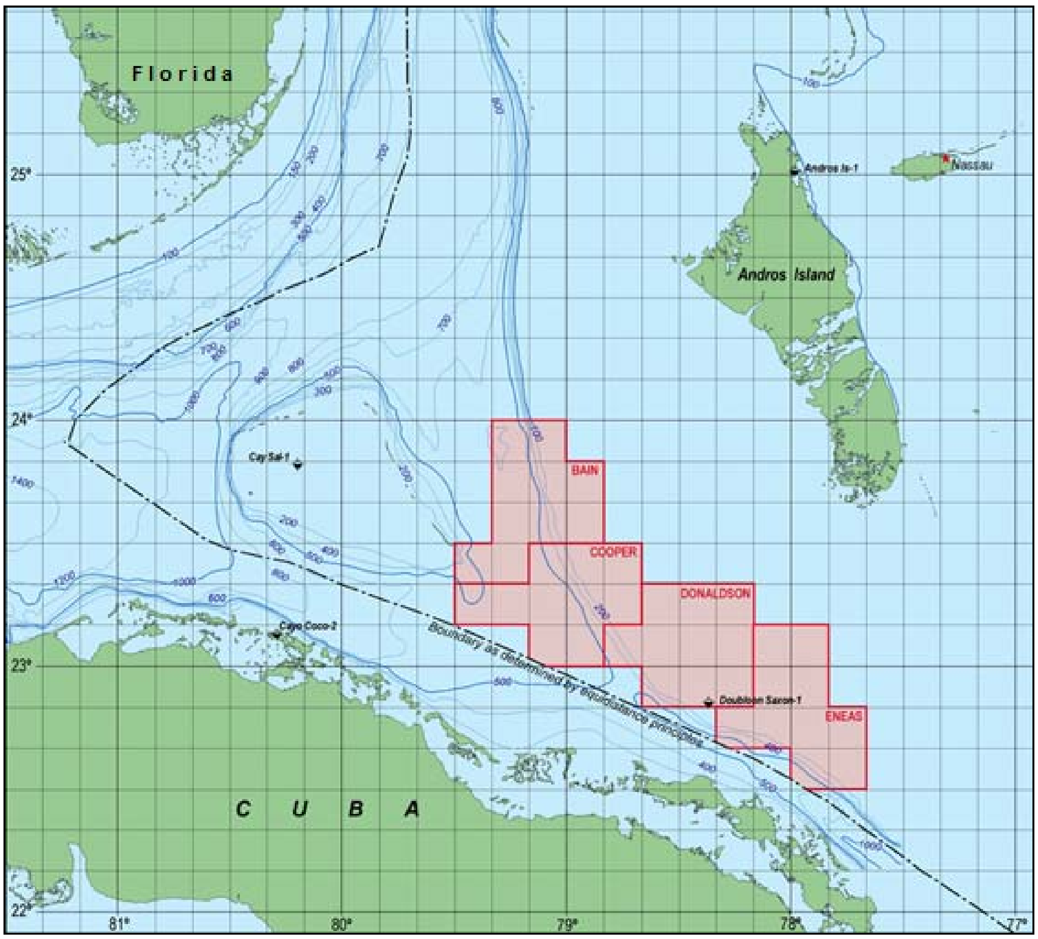

Figure ES-1: Bahamas Petroleum Company Southern License Blocks
Source: Bahamas Petroleum Company[1]

[1] International boundary line shown in the figure is an estimate determined using the equidistance principle and may differ from the coordinates agreed upon by Cuba and The Bahamas.

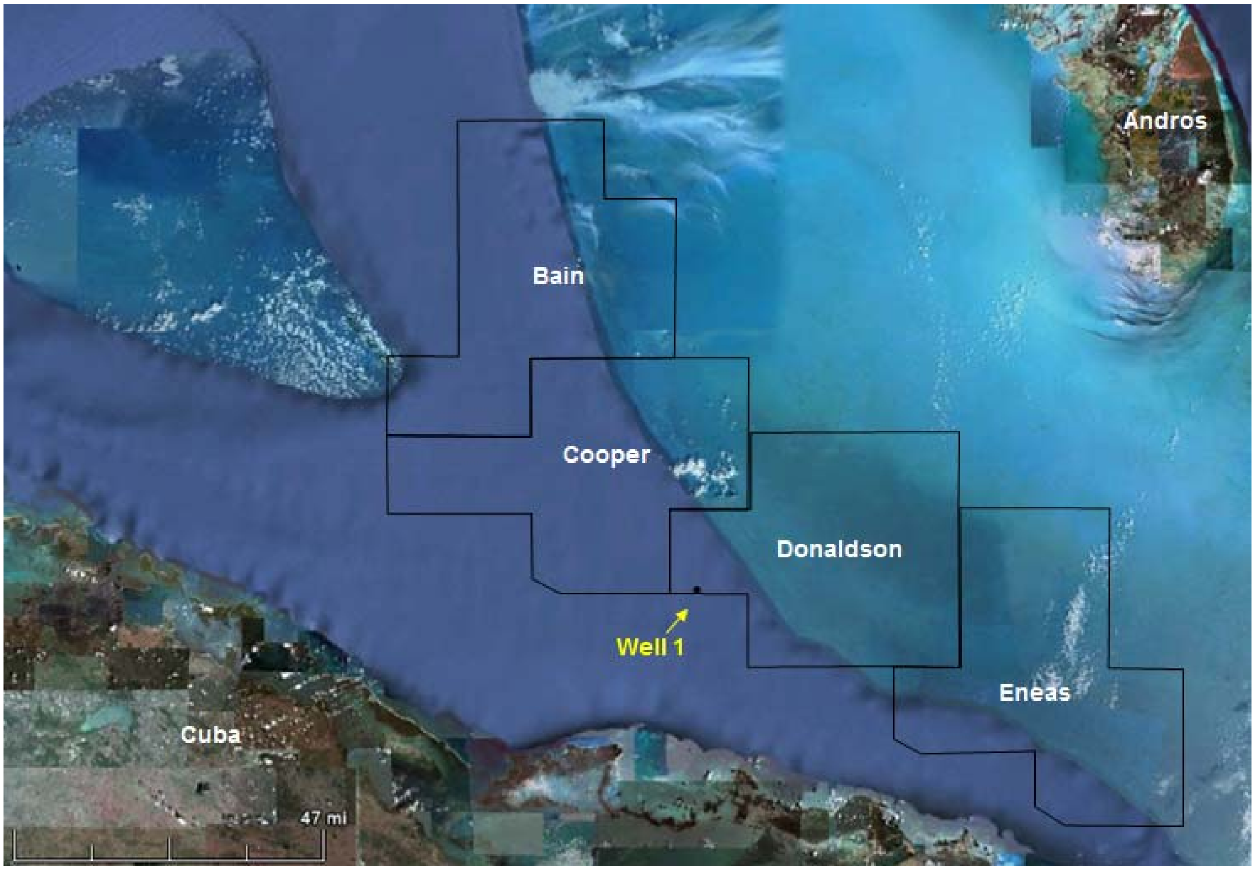

Figure ES-2: Proposed Location of the First Exploration Well
Note: Preliminary coordinates for the well are: 23°00'15.0340" N, 78°46'54.0242" W. Approximate block boundaries shown in black.
Source: Google Earth

The drilling rig will mobilize to the Blocks from its previous assignment, with plans to begin drilling ("spud") of the first well in the fourth quarter of 2012. Each well is scheduled to take approximately 100 – 130 days; therefore, the entire drilling program should be completed within 3-5 months for each well.

Drilling activities for each well will occur in four main phases:

- Rig Mobilization
- Drilling
- Well Completion and Appraisal
- Decommissioning and Abandonment

The drilling rig (likely a drillship or semi-submersible) and other aspects of the proposed program are very similar to the work currently being conducted offshore Cuba.

Affected Environment

The proposed activities will be conducted in a deepwater marine environment. The deepwater areas of the Blocks are located along the Old Bahama Channel and the Santaren Channel, both known shipping lanes (see Figure 4-39). There are a number of sensitive coastal areas facing the Blocks including: beaches, estuaries, mangroves and protected areas. Coral reefs and sea grass beds occur in shallow areas of the Blocks and fishing is conducted in shallow areas. However, these areas are away from potential drill sites. Whales, dolphins and sea turtles are known to inhabit waters in the area. Sea turtles and water birds nest on beaches and marshlands adjacent to the Blocks. No known environmental sensitivities exist in the immediate vicinity of the first proposed drill site. Potential project impacts and other baseline environmental and social conditions are summarized below and assessed in Chapter 5.

Study of the previous wells drilled in The Bahamas near the first proposed well site suggests that the reservoirs could be at or below normal well pressures. This means that oil or other liquids may be too heavy to flow to the surface without pumps (although if gas is present it will), reducing the probability of a blowout.

Potential Impacts and Alternatives

Many of the potential impacts identified for the Project are associated with routine events (for example, discharges and waste management) for which there are procedures and mitigation measures in place as part of standard operating practices. Potential hydrocarbon formations are expected to be low pressure, therefore Bahamas Petroleum Company expects to drill the wells mainly with seawater. However, a water based drilling fluid cannot be ruled out at this stage. If it is deemed that synthetic based fluids are unavoidable due to technical reasons, a strict policy of “total containment” will be followed. No synthetic based fluids or associated cuttings would be discharged, as drill cuttings may contain small particles of synthetic based fluid. The used fluids would be returned to the vendor for reprocessing and the cuttings would be shipped ashore to a suitable licensed land fill site for disposal.

Potential impacts associated with accidental events (particularly accidental spills and loss of well control) will require contingency planning and additional resources.[2] These impacts may include potential short term effects on marine water quality, marine fauna, sensitive shoreline features, tourism areas and fishing activities from spills of oil, fuel, wastes, or hazardous materials.

Bahamas Petroleum Company proposes to utilize shore base facilities in Freeport, Grand Bahama Island and/or Port Fourchon, Louisiana, United States. A slight increase in marine traffic from supply vessels traveling to/from the shore base to the drill sites is expected (maximum of 2-3 trips per week). In addition, a one km safety zone will be established around the drilling location that will be off limits to fishing and boat traffic.

Crew changes will possibly operate through Andros Town. The flight path, via helicopter, will be a direct line between the drill sites and the Andros Town Airport. The flight path will be primarily away from shore, so helicopters involved in the Project will not pass along potentially sensitive receptors.

The proposed drilling activities will require the provision of boats, food, accommodation, flights (fixed wing and helicopter), emergency services, construction materials and other goods and services that could create new jobs. However, the project is temporary (no more than 5 months per well) and limited (1-3 wells) so the Project is not going to generate many jobs for local residents at this stage due to the need of specialized skilled workers. However, if commercial

[2] The evaluation of impacts from non-routine events (particularly loss of well control) was based on detailed modeling conducted by researchers at the University of Miami. Their complete report, *Transport and Fate of Oil Particles Released in The Bahamas,* is attached as Appendix A.

reserves are identified, the impact to the local economy could be significant, both in terms of job creation and revenue to the government.

Prior to initiating the drilling, Bahamas Petroleum Company will analyze the seafloor conditions based on detailed geophysical and seafloor imagery to determine if there are any anomalies (e.g., steep seafloor slopes, boulders or gas vents) that could represent either higher biological diversity habitat than surrounding seafloor areas or potential hazards to safe and successful drilling. If any such features are observed, the specific location of the drill site can be adjusted to avoid them.

For exploratory drilling programs, alternatives result in little variation in terms of potential environmental and social impacts and are often limited because of technical requirements. Alternatives considered for the project (Chapter 2), included:

- Well Locations
- Type of Drilling Unit
- Type of Drilling Fluid
- Cuttings Disposal Methods
- Shore base Location
- “No Action” Alternative

No additional alternatives were considered for this Project given that:

- No protected areas were identified within the study area
- The Project will occur at least 15 miles (~24 km) from land, and over 25 miles (~40 km) from the nearest inhabited land
- Bahamas Petroleum Company will have adequate resources and programs in place to ensure protection of human health, safety and the environment

The identified impacts were determined acceptable, but mitigation measures have been proposed when appropriate.

Mitigation and Monitoring Required

An Environmental Management Plan (EMP) outline (Chapter 6) has been developed to manage potential impacts of the proposed drilling activities such that they remain at acceptable levels throughout the exploration program. Mitigation measures proposed include:

- Maintaining good housekeeping on board, particularly regarding materials storage, rig washing and routine maintenance operations
- Adhering to standard operating procedures during bunkering/refueling to minimize incidents
- Coordinating with local authorities regarding oil spill response preparations, including international response coordination
- Communicating with local port, marine navigation, and fishing authorities proposed locations and schedule
- Establishing a reliable means of communication between the drilling rig captain, government marine authorities, and fishermen during the drilling program
- Developing and implementing plans for monitoring vessel movements near the drilling unit and enforcing the one km safety zone
- Selecting low toxicity drilling fluids and other materials

- Prohibiting any overboard discharge of synthetic based drilling fluids and cuttings containing synthetic based fluids, in the unlikely event of these being used
- Prohibiting discharge of drill cuttings near sensitive areas
- Alignment of response activities with the Caribbean Island Oil Pollution Response and Cooperation Plan and The Bahamas Oil Spill Contingency Plan

Oil spill planning preparations for the proposed project could establish improved cooperation and preparedness for response planning that otherwise may not occur.

Re-evaluation of impacts considering the application of these and other mitigation and monitoring measures reveals that potential impacts can be classified as having a “low” level of significance. The EMP has been prepared in a format that can be used to guide those conducting the project activities in recognizing and minimizing potential impacts.

Consultant Information

The EIA Team is comprised of an integrated group of environmental and social impact specialists from Acorn International, LLC (“Acorn International”) of the United States and SEV Consulting Group (“SEV”) of The Bahamas, working in cooperation with Bahamas Petroleum Company. SEV is a multi-disciplinary consulting firm fully registered to perform EIAs in The Bahamas. SEV and its team members have performed a number of EIAs, management plans, and monitoring programs for developments throughout The Bahamas. SEV is currently working with the Nassau Airport Development Company as the environmental construction monitor for the Lynden Pindling International Airport Expansion Project and recently worked with the Albany Development (New Providence) on its EIA and EMP which included identifying impacts, recommending mitigation measures, designing a monitoring regime, training of staff on environmental issues and monitoring of relocated corals.

Acorn International has performed more than 80 EIAs for development projects worldwide, including more than 60 for oil and gas industry programs. This includes EIA and related studies for offshore exploration programs in the Caribbean, offshore the United States, Mexico, Nicaragua, Panama, Colombia, Venezuela, Trinidad and Tobago and Barbados. In addition to working with oil and gas companies worldwide, Acorn International has been called on to help governments in Africa, Asia and South America strengthen the means by which they regulate the environmental and social considerations of oil exploration and production activities.

Methodology

The EIA Team identified and evaluated potential project impacts based on a thorough evaluation of the baseline environmental and social conditions, proposed project activities and the team’s experience conducting over 60 EIAs for oil and gas projects. The EIA team used an internationally applied EIA methodology that incorporates lessons learned on oil and gas industry best practices from sources such as the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Finance Corporation (IFC), a member of the World Bank Group. The EIA Team has consistently applied this same methodology on oil and gas exploration program EIAs worldwide.

The impact identification and evaluation methodology is described in detail in Chapters 5 and 6.

In addition to the EIA, Bahamas Petroleum Company will commission well-specific EMPs for each drill site that incorporate project details that are not currently available. Each well-specific EMP will include:

- Overview and Purpose of Plan
- Well Site Specific Activities
- Well Site Specific Baseline Supplement
- Well Site Specific Impact Assessment Supplement
- Well Site Specific Mitigation Measures (including monitoring and reporting)

In addition, the following plans will be provided:

- Oil Spill Contingency Plan (including response to blowouts)
- Emergency Response Plan (including response to hurricanes)
- Waste Management Plan
- Health and Safety Plan
- Public Notification and Consultation Plan

1. Introduction

License Agreements with the Commonwealth of The Bahamas for the Bain, Cooper, Donaldson and Eneas Blocks (“the Blocks”) are held by Bahamas Offshore Petroleum Limited (“Bahamas Petroleum Company” or “the Company”), a wholly-owned Bahamian subsidiary of Bahamas Petroleum Company Plc. Bahamas Petroleum Company plans to conduct exploration drilling in the Blocks and has commissioned this Environmental Impact Assessment (EIA) in order to identify and manage potential environmental and social impacts of the drilling program.

This introductory chapter presents a background of the project, a definition of the study area, an introduction to the EIA team and a description of the EIA methodology.

1.1 Background

This report addresses the potential environmental and social impacts of the drilling program in the Bain, Cooper, Donaldson and Eneas Blocks (Figure 1-1). Bahamas Petroleum Company plans to drill one to three exploration wells during this exploration program. The well locations have not been finalized, but Bahamas Petroleum Company expects they will be located in water depths of approximately 1,650 ft. (~500 m). The current proposed location of the first well is in the Donaldson Block, approximately 80 miles (~130 km) from Andros Island and 25 miles (~40 km) from the nearest Cuban islands.

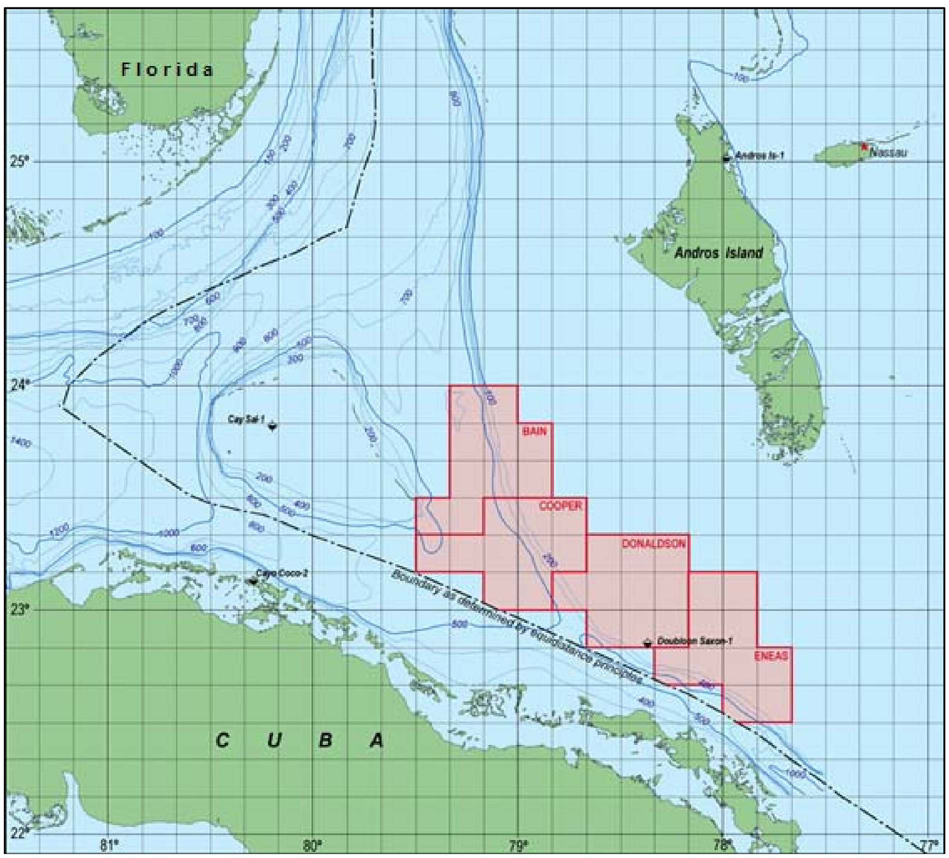

Figure 1-1: Exploration Program Concession Blocks
Source: Bahamas Petroleum Company[1]

[1] International boundary line shown International boundary line shown in the figure is an estimate determined using the equidistance principle and may differ from the coordinates agreed upon by Cuba and The Bahamas.

Support vessels will travel to and from an existing onshore base. Bahamas Petroleum Company is considering using shore base facilities in Freeport, Grand Bahama and/or Port Fouchon, Louisiana, United States of America (USA). The onshore base(s) will be used to supply food, water and fuel, and for supporting services such as docking of boats, waste management, movement and storage of cargo and for crew support. Helicopters and other air support are likely to use the Andros Town Airport in Andros and crew will then be flown by plane to/from either Lynden Pindling International Airport in Nassau, New Providence and/or other regional airports.

Drilling is expected to begin in the last quarter of 2012 and last approximately 6-10 months.

License requirements mandate Bahamas Petroleum Company to begin drilling an initial exploration well by March 26, 2013. If the first well doesn't encounter commercial hydrocarbon deposits Bahamas Petroleum Company will have an additional 2 years to complete a second well or surrender the licenses. If commercial quantities are indicated then Bahamas Petroleum Company would proceed to the appraisal drilling phase. During appraisal drilling the Company would anticipate drilling 3 to 5 wells over a 1 to 3 year period. It is unlikely wells would be drilled concurrently. Information collected during the appraisal drilling would be used to submit a "Plan of Development".

1.1.1 Additional Concessions in The Bahamas

In addition to the Bain, Cooper, Donaldson and Eneas Blocks, Bahamas Petroleum Company (through its subsidiary, Island Offshore Petroleum Limited, Figure 1-2) holds a license for the Miami Block, southwest of Freeport (Figure 1-3).

Bahamas Petroleum Company has also applied for licenses in the Santaren and Andros Blocks, and, in partnership with Statoil, the Falcones, Zapata and Islamorada Blocks.

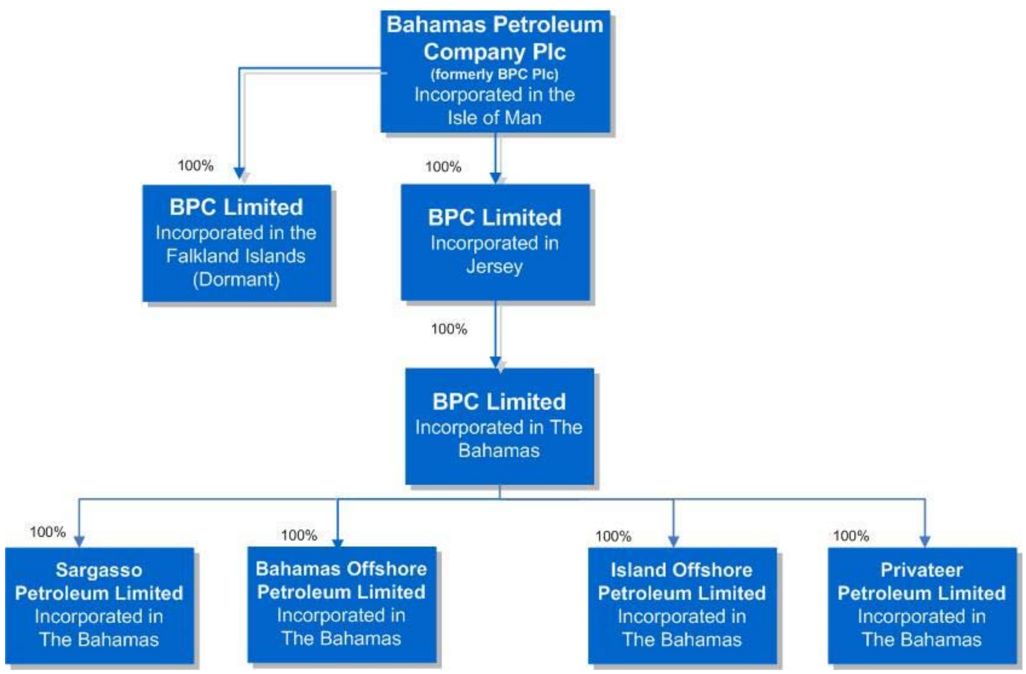

Figure 1-2: Bahamas Petroleum Company Corporate Structure
Source: Bahamas Petroleum Company

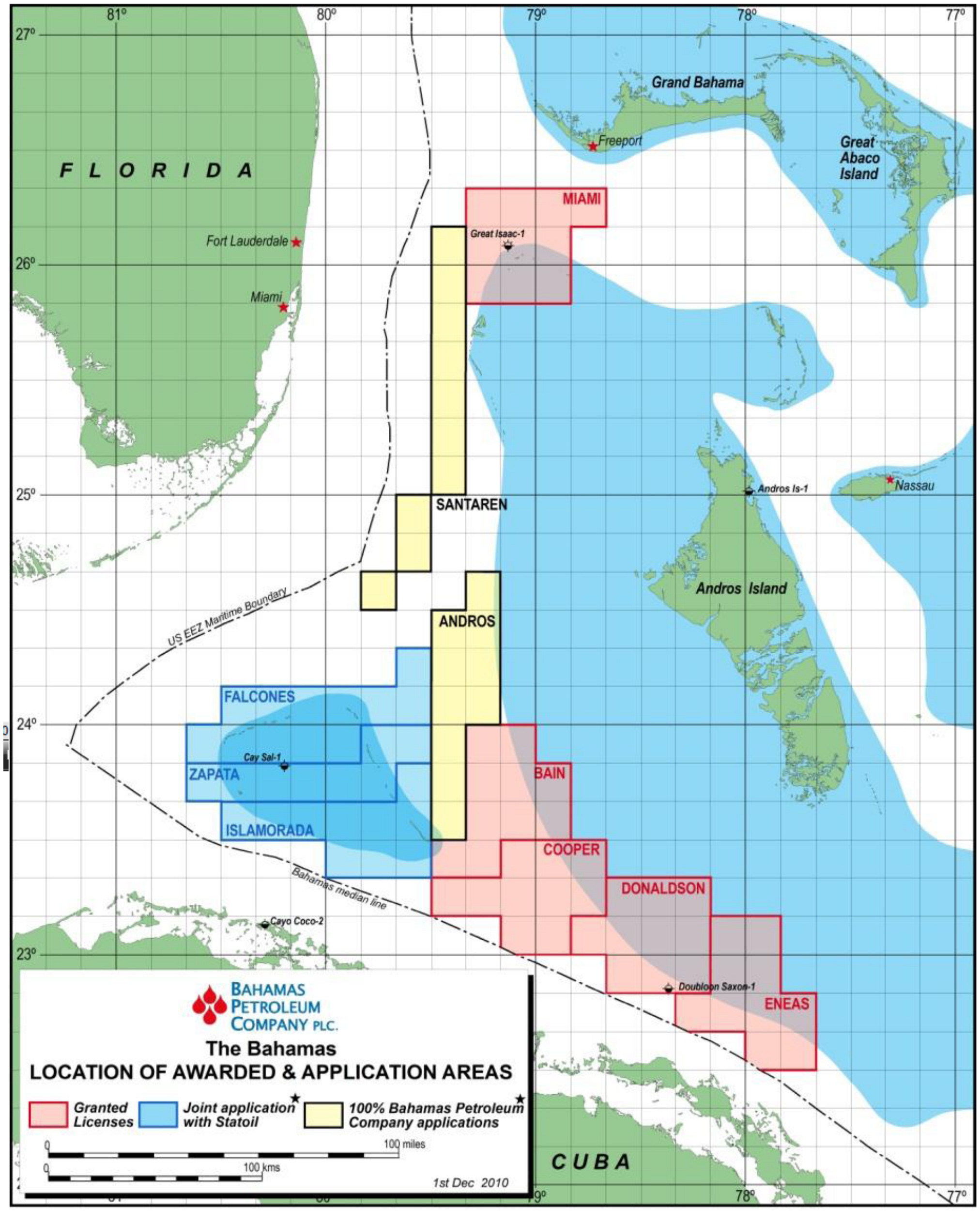

Figure 1-3: Bahamas Petroleum Company License and Application Areas
Source: Bahamas Petroleum Company[2]

1.1.2 History of Oil and Gas Exploration in The Bahamas and Surrounding Areas

<u>1.1.2.1 The Bahamas</u>
Oil and gas companies carried out exploration activities in The Bahamas region from the mid-1940s until the late-1980s. The major companies involved include: Esso (Exxon), Amoco, Tenneco, Texaco, Arco, Breco and Shell. The companies completed multiple seismic surveys, gravity and magnetic surveys, surface and subsea geochemical surveys, and geotechnical site

[2] International boundary line shown International boundary line shown in the figure is an estimate determined using the equidistance principle and may differ from the coordinates agreed upon by Cuba and The Bahamas.

surveys. Tenneco Oil Company was the most active in this respect. As shown in Figure 1-4 and Table 1-1, five wells were ultimately drilled in The Bahamas between 1944 -1986.[3]

Figure 1-4: Locations of Available Well Logs from Wells Drilled in the Region, 1944 – 1986
Source: Bahamas Petroleum Company

The Doubloon Saxon well was the deepest well drilled in The Bahamas (total depth of 21,739 ft.). Bahamas Petroleum Company is required to drill to 18,000 sub-sea total vertical depth (SSTVD), slightly deeper than the Great Isaac well and not as deep as Cay Sal well or Doubloon Saxon (see Table 1-1). The total well depth has not been finalized, but could be deeper or approximately the same as the Doubloon Saxon.

Once final well depths are known, expected pressures can be calculated (for any depth) based on an industry standard pressure gradient of 0.465psi per foot of depth. “Worst Case Discharge” calculations would identify expected pressures in the project area and that these calculations will be included in the well specific Environmental Management Plan.

[3] Bahamas Petroleum Company. 2011. Retrieved from the Bahamas Petroleum Company Website: www.Bahamas Petroleum Companyplc.com

Table 1-1: Wells Drilled in the Bahamas, 1947 – 1986

Well	Year	Location	Operator	Total Depth
Andros Island – 1	1947	Land	Superior	14,587 ft. (4,446 m)
Cay Sal – 1	1958	Offshore	Bahamas California Co. (Chevron)	18,905 ft. (5,763 m)
Long Island – 1	1970	Offshore	Bahamas Gulf	17,556 ft. (5,351 m)
Great Isaac – 1	1971	Offshore	Bahamas California Co. (Chevron)	17,848 ft. (5,440 m)
Doubloon Saxon - 1	1986	Offshore	Tenneco	21,739 ft. (6,626 m)

Source: Bahamas Petroleum Company

While companies did encounter oil in some wells, none deemed extraction commercially viable, and so the licenses expired. These wells demonstrate that the carbonate (limestone and dolomite) reservoirs drilled in The Bahamas do not contain the highly pressured reservoirs that occur off the Mississippi Delta, such as those encountered in the BP Macondo well. Overpressured reservoirs are not typical of carbonate reservoirs.

Alongside oil exploration, there is a long history of crude oil and refined petroleum products being shipped through Bahamian waters. Bahamas Oil Refining Company International Limited (BORCO) operates a 20-million barrel oil storage terminal in Freeport, Grand Bahama - the fourth largest in the world. Oil loading and storage facilities were first installed in Freeport in 1968 by Chevron Corporation. In addition, Statoil ASA operates the South Riding Point terminal, 22 miles (~35 km) east of BORCO on Grand Bahama. Both facilities are currently being upgraded in addition to expanding the oil storage capacities.

1.1.2.2 Florida

In addition to the activities referenced above, 14 exploratory wells were drilled between 1943 and 1986 in shallow waters near the Florida Keys (Figure 1-5). Approximately 30 wells were drilled in deep water (>500 ft.) off the Gulf Coast of Florida.

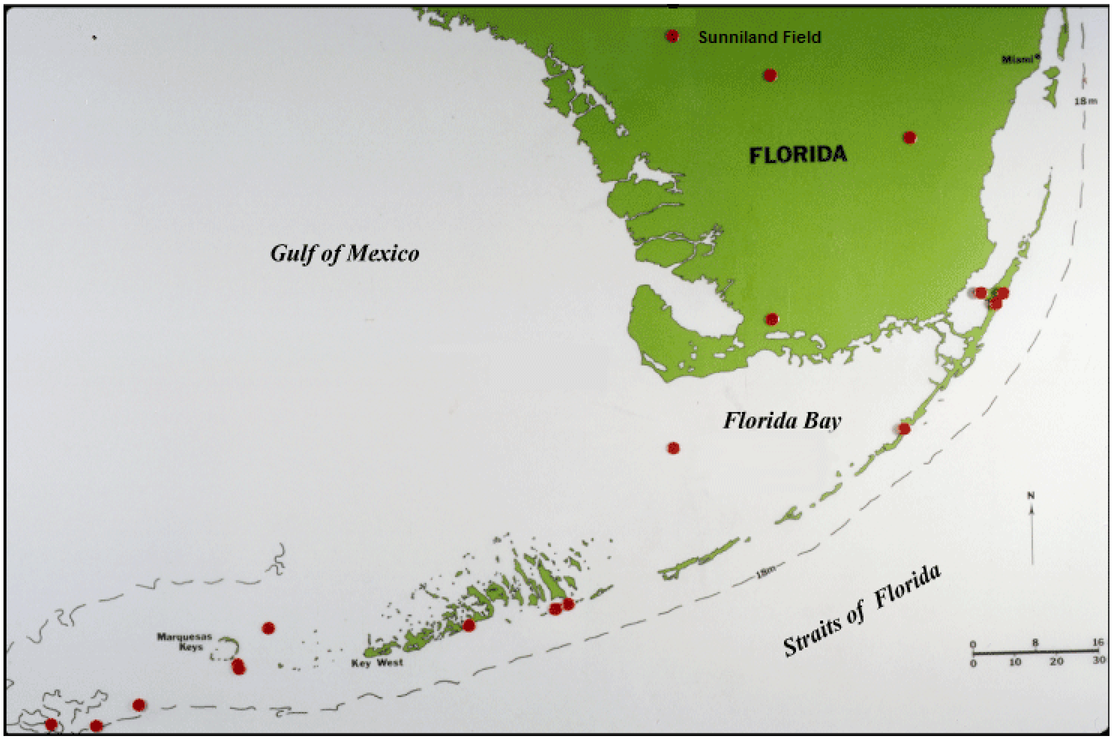

Figure 1-5: Wells Drilled in Southern Florida, 1943 – 1986
Source: Lidz et al. 2007[4]

1.1.2.3 Gulf of Mexico

The oil and gas industry began drilling in nearshore waters of the Gulf of Mexico in the late 1930's; however, the first well drilled "out-of-sight-of-land" (12 miles) was not until 1947[5]. Early offshore drilling used technologies modified from land-based rigs, but operators continually adapted to meet the challenges of operations in the sea such as waves, winds, tides and hurricanes.

As of May 2010, over 50,000 wells have been drilled in the US Gulf of Mexico (Figure 1-6) and the industry has developed new drilling technologies and procedures specifically to cope with drilling in deeper water environments.

The rate of blowouts in the oil and gas industry is very low (0.0048 blowouts per well drilled offshore in the US Outer Continental Shelf between 1996 and 2009) because of the common use of blowout preventers (BOPs) and rigorous health and safety standards, and policies and procedures that are focused on incident prevention.[6] The regulations and standards have been

[4] Lidz, B., Reich, C.D., and E.A Shin. 2007. U.S. Geological Survey (USGS) Professional Paper 1751: Systematic Mapping of Bedrock and Habitats along the Florida Reef Tract—Central Key Largo to Halfmoon Shoal (Gulf of Mexico). Retrieved from the USGS website: http://pubs.usgs.gov/pp/2007/1751/professional-paper/tile9-10/oil-wells.html

[5] Austin, D., B. Carriker, T. McGuire, J. Pratt, T. Priest, and A. G. Pulsipher. 2004. History of the Offshore Oil and Gas Industry in Southern Louisiana: Interim Report; Volume I: Papers on the Evolving Offshore Industry. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-049. 98 pp.

[6] Abbot, J. Measuring OCS Performance. US Department of Interior (DOI), Bureau of Ocean Energy Management, Regulation and Enforcement. Retrieved from the DOI Website: http://www.boemre.gov/perfmeas/index.htm

increased since the Macondo event. The geology of The Bahamas is considerably different from the Gulf of Mexico, as will be discussed later, and the development of pressure is considerably less likely.

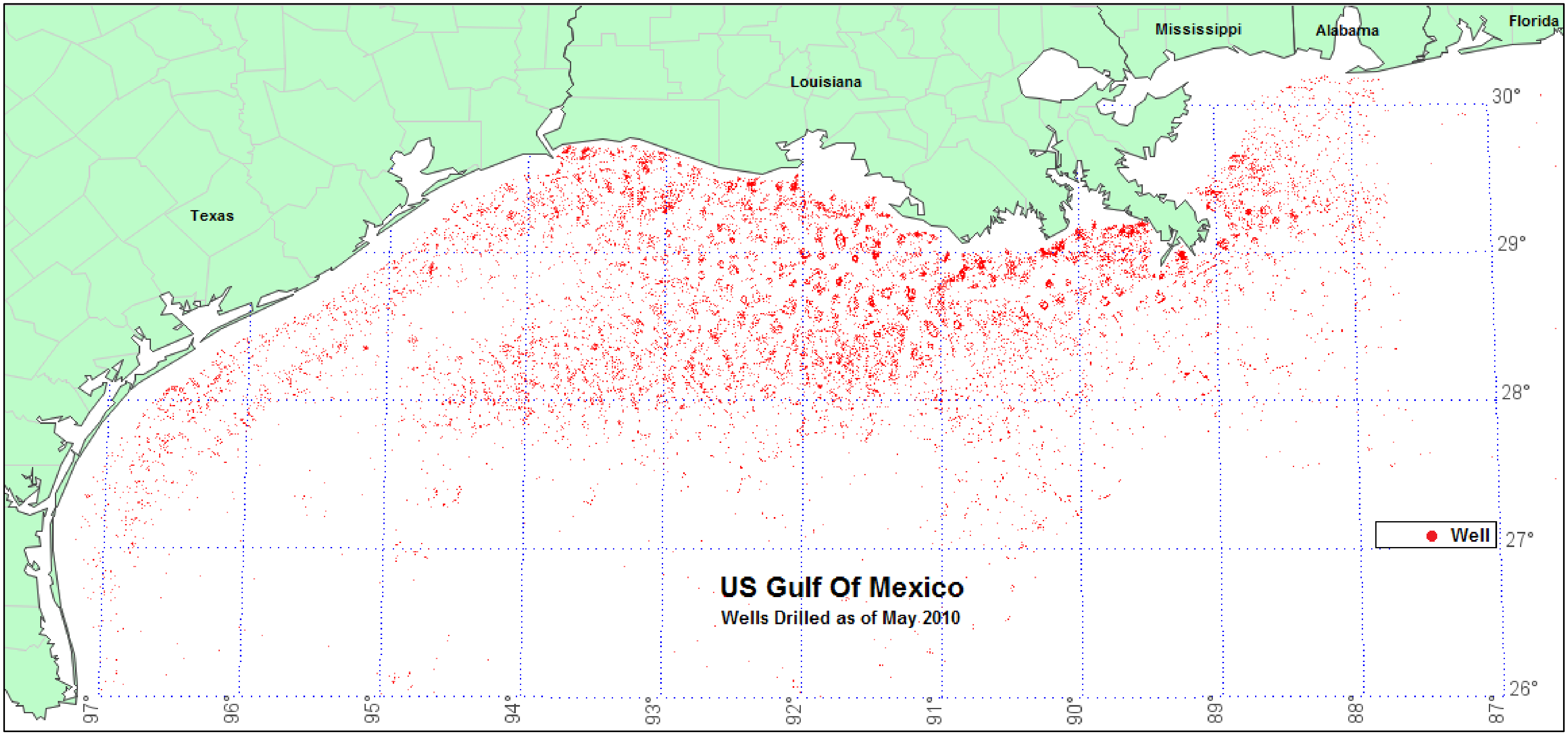

Figure 1-6: Wells Drilled in the US Gulf of Mexico
Source: Robslink.com, 2011[7]

[7] "US Gulf- 50,686 Individual wells/bore-holes (May 2010)". Accessed from the Robslink website: http://robslink.com/SAS/democd33/borehole.htm

1.1.2.4 Cuba

Recent improvements in exploration technologies, higher oil prices and changes to investment laws in Cuba have renewed interest in oil and gas exploration offshore Cuba. Since 1991, oil and gas companies have invested $USD 2.8 billion in exploration and production activities in Cuba.[8] There are currently 59 offshore blocks in the Cuban Gulf of Mexico, and 22 are under contract with operators (Figure 1-7). The average water depth of the blocks is 1,400 m and operators in Cuba expect to drill five additional wells offshore in deepwater beginning in 2011.[9]

Spain's Repsol completed drilling of the Yamagua well in 2004. Yamagua is located approximately 20 km offshore Cuba, an area known for tourism. The nearest areas of Bahamas Petroleum Company's blocks to the Cuban coast are slightly farther than this. Repsol will initiate exploratory drilling off the northwest coast of Cuba as early as December 2011, using a 6th generation semi-submersible rig, Scarabeo 9.

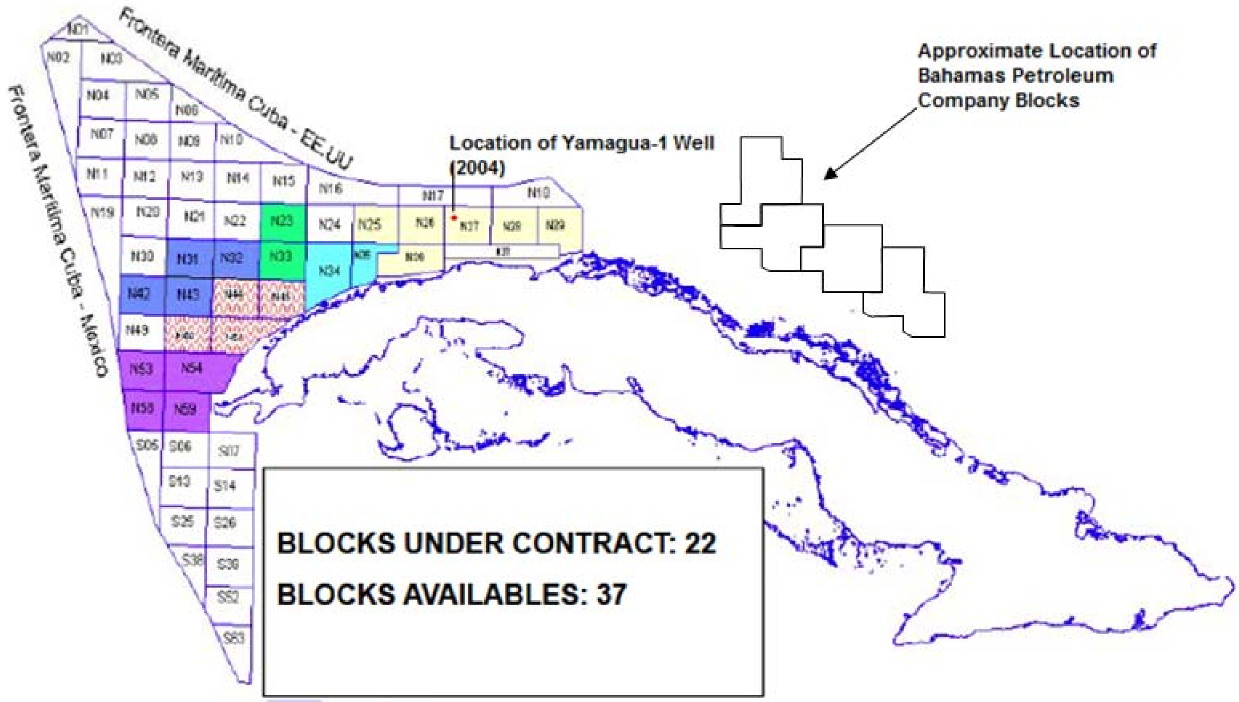

Figure 1-7: Oil and Gas Lease Blocks Offshore Cuba

Source: Adapted from Environmental Conference & Exhibition Presentation, Trinidad. May 12-13, 2011 [5]

1.1.3 Objectives of the EIA

This EIA has been prepared to meet three main objectives:

1. Comply with the terms of the License Agreements and Commonwealth of The Bahamas regulatory requirements
2. Satisfy Bahamas Petroleum Company corporate environmental and social impact management expectations
3. Support project planning and help the proposed exploratory drilling program proceed with minimal environmental and socio-economic impact

[8] "Highlights of Cuban Deepwater Drilling Programs". 2011. Environmental Conference & Exhibition, Trinidad. May 12-13, 2011.

[9] Rigzone. 2011. "Cuba to Drill 5 New Oil Wells by 2013". Dow Jones News Wires: Tuesday, April 05, 2011. Retrieved from the Rigzone website: http://www.rigzone.com/news/article.asp?a_id=105834

Bahamas Petroleum Company and its contractors will use this EIA to help identify and mitigate environmental and social impacts resulting from the drilling program.

This EIA will help support Bahamas Petroleum Company's efforts to deliver strong health, safety and environmental (HSE) performance in its activities and is designed to serve as a guide for Bahamas Petroleum Company and its contractors to plan and execute the proposed drilling program in an environmentally and socially responsible manner.

Following the process shown in Figure 1-8, the contents of the EIA report include:

- Technical Project Description: Description of the proposed activities (Chapter 2)
- Regulatory Framework Definition: Description of existing laws, regulations, agreements, and policies that may apply to the proposed activities (Chapter 3)
- Baseline Investigation: Description of the existing ("baseline") environmental and social conditions in the study area (Chapter 4)
- Impacts and Alternatives Analysis: Identification and evaluation of impacts that may result from the proposed activities (Chapter 5)
- Management Plan: Recommendation of practices required to mitigate and manage the potential impacts (Chapter 6)

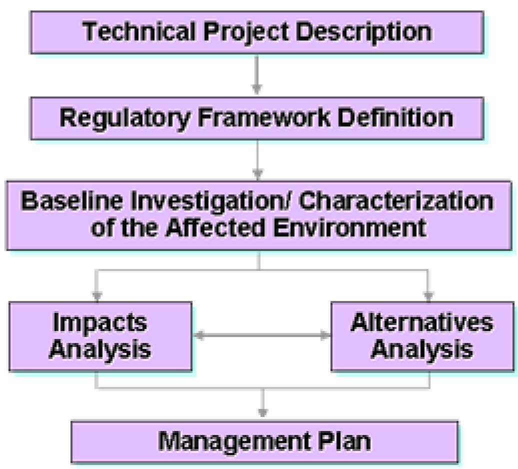

Figure 1-8: General EIA Process

An Executive Summary is included to provide a brief profile of the EIA.

Likely impacts and corresponding mitigation and management recommendations are summarized in matrices in Chapters 5 and 6. Details of the Oil Spill Model are presented in Appendix A that follows the text.

1.2 Study Area

The study area includes areas of direct and indirect impact (Figure 1-9). The Area of Direct Impact (ADI) includes:

- All potential drilling sites (portions of the Blocks with water depths greater than 300 m), including a 3 mile (~5 km) buffer that could be affected by emissions, discharges or other drilling related activities
- Port facilities likely to be located in Freeport, Grand Bahama and/or possibly Port Fourchon, Louisiana (see Figures 2-6 and 2-7, respectively, for aerial photographs of each) and Congo Town Airport in South Andros
- A transportation corridor, used by supply vessels and helicopters, to/from the Blocks and port facilities/airports

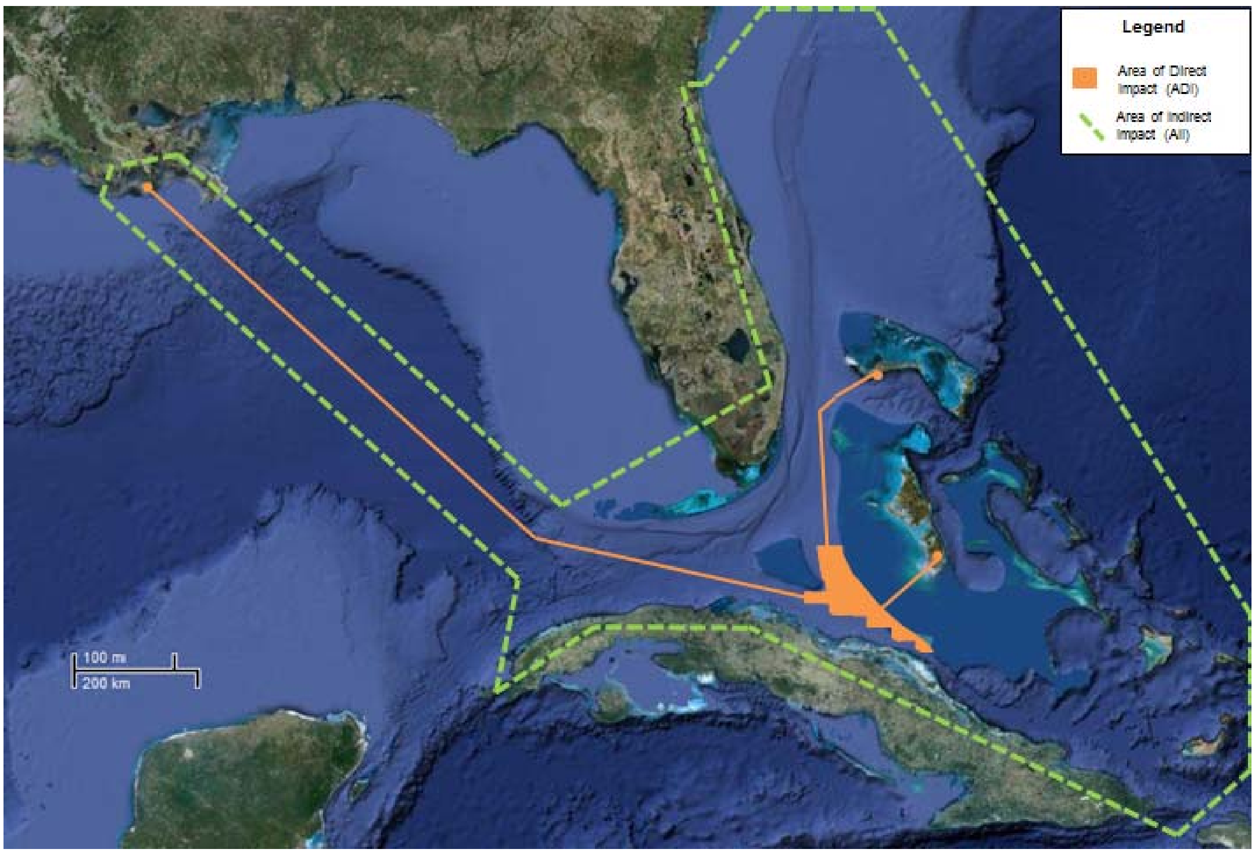

Figure 1-9: Area of Direct and Indirect Impact

The study area also includes the Area of Indirect Impact (AII), where project activities could have indirect or cumulative impacts, or be affected in the unlikely event of an extreme event. The extent of the AII will depend on site specific information, such as the location of the well and shore base.

The AII presented in Figure 1-9 is based on oil spill modeling presented in Appendix A for a potential well-site located in the Donaldson Block. The AII includes:

- All coastlines with probability greater than 1 percent (%) of oiling from a 'worst case' spill

- Approximate ocean surface with probability greater than 10 percent (%) of oil presence from a 'worst case' oil spill[10]
- Coastal communities (i.e. fishing or tourism dependent) adjacent to oiled coastline, and/or perceived oiled coastline[11] including ports, beaches, protected areas and other coastline features
- Potential transportation corridors to shore base, including a 50 mile buffer zone that could be impacted by a vessel collision and diesel fuel spill
- Potential shore base locations and 30 mile onshore buffer zone surrounding the port

The baseline chapter presented in Chapter 4 focuses on areas within the ADI, as these areas are more likely to be impacted by project activities, and presents an overview of all areas within the entire AII. Areas within the AII are covered at an appropriate level necessary to conduct a thorough impact assessment, but not as detailed as the ADI.

A Sensitivity Map is presented in Appendix C to highlight areas that require particular attention for oil spills and other project planning.

When the drilling program details are finalized, Bahamas Petroleum Company will develop well-specific Environmental Management Plans (EMP) that will define specific ADI and AII for each well, and provide additional baseline information if needed. Bahamas Petroleum Company will submit these well-specific EMPs to the Bahamian government for review prior to drilling each well to compliment the EIA. The EIA methodology is further described in Section 1.4.

1.3 EIA Team

The EIA Team is comprised of an integrated group of environmental and social impact specialists from Acorn International, LLC ("Acorn International") of the United States and SEV Consulting Group ("SEV") of The Bahamas, working in cooperation with Bahamas Petroleum Company. SEV is a multi-disciplinary consulting firm fully registered to perform EIAs in The Bahamas. SEV and its team members have performed a number of EIAs, management plans, and monitoring programs for developments throughout The Bahamas. SEV is currently working with the Nassau Airport Development Company as the environmental construction monitor for the Lynden Pindling International Airport Expansion Project and recently worked with the Albany Development (New Providence) on its EIA and EMP which included identifying impacts, recommending mitigation measures, designing a monitoring regime, training of staff on environmental issues and monitoring of relocated corals.

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[10] This area is defined by the probability to observe oil sheen with surface concentration > 0.05 μm

[11] For example, portions of the Bahamian, Cuba and Florida coastlines were determined to have less than 1 percent (%) chance of oiling in the event of an oil spill but were included in the AII as these regions would likely be associated with an oil spill and have "perceived impacts" by potential tourists.

Acorn International and SEV have established a partnership to provide international industries operating in The Bahamas with local expertise and international best practices in EIA and environmental and social impact management. Staff of Bahamas Petroleum Company worked closely with SEV and Acorn International to complete this EIA.

1.4 EIA Methodology

The EIA Team identified and evaluated potential project impacts based on a thorough evaluation of the baseline environmental and social conditions, proposed project activities and the team's experience conducting over 80 EIAs for oil and gas projects. The EIA team used an internationally applied EIA methodology that incorporates lessons learned on oil and gas industry best practices from sources such as the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Finance Corporation (IFC), a member of the World Bank Group. The EIA Team has consistently applied this same methodology on oil and gas exploration program EIAs worldwide.

The impact identification and evaluation methodology is described in detail in Chapters 5 and 6.

In addition to the EIA, Bahamas Petroleum Company will commission well specific EMPs for each drill site that incorporate project details that are not currently available. Each well specific EMP will include:

- Overview and Purpose of Plan
- Well Site Specific Activities
- Well Site Specific Baseline Supplement
- Well Site Specific Impact Assessment Supplement
- Well Site Specific Mitigation Measures (including monitoring and reporting)

In addition, the following plans will be provided:

- Oil Spill Contingency Plan
- Emergency Response Plan (including response to hurricanes)
- Waste Management Plan
- Health and Safety Plan
- Public Notification and Consultation Plan

2. Project Description

This Chapter discusses the various activities which will be completed by Bahamas Petroleum Company as part of the exploratory drilling program in the Bain, Cooper, Donaldson and/or Eneas Blocks, offshore The Bahamas. The Project will be performed in accordance with the License Agreements between Bahamas Offshore Petroleum Ltd ("Bahamas Petroleum Company" or "the Company") and the Commonwealth of The Bahamas. Information used to develop this Chapter was provided by both Bahamas Petroleum Company and other industry sources.

2.1 Project Location and Schedule

The Blocks, shown in Figure 2-1, are located offshore The Bahamas, southwest of Andros Island adjacent to the marine border with Cuba and cover approximately 3 million acres (Table 2-1). Bahamas Petroleum Company has not finalized the well locations, so for the purposes of this EIA, it is assumed the wells could be drilled in the deepwater (>300 m) portions of the Blocks. No wells will be drilled on Great Bahama Bank. The proposed wells will be located in water depths of approximately 1,650 ft. (~500 m). The current proposed location of the first well (Figure 2-2) is in the Donaldson Block, approximately 80 miles (~130 km) from Andros Island and 25 miles (~40 km) from the nearest Cuban islands.

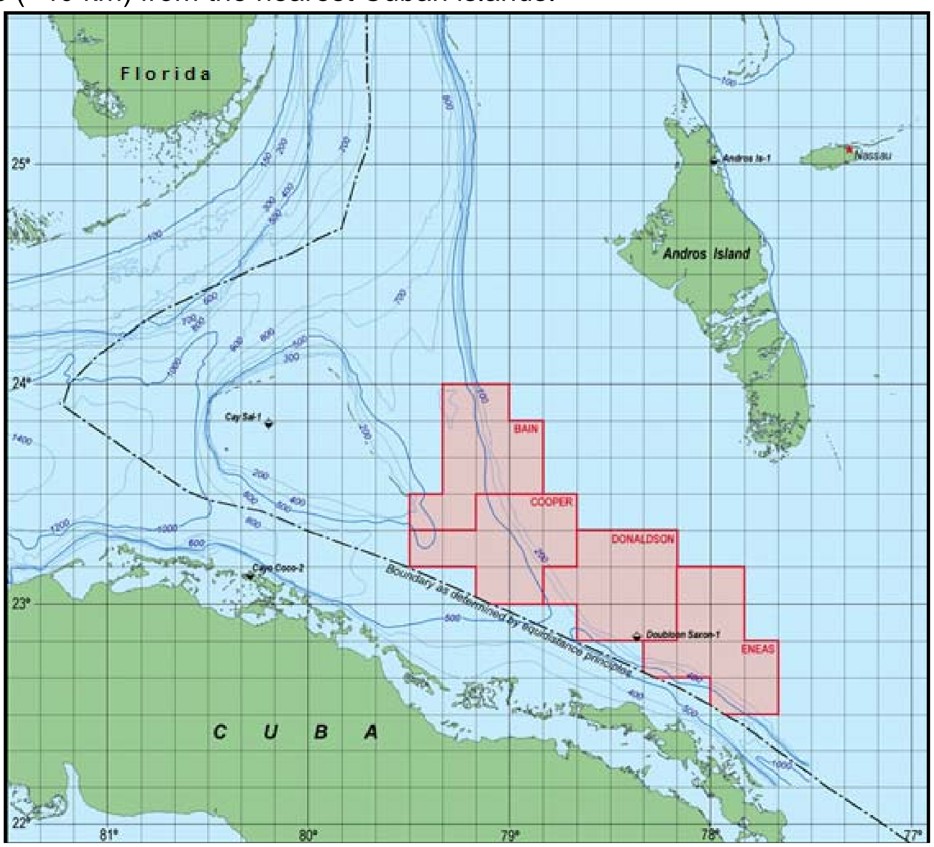

Figure 2-1: Bahamas Petroleum Company License Blocks
Source: Bahamas Petroleum Company[1]

[1] International boundary line shown International boundary line shown in the figure is an estimate determined using the equidistance principle and may differ from the coordinates agreed upon by Cuba and The Bahamas.

Table 2-1: License Areas

Block	License Area	
	Acres	km^2
Bain	775,468 acres	3,138 km^2
Cooper	777,934 acres	3,148 km^2
Donaldson	778,855 acres	3,152 km^2
Eneas	780,316 acres	3,158 km^2
Total	3,112,573 acres	12,596 km^2

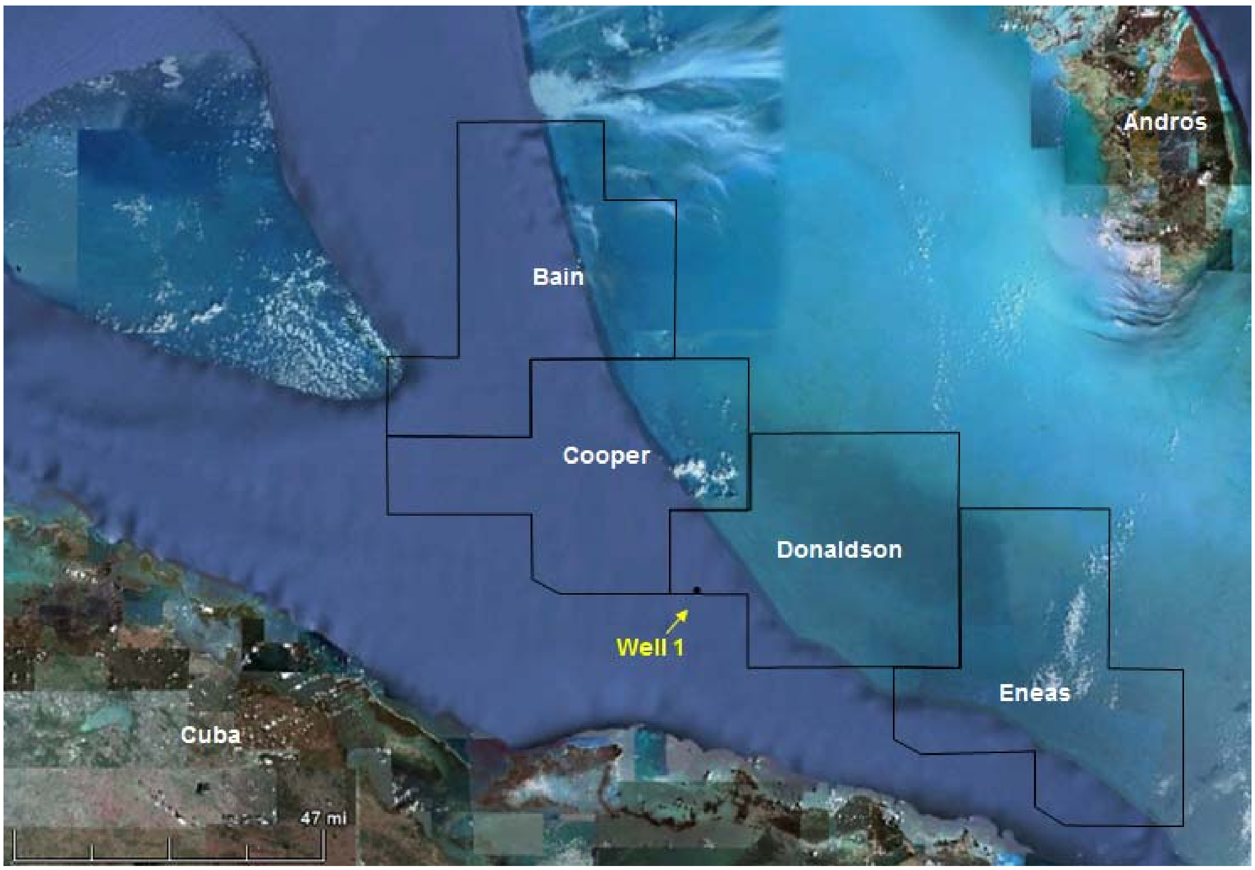

Figure 2-2: Proposed Location of the First Exploration Well

Note: Preliminary coordinates for the well are: 23°00'15.0340" N, 78°46'54.0242" W. Approximate block boundaries shown in black.[2]

Source: Google Earth

The drilling rig will mobilize to the Blocks from its previous assignment, with plans to begin drilling ("spud") of the first well in the last quarter of 2012. Each well is scheduled to take

[2] It is anticipated that the first well will be located at the coordinates provided in Figure 2-2. This is the location used for the oil spill modeling (Appendix A). Additional modeling will be completed if the well location is located further than 5-7 kilometers from this location. No wells are expected in waters less than 200m depth.

approximately 100 – 130 days; therefore, the entire drilling program should be completed within 3-5 months for each well. A detailed diagram of the proposed schedule is included as Appendix B.

2.2 Rig Specifications

There are many types of drillings rigs that can be used offshore. For exploration drilling, rigs need to be moveable (as opposed to permanent structures) as they are only used for a short period of time before being relocated for another assignment. Typical drill rigs used for offshore exploration drilling include[3]:

Drilling barges: Drilling barges are large, floating platforms, which must be towed by tugboat from location to location. They are used mostly for shallow water drilling, such as in lakes, swamps, rivers, canals and very shallow marine waters. Drilling barges are typically used in water depths up to 25 ft. (7.5 m). Not considered a candidate.

Jack-up rigs: Jack-up rigs are very common in shallow water marine environments. They consist of a large platform with three legs that are lowered to the sea floor once the rig is on location. The drilling rig is then "jacked-up" until the platform is raised above the water. Jack-up rigs are typically used in water depths up to 300 ft. (91 m), although some can drill in deeper waters. Not considered a candidate.

Submersible rigs: Submersibles have large pontoons and/or columns that are filled with air during transport to the drill site. Like jack-up rigs, submersibles are supported by direct contact with the sea floor. Once at the drilling location, the air of the outer pontoons and/or columns hull is released, lowering the hull until it rests on the sea floor. Submersible rigs are typically used in water depths up to 25 ft. (7.5 m). Not considered a candidate.

Semi-submersible rigs: While some semisubmersibles can be self-propelled, they are typically towed to the drilling location by 2 or 3 tug boats at a speed of 4-6 knots and arrive 2-3 days prior to drilling. A semi-submersible rig works on the same principle as a submersible rig: through the "inflating" and "deflating" of its pontoons and/or columns. Once on location, the rig's pontoons and/or columns are ballasted with sea water until the rig is partially submerged. The main difference with a semi-submersible rig, however, is that the rig does not submerge to the sea floor. Instead, the rig is partially submerged, but still floats above the drill site. The rig is then held in location either by anchors (Section 2.2.1) or dynamic positioning (Section 2.2.2). Semi-submersible drilling rigs are typically used in water depths of 300 - 10,000 ft. (91 – 3,048 m).

Drillships: Drillships are marine vessels (boats/tankers) that have either been retrofitted or specifically designed for drilling offshore. They are typically used in deep water or in areas with rough seas and can sail to location without assistance from other boats. Depending on the unit size, they can also be loaded with much of the equipment necessary to drill the well prior to sailing and they typically have sizable tank storage in the hull. Drillships typically use dynamic positioning to maintain location, although some are anchored. Drillships are typically used in water depths of 300 - 35,000 ft. (91 - 10,668 m)

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[3] Hyne, N. J. 2001. Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production: 2nd Edition. Penn Well Corporation: Tulsa, OK.

Based on the expected water depth (approximately 1,650 ft.), Bahamas Petroleum Company expects to drill using a semi-submersible drilling rig or drillship. Both types of rigs have similar basic components, including:

- Derrick, draw-works and top drive
- Casing and pipe racks
- Primary and emergency generators
- Mud circulation and solids removal equipment
- Bulk storage tanks for fuel, mud, cement, fresh water, brine, synthetic oil
- Safety and fire-fighting equipment
- Potable water system
- Sewage treatment
- Personnel accommodations and support facilities, including medical

For both drilling rig types, primary control of subsurface fluid pressures is achieved via the hydrostatic pressure imposed by drilling fluids (Section 2.5.2.2). Electrically powered pumps are utilized to circulate the drilling fluids. Secondary well control (to avoid accidental release of hydrocarbons from the subsurface reservoir penetrated by the drilling) is achieved using blow-out preventers (BOPs) (Section 2.5.2.1). Drilling activity is continually monitored using a system of instruments, gauges, sensors and crew.

In addition to the above, specifics of both types of drilling rigs are described below. A typical semi-submersible rig is shown in Figure 2-3 and typical specifications are listed in Table 2-2. A typical drillship is shown in Figure 2-4 and typical specifications are listed in Table 2-3.

Selection of the specific rig to contract for this assignment will include a detailed analysis of at least the following broad areas (in no particular order):

- Unit type, age and condition
- Environmental performance and systems
- Rig certification and classing (e.g. ABS, DNV etc.)
- Well control systems, maintenance and management
- Equipment maintenance schedules and adherence
- Spill plans
- Safety record and systems
- Technical performance record
- Rig operator reputation
- Economic factors
- Crew experience and competency
- Company quality management systems
- Waste stream tracking
- Insurance
- Training records (especially International Well Control Forum)
- Rig equipment audit
- Quality systems vetting/audit

Figure 2-3: Typical Semi-Submersible Drilling Rig

Source: www.maersk-drilling.com

Table 2-2: Typical Semi-Submersible Drilling Rig Specifications

Parameter	Unit	
	Metric	Imperial
Principal Dimensions		
Length of main deck	77.5 m	254.3 ft.
Breadth of main deck	78.5 m	255.9 ft.
Depth to main deck	37 m	121.4 ft.
Length overall	117 m	383.9 ft.
Operational draft	20.5 m	67.3 ft.
Transit draft	9.7 m	31.8 ft.
Capacities		
Bulk mud and cement	1,360 m^3	48,000 ft^3
Liquid mud (deck)	1,400 m^3	8,800 bbls
Liquid mud (floaters)	1,500 m^3	9,400 bbls
Base oil	750 m^3	4,700 bbls
Brine	750 m^3	4,700 bbls
Drill water	2,000 m^3	12,500 bbls
Potable water	800 m^3	5,000 bbls
Fuel oil	4,500 m^3	28,000 bbls
Sack storage	10,000 sacks	
Pipe racks	900 m^2	9,700 ft^2
Vertical riser storage	100 x 75 ft.	
Drilling Equipment		
Derrick (main + auxiliary)	210 ft. – 2,000/ 1,000 kips	
Rotary table	2 x 60.5”	
Draw works	3,300 kW + 2,250 kW	
Traveling block	2,000 + 1,000 kips	
Top drive	750 t	
Riser	21” OD	

Parameter	Unit	
	Metric	Imperial
Riser joint length	75 ft.	
Riser tensioners	6 x 500 kips	
Mud pumps	4 x 1,650 kW	
Machinery / Equipment / Fittings		
Main generator sets	8 x 4,750 kW	
Azimuthing thrusters	8 x 4,000 kW	
Mooring	8 windlasses	
Mooring chain	3.5”	
Mooring anchors	8 x 20 t HHP	
Deck crane	1 x 90 t	
Knuckle boom crane	150 t	

Source: www.deepwater.com

Figure 2-4: Typical Drillship

Source: www.deepwater.com

Table 2-3: Typical Drillship Specifications

Parameter	Unit	
	Metric	Imperial
Principal Dimensions / Operating Parameters		
Length	255 m	835 ft.
Breadth	38 m	125 ft.
Depth	19 m	62 ft.
Operational draft	13 m	42 ft.
Transit draft	9 m	30 ft.
Maximum drilling	3,048 m	10,000 ft.
Maximum drilling depth	10,668 m	35,000 ft.
Capacities		
Bulk mud	453 m^3	16,000 ft^3
Bulk cement	453 m^3	16,000 ft^3
Drill water	2,178 m^3	13,700 bbls
Potable water	795 m^3	5,000 bbls
Fuel oil	3,975 m^3	25,000 bbls
Pipe racks	4,318 mT	4,750 (short) tons
Drilling Equipment		
Derrick (main + auxiliary)	4 mm lb dual activity	
Rotary table	2 x 60.5”	
Draw works	2 x 5,000 hp with 2” line	
Traveling block	2 x 907 mT (2 x 1000 short tons)	
Top drive	2 x 590 mT (2 x 650 short tons)	
Riser tensioners	6 x 400 (short) tons	
Mud pumps	4 x 2200 hp, 7500 psi	
Shale shakers	8	
Moon pool	30 ft. x 80 ft.	
Machinery / Equipment / Fittings		
Main generator sets	4 x 9,772 hp and 2 x 4700 hp	
Emergency power	1 x 3,257 hp	
Cranes	4 x 60 mT (4 x 66 short tons)	

Source: www.deepwater.com

To maintain location, semi-submersible drilling rigs and drillships can either use a mooring spread (anchors) or a dynamic positioning system. A detailed risked plan will be put together in combination with specialist companies, Bahamas Petroleum and the rig owner for the rig move, transport and anchoring program (if necessary). It will also cover safe recovery of the anchors. This plan would be submitted to the government prior to moving the rig if necessary.

2.2.1 Mooring Systems

A typical mooring system utilizes a set of anchors normally arranged in a symmetrical pattern, generally with between 8 and 12 anchors (Figure 2-5). This style of mooring maintains the vessel on location with a fixed heading. Anchors are placed using specifically designed Anchor Handling boats. The anchors are set on the boats and carried to a pre-determined location, in a pre-determined order. The anchor is then run from the boat to the seabed and tensioned using the winches on the drilling rig.

Typically, the surface location will be selected a safe distance away from sea bottom hazards or environmentally sensitive areas. These can be manmade, such as cables and pipelines or sensitive areas such as coral. A safe distance +/- 200m is kept to prevent any dropped objects falling from the rig and impacting the highlighted object or the anchor chains fouling the area. Anchors are typically 1-2Km long. The locations are specially selected to provide stability to the rig and protect the environment around the anchor. The sea bottom conditions will be checked prior to setting the anchor if the area is not well known.

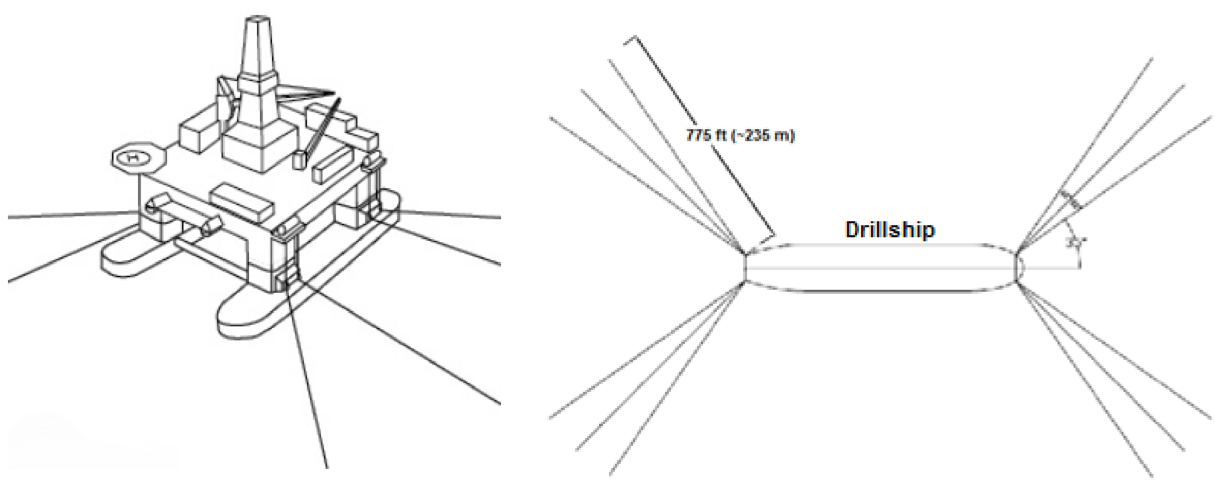

Figure 2-5: Typical Mooring Spreads

Source: Modified from http://www.zebecmarine.com and http://www.dredgingengineering.com

2.2.2 Dynamic Positioning

Dynamic positioning systems consist of a computerized controls system that uses acoustic and global positioning satellite inputs to monitor the drilling rig's position. As the drilling rig operates, computer controlled propellers and thrusters continually react to environmental loads such as ocean currents, swells and winds, to maintain the rig's position. There are typically three different and independent positioning systems, such that failure of any one system will not result in an unplanned drive off of position. Drilling rigs with dynamic positioning are likely to be later generation and larger drilling units. There are fewer of these available worldwide.

2.3 Support Operations

A shore base is required to support drilling operations. In particular, the shore base will be needed to supply food, water and fuel, and for supporting services such as docking of boats, waste management, movement and storage of cargo and for crew support. In addition, the shore base will likely be near onshore certified waste management facilities. Based on the current availability of infrastructure and service providers needed to support drilling, and the project timeline, Bahamas Petroleum Company is considering facilities in Freeport, Grand Bahama Island and/or Port Fourchon, Louisiana, United States.

2.3.1 Freeport, Grand Bahama, The Bahamas

The industrial and port complex of Freeport (Figure 2-6) was created in 1955 to provide a focus for industrial activity in The Bahamas. The Freeport Container Port opened in 1997 and a major ship-care facility opened at the Grand Bahama Shipyard in 2000. Also at Freeport, in the Northwest Providence Channel, Bahamas Oil Refining Company International Limited (BORCO) operates a 20-million barrel oil storage terminal.

Figure 2-6: Aerial View of Freeport Container Port

Source: http://www.bpcplc.com/the-bahamas/about-the-bahamas

2.3.2 Port Fourchon, Louisiana, United States of America

Port Fourchon (Figure 2-7) is Louisiana's southernmost port, located on the southern tip of Lafourche Parish, Louisiana, on the Gulf of Mexico. Port Fourchon currently services over 90% of the Gulf of Mexico's deepwater oil and gas production. It is one of the best dedicated oil and gas supply bases in the world.

Figure 2-7: Aerial View of Port Fourchon, Louisiana, USA

Source: http://www.offshore-mag.com

2.3.3 Equipment and Personnel Transportation

Equipment and materials required to support the drilling operations will be delivered to the drilling rig by Platform Supply Vessels (PSVs) - a typical PSV is shown in Figure 2-8. Currently, Bahamas Petroleum Company plans to utilize 1 or 2 PSVs, with each making approximately 1-3 trips per week between the shore base and drilling location (Figure 2-10). If Port Fourchon is the supply base, there will be 1 trip per week per PSV and if it is Freeport, then 2-3 trips per week per PSV. Materials will be loaded and unloaded to/from the PSVs using cranes. Bulk fluids and materials will be pumped or blown from the PSVs to the drillship via hoses between the drilling rig and PSVs.

Figure 2-8: Platform Supply Vessel
Source: www.marinetraffic.com

Crew changes will operate, likely via helicopter. It is anticipated that 1-2 helicopters will be required to support drilling operations conducting a total of approximately 3-5 trips per week. The number of trips would be dictated by the size of the helicopter. Bahamas Petroleum Company anticipates crew changes will operate out of Congo Town, South Andros (which is 5,300 ft. x 100 ft. and equipped with firefighting supplies, Figure 2-9). This would require a plane to transport each new crew shift to Andros, a helicopter would then transport new crew shift offshore, the helicopter would pick-up the old shift and transport to Andros, and the same plane would then transport old shift out of Andros.

Figure 2-9: Congo Town Airport, South Andros
Source: http://southandroscollege.org

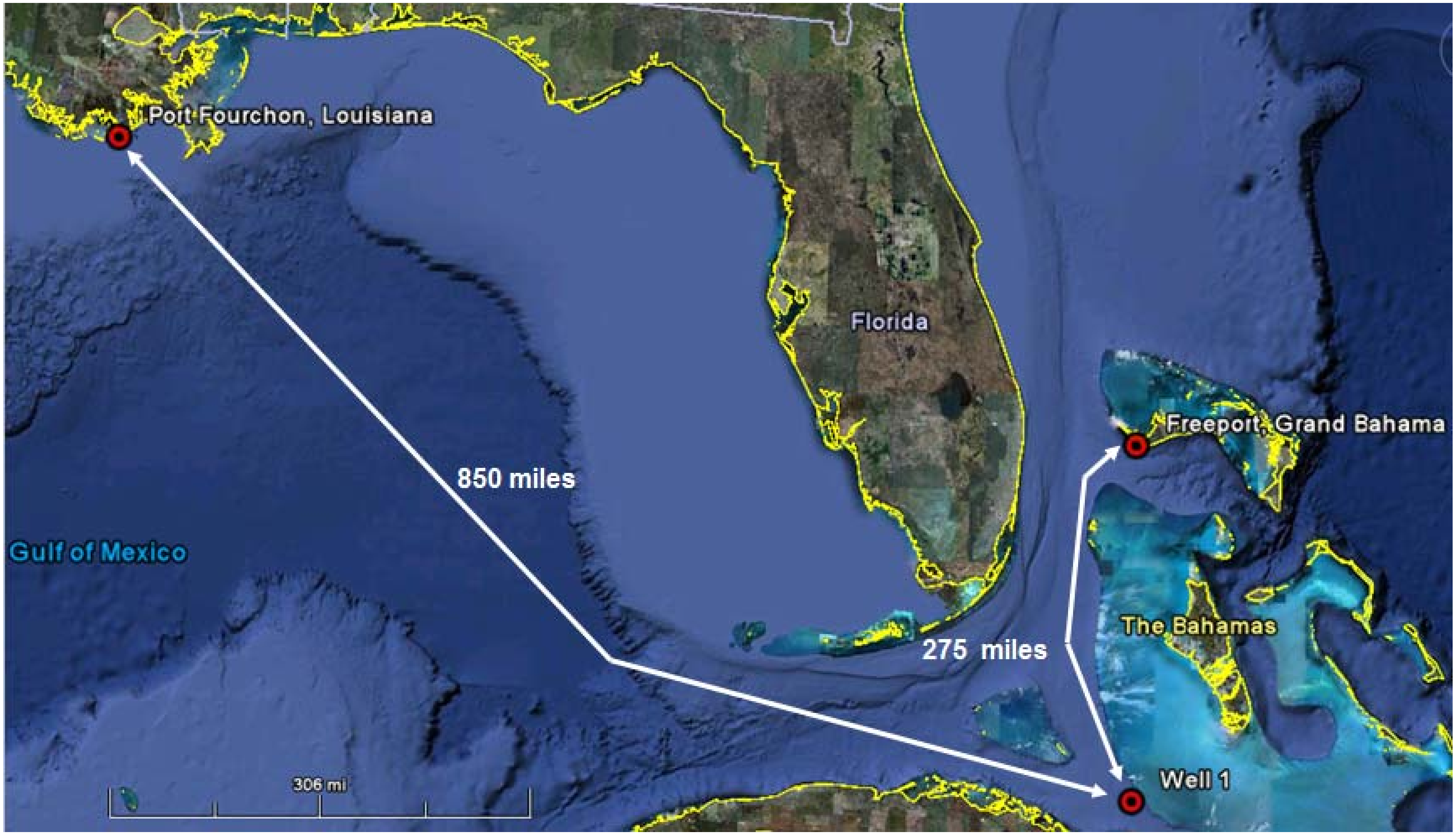

Figure 2-10: Potential PSV Sailing Routes

Source: Modified from Google Earth

2.4 Human Resource Estimation

Semisubmersibles and drill ships are largely self-sufficient rigs and house up to 200 people. A typical rig crew is 100-115, depending on the vessel and includes approximately:

- 4 – 6 Company supervisor and representatives
- 60 Rig maintenance crew
- 20 – 30 Drilling support service crew
- 15 – 20 Catering and support staff

Personnel will work on rotation (14-days on / 14-days off or 28-days on / 28-days off) and will live on the drilling rig during their duty schedule (“hitch” or “rotation”). At the conclusion of a duty schedule, workers will be transported by helicopter/boat and will be replaced by their alternates for the next rotation. Off duty workers may take commercial flights to their home country to stay until they report back to duty for their next shift. Some team members could be required to stay locally if needed for emergency response purposes. Bahamas Petroleum Company or the drilling contractor will help identify and obtain long-term housing for workers that plan to stay in The Bahamas between shifts (for emergency purposes or otherwise).

2.5 Drilling Activities

Drilling activities for each well will occur in four main phases:

- Rig Mobilization
- Drilling
- Well Completion and Appraisal
- Decommissioning and Abandonment

2.5.1 Rig Mobilization

The drilling rig will mobilize from its previous assignment and arrive in The Bahamas in the last quarter of 2012 to drill in the Bahamas Petroleum Company Blocks.

2.5.2 Drilling

Deepwater offshore drilling is performed through careful advancement of drilling equipment to a desired depth beneath the sea floor. Fluids are used to cool the drill bit, carry formation cuttings to surface and control formation pressures. The design of the first well (including fluid program) and associated planned activities for the Project are described in this section.

<u>2.5.2.1 Well Design and Drilling Program</u>

The initial phase of the drilling operation is commonly referred to as the “riserless” portion of the well drilling operations. The initial step in the riserless drilling phase involves jetting in structural casing (also known by some operators as conductor pipe) that is typically 30”. This first string of casing provides the structural support for all subsequent casing strings and the blowout preventer (BOP) stack. The structural casing must be able to resist bending loads imposed on it by movement of the drilling unit due to positioning adjustments that are continually being made.

In the drilling assembly, the drill string is connected to the top of the structural pipe by way of a releasable running tool having a J-latch or other release mechanism that lands in a profile of a low pressure wellhead housing (LPWHH) assembly that is mounted on top of the 30” structural pipe. The drill string continues below the running tool and extends down the entire length of the interior of the drive pipe. The lower end of the drill string terminates with a jetting assembly (generally a large-diameter drill bit on a positive-displacement motor).

The drilling/landing string is initially connected to the top of the structural pipe to enable both elements to be lowered to the sea floor together. Once the structural pipe/landing string assembly touches the sea floor, fluid circulation is initiated down the drilling/landing string with the fluid returns coming up inside the structural pipe and discharging to sea/sea floor, and the jetting operations begin. As the jetting assembly penetrates the sea bottom formation, the drill string lowers with the structural pipe falling snugly into the borehole made from the rotating and jetting action of the bit. This drilling/jetting operation continues until the entire section of structural pipe penetrates the same length of formation or until such time as the gravitational forces acting on the conductor pipe will no longer overcome the effect of skin friction. Once this is accomplished, the drill string is disconnected from the structural pipe to enable the drill string to move independently with respect to the structural pipe, where it can facilitate additional drilling operations or can be pulled back to the drilling unit for re-configuration of the drilling assembly.

During the riserless drilling phase, when the structural pipe is penetrating into the formation due to gravitational force, seawater is utilized as the drilling fluid. Thus the seawater, and periodic water-based gelled sweeps (small volumes of viscous fluid) travelling down through the interior of the drill string (if needed) , functions to clean the borehole bottom and carry the cuttings up the annulus formed by the exterior of the drill string and the interior of the structural pipe. This fluid then exits the annulus at the top of the drive pipe to be released into the sea and settle to the sea floor around the bore hole. All previous wells in The Bahamas were drilled using only aerated seawater and Bahamas Petroleum Company expects to utilize only seawater for the drilling program also.

The second phase of the riserless drilling phase of the well construction process constitutes drilling of a 26” open hole section below the 30” structural pipe with seawater and periodic water-based gelled sweeps with the returns exiting the top of the 30” structural pipe and being dispersed around the well location along the sea floor. When drilling operations are finished on the 26” open-hole section, the wellbore is displaced with viscous water-based mud and the drilling assembly is removed from the wellbore. A 20” casing (sometimes referred to as a surface casing) is run in the wellbore and latched into the top of the 36” structural pipe’s LPWHH via an assembly at the top of the 20” surface pipe called a high-pressure well head housing (HPWHH), where it is cemented into place. The fluid returns from inside the wellbore are also discharged to the sea around the well location. This HPWHH assembly mounted at the top of the 20” surface casing provides the pressure-containing integrity necessary for the remainder of the well construction operations. This assembly is the point to which the BOP Stack is connected to the well. It has profiles inside of its bore to facilitate the hanging of additional casing strings that will be deployed into the wellbore during the well construction process. After the 20” surface casing is cemented in place, the BOP stack is deployed on a marine riser assembly and latched up to the HPWHH assembly, and then pressure tests are conducted on the BOP. The BOP makes up the bottom portion of the riser for the duration of the well drilling process. It is at this point that the riserless drilling phase of the well construction process is concluded.

Subsequent drilling operations after the riserless drilling phase will utilize the riser pipe, which provides the conduit for drilling fluid (mud) circulation between the well and the rig. If the well’s drilling fluid program requires synthetic based fluid to continue well operations, it is at this point the switch from water-based to synthetic based fluid would occur. However, this is highly unlikely given the expected well characteristics.

The mud characteristics are adjusted on the rig and pumped to the bottom of the drill string. The fluid is circulated from the drill bit and returned through the annulus between the well bore and drill string inside of the borehole, and the annulus between the riser and the drill string (returning flow) and into the fluid processing system onboard the drilling unit instead of returning wellbore fluids and drilled cuttings to the seabed. During this phase of the well construction process, wellbore fluids, drilling cuttings and residual cement will be returned to the rig's mud processing equipment where drill cuttings will be separated from the drilling fluid. If synthetic based muds are needed, cuttings and spent fluids would be shipped to shore for disposal.

Figure 2-11 presents a mechanical diagram of the down-hole and sea-floor aspects of the drilling operation to be used. Consistent with international industry practice, Bahamas Petroleum Company plans to establish a 1 km radius buffer or "exclusion" zone around the drilling rig based on industry standard operating procedures. The exclusion zone will be kept clear of all unauthorized vessels to minimize the potential for collisions that could result in a spill from the well.

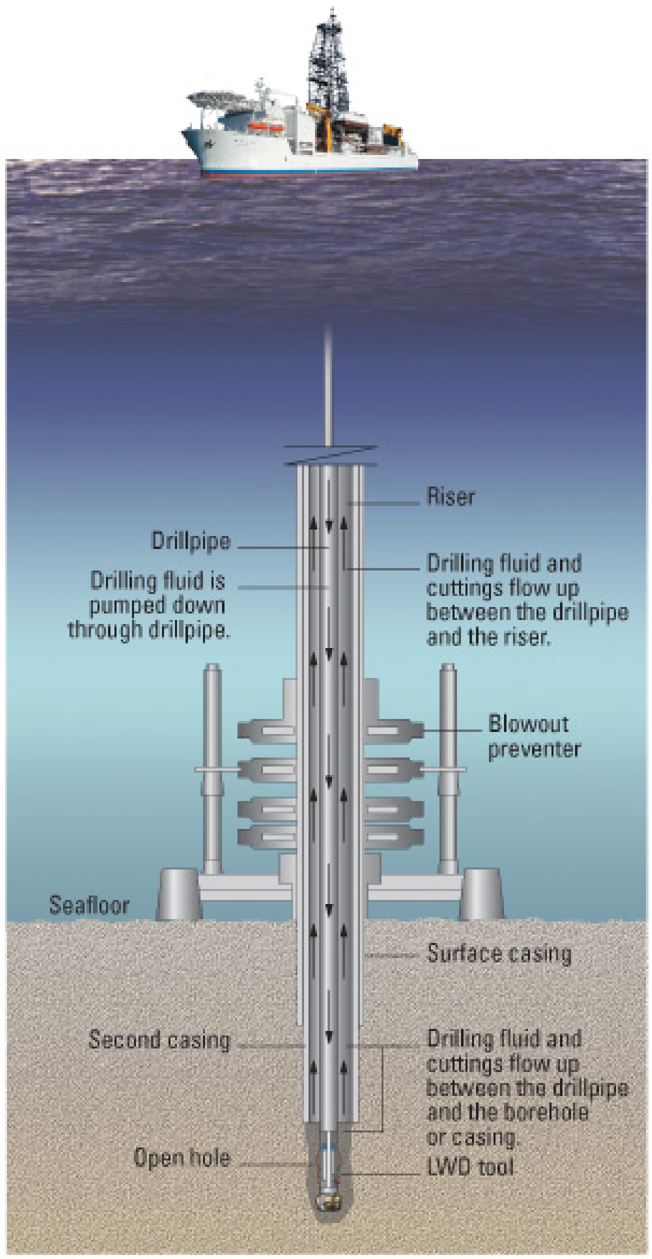

Figure 2-11: Diagram of Well Drilling Mechanics
Source: Schlumberger http://www.glossary.oilfield.slb.com (modified)

2.5.2.2 Drilling Fluid

The primary functions of the drilling fluid are to:

- Lubricate, cool and clean the drill bit
- Carry cuttings out of the wellbore
- Reduce friction between the drill string and the wellbore
- Prevent the inflow of formation fluids by adjusting the density of the drilling fluid
- Form a filter cake to seal off the formation and maintain integrity of the wellbore

Drilling fluids are composed of a number of elements, including weighting agents, viscosity agents and other components. Based on the low-pressure reservoirs encountered in past drilling programs, seawater and sweeps of water based fluids are expected to be used. If higher formation pressures are encountered or cuttings are not adequately being removed using seawater and water based fluids, synthetic based fluids could be used.

If synthetic based fluids are used, they will not be discharged. Management of drill cuttings is described in Section 2.6.1.4.

2.5.2.3 Logging

Drill logs will be completed to provide a profile of the entire length of the wellbore by measuring a variety of parameters including electrical, acoustic and radioactivity of the formation which has been drilled. Analysis of the logs will allow Bahamas Petroleum Company to estimate factors including lithology, porosity, permeability, fluid content, volumes, and which zones within the well are most likely to produce hydrocarbons.

The conventional logs run are:

- Gamma ray – effectively measures the content of clay minerals
- Resistivity – allows the estimation of the type of fluid present in the pore space in the formation
- Sonic logs – measure the time it takes an acoustic wave to travel a certain distance; this helps in the estimation of the density and porosity of the formation
- Density - measures the apparent density of the formation; needed to estimate the porosity of the formation
- Neutron – Indicates the content of hydrogen in the formation; this helps identify zones with greater pore space in the formation, in which hydrocarbons may be stored

2.5.2.4 Coring

During the drilling operations Bahamas Petroleum Company will periodically collect rock samples through side-wall coring. In this process sampling devices are fired into the sidewalls of the well to extract samples of the rock. In addition, in good potential reservoir depths Bahamas Petroleum Company may elect to extract rock cores through the drilling process.

2.5.3 Well Completion and Appraisal

After drilling and casing the well (and assuming that commercial hydrocarbons have been identified in logs), it must be 'completed' to enable it to produce oil and/or gas. Small holes called perforations are made in the portion of the casing which passes through the production zone, to provide a path for the oil/gas to flow from the reservoir into the production tubing and out of the well.

Following completion, a production test will be performed which consists of flowing the well to remove residual completion fluids and cuttings, and measuring physical and chemical characteristics. The primary intent is to measure pressure and flow rates, and to gather representative fluid samples. These measurements are used to determine commercial viability, as well as to plan potential completion and production facilities. The typical well testing layout is shown in Figure 2-12.

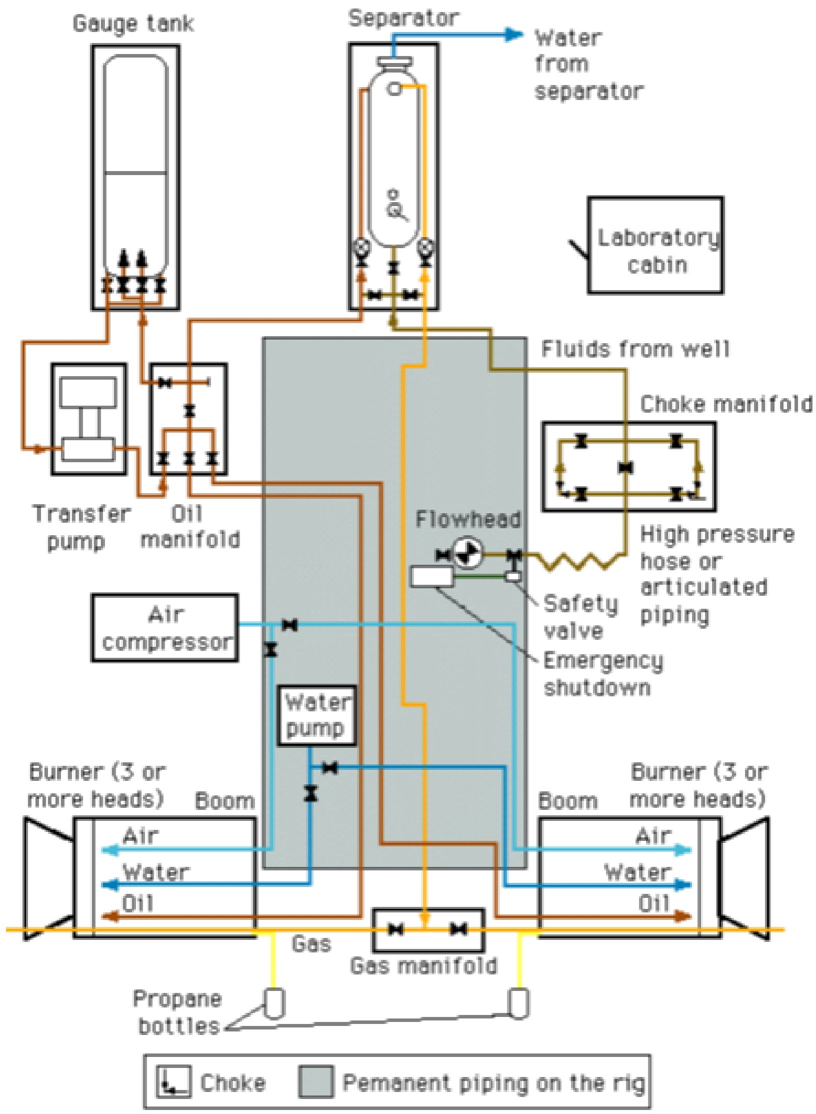

Figure 2-12: Typical Well Testing Layout

Source: United States Minerals Management Service (now Bureau of Ocean Energy Management, Regulation and Enforcement), 2004[4]

Reservoir fluids will pass through a separator; gas and oil will be flared (burned). In the petroleum industry, flaring is used to consume waste gases through controlled combustion in an open flame. Flaring occurs during well testing and production operations. It is routinely used to dispose of flammable gases and oils that are either unusable or uneconomical to recover. Well testing burns are will be minimized and are likely to last only a few hours at a time.

[4] United States Minerals Management Service (now Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE)), 2004. Guidance on Safety of Well Testing. Report Number 4273776/DNV, Revision 01; 1 July 2004, p. 5

Produced water will be treated to local and international standards prior to discharge. In general, water zones can be identified prior to perforating and therefore avoid water production during short flow periods.

2.5.4 Decommissioning and Abandonment

Following drilling and (if applicable) testing, the well will be either temporarily or permanently abandoned depending on data collected during the drilling, logging and testing (if any) activities and the rig will move away to its next assignment.

<u>2.5.4.1 Well Decommissioning and Abandonment</u>

Once the exploratory drilling has been completed, well abandonment will be performed in accordance with international industry-accepted practices for offshore wells. If a well is temporarily suspended, cement and mechanical plugs will be used to isolate any hydrocarbon-bearing formations from the seabed. The drill string, riser and BOP equipment will be removed from the wellhead. Wellheads will be left in place, as the water depth precludes damage and allows for future well re-entry at a later date.

If a well is to be abandoned any productive zones will be isolated from each other and from the surface. Two mechanical barriers will be placed (and tested) between any identified productive zones and the surface. Wellhead equipment will be recovered from the well and the casing will be cut off 5 m below the seabed. A site (debris) survey will be undertaken using a remotely operated vessel (ROV) prior to rig departure.

The well suspension or abandonment program will be designed to prevent contamination of potential aquifers by hydrocarbons and potential flow of hydrocarbons or other fluids within the wellbore or to the sea bed.

<u>2.5.4.2 Perform Remotely Operated Vehicle Survey</u>

Prior to demobilization from the drill site, a ROV will be deployed from the drillship to perform a video inspection of the drill site. The ROV will be used to check if any equipment or debris has been left in place or if any unexpected potential impacts have occurred, in which case mitigation measures will be developed to resolve these issues. A typical ROV can provide video inspections up to 500 ft. (~150 m) down current from the well site to document the extent of drill cutting deposition on the sea floor.

<u>2.5.4.3 Recover Seafloor Equipment and Release Rig</u>

Once the well has been secured and all necessary equipment retrieved, the drilling rig will be prepared for movement to its next drill location.

2.6 Environmental, Health and Safety Management

Programs will be in place throughout the Project to manage the health, environment and safety aspects of the drilling program as described in the following sections. At present, The Bahamas does not have a set of comprehensive regulations governing the oil and gas industry in place. Bahamas Petroleum Company will utilize specific standards as referenced below and the guidelines proposed by The Bahamas Environment, Science and Technology (BEST) Commission in Appendix E of this report.

2.6.1 Waste Management

Wastes, including sanitary, gray water, food, domestic and industrial, and drill cuttings, will be generated during the project. A Waste Management Plan will be in place for the project detailing appropriate storage, handling and disposal practices for each waste. The workforce will be trained in a Hazard Communication Program so that potentially hazardous materials transported between the vessel and shore are properly labeled and handled. The following sections describe waste handling practices for the project. Discharges will be in compliance with international standards (e.g., International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 [MARPOL 73/78]).

2.6.1.1 Sanitary and Domestic Liquid Waste

The drilling rig will be equipped with a wastewater treatment plant with capacity to handle wastes generated by the expected full crew complement (up to approximately 200 persons). The wastewater treatment plant will be able to separate the black water (from bathrooms) and grey waters (from showers, hand basins and kitchens) (Figure 2-13). Sewage treatment on offshore drilling rigs is typically achieved using a process of aeration, settling and chlorination to break down and sanitize sewage and other wastewater.

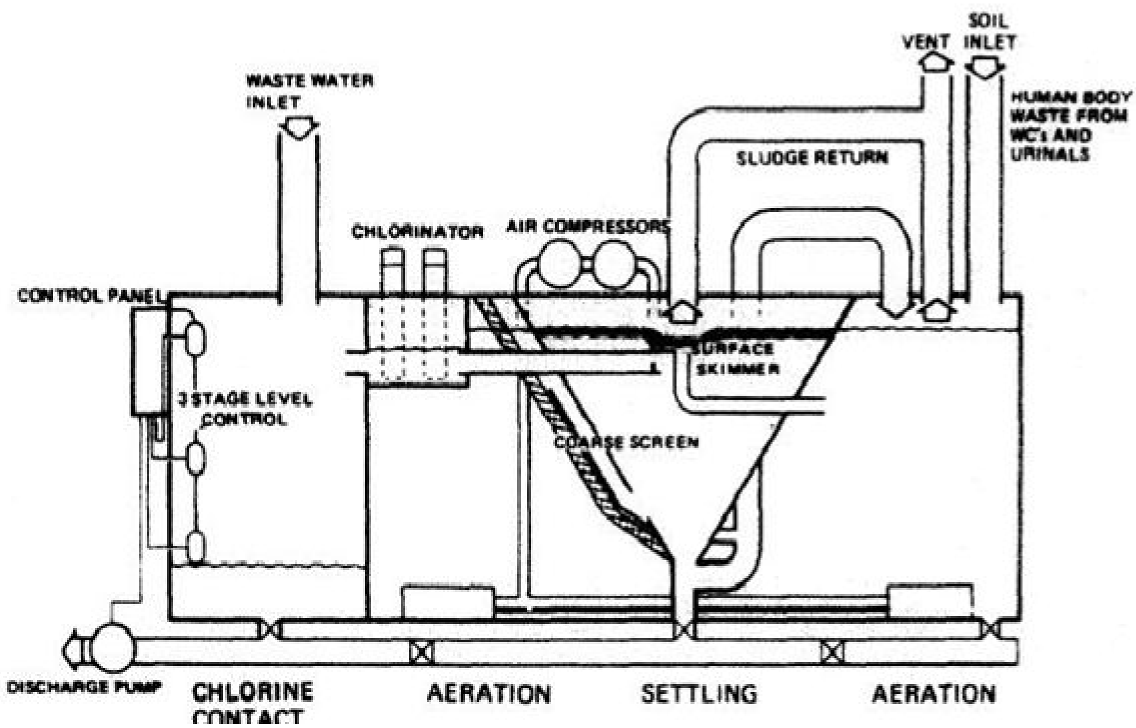

Figure 2-13: Schematic of Typical Offshore Waste Treatment Plant

Source: Taylor, B.A. 1996.[5]

After treatment, the black and gray waters will be discharged to sea via a hose or dedicated port in the deck. In accordance with the provisions of MARPOL 73/78 Annex IV, discharges will have no floating solids, will not cause discoloration of the surrounding waters and will have less than 1 mg/l of residual chlorine. Solids can also be segregated and transported to shore for disposal at approved locations if deemed necessary. The wastewater discharge system is rig dependent and will be described in detail in the Environmental Management Plan.

[5] Taylor, B.A. 1996. Introduction to Marine Engineering. Burlington, MA: Elsevier Butterworth-Heinemann.

Typically, a person generates approximately 30 gallons/day (110 liters/day) of black water and 60 gallons/day (220 liters/day) of grey water. Assuming approximately 200 persons at a time will be needed for offshore activities, it is expected that approximately 6,000 gallons (22,700 liters) of black water and approximately 12,000 gallons (45,400 liters) of grey water may be generated, treated and discharged per day. Additional black and grey water produced from the PSVs will be treated onboard each vessel in accordance with MARPOL 73/78.

2.6.1.2 Food and Domestic Solid Waste

This waste will be generated from offices, sleeping areas and recreation areas. It is estimated that approximately 4 ½ pounds (~2 kg) will be generated per person per day. With a maximum expected crew of 200 persons on board the drilling rig, this amounts to approximately 900 pounds (~400 kg per day). Dry solid materials will be segregated and returned to the shore base for recycling or disposal. Food wastes will be ground up into particles not larger than one inch (25 mm), and disposed of at sea from a discharge pipe located at least 20 ft. (6 m) below the water surface, not less than 3 nautical miles (5km) from the shore, in accordance with MARRPOL 73/78. Domestic solid wastes such as paper, cardboard, aluminum cans, etc., will be sorted, compacted, packaged and transported to approved waste management facilities via the shore base for recycling or proper disposal, as appropriate.

2.6.1.3 Industrial Waste

Industrial solid wastes include packaging material, construction materials, rubber, bulk scrap metal, drums, containers and other by-products generated during offshore drilling activities. Industrial wastes will be sorted and temporarily stored in appropriately marked containers pending disposal. Additional precautions and safeguards will be used to dispose of special wastes (such as batteries and medical wastes) properly. Once on land, wastes will be packaged and transported by licensed waste management companies for proper handling, treatment and disposal.

Industrial liquid wastes include used oils and other liquids such as paint thinner and lubricants. Hazardous liquids will be stored in tanks, pending treatment, recovery or disposal. On average, the Project will generate approximately 5,300 gallons/well (~20,000 liters/well) of waste oil. Bahamas Petroleum Company will develop a project specific Waste Management Plan with the drilling contractor prior to drilling.

2.6.1.4 Drill Cuttings

During drilling activities, drill cuttings will be passed through solids control equipment and dryers prior to being discharged overboard into the sea. Table 2-4 presents the expected volumes that will be generated during different stages of drilling. Drill cuttings and fluids will pass through solids removal equipment consisting of scalping shakers, primary shakers and centrifuges (see Figure 2-14 for an example of a shaker). Centrifuges use centrifugal force to separate the drilling fluid from smaller solids, allowing the drilling fluid to be returned to the circulating system and the solids to be discharged overboard. If it is deemed that synthetic based fluids are unavoidable due to technical reasons, a strict policy of “total containment” will be followed. No synthetic based fluids or associated cuttings would be discharged, as drill cuttings may contain small particles of synthetic based fluid. The used fluids would be returned to the vendor for reprocessing and the cuttings would be shipped ashore to a suitable licensed land fill site to be disposed.

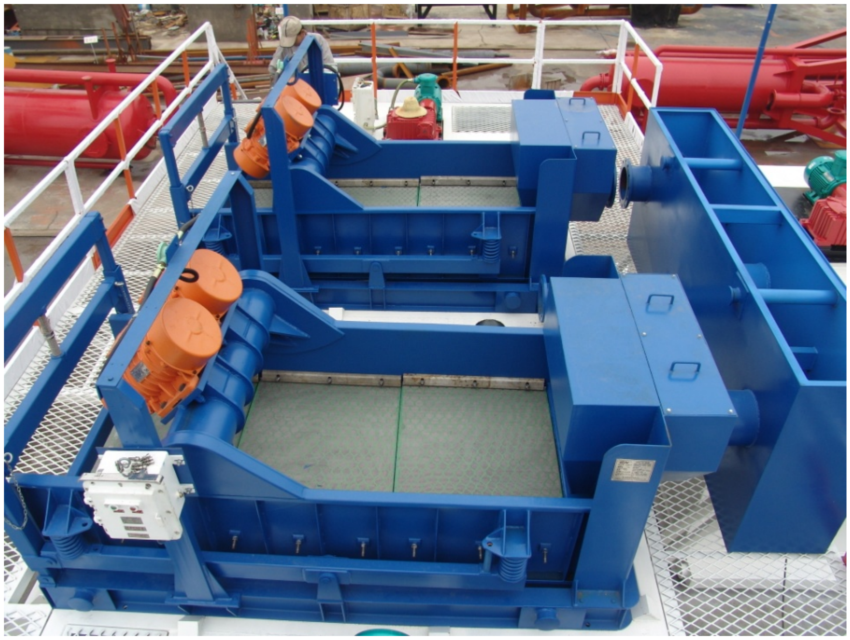

Figure 2-14: Typical Shale Shaker

Source: http://oilfield.gnsolidscontrol.com/

Table 2-4 estimates cutting discharges per well. Estimates are expected to vary depending on the well location.

Table 2-4: Example Drilling Fluid Program and Projected Discharges[6]

Interval	Boring Depth	Fluid Type	Estimated Cutting Discharges	Discharge Location
30"	240 ft.	Seawater with viscous sweeps	1,178 ft^3	Seafloor
26"	3,130 ft.	Seawater with viscous sweeps	11,540 ft^3	Seafloor
17.5"	4,960 ft.	Seawater with viscous sweeps	8,285 ft^3	Overboard drillship
12.25"	7,040 ft.	Seawater with viscous sweeps	5,762 ft^3	Overboard drillship
8.5"	6,000 ft.	Seawater with viscous sweeps	2,364 ft^3	Overboard drillship
6"	2,000 ft.	Seawater with viscous sweeps	393 ft^3	Overboard drillship
Total	23,370 ft.	-	29,522 ft^3	-

2.6.2 Discharges

In addition to discharge of drill cuttings and food waste described in Section 2.6.1, discharges will also be generated from deck drainage and other sources described below. Discharges will meet MARPOL requirements.

[6] This is an example drilling fluid program and does not represent the depth of the well

2.6.2.1 Deck Drainage

Wastewaters resulting from rainfall, rig washing, deck washing, tank cleaning operations, and runoff from curbs and gutters, including drip pans and work areas are directed to water treatment systems. Runoffs are passed through a water drain system that has a sensor to detect oil. If oil is detected, the flow is diverted to an oily water system. This system is designed to avoid discharges that will create sheen on the ocean surface. Water containing less than 15 parts per million (ppm) of hydrocarbons on a micro-concentration will be discharged overboard.

The volume of deck drainage varies with the amount of rainfall and the overall dimensions of the drilling rig. A typical drilling rig has an area of 80,700 $ft.^2$ (~7,430 m^2) and The Bahamas receives an average of approximately 50 inches (1270 mm) of rain per year. Assuming a similar rainfall average at the drill sites, the total deck drainage volume over a period of one month would be less than 16,375 gallons (62 m^3). In addition, deck washes, tank cleanings and other uses will consume relatively small amounts of water.

2.6.2.2 Bilge Water

Support vessels will occasionally discharge treated bilge water. Consistent with MARPOL requirements, these vessels retain onboard bilge water until it can be discharged offshore or sent to an approved reception facility at the shore base, unless it is treated by approved oily water separators and monitoring equipment before being discharged to the sea. Vessels will employ approved equipment, examined and tested in accordance with the specifications and requirements of the International Maritime Organization Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships.

2.6.2.3 Brine

During the drilling program, sea water will be extracted from waters surrounding the drillship and desalinated and/or filtered, if needed. The most modern systems can generate up to 100 tonnes of potable water per day. On older units, this can be as low as 10 tonnes with further potable water being supplied by vessel. The brine discharge is generally very small and quickly dissipates within the sea. The estimated volumes will be included in the well-specific Environmental Management Plans once a rig has been selected. Brine generated from desalination of sea water (through reverse osmosis) will be discharged directly to sea consistent with MARPOL requirements or others requested by the BEST Commission.

2.6.2.4 Ballast Water

Ballast water will be discharged to sea according to the rig specific Ballast Water Discharge Management Plans. These plans will comply with IMO guidelines.

2.6.2.5 Other Discharges

Water will be used to cool process equipment and engines through a closed loop system. Cooling water discharges are not expected. Additional discharges from boiler blow-down or other miscellaneous sources are possible, but negligible. If needed, these will be treated to meet MARPOL requirements before discharge.

2.6.3 Air Emissions

Diesel engines that power the drilling rig, diesel engines and generators used on the rig to power drilling and other equipment, and flaring emit carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), and volatile organic compounds (VOC), as well as particulate matter (PM) and greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). These emissions will be temporary. A typical exploration well (not including flaring) produces approximately 2,000 metric tons of CO_2 equivalent per well, mostly from diesel-driven electrical generators and equipment.

If commercial hydrocarbons are found, flaring from well testing will also create air emissions. The amounts of air emissions would depend on the volume of gas burned and total carbon level in the feed. Even if flaring is required, it would be limited to a few days.

Diesel engines used on the drilling rig are certified by manufacturers. Bahamas Petroleum Company will conduct a rig audit prior to commencement of drilling that will include a check of primary diesel engines to confirm equipment is in good working order and within manufacturer's specifications. Flaring, if any, will be monitored and volumes recorded. Monitoring methods for flares will be included in the well-specific Environmental Management Plans.

2.6.4 Environment, Health, and Safety

Bahamas Petroleum Company will hire a drilling contractor that has strong environmental, health and safety (EHS) programs that will apply to the project. Complete evaluation plans will be developed for selection of a drilling contractor at a later date. Evaluation will include historical lost time incidents, first aid cases, safety reporting systems and other safety stats; policies, guidelines and systems in place for all EHS; spill plans, waste management streams, blow-out control, wild well plans, training and competency (records), International Well Control Forum training and records; permitting system, maintenance plant performance management system, critical equipment list and schedules, marine standards, rig certification and classing. Lastly, it is likely that an independent audit of the drilling unit will be commissioned prior to contracting.

Plans specific to the project will be put in place to protect the health and safety of the workforce and the public while reducing potential impacts to the environment.

The most significant environmental impact from offshore drilling operations is typically associated with a potential oil spill, particularly a large spill resulting from loss of well control or blow-out. Mitigation measures to manage such an incident are described below.

2.6.4.1 Well Control

Well blowouts occur in extremely rare, accidental circumstances when drilling penetrates gas, oil or water pockets that are under such high pressure that the hydrostatic "back-pressure" of the drilling mud is overcome allowing reservoir fluids to escape the wellbore until the well is brought back under control. Normally, reservoir fluids are never allowed to escape the wellbore. Previous wells drilled in The Bahamas have encountered low pressure reservoirs and similar conditions are expected during the proposed drilling campaign.

All wells drilled in this exploration program will be equipped with well control equipment. This equipment is capable of shutting off the flow of fluids, and containing the pressure in the well.

Bahamas Petroleum Company plans to follow guidelines included in 30 CFR 250.213(g), 30 CFR 250.243(h), 30 CFR 250.219(a)(2)(iv) and 30 CFR 250.250(a)(2)(iv).

2.6.4.2 Spill Prevention and Response

In the event of an accidental spill, the drilling rig and support vessels will be outfitted with the necessary safety and emergency response equipment to manage all potential emergencies.

Standard practice in the oil and gas is to utilize a tiered preparedness and response system to ensure that appropriate resources can be mobilized rapidly to provide an effective response to any spill, small or large. The three Tiers are described below[7]:

Tier 1: Tier 1 events are relatively small and/or affect a localized area. Spills that are considered Tier 1 spills (small, operational-type spills) will be addressed using equipment on board vessels. Supply vessels will maintain equipment to address Tier 1 spills (containment and dispersant) and crews will be trained in the use of this equipment.

Tier 2: Tier 2 events are more diverse in their scale and by their nature and involve potentially a broader range of impacts and stakeholders. To respond to a Tier 2 spill, Bahamas Petroleum Company will utilize resources of a contracted third party oil spill response organization, for example Clean Caribbean & Americas, a membership organization capable of responding to spills in the Blocks. If needed, additional pollution abatement equipment is available in The Bahamas and in other areas of the Caribbean, namely in: Aruba (Valero Refinery N.V.), Bonaire (BOPEC), Curaçao (ISLA), Puerto Rico, St. Croix (under the MSRC organization), St. Eustatius (Statia Terminals), Trinidad and Venezuela.

Management responsibilities in a Tier 2 event are usually shared in a collaborative approach and a critical feature is the integration of all resources and stakeholders in the response efforts.

Tier 3: Tier 3 events are rare but have the potential to cause widespread damage, affecting many people and overwhelming the capabilities of local, regional and even national resources. Clean Caribbean & Americas will be available 24-hours per day for a Tier 3 spill and will be capable of deploying internationally recognized best practices and technologies. These include:

- Dispersant and application equipment
- In-situ burn equipment
- Containment boom and anchoring equipment
- Mechanical recovery / skimming systems
- Temporary and intermediate storage and pumps
- Command, control and communications equipment
- Beach clean-up equipment
- Other support supplies

The resources described above and Bahamas Petroleum Company's careful planning will help ensure that sensitive coastal resources and local fishing activities are protected in the event of a spill.

Oil spill trajectory modeling was performed for this Project to help Bahamas Petroleum Company and its drilling contractor prepare for a spill (see Chapter 6). Bahamas Petroleum Company will have an Oil Spill Contingency Plan in place that describes how spills will be prevented, minimized and addressed based on the results of this modeling. In addition to Bahamas Petroleum Company's plans, there will be a Shipboard Oil Pollution Emergency Plan (SOPEP) and an Emergency Response Plan (ERP) for the rig. Both the drilling rig and supply vessels have set protocols in place for conducting refueling in order to prevent spills. Bahamas Petroleum Company will review these procedures prior to drilling. These procedures will be included in the well specific environmental management plan.

[7] International Petroleum Industry Environmental Conservation Association (IPIECA). 2008. Oil Spill Preparedness and Response: Report Series Summary. Accessed June 5, 2009 from the IPIECA Website: http://www.ipieca.org/

Bahamas Petroleum Company plans to follow guidelines included in 30 CFR 250.219.

2.6.4.3 Emergency Response

Bahamas Petroleum Company will have an Emergency Response Plan in place to address potential emergencies and threats to the health and safety of personnel and the public. Drilling rig staff will have Basic Offshore Survival and Induction Emergency Training (BOSIET) or internally recognized equivalent. Prior to spud and throughout drilling operations, Bahamas Petroleum Company and its contractors will carry out a number drills.

No hydrogen sulfide gas (H_2S) is anticipated during the drilling of this well. However, H_2S procedures will be in place prior to commencement of drilling. The drilling rig will always have a minimum level of breathing apparatus sets and H_2S drills will be performed on a regular basis. H_2S monitors onboard the ship will be checked regularly.

H_2S and other gases are not taken to the rig uncontrolled. Small amounts of gas can be entrained in the mud or in a “kick”. This will always be circulated from the well in a controlled manner and vented using the appropriate systems (degasser or diverter system for example).

If high H_2S levels are detected during any operation, an alarm will be sounded. All non-essential personnel will be moved to accommodation which is positively pressurized. The well will be brought under control and shut-in if necessary.

Bahamas Petroleum Company plans to follow guidelines included in 30 CFR 250.215.

While Bahamas Petroleum Company intends to drill outside of hurricane season to avoid potential disruption from hurricanes, the ERP will contain hurricane preparedness and response. In the event that the company is forced to drill during hurricane season, the company will follow standard industry practices for managing this risk (i.e. International association of Drilling Contractor recommendations), for example closure of the well and mobilization of the rig to a safe area. Time required to close the well and mobilize the drilling rig varies by type from approximately 1-3 days for a drillship and 3-7 days for a semi-submersible. Rig selection will include consideration for the time/cost associated with hurricane preparedness and response.

2.7 Project Alternatives

Viable alternatives that can be considered for offshore exploration drilling activities are often limited because of technical requirements for drilling programs. These include the requirement to locate a well above or near a target hydrocarbon reservoir, the requirement to use specific types of equipment, materials (e.g. drilling fluids) techniques based on the water depth and geology of the drill site, and the requirement to carefully schedule drill ships far in advance.

Alternatives considered for the Project are described below.

“No Action” Alternative: If the Project did not take place, the potentially adverse impacts described in Chapter 5 would not occur. However, taking no action would also prevent the potential net positive benefits if commercial quantities of hydrocarbons are discovered and produced as a result of the drilling. These potential benefits include increased revenue to the Commonwealth of The Bahamas and the potential indirect benefit to local businesses that may support the Project. For example, as stated in Chapter 1, oil and gas companies have invested $USD 2.8 billion in exploration and production activities in Cuba since 1991.[8] The no action alternative would also preclude further development and revenue for the area that could result if the exploration drilling program reveals that the targeted hydrocarbon reservoirs are commercially viable. Based on the fact that the potentially adverse impacts are manageable and the potential benefits of the drilling program, the "No-Action" alternative is not warranted.

Well Location: A number of potential well locations were selected based on review and interpretation of geophysical data. The first well location identified in Section 2.1 and additional well locations will be identified at a later date. When environmental sensitivities are present, companies can use directional drilling (horizontal and extended reach) techniques to avoid sensitive surface areas and to gain access to the reservoir from less sensitive surface areas. The evaluation of potential impacts presented in Chapter 5 drilling indicates that there are no known locations within the Blocks at which drilling would be likely to result in insurmountable environmental and social impacts**.** The wells will only be drilled in deep water (>300 m) locations, therefore the location of the wells will not likely result in a significantly more negative or positive impact on the environment, no matter the location.

Type of Drilling Rig: The various drilling rigs typically used in offshore exploration drilling are described in Section 2.2. Given the expected water depth at the proposed drilling locations, two types of drilling units were evaluated: semi-submersibles and drillships. Bahamas Petroleum Company and its contractors will follow the same practices and procedures for mitigating potential impacts of the Project regardless of the rig and drilling method used. Further, potential impacts of both types of rig are the same.

Types of Drilling Fluids: As discussed in Section 2.5.2, drilling fluids are used to lubricate the drill bit and circulate drilled cuttings out of the well bore. There are three major types of drilling fluids:

1. water based fluids,
2. synthetic based fluids, and
3. oil based fluids.

Water based fluids consist of freshwater or saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and/or water soluble polymers. Synthetic based fluids include linear-α-olefins, poly-α-olefins, internal olefins, linear alkyl benzenes, ethers, esters, or acetals[9]. Oil-based fluids are still used in some drilling operations, but they are considered environmentally inferior and therefore Bahamas Petroleum Company intends to drill only with seawater and periodic seeps of water based drilling fluids. If needed, synthetic based drilling fluids will be used; however, neither synthetic based fluids nor the associated cuttings would be discharged to sea. Bahamas Petroleum Company will not use oil based muds for this drilling program.

Synthetic-based fluids are more environmentally benign than traditional oil-based fluids. This is because the constituents of the oil-based fluids are more persistent (degrade over a much longer period of time) than the synthetic oils that comprise synthetic-based fluids. If it is deemed that synthetic based fluids are unavoidable due to technical reasons, a strict policy of "total

[8] "Highlights of Cuban Deepwater Drilling Programs". 2011. Environmental Conference & Exhibition, Trinidad. May 12-13, 2011.

[9] Neff, JM, S.McKelvie and RC. Ayers Jr. 2000. Environmental Impacts of Synthetic Based Drilling Fluids. Report prepared for MMS by Robert Ayers & Associates, Inc. August 2000. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-064. 118 pp.

containment" will be followed. No synthetic based fluids or associated cuttings would be discharged, as drill cuttings may contain small particles of synthetic based fluid. The used fluids would be returned to the vendor for reprocessing and the cuttings would be shipped ashore to a suitable licensed land fill site to be disposed.

Cuttings Disposal: There are numerous methods for disposal of drill cuttings (rock pieces) associated with drilling. The three main disposal options include:

1. Ship to shore for onshore treatment – The process typically involves processing the drill cuttings on the rig, storage and transportation to shore, and onshore treatment/disposal. Transportation to shore requires loading onto a supply vessel, offloading to ground transportation and offloading at a certified waste facility for treatment. Treatment options include thermal desorption (heating until hydrocarbons are recovered then reuse of cuttings – i.e. for road construction or fill), fixation (mixing with lime or cement then sending to a monitored landfill), or composting/bioremediation (mixing with woodchips or other biomass and inoculation with bacteria then disposal at a monitored landfill).
2. Cuttings reinjection – Reinjection is a process that involves grinding cuttings to a small size and mixing with sea water to create a stable suspension that is injected back into the geological formation. This is not typical for exploration wells.
3. Offshore discharge after treatment – Described in Section 2.6.1.4, this process involves passing drill cuttings and fluids through solids control equipment to remove drilling fluids from cuttings. Advances in drilling fluids and mechanical solid control equipment has allowed continued discharges of cuttings to meet and exceed the environmental performance of hauling drill cuttings to shore for treatment and disposal. The controlled discharge of cuttings approach has been evaluated and embraced by both operators and regulators as a viable and responsible approach to managing and minimizing air, water and solid waste discharges from offshore drilling operations.[10]

Different approaches for treatment and disposal of drill cuttings are applied in various countries depending on the type of drilling fluids used (i.e. water, oil or synthetic based), environmental conditions (i.e. water depth, proximity to sensitive habitats, etc.) and regulatory regimes. In most countries, treatment and discharge of cuttings to sea in the preferred alternative to shipping to shore, and reinjection is typically unfeasible for an exploration well.

Shore Base Location: Bahamas Petroleum Company will evaluate multiple locations for a potential shore base. Preference will be given to use of nearby service providers in order to reduce energy consumption and support local businesses, but wastes generated from the drilling require certified facilities capable of treating and disposing of multiple types of waste, some hazardous. Preliminary investigations suggest Freeport, Grand Bahama or Port Fourchon, Louisiana are the most viable alternatives. Travel from the Blocks to either location would require passing by sensitive marine environments. The primary difference between the two sites from an environmental and social perspective is distance. Travel to Port Fourchon would increase the project-related fuel consumption and air emissions. However, the project is temporary and the number of trips required to Port Fourchon would be limited, so does not warrant a separate impact evaluation. Disposal locations may be added or changed throughout the exploration drilling program, if more convenient certified waste disposal facilities are encountered.

[10] International Association of Oil and Gas Producers (OGP). 2003. Environmental Aspects of the Use and Disposal on Non Aqueous Drilling Fluids Associated with Offshore Oil and Gas Operations: Report No. 342. Retrieved from OGP Website: http://www.ogp.org.uk/pubs/342.pdf

No additional alternatives were considered for this Project given that:

- No protected areas were identified within the Project area
- The Project will occur in a remote offshore environment
- Bahamas Petroleum Company will have adequate resources and programs in place for protection of human health, safety and the environment

3. Legislative and Institutional Framework

This Chapter describes the legislative framework (Sections 3.1 – 3.2) and institutional framework (Section 3.3) governing oil and gas exploration activities in The Bahamas. The Bahamas Environment, Science and Technology (BEST) Commission (Section 3.3.1) is the environmental regulatory authority in charge of reviewing Environmental Impact Assessments (EIA) for development projects (Section 3.4).

3.1 Local Legislation and Regulations

Relevant legislation and regulations that will be considered for the Bahamas Petroleum Company project include:

Antiquities, Monuments and Museum Act 1998
This Act provides for the preservation, conservation and restoration of historical, paleontological and archaeological resources.

Archipelagic Waters & Maritime Jurisdiction Act 1993
This Act establishes the boundaries of the archipelagic waters that come under the jurisdiction of The Bahamas as prescribed under the Law of the Sea Convention. The Bahamas thus has authority over these waters, the seabed and the resources found therein.

Bahamas National Trust Act 1959
This Act establishes The Bahamas National Trust as the entity that advises the Government on areas for preservation and conservation. It gives the Trust the power to create by-laws to be in effect in the protected areas it establishes. These areas are of environmental, historical and/or cultural importance. The Act was amended in 2010.

Coast Protection Act 1968
This Act serves to regulate construction or alteration of the coastline for the purpose of the protection of land. It also provides for protection against encroachment and erosion by the sea.

Conservation and Protection of the Physical Landscape of The Bahamas Act 1997
This Act prohibits all significant excavation, landfill operation, quarry mining or mining of physical natural resources (such as sand) without permission of the Director of Physical Planning. The Act also gives the Director the authority to request an EIA for any excavation or land reclamation activities. It also provides for the protection of trees that are rare and of historical significance and imposes stiff penalties for violators of this law.

Continental Shelf Act 1970
This Act provides for the protection, exploration and exploitation of the continental shelf. It gives The Bahamas Government sovereignty over the continental shelf.

Environmental Health Services Act 1987
This Act promotes conservation and maintenance of the environment and also addresses the control of contaminants and pollutants that may adversely affect the environment and human health. The Act also outlines regulations with respect to water supplies, solid and liquid waste, beaches, seaports, harbors and marinas.

Environmental Health Services (Collection and Disposal of Waste) Regulations 2004

These regulations provide for the collection and disposal of domestic, commercial and construction waste. Commercial waste includes ashes, refuse and rubbish. Construction waste includes any waste materials from construction, renovation, repairs and demolition.

Fisheries Resources (Jurisdiction & Conservation) Act 1977

This Act establishes the Exclusive Fishery Zone (EFZ). It reflects concern with respect to conservation and management of the marine environment and its resources. It also recognizes traditional fishing rights and provides for the declaration of protected marine areas and regulation of the fishing industry.

Forestry Act 2010

This Act provides for the:

- Setting of royalty fees, permits, leases, and license fees for utilization of forest produce and non–timber forest produce from the forest estate
- Management, conservation, control and development of forests, and the promotion and regulation of forest industries
- Promotion of the conservation and management of wildlife and wildlife habitat in forest reserves, protected forests and conservation forests

The Act also provides for the regulation and management of wetlands as these are classified as forests under the legislation.

Health and Safety at Work Act 2002

The Act provides for:

- Securing the health, safety and welfare of persons at work
- Protecting persons other than persons at work against risks to health or safety arising out of the activities of persons at work
- Controlling the keeping and use of explosive, highly flammable or other dangerous substances and preventing the unlawful acquisition, possession and use of such substances

Marine Mammal Protection Act 2005 and Marine Mammal Protection (General) Regulations 2005

The Act prohibits the taking and harassing of wild occurring marine mammals. It establishes the licensing and permitting system for capture of marine mammals for captive facilities as well as for scientific research on marine mammals.

The Regulations outline the application process for licenses to conduct scientific research on marine mammals and to operate a vessel to engage in or facilitate the observation of wild occurring marine mammals.

Merchant Shipping (Oil Pollution) Act 1976

This Act provides for the proper registration of ships, the control, regulation and orderly development of merchant shipping in The Bahamas, proper qualification of seamen and regulation of employment conditions for seamen. These provisions advocate ship safety and competency which prevent shipping accidents that can be detrimental to the marine environment as well as result in human casualties.

Planning and Subdivision Act 2010
This Act provides for:

- A land use planning based development control system led by policy, land use designations and zoning
- Prevention of indiscriminate division and development of land
- Efficient and orderly provision of infrastructure and services to the built environment
- Promotion of sustainable development in a healthy natural environment
- Maintenance and improvement of the quality of the physical and natural environment
- Protection and conservation of the natural and cultural heritage of The Bahamas
- Planning processes that are fair by making them open, accessible, timely and efficient
- Recognition of the decision making authority and accountability of the Government in land use planning
- Planning for the development and maintenance of safe and viable communities
- The submission of an Environmental Impact Assessment as part of various types of development projects

The Act provides for regulating activities such as quarrying, mining, road construction and subdivision development.

Petroleum Act 1971
This Act provides for the exploration, boring and getting of petroleum. The Act establishes a permitting, licensing and leasing system for the exploration, prospecting and mining of petroleum.

Port Authorities Act 1962
This Act provides for the regulation and control of ports, harbors and navigational aids throughout The Bahamas as well as pilots and pilotage. It also regulates dredging activities for harbors and ports. The Act prevents dumping of ship ballast water in Bahamian harbors. This can prevent the introduction of exotic species and pollution of waters.

Water and Sewerage Corporation Act 1976
This Act establishes the Water and Sewerage Corporation. Functions of this organization include the application of appropriate standards and techniques for investigation, use, control, protection, management and administration of water. The Corporation is also mandated to oversee waste disposal, water treatment and water quality.

Wild Birds Protection Act 1952
This Act provides for the protection of wild birds. The Act lists several species including the White-Crowned Pigeon, Whistling Duck and Yellow-Crowned Night Heron.

3.1.1 Draft Legislation

Over the years, there have been a number of draft bills for environmental legislation developed that have not yet been enacted including:

- Draft Environmental Protection (Effluent Limitations) Regulations 1995
- Draft Environmental Health Air Emissions Regulations
- Draft Pollution Control and Waste Management Regulations 2000
- Draft Environmental Impact Assessment Regulations 2000

3.2 Regional and International Treaties and Conventions

The international environment-related instruments to which the Bahamas is a contracting party are listed below.

Convention on the International Regulations for Preventing Collisions at Sea
Concluded: London, England, 20 October 1972
Depository: International Maritime Organization
Signed: 22 July 1976

The Convention on the International Regulations for Preventing Collisions at Sea (COLREGs – 1972) was designed to update and replace the Collision Regulations of 1960, which were adopted at the same time as the 1960 SOLAS Convention. The COLREGs include 38 rules divided into five sections: Part A - General; Part B - Steering and Sailing; Part C - Lights and Shapes; Part D - Sound and Light signals; and Part E - Exemptions. There are also four Annexes containing technical requirements concerning lights and shapes and their positioning; sound signaling appliances; additional signals for fishing vessels when operating in close proximity to other vessels, and international distress signals.

One of the most important innovations in the 1972 COLREGs was the recognition given to traffic controls and safe distance requirements. Rule 10 gives guidance in determining safe speed, risk of collision and conduct of vessels operating in or near other vessels. This rule requires vessels to avoid the path of other vessels that have limited maneuverability due to the need to stay on position or course as part of an activity requiring precise location or placement. Ships engaged in the drilling and occasional supply/transfer activities in the proposed drilling program are considered to have limited maneuverability.

International Convention for the Prevention of Pollution from Ships
Concluded: London, England, 17 February 1978
Depository: International Maritime Organization
Signed: 07 June 1983

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL 73/78 is a combination of two treaties adopted in 1973 and 1978, respectively, and updated by amendments through the years. There are currently six technical annexes, of which parties must accept Annexes I and II (the others are voluntary). The six annexes are shown in Table 3-1.

Table 3-1: MARPOL Annexes

Annex	Description
Annex I	Regulations for the Prevention of Pollution by Oil
Annex II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk.
Annex III	Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form.
Annex IV	Prevention of Pollution by Sewage from Ships.
Annex V	Prevention of Pollution by Garbage from Ships.
Annex VI	Prevention of Air Pollution from Ships (entered into force 19 May 2005).

International Convention on Oil Pollution Preparedness, Response and Cooperation
Concluded: London, England, 30 November 1990
Depository: International Maritime Organization
Signed: 04 October 2001

Parties to the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) convention are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units are also required to have oil pollution emergency plans (or similar arrangements) which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents, such as The Bahamas National Oil Spill Contingency Plan and the Caribbean Island Oil Pollution Response and Cooperation Plan.

International Convention for the Safety of Life at Sea
Concluded: Montego Bay, Jamaica, 01 November 1974
Depository: International Maritime Organization
Signed: 16 February 1979

The International Convention for the Safety of Life at Sea (SOLAS, 1974) is widely considered to be the most important international treaty dealing with safety of operations for commercial ships. SOLAS requirements address fire prevention and detection, lifesaving equipment and navigation safety rules.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
Concluded: Basel, 22 March 1989
Depository: United Nations
Signed: 12 August 1992

This Convention is the response of the international community to the problems caused by the annual world-wide production of hundreds of millions of tons of waste. These wastes are hazardous to people or the environment because they are toxic, poisonous, explosive, corrosive, flammable, eco-toxic, or infectious.

This global environmental treaty strictly regulates the transboundary movements of hazardous wastes and provides obligations to its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner. The main principles of the Basel Convention are:

- Transboundary movements of hazardous wastes should be reduced to a minimum consistent with their environmentally sound management
- Hazardous wastes should be treated and disposed of as close as possible to their source of generation
- Hazardous waste generation should be reduced and minimized at the source

In order to achieve these principles, the Convention aims to control the transboundary movement of hazardous wastes, monitor and prevent illegal traffic, provide assistance for the environmentally sound management of hazardous wastes, promote cooperation between Parties in this field, and develop technical guidelines for the management of hazardous wastes.

United Nations Convention on the Law of the Sea
Concluded: Montego Bay, Jamaica, 10 December 1982
Depository: United Nations
Signed: 29 July 1983

The Law of the Sea Convention is referred to as "a constitution for the world's oceans". It obligates Contracting Parties to protect and preserve the marine environment and also confirms sovereignty of States in their territorial seas and exclusive economic zones. It addresses issues such as freedom of the high seas, protection of fishery resources, marine pollution and marine scientific research.

United Nations Framework Convention on Climate Change (UNFCCC)
Concluded: New York, 9 May 1992
Depository: United Nations
Signed: 12 June 1992

Global climate change refers to all aspects of the planet's climate that are or might be changing. This Convention was developed due to the concern of countries that human activities were significantly increasing the atmospheric concentrations of greenhouse gases. These increased concentrations are believed to enhance the greenhouse effect leading to additional warming of the planet's atmosphere and the oceans. This warming can cause changes in ocean currents and wind patterns as well as regional and local changes in temperature and precipitation. Such changes can have adverse impacts on natural ecosystems and humankind.

The objective of the UNFCCC is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human interference with climate systems of the planet. Achievement of such a level would allow ecosystems to naturally adapt to climate change, ensure that food production is not threatened, and enable economic development to proceed in a sustainable manner.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
Concluded: Washington, DC, 3 March 1973
Depository: United Nations
Signed: 20 March 1979

The international wildlife trade, worth billions of dollars annually, has caused massive declines in the numbers of many species of animals and plants. The scale of over-exploitation for trade aroused such concern for the survival of species that an international treaty was drawn up to protect wildlife against such over-exploitation and to prevent international trade from threatening species with extinction.

Known as CITES, this Convention now has a membership of 152 countries. These countries act by banning commercial international trade in an agreed list of endangered species and by regulating and monitoring trade in others that might become endangered.

Convention on Biological Diversity
Concluded: Rio de Janeiro, 5 June 1992
Depository: United Nations
Signed: 12 June 1992

Biological diversity refers to the variability of living organisms in terrestrial, marine and other aquatic ecosystems. The Earth's biological resources are vital to humanity's economic and social development. As a result, there is a growing recognition that biological diversity is a global asset of tremendous value to present and future generations. At the same time, the threat to species and ecosystems has never been as great as it is today. Species extinction caused by human activities continues at an alarming rate.

The main objectives of the CBD are the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the use of genetic resources. These objectives are to be achieved through:

- Development of national strategies, plans or programs for the conservation and sustainable use of biodiversity
- Establishment of a system of protected areas
- Rehabilitation and restoration of degraded ecosystems
- In-situ and ex-situ conservation of biodiversity [*In-situ conservation* is the conservation of ecosystems and natural habitats, and the maintenance and recovery of species in their natural surroundings. Protected areas and national parks are examples of in-situ conservation sites. *Ex-situ conservation* is the conservation of components of biodiversity, whether it is genes, individuals or populations, outside their natural habitats. Zoos and aquariums are examples of ex-situ conservation facilities.]
- Establishment and maintenance of programs for scientific and technical education and training in measures for the identification, conservation and sustainable use of biodiversity and its components
- Promotion of biodiversity research
- Promotion and encouragement of the understanding of the importance of, and the measures required for, the conservation of biodiversity
- Introduction of appropriate procedures requiring environmental impact assessment of proposed projects that are likely to have significant adverse effects on biodiversity

Vienna Convention for the Protection of the Ozone Layer
Concluded: Vienna, 22 March 1985
Depository: United Nations
Signed: 1 April 1993

The amount of ozone that forms between 49,215 and 180,455 feet above the earth's surface is known as the ozone layer. The ozone layer shields the earth from harmful solar rays. It protects all life on the earth and acts like a space suit for plants, animals and humans. The layer also affects the temperature distribution of the atmosphere and regulates the earth's climate.

Ozone depletion is caused by ultraviolet radiation (from the sun's rays) and volcano eruptions. However, man-made chemicals are the main contributors of ozone depletion. The most harmful ones are as follows:

a. Chlorofluorocarbons (CFC's)
b. Hydro fluorocarbons (HCFC's)
c. Carbon tetrachloride
d. Methyl chloroforms
e. Halos
f. Methyl bromide

Ozone depletion can lead to the following effects:

a. Non-melanoma skin cancers
b. Reduction in the defenses of the immune system and the effects of vaccination
c. Increased eye damage producing snow blindness that can further develop into cataracts
d. Disruption of the ocean life and the marine food web due to the effect of UV-B radiation on plankton
e. Increased air pollution with the toxic ozone gas in the lower atmosphere
f. Stunted growth in plants
g. Damage to materials like paints

Since the use of ozone depleting substances has been widespread, there had to be some international consensus or agreement to protect the entire earth from these harmful substances. Therefore, the Vienna Convention for the Protection of the Ozone Layer was devised. Parties to the Convention are obligated to adopt legislation or administrative measures to control, reduce or prevent human activities under their jurisdiction that are likely to have an adverse impact on the ozone layer. This includes the control or prevention of the use of ozone-depleting substances.

Montreal Protocol on Substances that Deplete the Ozone Layer
Concluded: Montreal, 16 September 1987
Depository: United Nations
Signed: 4 May 1993

In January of 1989, the Montreal Protocol was fully implemented to control production, consumption and the use of ozone-depleting substances.

As of April 2000, there have been 173 developed and developing countries that have agreed to the policies outlined by the Protocol. The Montreal Protocol dictates that gradually all CFC's and halons will be banned. Specific time frames are set for developed and developing countries to completely phase out use of these substances. The time frame for developing countries is longer than that of developed.

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
Concluded: New York, 11 August 1995
Depository: United Nations
Signed: 16 January 1997

It has been recognized that the management of high seas fisheries is inadequate in many areas of the world, resulting in the over-utilization of some resources. This agreement was developed as many countries recognized the need to avoid adverse impacts to the marine environment, preserve biodiversity, maintain marine ecosystems and minimize the risk of long-term adverse effects of fishing operations. The Agreement serves to ensure the long-term conservation and sustainable use of straddling fish stocks and highly migratory fish stocks through effective implementation of the United Nations Convention on the Law of the Sea.

Mechanisms to achieve this include cooperation between countries to manage fisheries resources and migratory fish stocks, proper scientific assessment of stocks, and effective monitoring and enforcement of fishing operations.

Ramsar Convention on Wetlands
Concluded: Ramsar, Iran, 2 February 1971
Depository: United Nations
Signed: 7 June 1997

The Convention on Wetlands, signed in Ramsar, Iran, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 121 Contracting Parties to the Convention, with 1027 wetland sites, totaling 78.1 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance.

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species.

The Convention's mission is the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world.

Ramsar is the first of the modern global intergovernmental treaties on conservation and wise use of natural resources.

Kyoto Protocol to the United Nations Framework Convention on Climate Change
Concluded: Kyoto, 11 December 1997
Depository: United Nations
Signed: 9 April 1999

This Protocol was developed under the UNFCCC. It provides for the reduction of greenhouse gas emissions to protect the environment.

The Kyoto Protocol includes emissions targets and timetables for industrialized nations and market-based measures for meeting those targets. The Protocol sets binding emissions targets for developed nations. The specific limits vary from country to country, though those for the key industrial powers of the European Union, Japan, and the United States are similar -- 8% below 1990 emissions levels for the EU, 7% for the U.S., 6% for Japan.

The emissions targets for the developed countries are to be achieved over the commitment period 2008 to 2012. The greenhouse gases covered by the Protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

Cartagena Protocol on Biosafety
Concluded: Cartagena, 29 January 2000
Depository: United Nations
Signed: 24 May 2000

With modern biotechnology, researchers can now take a single gene from a plant or animal cell and insert it into another plant or animal cell to give the cell a desired characteristic, such as resistance to disease. Organisms resulting from the use of such techniques are referred to as living modified organisms (LMOs). This is sometimes done in the production of crops, such as corn, tomatoes and soybeans. Biosafety refers to efforts to reduce and eliminate the potential risks resulting from biotechnology and its products.

As biotechnology is a fairly new field, there is much about the interaction of LMOs with ecosystems that is still unknown. Countries party to the Convention on Biological Diversity agreed that there was a need to develop appropriate procedures to address the safe transfer, handling and use of LMOs as these could have adverse effects on the conservation and sustainable use of biological diversity. The Cartagena Protocol is the result of the process to develop such procedures. The Protocol also takes into account the risks these organisms present to human health and focuses specifically on their transboundary movement (i.e. from one country to another).

Countries that are party to the Protocol are obliged to ensure that the development, handling, transport, use, transfer and release of any LMOs are undertaken in a manner that prevents or reduces the risks to biological diversity and to human health.

The United Nations Convention to Combat Desertification and Drought (UNCCD)
Concluded: Paris, 15 October 1994
Depository: United Nations
Signed: 10 November 2000

This Convention offers new hope in the struggle against desertification and drought. Desertification and drought are problems of global dimension as they affect all regions of the world and it is a global effort that is necessary to combat desertification and mitigate the effects of drought.

Desertification is caused by climate variability and human activities. In the past, drylands recovered easily following long droughts and dry periods. Under modern conditions, however, they tend to lose their biological and economic productivity quickly unless they are sustainably managed. Drylands on every continent are being degraded by over cultivation, overgrazing, deforestation, and poor irrigation practices. Such overexploitation is generally caused by economic and social pressure, ignorance, war, and drought.

Desertification is primarily a problem of sustainable development. It is a matter of addressing poverty and human well-being, as well as preserving the environment. Social and economic issues, including food security, migration, and political stability, are closely linked to land degradation. So are such environmental issues as climate change, biological diversity, and freshwater supplies. The Convention emphasizes the need to coordinate research efforts and action programs for combating desertification and drought with these related concerns.

The UNCCD will be implemented through action programs. These programs are the core of the Convention. At the national level, they will address the underlying causes of desertification and drought and identify measures to prevent and reverse them. Action programs are detailed in the four regional implementation annexes to the Convention - Africa, Asia, Latin America and the Caribbean, and the Northern Mediterranean.

The Bahamas is also party to a number of Conventions under the International Maritime Organization (IMO). These Conventions deal with issues such as ship safety, prevention of marine pollution and prevention of collisions at sea. All these issues relate to protection of the marine environment and its resources. The International Convention for the Prevention of Pollution from Ships (MARPOL) contains a number of Annexes that deal specifically with marine pollution from oil, noxious liquid substances, harmful substances and garbage.

In addition to the above treaties, Bahamas Petroleum Company and its contractors will align emergency response planning with two key national/international plans, namely:

1. The Bahamas National Oil Spill Contingency Plan, 1999
2. Caribbean Island Oil Pollution Response and Cooperation Plan, 2009

3.3 Institutions

3.3.1 Government

Government agencies that will be involved with aspects of approval and permitting of this project include:

Bahamas Environment, Science and Technology (BEST) Commission

The BEST Commission, formed by a directive from the Chief of State in 1994, has in effect been the country's environmental agency since 1995. The BEST Commission, a division of the Ministry of the Environment, is responsible for developing the Government of The Bahamas' (GOB) environmental and natural resource management policies. As mandated, the BEST Commission is responsible for the administration of the EIA process, overseeing the technical review of EIAs, coordinating the public review of EIAs, and providing advice to Cabinet for consideration in their decision-making process.

The BEST Commission is also the lead agency in ensuring that the GOB implements its requirements under the various international Conventions on environmental matters such as biodiversity, climate change, wetlands, land degradation, etc. In this role, The BEST Commission establishes committees, drawing on appropriate staff from different government agencies, for promoting actions to implement the specific requirements of the various conventions. To date, committees have been established on wetlands, climate change and biodiversity.

The BEST Commission also collaborates closely with other agencies with responsibilities for environmental matters such as the Water and Sewerage Corporation, Ministry of Agriculture and Fisheries, Department of Meteorology, and The Bahamas National Trust.

Department of Environmental Health Services (DEHS)

Under the *Environmental Health Act* of 1987, and the Environmental Health Regulations, the DEHS mandate is to promote and protect public health and ensure conservation and maintenance of the environment. One role of the DEHS is to regulate, monitor, and control actual and likely contamination and pollution of the environment and establish minimum standards required for a clean, healthy, and pleasing environment. The Environment Monitoring and Risk Assessment (ERMA) Division of DEHS, formerly the Public Analyst Laboratory, has the responsibility for some aspects of environmental monitoring, including monitoring of coastal water quality and potable water quality.

For proposed projects, the DEHS evaluates the effectiveness of pollution control measures and initiatives to protect the health and safety of workers, and the natural environment. DEHS is responsible for solid waste management and also issues effluent discharge and emissions permits.

Department of Labour

The Department of Labour oversees labor relations and occupational health and safety. The Department is the lead agency for regulating occupational health and safety under the *Health and Safety at Work Act* (2002). Through its Inspection Unit, the Department also conducts inspections to insure adequate worker safety and compliance with regulations.

Department of Marine Resources

The Department is responsible for the management and development of fishery resources as well as the promotion of the growth of fisheries under the principles of sustainable use and integrated management.

Department of Physical Planning

The Department authorizes activities such as dredging, filling, harvesting or removal of protected trees, and any work that will affect coastlines. It also administers the new *Planning and Subdivision Act of 2010*, which includes ensuring the preparation of land use plans and other physical planning activities.

Ministry of the Environment

The Ministry of the Environment oversees conservation of wild animals, birds, and plants, as well as forests. It administers the Wild Birds and Wild Animals Protection Acts.

Ministry of Public Works

The Ministry oversees and maintains physical infrastructure in the country. It is entrusted with the administration of the *Building Control Act* (*BCA*) and Regulations.

Office of the Prime Minister

The Office of the Prime Minister (OPM) is the office responsible for direct foreign investment in the country, the management and disposal of Crown Estate, and trade and industrial policy Development. Petroleum Operations are conducted under the aegis of OPM in accordance with the Petroleum Act 1971 and the Petroleum Regulations and amendments. The Office issues permits of geographical activities and licenses upon the direction of the Cabinet.

Port Department

The Department is responsible for safety and competency of those working at sea including prevention of accidents that can be detrimental to the marine environment. The Port Department is also responsible for regulating the disposal of ship ballast.

Water and Sewerage Corporation (WSC)

The WSC, with its Water Resources Management Unit (WRMU), has responsibility for optimal development of the country's water resources and the control of water quality. It shares (with DEHS) the responsibility for monitoring water quality. WSC issues water supply franchises to developers in areas where the supply of water is impractical for the GOB or its agencies to undertake.

3.3.2 Non-Governmental Organizations

Non-governmental organizations (NGO) that are active in The Bahamas include:

Andros Conservancy and Trust (ANCAT)

ANCAT was founded in 1999 to protect, preserve, enhance and restore the natural resources and marine environment of Andros Island. It works through education, conservation and management efforts.

Bahamas National Trust (BNT)

The BNT was established by an Act of Parliament in 1959, which makes it unique in the NGO community. It represents a unique collaboration of governmental, private sector and scientific interests dedicated to the conservation of the natural and historic resources of The Bahamas for the enjoyment and benefit of the Bahamian people. The major mandate of the Trust is management of the National Parks System of The Bahamas.

Bahamas Reef Environment Educational Foundation (BREEF)

The Bahamas Reef Environment Educational Foundation (BREEF) is concerned primarily with coral reef education and fund-raising for the protection of marine resources of The Bahamas through education. Its mission is to strengthen the symbiosis between the Bahamian people and the reefs, which protect, nourish, and enrich us, by focusing Bahamian and allied minds on this relationship. The Foundation’s *raison d’etre* is the restoration of the reefs of The Bahamas to their former glory and abundance.

Bahamas Sportfishing and Conservation Association (BSCA)

The BSCA is dedicated to the preservation of marine and coastal systems in the Caribbean, the protection of the sport fish in this remarkable fishery, and the sustainability of economic benefits the sportfishing industry provides to the Bahamian people. It focuses on increasing education and public sensitivity to marine conservation issues, species and habitat protection, marine conservation and research and sustainability of the sportfishing industry.

Nature’s Hope for Southern Andros (NHSA)

NHSA is based in Southern Andros and is focused on promoting environmental stewardship and conservation in that community. Recent activities have involved beach clean-ups and environmental education activities for local school children.

reEarth

reEarth is a nonprofit, environmental watch group founded in 1990 and dedicated to increasing public awareness and understanding of environmental issues. It has been involved in increasing public awareness on issues, such as risks to dolphin populations, destruction of tropical rainforests, long-line fishing, coral reefs, and oceans.

San Salvador Living Jewels

SSLJ is working to create protected areas on the San Salvador Island to conserve unique plant and animal biodiversity, including iguanas and the San Salvador woodpecker.

The Nature Conservancy (TNC), Bahamas Office

The Nature Conservancy has been working in The Bahamas for more than 10 years along with the Bahamas Government and a variety of partners to protect natural resources. TNC is working along with the BNT, Department of Marine Resources and the BEST Commission to build political support and garner long term financing for protected areas across the Caribbean through an initiative called The Caribbean Challenge. TNC Bahamas has also completed a number of assessment and planning activities for the island of Andros including the development of a land and sea use plan under the Integrated Watershed and Coastal Area Management (IWCAM) project.

3.3.3 Other

Small Island Sustainability Program (College of The Bahamas)

The SIS program began at the College of The Bahamas in 2009. It offers Bachelor degrees in sustainability with a focus on agriculture, tourism and ecology. Students are given opportunities to participate in research projects related to environmental issues and natural resource sustainable use and conservation in The Bahamas.

Gerace Research Centre

The Gerace Research Centre (formerly the Bahamian Field Station), which occupies a former US Naval Base on San Salvador Island, has been in operation for over 30 years as an educational and research institution. The Gerace Research Centre provides accommodations, laboratory space, and logistical support for both teachers and researchers interested in the diverse and unique tropical environments available on San Salvador.

3.4 International Guidelines

Bahamas Petroleum Company and its contractors will comply with standard industry best practices for managing environmental, health and safety. For example, the Company will follow guidelines of the International Association of Drilling Contractors (IADC) and International Association of Oil and Gas Producers (OGP).

3.4.1 International Association of Drilling Contractors

IADC publishes guides to supplement company health, safety and environmental (HSE) programs and operating procedures. The guides based on experience and study over many years by the industry. Bahamas Petroleum Company will work with the drilling contractor to follow key recommendations of IADC, such as those presented in the *HSE Case Guidelines for Mobile Offshore Drilling Units*[1].

The guidelines present best practices for all aspects of managing HSE risk for offshore drilling, including: hurricane response, waste management, management systems, and oil spill preparedness.

3.4.2 International Association for Oil and Gas Producers

The International Association for Oil and Gas Producers (OGP) (originally called the E&P Forum) was started to provide a global forum in which members identify and share best practices to achieve improvements in health, safety, the environment, security, social responsibility, engineering and operations. Most of the world's leading publicly-traded, private and state-owned oil & gas companies, oil & gas associations and major upstream service companies are members. OGP represents the interests of the upstream industry before international regulators and legislators in UN bodies and is also accredited to a range of regional bodies that include OSPAR, the Helsinki Commission and the Barcelona Convention.

[1] International Association of Drilling Contractors. 2010. Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units. Accessed from the IADC website: http://www.iadc.org/hsecase/MODU%20HSE%20Guidelines%20ALL.pdf

OGP develops guidelines to help industry institutionalize the best practices identified by its members. The guidelines and other studies are available on the OGP website (http://www.ogp.org.uk/) on a number of topics, such as:

- Preventing the Next Major Incident, 2005
- Guidelines for Waste Management with Special Focus on Areas with Limited Infrastructure, 2009

3.5 Environmental Impact Assessment Process

While the new Planning and Subdivision Act speaks to criteria for projects that will be required to prepare and submit Environmental Impact Statements (EIS), the EIA process is not standardized and the steps for review of an EIA or EIS varies depending on the agency who has initiated the EIA and is managing the review process. In the past, the most common path for the EIA Process has evolved as described Figure 3-1. The primary agency responsible for the review of EIA/EIS is the BEST Commission.

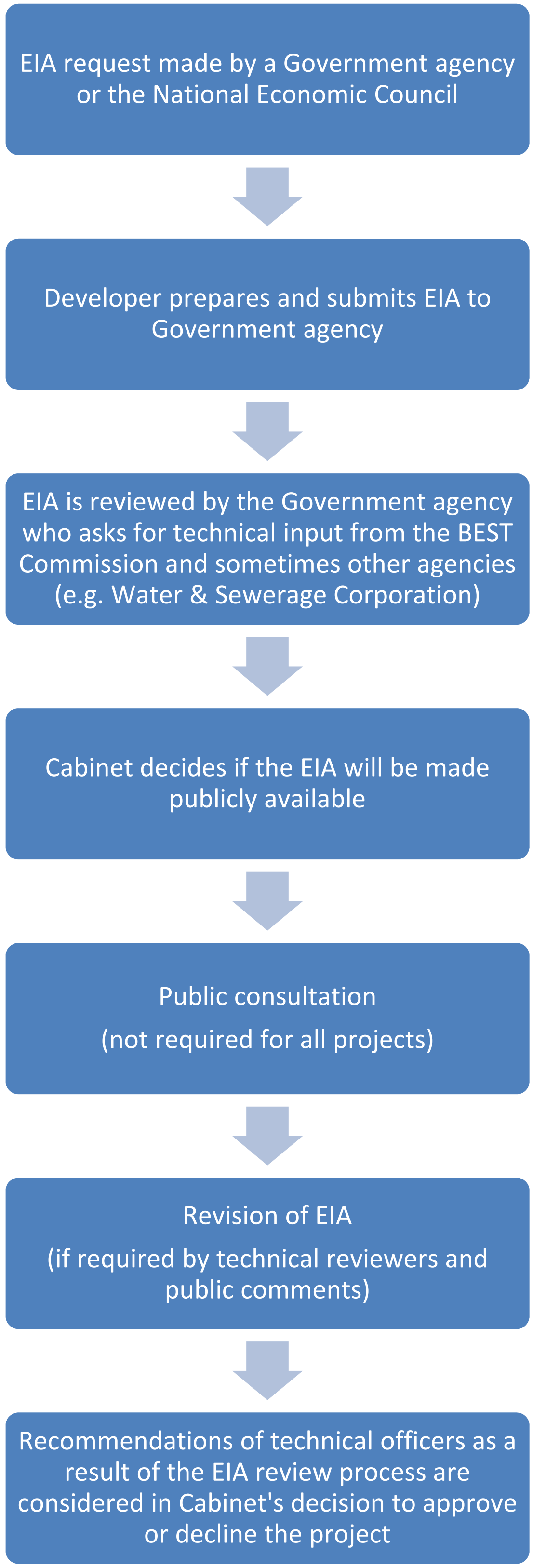

Figure 3-1: Common EIA Approval Process in The Bahamas

Changes to this process may occur if regulations for the EIA process are developed under the Planning and Subdivision Act.

3.6 Company Policy

Bahamas Petroleum Company will implement a number of plans for the project to protect the health and safety of employees and the public and minimize impacts to the environment (described in Chapter 6). The Company will also abide by the commitments of their Health, Safety and Environmental Policy, Figure 3-2.

Health, Safety and Environmental Policy Within Bahamas Petroleum Company

September 13th, 2011

OUR COMMITMENT

Bahamas Petroleum Company ("Bahamas Petroleum") is committed to reducing risk and maintaining environmentally responsible exploration in addition to Preserving the Environment for Future Generations.

OUR POLICY

Our Policy to Achieve this commitment is to:

- Establish a culture that promotes employee involvement in maintaining a safe work environment whilst recognizing that health, safety and environmental incidents are preventable;
- Demonstrate visible and active leadership that engages employees, contractors and service providers to manage health, safety and environmental performance as a line responsibility with clear authorities and accountabilities.
- Maintain "stop work policies" that establish the responsibility and authority for all employees and contractors to stop work they believe to be unsafe.
- Manage all projects, products and processes through their life-cycles in a way that protects health and safety and minimizes impacts on the environment.
- Strive for zero injuries and incidents;
- Be a recognized leader in environmental stewardship by respecting our neighbours and contributing to the society in which we operate;
- Promote continuous improvement in our processes, reducing risk to health, safety and the environment; and
- Work with governments and stakeholders where we operate to develop regulations and standards that improve the health and safety of people and the environment.
- Maintain a secure work environment to protect ourselves, our contractors and the Company's assets from risk of injury, property loss or damage resulting from hostile acts.

BAHAMAS PETROLEUM COMPANY PLC.

- Communicate our commitment to this policy to our subsidiaries, affiliates, contractors and governments worldwide and seek their support.

OUR ACCOUNTABILITIES

Bahamas Petroleum will ensure employees are:

- Provided with sufficient information, instruction, training, and supervision to enable them to carry out their tasks competently and safely.
- Provided with an understanding of this policy and their responsibilities in controlling and improving performance.
- Knowledgeable of the hazards and risks associated with their jobs.

Everyone has a responsibility to work safely and in an environmentally sound manner.

- **Our number one priority is the safety and well-being of the public, our employees, and contractors.**
- **Our business activities will be conducted to minimize our environmental impact.**

Dr. Paul Gucwa
Chief Operating Officer

Figure 3-2: Bahamas Petroleum Company Health, Safety and Environmental Policy

Source: Bahamas Petroleum Company

Bahamas Petroleum Company will evaluate the drilling and other contractor's health and safety training and other procedures to confirm that the contractor's policies meet industry standards for health and safety training and emergency response capabilities.

4. Baseline Environmental and Socioeconomic Conditions

Bahamas Petroleum Company's Bain, Cooper, Donaldson and Eneas Licenses cover some 3.2 million acres in the southern Bahamas. This section evaluates the current environmental and socioeconomic conditions in the project area of influence. The physical features, such as climate, currents and geology are described as well as biological features, such as protected areas, endangered species and unique habitat.

4.1 Physical Environment

4.1.1 Climate and Meteorology

The climate for the study area is strongly influenced by the trade winds; with The Bahamas generally having warm weather year-round. The climate is sub-tropical, with two distinct seasons: hot wet summers which extend from May to October and warm drier winters which extend from November to April, with winter incursions of polar air. The length of day (interval between sunrise and sunset) varies from 10 hours and 35 minutes in later December to 13 hours and 41 minutes in late June.

4.1.1.1 Temperature

The average temperature in The Bahamas is 77°F (24.8°C) (Table 4-1). The month of August has the highest monthly average temperature of 90°F (32°C). The lowest monthly average temperature is 63°F (17°C) and occurs in January and February[1].

Table 4-1: Average Monthly Temperatures for The Bahamas

Month	Average Minimum Temperatures (°F)	Average Maximum Temperature (°F)	Average Temperature (°F)
January	63	77	70
February	63	77	70
March	66	81	73
April	68	82	75
May	72	84	78
June	75	88	82
July	75	88	82
August	75	90	82
September	75	88	82
October	73	86	80
November	68	81	74
December	64	79	72

Source: Bahamas Meteorology Department, 2011

4.1.1.2 Precipitation

Rainfall varies locally, but there is a gradient of about 60in (1500mm) per annum in the north, to about 30in (750mm) in the south-eastern island of Inagua. The southern islands are rainfall deficient and susceptible to drought, as is reflected by the native vegetation. Most of the rainfall in The Bahamas occurs during the hurricane season from June to November (Table 4-2).

[1] Bahamas Meteorology Department. 2011. Historical Weather Data for The Bahamas. Nassau, Bahamas: Department of Meteorology. Accessed from The Bahamas Meteorology Department website: http://www.bahamasweather.org.bs/index.php.

The Bahamas receive an average of 53.3in (1353mm) of rainfall per year, or 4.4in (113mm) per month. On average, there are 136 days per year with more than 0.004 in (0.1mm) of rainfall. March is the driest month, with an average of 1.4in (35mm) of rainfall (precipitation) occurring across 5 days. June is the wettest month, with an average of 9.2in (234mm) of rainfall (precipitation) occurring across 16 days. The average annual relative humidity is 78.8%, ranging from 77% in April to 82% in September.[2]

Table 4-2: Average Monthly Precipitation for The Bahamas

Month	Average Rainfall (in)	Wet Days (>0.004 in)	Relative Humidity (%)
January	1.9	7	79
February	1.6	6	78
March	1.4	5	78
April	1.9	5	77
May	4.8	12	77
June	9.2	16	79
July	6.1	16	78
August	6.3	17	79
September	7.5	18	82
October	8.7	17	81
November	2.3	9	79
December	1.6	8	78

Source: Bahamas Meteorology Department, 2011

4.1.1.3 Air Quality

The project area is located in an offshore environment away from commercial developments and other point source emissions. Passing vessels contribute to local air emissions, but these are temporary and quickly dispersed in the winds offshore. The contribution of these emissions to air is unlikely to have a significant effect on local air quality.

4.1.1.4 Wind

The Bahamas and Cuba are positioned near the southern border of the Trade wind belt and experience almost constant, moisture-laden breezes from the east or southeast. In the winter, the trade winds shift southward and the winds are less constant. The mean wind speeds do not appear to vary significantly on a monthly basis. The average monthly wind speeds (Table 4-3) vary from 6.2mph (10km/h) in September to 8.9mph (14.3 km/h) in March. The highest average wind speeds are experienced during the late fall and winter months.

[2] Bahamas Meteorology Department, 2011.

Table 4-3: Average Monthly Wind Speed Miles Per Hour (MPH) for The Bahamas[3]

Month	Average Wind Speed (MPH)
January	8.0
February	8.6
March	8.9
April	8.3
May	7.9
June	7.2
July	7.1
August	6.9
September	6.2
October	7.4
November	8.1
December	7.8

Source: Bahamas Meteorology Department, 2011

Because of shifting winds, weather in both Cuba and The Bahamas is influenced by fronts advancing from the North American continent. These fronts result in cooler conditions than average, but the presence of the northerly flowing Gulf Stream prevents temperatures from reaching freezing conditions. Cold fronts, which generate strong winds of 22.9 to 28.6mph (37-46km/h) as well as cooler air, are typically preceded by winds from the southwest, which rotate to the west, then northwest, as the front passes. In general, winds in The Bahamas and northern Cuba are predominantly south-easterly blowing during the summer and north-easterly during the winter. Figure 4-1 below provides information on winds for the years 2004 to 2009 at 80.0W & 24.5N, inclusive of hurricane events for that period.

According to the report provided by Villy Kourafalou in 2011 the "Statistical analysis of surface meteorological data from C-MAN buoy stations off South Florida has shown that point data are representative of the monthly mean wind speed and direction over the Florida Straits, as the fields are fairly coherent and homogeneous". Kourafalou had selected what they considered to be a characteristic location near the Cay Sal bank to generate the wind data for their report. They extracted time series of 3-hourly wind vectors from the COAMPS atmospheric data set. These data are represented in the Figure 4-1. Figure 4-2 presents a graphic representation of the average climate variables for The Bahamas.

3 Bahamas Meteorology Department, 2011.

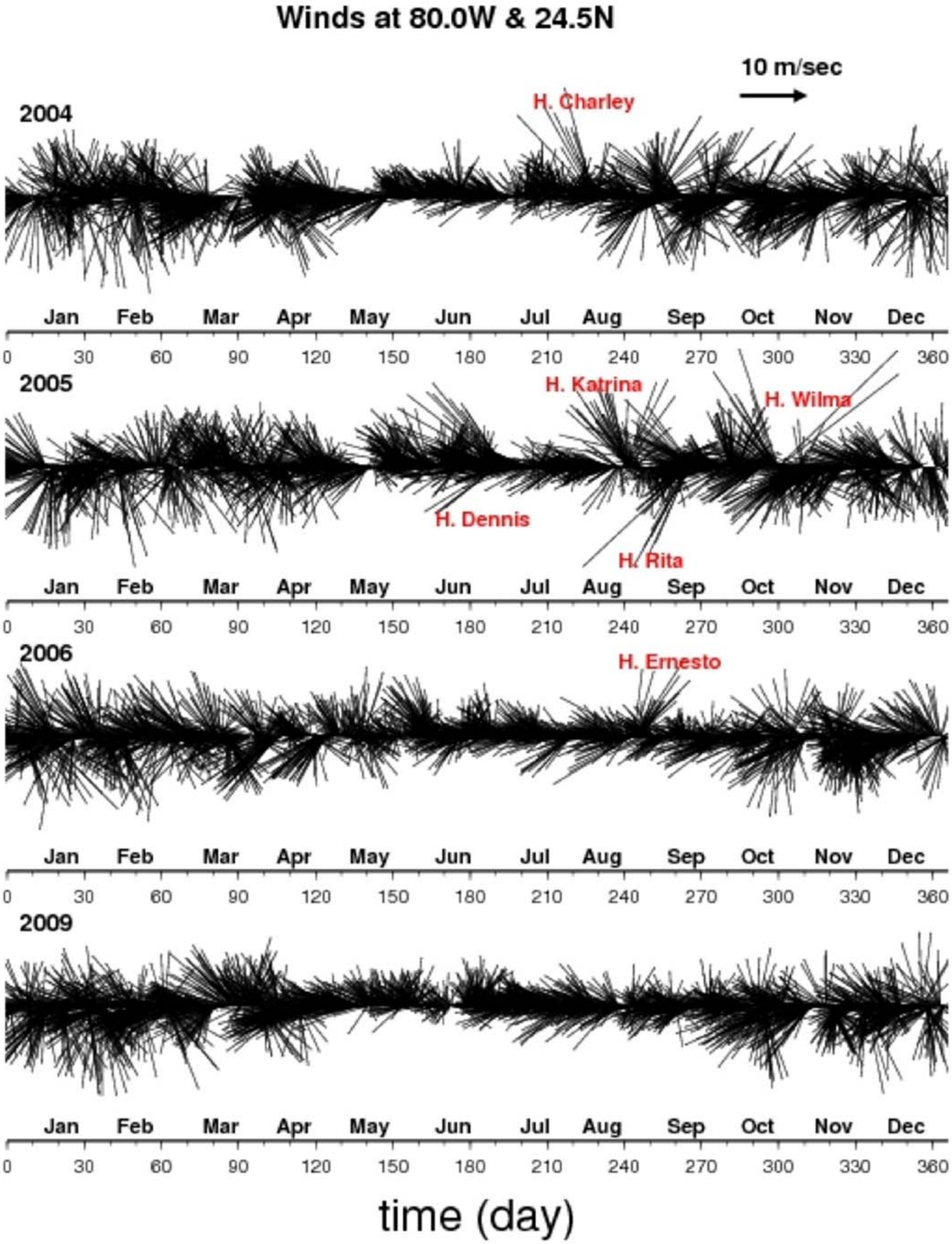

Figure 4-1: Wind Vectors for at 80.0W & 24.5N for 2004, 2005, 2006 & 2009.

Note: Red Letters Mark Hurricanes

Source: Kourafalou, et al., 2011[4]

[4] Kourafalou, V., Paris, C., Kang, H. and M. Le Henaff. 2011. Transport and Fate of Oil Particles Released in The Bahamas (Unpublished). Bahamas Petroleum Company Final Report August 2011. Miami, Florida.

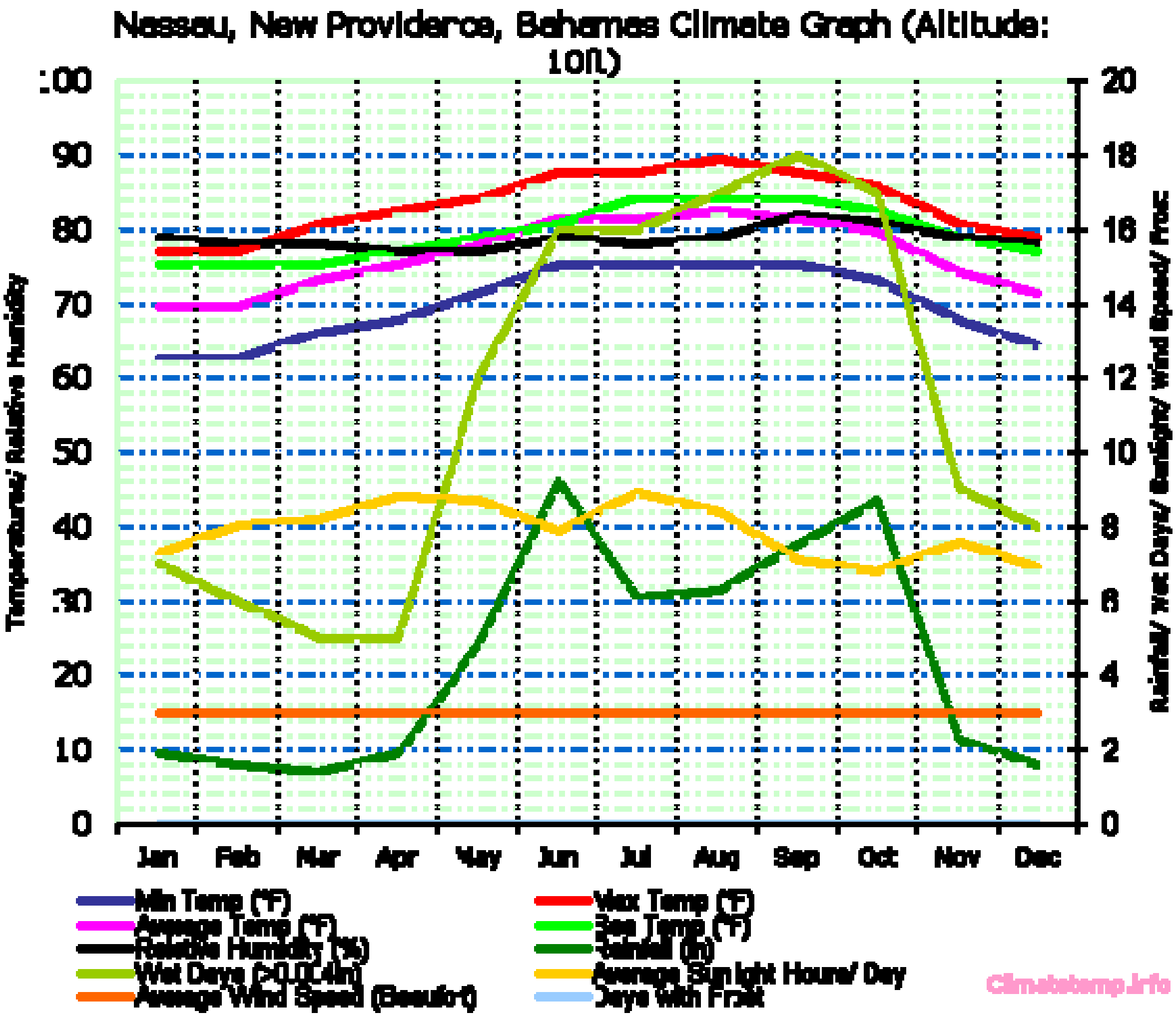

Figure 4-2: Climate Graph for The Bahamas (Imperial)

Source: Climatetemp website, 2011[5]

4.1.1.5 Natural Hazards

The proposed drill sites are within the Atlantic Tropical Cyclone basin. This basin includes much of the North Atlantic, Caribbean Sea, and the Gulf of Mexico. On average, 6 to 8 tropical storms form within this basin each year. The 2004 and 2005 hurricane seasons saw significantly greater than average activity. The 2004 Atlantic hurricane season saw 15 storms formed with 9 becoming hurricanes. During the 2005 Atlantic hurricane season, a record 28 tropical and subtropical storms formed, of which 15 became hurricanes. The formation of these storms and possible intensification into mature hurricanes takes place over warm tropical and subtropical waters. Eventual dissipation or modification typically occurs over the colder waters of the North Atlantic or when the storms move over land and away from the sustaining marine environment. This occurs over a period of about 7 to 8 days after formation. The official hurricane season

[5] Climatetemp.info. 2011. Bahamas Climate Guide to the Average Weather and Temperatures Accessed from the Climatetemp website: http://www.bahamas.climatetemp.info/.

lasts from June 1st to December 1st. Category 1 through 5 hurricane tracks and tropical storm tracks in The Bahamas are shown in Figure 4-3, below.

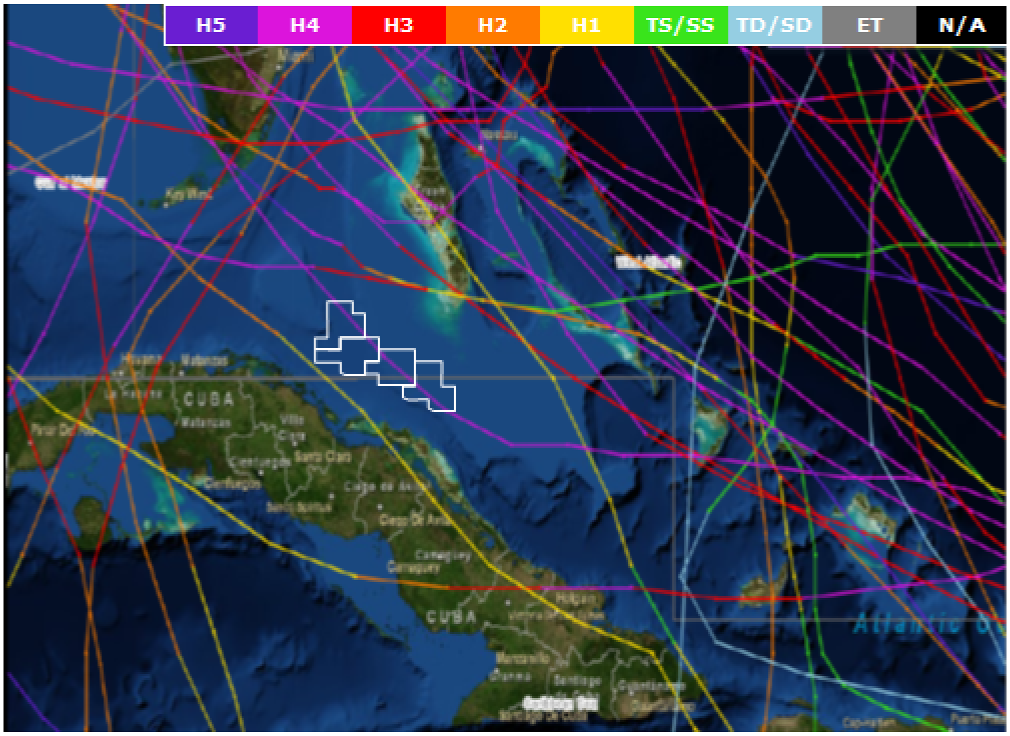

Figure 4-3: Historical Hurricane Tracks for the West Atlantic
Note: Approximate block boundaries shown in white
Source: NOAA, 2011[6]

Category 4 and 5 hurricanes that have impacted the project area of influence over the past century are as follows:

Category 4	Not named	1919
	Not named	1926
	Not named	1929
	Not named	1945
Category 5	Not named	1935
	Hurricane Donna	1960
	Hurricane David	1979
	Hurricane Georges	1998
	Hurricane Rita	2005

Storms of lesser strength that have impacted the project area of influence since 1995 include:

- Hurricane Lili (1996) – Category 2
- Hurricane Michelle (2001) – Category 1
- Tropical Storm Ernesto (2006)
- Tropical Depression Chris (2006)
- Tropical Storm Noel (2007)

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[6] National Oceanic and Atmospheric (NOAA). 2011. Historical Hurricane Tracks. Charleston, South Carolina: Coastal Services Center. Accessed from the NOAA website: www.csc.noaa.gov/hurricanes .

There have been 11 storms, which have passed through the project area since 1999.

The entire Bahamas region averages 1 storm every 10 years. Probability of a Category 3, 4 or 5 storm during the months of June to November (based on empirical evidence collected by US National Oceanic and Atmospheric Administration) is shown in Figure 4-4.

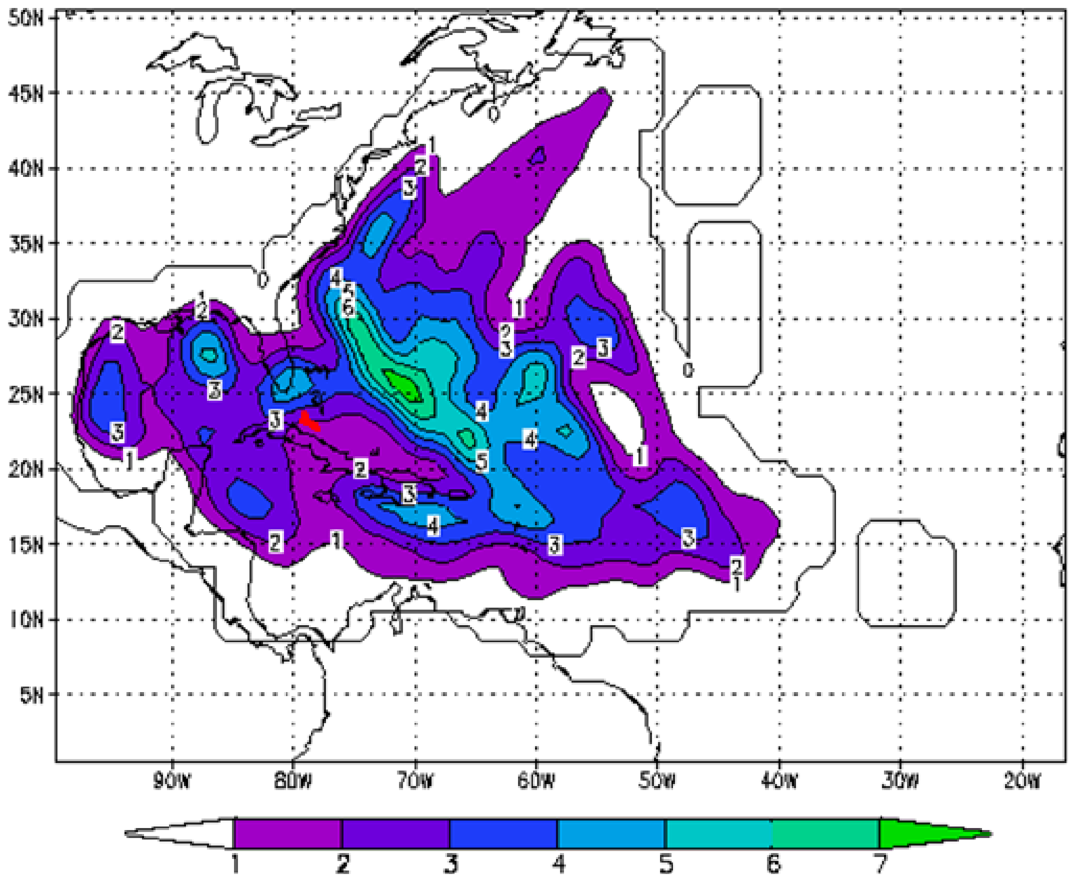

Figure 4-4: Percent (%) Chance of a Category 3, 4 or 5 Hurricane during June to November

Source: National Oceanic and Atmospheric Administration (NOAA), 2011[7]

Recent hurricanes that have impacted other areas of The Bahamas outside of the project area of influence include:

- Hurricane Andrew (1992) - Category 5
- Hurricane Bertha (1996) - Category 1
- Hurricane Floyd (1999) - Category 4
- Hurricane Frances (2004) - Category 4

[7] National Oceanic and Atmospheric Administration (NOAA). 2011. Hurricane Research Division Frequently Asked Questions. Accessed from the NOAA website: http://www.aoml.noaa.gov/hrd/tcfaq/G11.html

4.1.2 Geology

4.1.2.1 Tectonic History and Stratigraphy

The Bahamian Archipelago consists of two carbonate banks which were formed by a chain of carbonate platforms. The Bahamas were originally formed by the rifting of Pangea, the super-continent, which resulted in the opening of the North Atlantic basin. The rifting of Pangea was accompanied by volcanic activity due to the collision of the North American and Caribbean plates. The collision was a result of the subduction of one plate sliding under the other. Evidence of volcanic activity is found in the tilted fault blocks of Jurassic volcaniclastics, which are commonly found in the Florida Straits area. In the southern region of The Bahamas, the basement rocks are oceanic crust, showing that the area was not a transitional region during the opening of the North Atlantic basin[8].

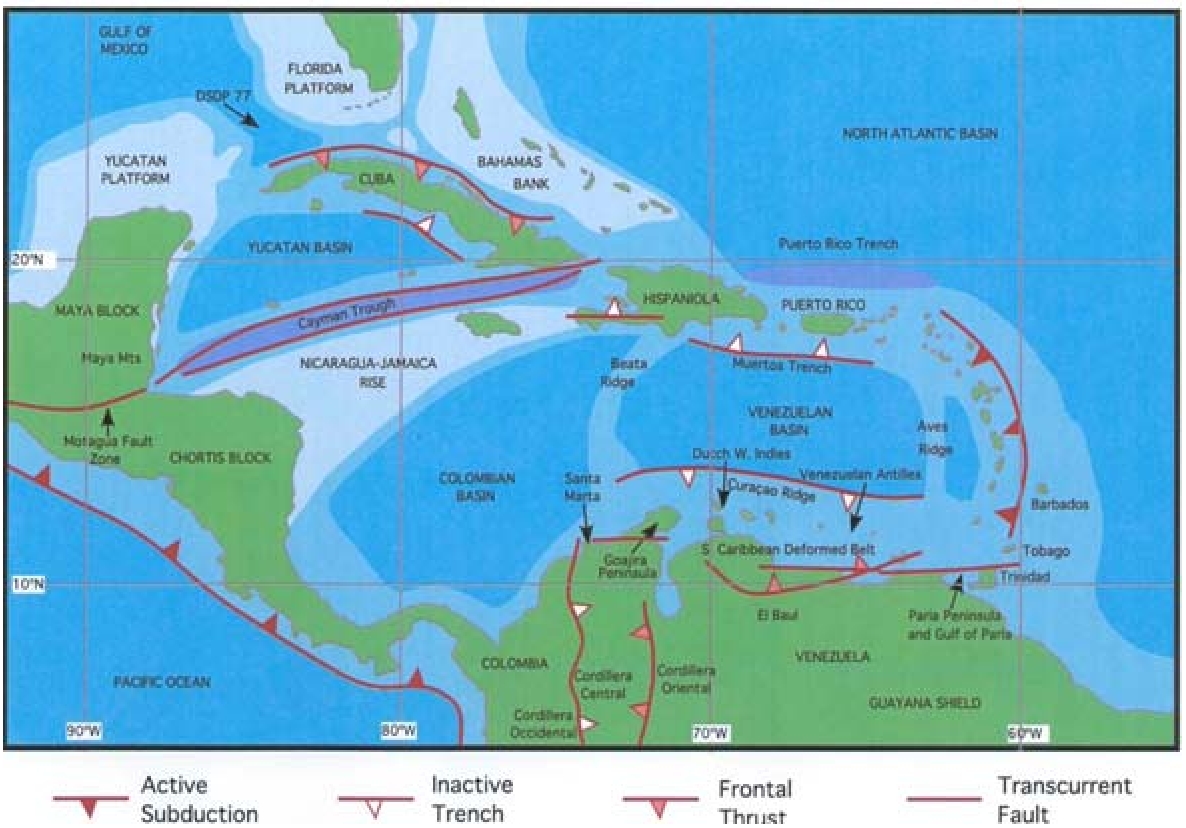

Figure 4-5: Current Regional Tectonic Setting
Source: Eberli 2007[9]

The current regional tectonic setting is shown on Figure 4-5, summarizes the Tectonic events as:

- Opening of North Atlantic (200 million years)
  - Establishment of rift geometry and bank-trough morphology

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8 Curran, H., White, A., and B. White 1995. Terrestrial and Shallow Marine Geology of the Bahamas and Bermuda. Northampton, Massachusetts: Geological Society of America.

9 Eberli, G. 2007. "Tectonic Evolution and Paleogeography of the Bahamian Archipelago" complied for Bahamas Petroleum Company Limited, March 2007(Unpublished report).

- Passive continental margin stage (180 – 90 million years)
    - o Platform growth and expansion, partly filling of rift basins to form large platform (megabank)
- Plate re-organization in Pacific, begin of eastward movement of Caribbean plate
    - o Break-up of megabank and formation of new seaways
- Collision of Cuba with America (60 – 35 million years) (Figure 4-6)
    - o Back step of platform margins
    - o Drowning of portions of the archipelago
    - o Evolution of the Cuban fold and thrust belt
- Change of direction of Caribbean plate from SW – NE to W – E
    - o Jump of plate boundary south of Cuba
    - o Drastic reduction in shortening between Cuba and The Bahamas
    - o Renewed platform expansion

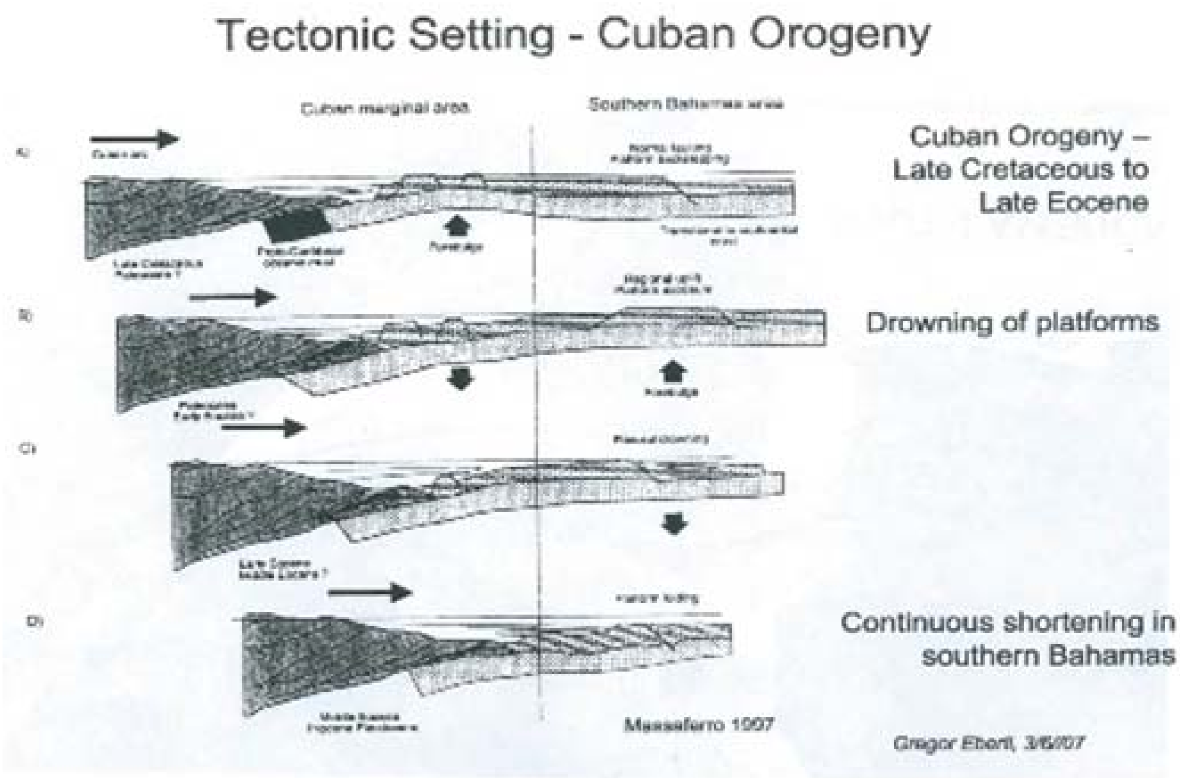

Figure 4-6: Tectonic Settings –Cuban Orogeny[10]
Source: Masaferro, J.I. Bulnes, M., Poblet, J. and G.P. Eberli, 2002

[10] Masaferro, J.L., Bulnes, M., Poblet, J. & G.P Eberli. 2002. Episodic Folding Inferred from Syntectonic Carbonate Sedimentation: the Santaren Anticline, Bahamas Foreland. Sedimentary Geology, 146(1/2): 11-24. ISSN: 0037-0738

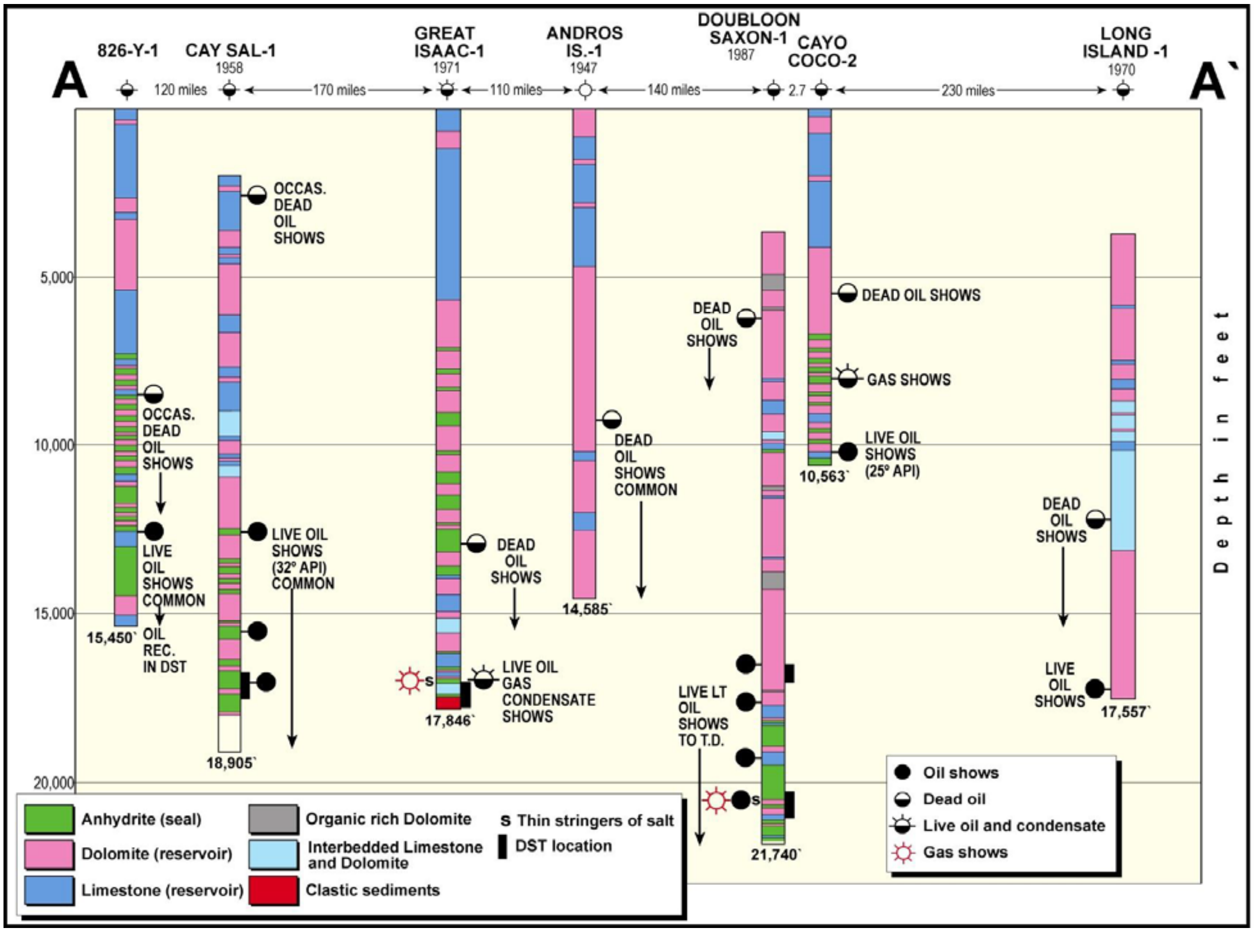

Figure 4-7: Wells Drill throughout The Bahamas
Source: Bahamas Petroleum Company

The banks formed over the horst and graben rift structures created during the break-up and opening of the Atlantic approximately 200 million years ago. The platforms were initiated in latitude with a warm climate that favored carbonate deposition.[11] Limestone, dolomite and anhydrite sediments continued to accumulate through the Jurassic and Cretaceous and reached thicknesses in excess of 20,000 feet as seen in the previous wells drilled in The Bahamas (Figure 4-7).

Bahamas Petroleum acquired modern 2D seismic in 2010 and 2011 (Figure 4-8). These data revealed several large contractional structures within the Bain, Cooper and Donaldson licenses. These large structures represent the Bahamian Foreland of the Cuban Bahamian Fold and Thrust belt initiated by the collision of Cuba with America.

There is an important difference between the geology of The Bahamas and that of the central Gulf of Mexico. In the central and western Gulf of Mexico, the sediments consist of sands and shales which are carried to the Gulf by major river systems and deposit very rapidly. This rapid deposition often leads to the development of high pressure in the sandstones and shales as the sediments are buried faster than the trapped water can escape. These high pressures were one

[11] Schettino, A. and E. Turco. 2009. Breakup of Pangaea and Plate Kinematics of the Central Atlantic and Atlas Regions. Geophysical Journal International, 178: 1078–1097.

of the factors leading to the Macondo spill in 2010. In The Bahamas, the carbonate rocks accumulated slowly over a much longer period of time and high or abnormal pressures are not expected; and were not seen in the wells drilled previously.

4.1.2.2 Geomorphology

The geomorphologic landscapes of the Bahama Islands can be attributed to the accumulation and erosion of carbonate sediments and rocks by currents, waves, and winds. There are two major landforms which dominate landscapes of The Bahamas, including:

- Eolianite ridges that rise from a few meters to 63 meters above sea level.
- Lowlands comprised of marine and terrestrial deposits.

Lands in the interior of the islands are typically below sea level and can contain marine to hypersaline lakes.

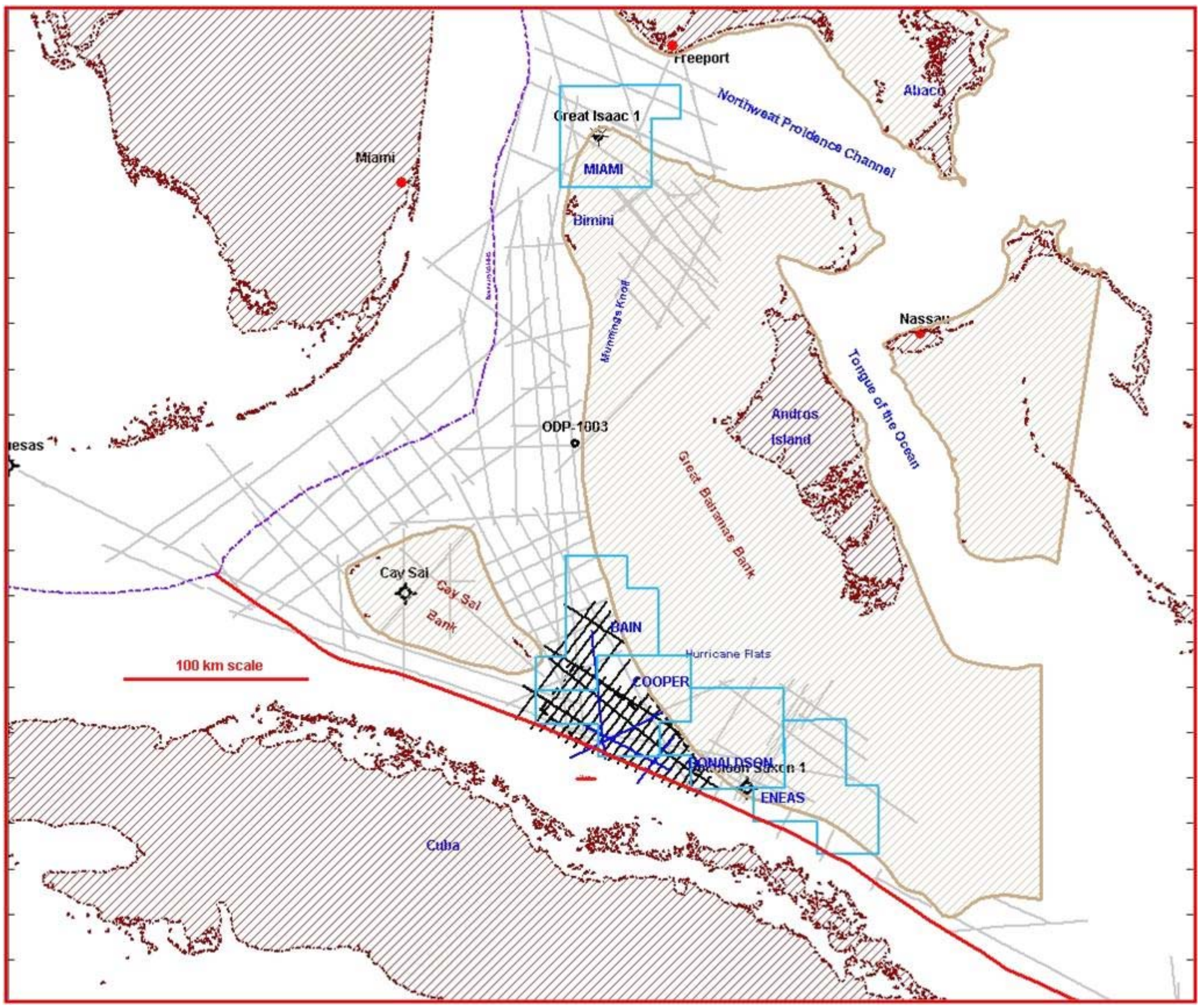

Figure 4-8: Bahamas Petroleum Company Licenses and Location of Seismic Data Lines

Note: New Data Lines Shown in Black

Source: Rowan Consulting, Inc. 2011

4.1.2.3 Bathymetry

Based on the multi-beam survey conducted in August 2011 by Fugro, the bathymetric depth for the project area ranges from 100 meters to 570 meters. This confirms that the depths used in the hydrodynamic model in the *Transport and Fate of Oil Particles Released in The Bahamas* 2011 report by Kourafalou, et al. are correct (Figure 4-9).

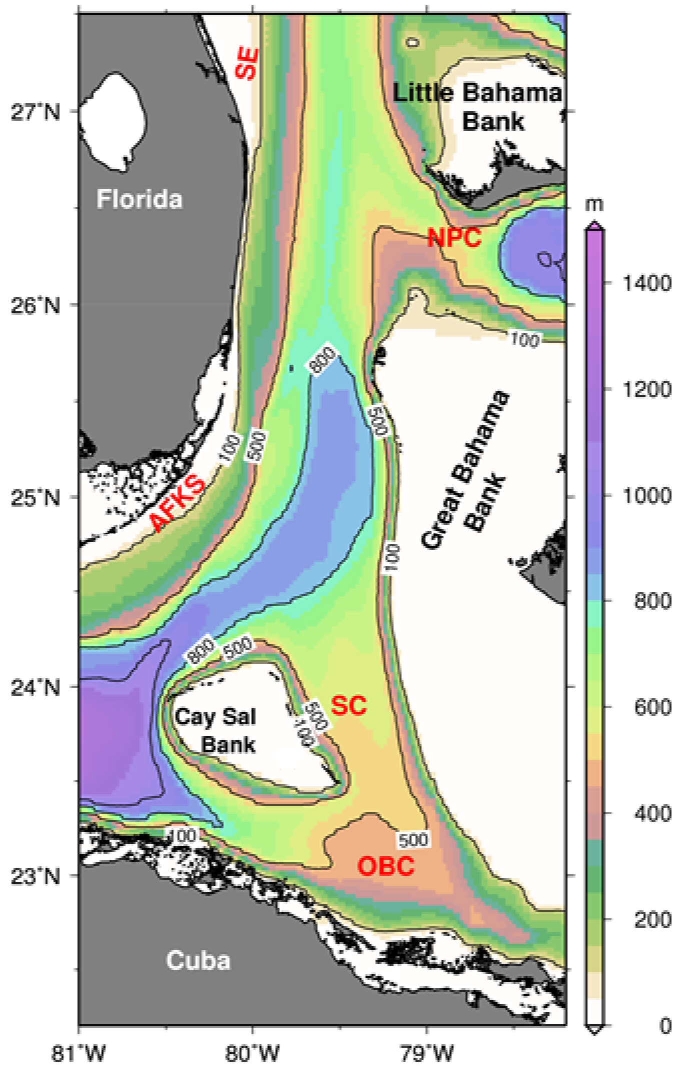

Figure 4-9: Topography in the Florida Straits
Source: Kourafalou, et al., 2011[12]

4.1.2.4 Geologic Hazard

The Bahama Islands occupy a large carbonate platform along the subsiding continental margin of North America. All surficial materials and bedrock are calcareous and most exposed materials are Quaternary in age. The topography is very subdued; most of the islands are nearly flat and the maximum elevation of the archipelago is 206 feet (63 meters). Small slopes, no more than several feet high, can be found along certain coastlines.[13]

[12] Kourafalou, et al. 2011.(unpublished)

[13] Adams, R. W. 1985. General Guide to the Geological Features of San Salvador, in Field Guide to the Geology of San Salvador (3rd Edition), ed. D T Gerace, pp. 1-66. San Salvador, Bahamas: College Center of the Finger Lakes.

Due to the flat topography of the Bahama Islands, landslides are rare and often limited to small rock falls and rock slides along the coasts caused by wave erosion.[14]

Formation of sinkholes and caverns are common.[15] Such phenomenon typically occurs in The Bahamas as a result of chemical dissolution of carbonate rocks (i.e. limestone and dolomite). Sinkholes and caverns emerge as the rocks are weathered by chemical interactions with water. Previous wells drilled in The Bahamas encountered highly fractured carbonate zones and caverns.

4.1.2.5 Seismicity

There are several active fault systems on the southern side of Cuba that produce numerous seismic events each year[16]. While most registered seismic events pass unnoticed, the island of Cuba has been struck by a number of destructive earthquakes over the past four centuries, including several major quakes with a magnitude of 7.0 or above. Figure 4-10 shows the fault lines in the Caribbean.

Figure 4-10: Fault Lines in the Caribbean
Source: DeMets and Wiggins-Grandison, 2007[17]

Approximately 70% of seismic activity in Cuba emanates from the Oriente fault zone located in the Mid-Cayman spreading center also known as the Bartlett-Cayman fault system. This system

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[14] Carew, J.L., and J.E. Mylroie, 1985. The Plesitocene and Holocene Stratigraph of San Salvador Island. Bahamas, with Reference to Marine and Terrestrial Lithofacies at French Bay. In H.A. Curran (ed.), Pleistocene and Holocene Carbonate Environments on San Salvador Island, Bahamas. Boulder: Geological Society of America Field Trip Guidebook 2: 1-10.

[15] Mylroie, J.E., 1983. Caves and Karst of San Salvador. In D.T. Gerace (ed.), Field Guide to the Geology of San Salvador (3rd Edition), P. 1-66. San Salvador, Bahamas, College Center of the Finger Lakes Bahamian Field Station.

[16] Cotilla Rodriquez, M.O., H.J. Franzke and D. Cordoba Barba. Seismicity and Sesimoactive Faults of Cuba. Russian Geology and Geophysics 48(6), pp 505-522. 2007.

[17] DeMets, C. and W. Wiggins-Grandison. Deformation of Jamaica and Motions of the Gonave Microplate from GPS and Seismic Data. Geophysical Journal International. 168: 362-378. 2007.

runs along the south-eastern coast of Cuba and marks the tectonic boundary between the North American Plate and the Caribbean Plate. Destructive earthquakes originating from the Oriente fault occurred in 1766 (M_i=7.6), 1852 (M_i=7.2) and 1932 (M_s=6.75). These active zones are not in the immediate area of the Bahamas Petroleum Company Licenses. It is unlikely that the project area would be affected in the event of an earthquake.

4.1.2.6 Tsunamis

A tsunami in the Atlantic Ocean is a rare event, partially due to the lack of active plate boundaries.

The only active plate boundaries are along the eastern edge of the Caribbean and the Cayman trough south of Cuba and the eastern edge of the Scotia Plate in the South Atlantic. The lack of activity accounts for the low incidence of earthquake-generated tsunamis. There are only three recorded tsunami events in the Atlantic basin, and they were all generated by earthquakes:

- 1755 Lisbon Portugal earthquake
- 1918 Puerto Rico earthquake
- 1928 Grand Banks, Canada earthquake[18].

None of these events had any reported significant impacts for The Bahamas or Cuba in the project area of influence.

4.1.3 Oceanography

Oceanography covers a wide range of topics, including marine organisms, ecosystem dynamics, ocean currents, waves and geophysical fluid dynamics. This section will discuss the issues of waves, tides, currents, temperature, salinity and density.

4.1.3.1 Waves and Tides

Waves

The windward (eastern) margins of the Great Bahama Bank (GB) at Long Island and Little Bahama Bank at eastern Abaco, according to Bergman have the highest wave energy due to no structures impeding the movement of waves and swell energy from the open Atlantic whereas, the southwest Great Bahama Bank is shielded by an energy-absorbing environment, resulting in a lower wave energy. Wave energy is seasonal in The Bahamas with the highest wave energy occurring in the winter months (Table 4-4).

Table 4-4: Percent Frequency of Wave Heights at Southwest Great Bahama Bank (GB)

Month	J	F	M	A	M	J	J	A	S	O	N	D
% freq. > 1.5m GB	34	32	28	28	23	21	29	19	20	21	32	39
% freq. > 2.4m GB	3	3	3	4	2	2	2	1	2	2	7	5
% freq. > 4 m GB	0	0	1	0	0	1	0	0	0	0	0	0

Source: Adapted from the National Buoy Data Center, 1973

Waves in the area of the Bahamas Petroleum Company licenses are generated by wind. Wind in the two major ocean channels near the project site, the Old Bahama Channel and the Santaren Channel, are generally out of the east. Waves 50 feet (15 m) high are not unusual during severe storms throughout The Bahamas.

[18] National Oceanic and Atmospheric Administration. 2011. Tsunami Travel Time Maps for the Atlantic. Accessed from the NOAA website: www.ngdc.noaa.gov/hazard/tsu_travel_time_events.shtml .

Tides

A study in the project area indicated that tides in the region are predominately influenced by the Old Bahama Channel.[19] Figure 4-11 identifies diurnal frequency currents for the first 20 days in October of 1991. During the period of 1990-1991, large pulses of current flows were recorded in the direction of the Florida Straits at 250 m depth with speeds approaching 200 cm s^{-1}. It is believed that there were large diurnal tidal current shears being generated intermittently when conditions were favorable. According to Bergman, et al., the Great Bahama Bank experiences tidal currents that are generally radially oriented and sweep bankward (0.32 m/s) during flood tides and off bank during ebb tides.[20] Kourafalou and Bergman had the same conclusion that the strongest currents are oriented parallel to, as opposed to the on/off-bank direction of the Great Bahama Bank.[21] [22]

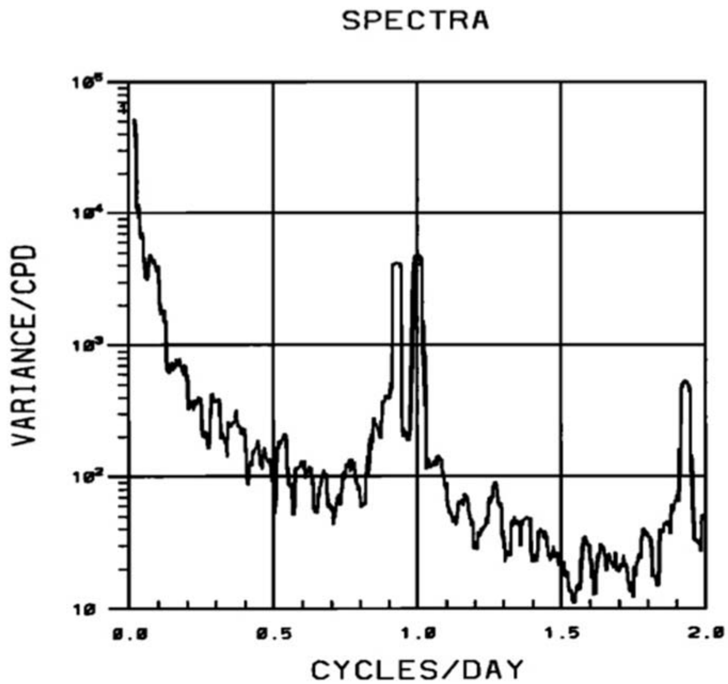

Figure 4-11: Spectra off 3-HLP along-channel Velocity Component showing the Strong Tidal Signals

Note: (1-26 hours; 24-hours – P1/K1; 12.5 hours – M2)

Source: Atkinson, 1995[23]

4.1.3.2 Currents

In general, ocean currents can be divided into two types of flow based on the forces that drive them. Most currents in the upper kilometer of the ocean are driven by the wind. Mixing drives deeper currents, which brings very cold dense water up to the surface.

[19] Atkinson, L.P. 1995. Current Meter Observations in the Old Bahama Channel. Center for Coastal Physical Oceanography. Old Dominion University, Norfolk, Virginia. 1995.

[20] Bergman, K.L., H. Westphal, X. Janson, A. Poiriez, and G. Eberli. 2010. Controlling Parameters on Facies Geometries of the Bahamas, an Isolated Carbonate Platform Environment, In: Carbonate Depositional Systems: Assessing Dimensions and Controlling Parameters. New York: 1st Edition, 2010, VII, 270 p.

[21] Kourafalou, et al. 2011.(unpublished)

[22] Bergman, et al. 2010

[23] Atkinson, 1995.

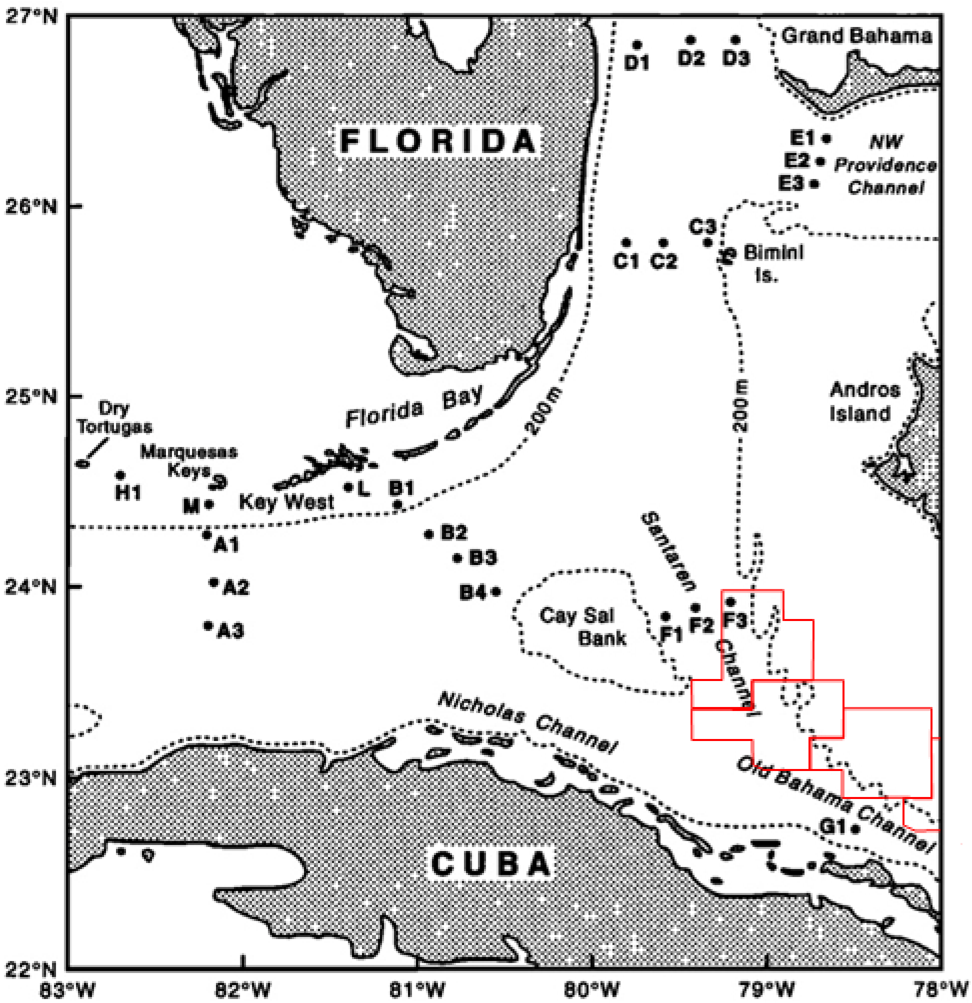

Figure 4-12: Map of Various Channels in the Project Area
Note: Approximate block boundaries shown in red
Source: Atkinson, 1995

The Old Bahama Channel and the Santaren Channel are located adjacent to the Blocks and have a direct influence on current flows for the area (Figure 4-12). Water coming from the Old Bahama Channel has a direct connection to the water flowing northward in the Florida Straits and the subtropical North Atlantic Ocean to the east. Additionally, the Santaren Channel and the Nicholas Channel receive Western Atlantic water through the Old Bahama Channel. It has also been concluded that water reaches the Little Bahama Bank from the Old Bahama Channel by flowing east along the Santaren Channel[24]. Recent research undertaken by Atkinson indicates that the Old Bahama Channel contributes 2 Sverdrup (Sv) [25] to the Florida Current. Water from the Old Bahama Channel, which terminates in the Florida Straits, passes predominately through the Santaren Channel and not the Nicholas Channel[26]. Table 4-5 indicates the flow direction,

[24] Wust, G., Stratification and Circulation in the Antillean –Caribbean Basin., Columbia University Press, 1964
[25] Bergman, et al., 2010.
[26] Atkinson, 1995.

velocity and volume of Bahamian currents[27]. The negative flow volumes and velocities indicate reversal of mean flow direction.

Table 4-5: Current Direction and Velocities for the Channels near the Licenses[28]

Current or Passageway	Mean flow direction	Mean flow velocity	Max. surface flow velocity	Mean flow vol. (upper 200 m) [SV]	Flow vol. range (upper 200 m) [SV]
Florida Current at 26°N	NNW	--	>170 cm/s	15.5 ±1.4	13.7-17.6
Florida Current at 27°N	N	--	>160 cm/s	16.5 ±2.4	13.1-19.3
Santaren Channel	N	-10-20 cm/s	20 cm/s (300-400 m depth)	1.8	--
Old Bahama Channel	NW	~26 cm/s	193 cm/s (250 m depth)	1.9	6.6- (-2.4)

Data shown in Figure 4-13 and 4-14 provide data on the seasonality of the currents at different depths (surface, 300m, 500m) surrounding and within the project area. Based on the analysis presented by University of Miami the deep currents were found to be generally much weaker and often in the reverse direction than the surface currents. With respect to the Old Bahama Channel, it was discovered that there is a strong tendency for surface inflow to be along Cuba and outflow along the Bahamas.

[27] Atkinson, 1995.
[28] Bergman, et al., 2010

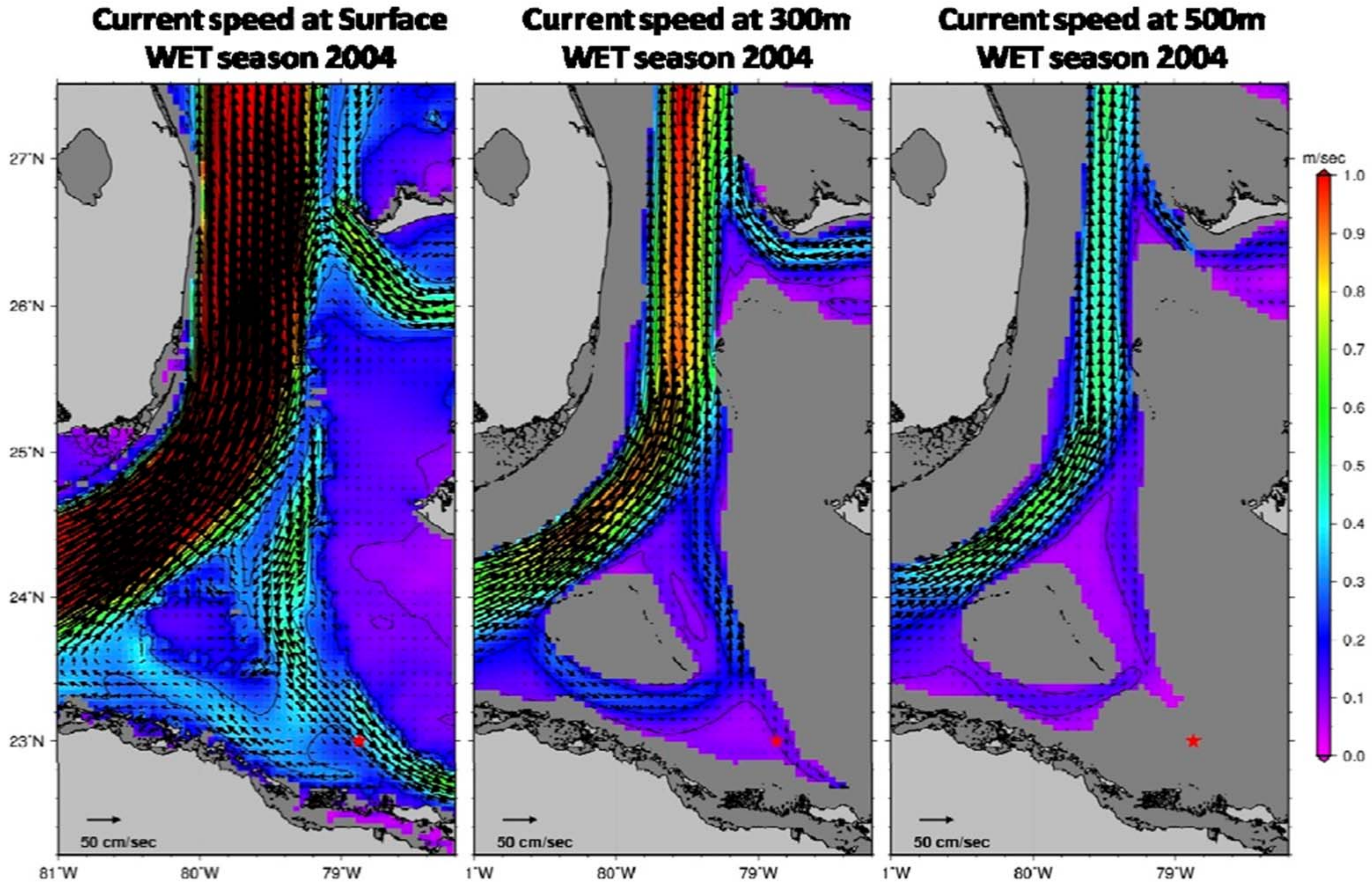

Figure 4-13a: Seasonal Mean Current Patterns (Surface, 300m and 500m) in the Florida Straits for Wet Season in 2004

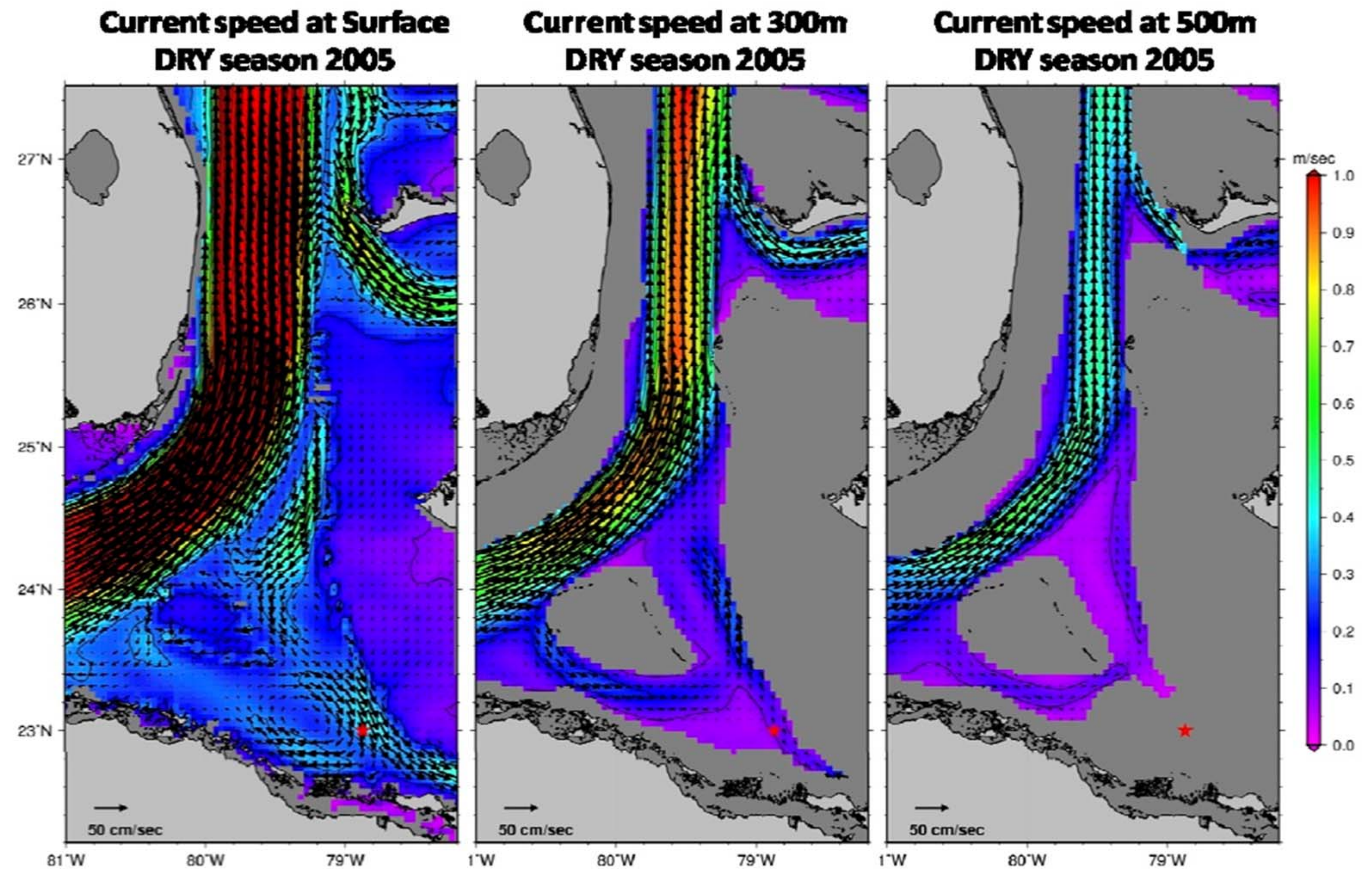

Figure 4-13b: Seasonal Mean Current Patterns (Surface, 300m and 500m) in the Florida Straits for Dry Season in 2005[29]

[29] Kourafalou, et al. 2011.

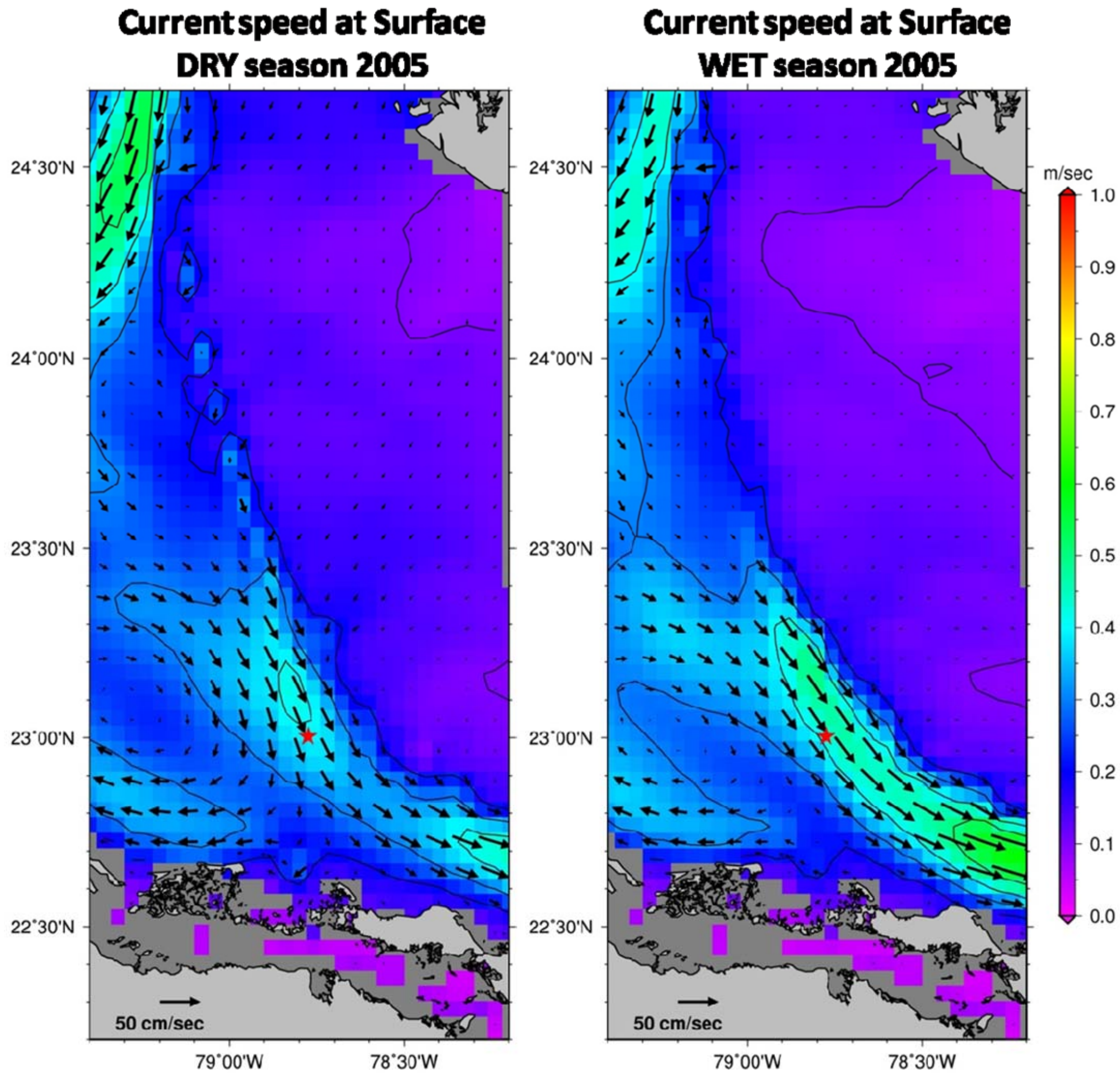

Figure 4-13c: Seasonal Mean Current Patterns (Surface) in the Florida Straits for Dry and Wet Season in 2005[30]

[30] Kourafalou, et al. 2011.

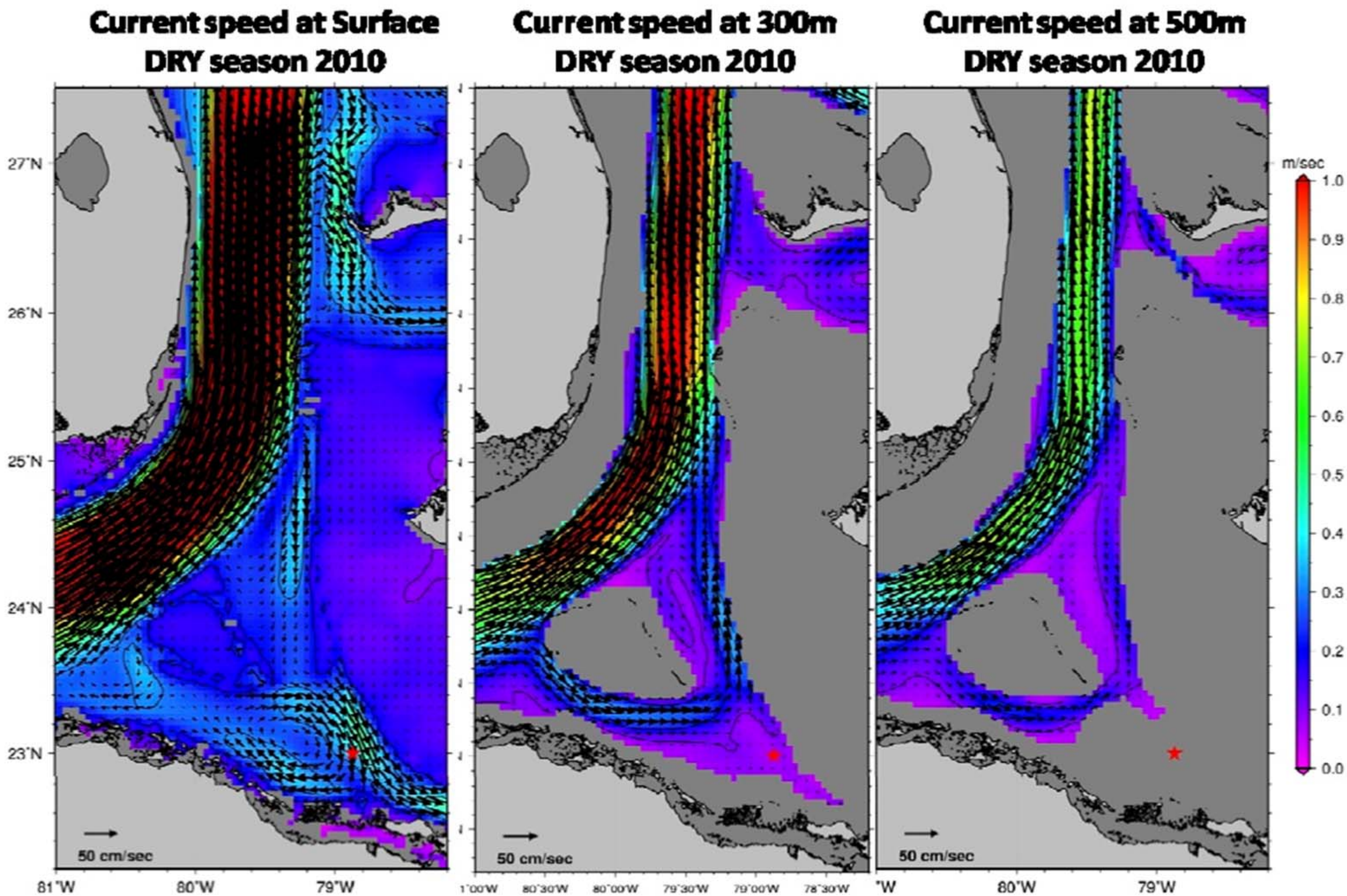

Figure 4-14a: Seasonal Mean Current Patterns (Surface, 300m and 500m) in the Florida Straits for Dry Season in 2010[31]

[31] Kourafalou, et al. 2011

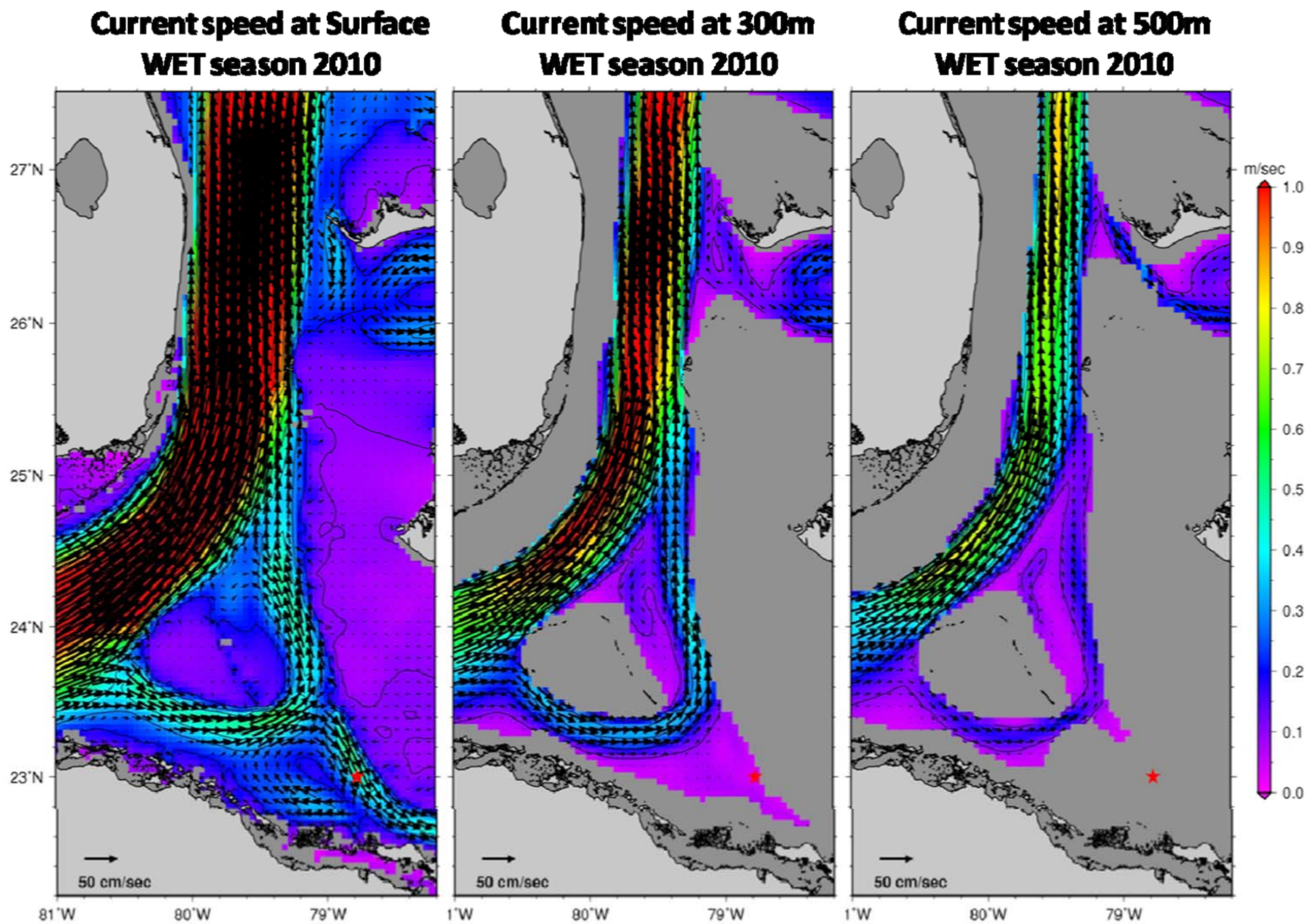

Figure 4-14b: Seasonal Mean Current Patterns (Surface, 300m and 500m) in the Florida Straits for Wet Season in 2010[32]

[32] Kourafalou, et al. 2011

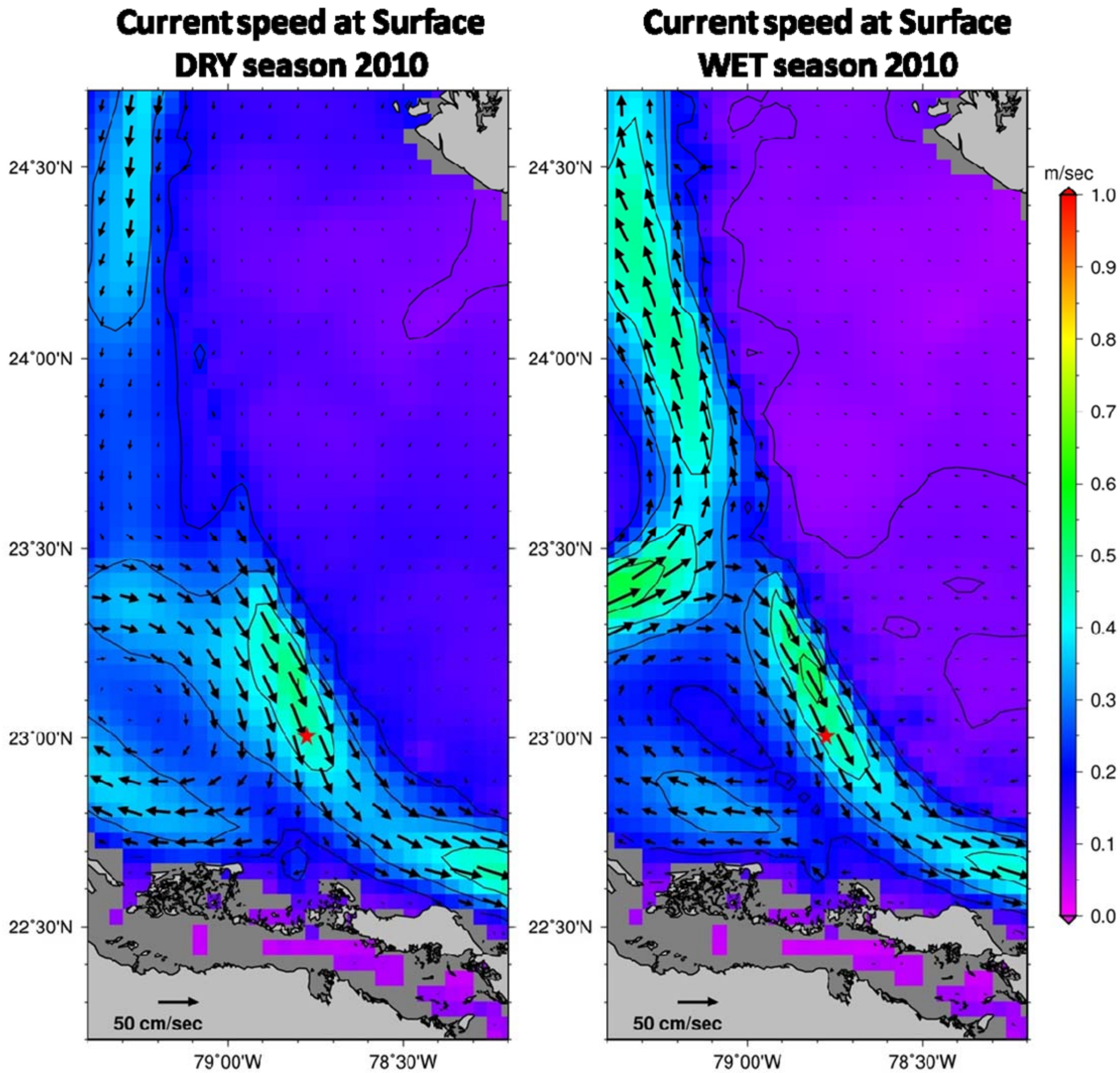

Figure 4-14c: **Seasonal Mean Current Patterns (Surface) in the Florida Straits for Dry and Wet Season in 2010**[33]

[33] Kourafalou, et al. 2011

From the University of Miami analysis, Figures 4-13 and 4-14 shows seasonally (long term) averaged currents, therefore it is reasonable to have smaller values than the instantaneous measurements (due to changes in current direction that create positive and negative values that can average out, dropping the mean values) shown in Table 4-5.

4.1.3.3 Marine Water Quality

In order to determine the marine water quality in the project area, a series of sampling activities were undertaken from June 12-13, 2011. Dissolved oxygen data will be collected during the ROV survey and provided upon collection.

Salinity

The salinity of the oceans varies between 30 and 37 grams of salt per liter on the Practical Salinity Scale (PSS). According to Bergman, on the Great Bahama Bank the salinity ranges from 36 to 46 part per thousand (ppt) with the highest salinities occurring during the summer months when evaporation is at a maximum (see Figure 4-15).

The salinity readings for the project site were taken between June 12 and 13, 2011 over an intermitting two-hour period each day. The results indicated that the average salinity for the area with depths ranging from 13 to 1,591.21 feet (485 meters) were 36.55 PSS. There was no significant change in salinity at the various depths.

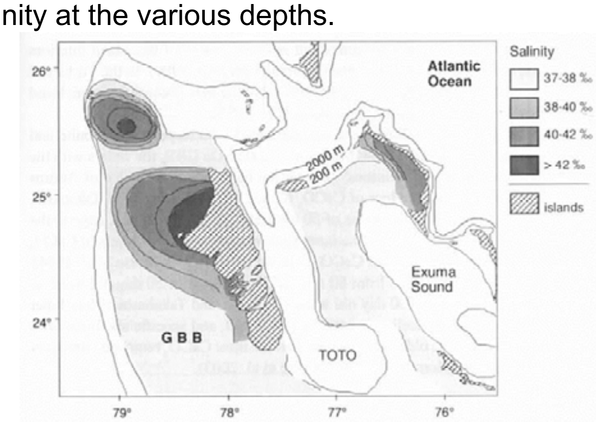

Figure 4-15: Salinities on the Great Bahama Bank, summer 1955 and 1956.
Source: Bergman, et al., 2010

Density

One of the most important physical properties of sea water is its weight or density. The density of fresh water depends mainly on temperature: warm water floating on top of cold water. However, sea water's density depends on its level of salinity and pressure, as pressure compresses water slightly, making it heavier. Table 4-6 contains data collected from the area.

Table 4-6 provides information on the comparison of seawater characteristics for salinity, pressure, temperature and density at depth in the licenses.

Table 4-6: Comparison of Seawater Characteristics at the Licenses Location

Depth (feet)	Temperature °F	Salinity (PSS)	Density (1000kg/ m^3)
13	81	36.4	23.7
112	79	36.6	24.3
164	78	36.7	24.6
328	76	36.7	25.3
492	71	36.9	26.1
656	70	36.9	26.6
820	67	36.7	27.3
984	64	36.5	27.7
1148	63	36.4	28.0
1312	59	36.0	28.4
1476	57	35.9	28.8
1575	56	35.8	29.0

Source: Fugro, 2011[34]

Sea Temperature

The temperature of the world's ocean is highly variable over its surface, ranging from less than 32°F (0°C) near the poles to more than 84°F (29°C) in the tropics. Seventy-five percent of the water in the ocean falls within the temperature range of 30 to 43°F (−1 to +6°C) and the salinity range of 34 to 35.

The average sea surface temperature for The Bahamas is 79°F (30°C) with the highest monthly average occurring in July to August at 84°F (28.8°C). The average minimum sea surface temperature occurs during January to March at 75°F (23 °C). Figure 4-14 provides a map of the average sea surface temperatures within the project area of influence. The range of sea surface temperature depicted in Figure 4-16 is 84.2 to 86^{0}F (29 to 30^{0}C) for the project area and the data collected by Furgo indicated a surface of 81^{0}F during the summer when the surface data point was collected.

The June data collection exercise by Fugro for Bahamas Petroleum Company generated temperature ranges of 80.87°F (27.15°C) at 12 feet (4 meters) to 56.84°F (13.80°C) at 1,591.21 feet (485 meters). Table 4-6 shows the temperature and depth comparison at the project site. There is a decline in temperature with depth, due to the heat energy of the sun being absorbed in the first few centimeters at the ocean’s surface. At depth, most of the ocean is very cold.

[34] Fugro, 2011

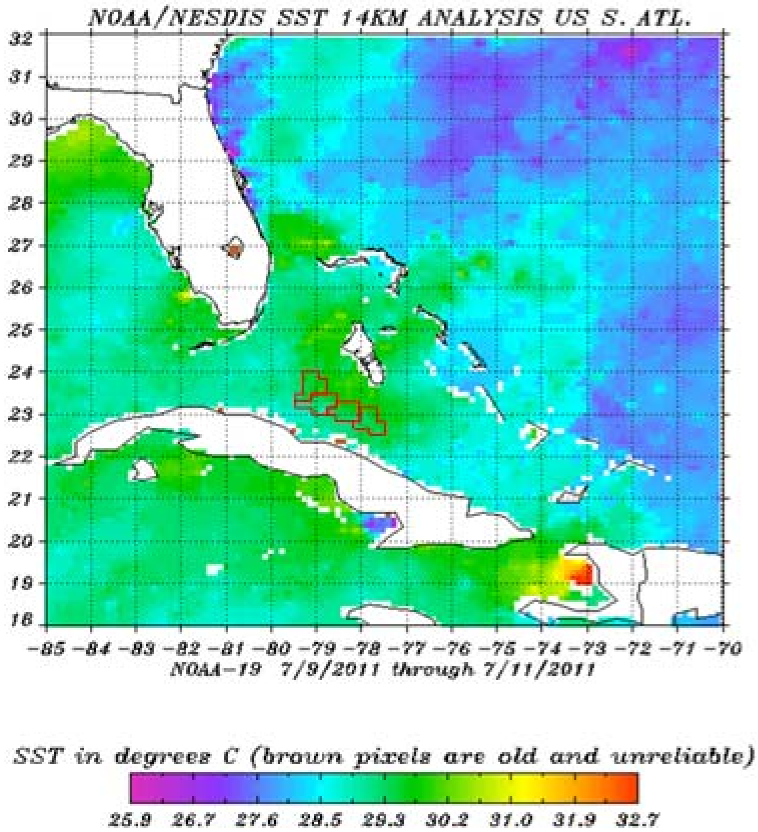

Figure 4-16: Sea Surface Temperatures in the Atlantic Ocean[35]
Note: Approximate block boundaries shown in red
Source: NESDIS, 2011

4.2 Biological Environment

Drilling will only occur in deepwater (depths greater than 300 m) away from beaches, mangrove, sea grass beds and coral reefs (these are predominantly shallow water habitats). However, due to their high intrinsic value (locally and regionally), importance to the marine fauna and local communities and due to their proximity to the drilling area these areas are described below. All information included in Sections 4.2 and 4.3 applies to The Bahamas generally as there is limited information available specific to the project area.

Andros Island is the closest inhabited Bahamian island and is approximately 80 miles (~130 km) from the first proposed well site. Information is provided on the Great Bahama Bank, and Cay Sal Bank and its associated small cays which are approximately 15 miles (25 km) from the blocks. The coastal and marine environment of Bimini is also discussed as it is within the project area of influence.

Information about the northern coast of Cuba and the south-eastern coast of Florida is referenced in Section 4.4.6 as these locations are within the project area of influence.

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[35] National Environmental Satellite Data and Information Service (NESDIS). Sea Surface Temperature Contour Maps. Accessed from the NESDIS website: www.osdpd.noaa.gov/data/sst/sst_anal_fields.html. 2011.

4.2.1 Coastal and Marine Ecosystems

Andros is the largest island in The Bahamas at 100 miles long and 45 miles wide. The east side of Andros is bordered by the Tongue of the Ocean, a 6000-foot (1,800 m) deep abyss that separates Andros from New Providence. The third largest barrier reef in the world runs 140 miles (230 km) along the east coast of Andros (see Figure 4-17). Figure 4-18 shows a map of Andros Island with respect to the entire Bahamas and also its many settlements and creeks. The west side of Andros is surrounded by the shallow waters of the Great Bahama Bank.

Figure 4-17: Photo of Andros Barrier Reef[36]
Source: The Nature Conservancy, 2003

Many of the marine and terrestrial habitats on Andros are intimately linked not only above ground through flowing tidal waters, but also underground because of groundwater filtration through porous limestone rock and the extensive system of interconnected inland and marine limestone caves and cavities, known as blue holes. Andros has the highest concentration of blue holes in the Western Hemisphere, and the largest reservoir of freshwater in The Bahamas.

[36] The Nature Conservancy. 2003. Ecoregional Conservation Plan of the Bahama Archipelago.

Figure 4-18: Map of Andros Island, The Bahamas
Source: Coldwell Banker Website[37]

[37] Coldwell Banker. 2011. Maps of the Islands of The Bahamas. Accessed from the Coldwell Banker website: www.coldwellbankerbahamas.com; and, Andros Island, The Bahamas. Accessed from www.expatsinthebahamas.com. 2010.

The largest freshwater estuary system in The Bahamas occurs on the west side of Andros Island in the Lake Forsyth/Turner Sound/Wide Opening area. Freshwater inputs support several unique breeding grounds in the area and are essential for ensuring that the west side of Andros will continue to function as one of the most important nursery systems in The Bahamas for several organisms including the Queen conch (*Strombus gigas*) and Nassau grouper (*Epinephelus striatus*). The habitats on the west side of Andros include seagrass beds, creeks and mangroves. See Appendix C for locations.

The bight areas of Andros help to transport larvae and fish to major spawning areas on the east side of the island.

The western Great Bahama Bank is characterized as a sheltered bank with continuous cays. Acroporid corals such as elkhorn and staghorn corals are found in this area of the bank and in 2003[38] were assessed to be in fair condition. This area is also important for:

- Atlantic spotted dolphin
- Queen conch,
- Spiny lobster,
- Nassau grouper,
- Rock iguanas; and
- West Indian flamingos.

The western Great Bahama Bank is classified by The Nature Conservancy as a high priority bank system for protection of biological diversity.

The Cay Sal Bank is the third largest and westernmost of the Bahama Banks. It is approximately 30 miles (~50 km) from Cuba, separated by the Nicholas Channel. Cay Sal Bank is an isolated, submerged platform, roughly triangular in shape, with a base along the south rim of 65 miles (~105 km), and a width of 41 miles (66 km) north-south, with islets along its rim, except along the south side facing Nicholas Channel where it has only numerous rocky coral heads. As such, it is one of the largest atolls in the world. Depths on this bank range from 30-50 ft. (~9–16 m). Figure 4-19 shows a map of Cay Sal Bank with those cays which are above mean sea level, including Anguilla Cays.

Anguilla Cays, near the southeast extremity of Cal Say Bank, consist of several elongated, scrub-covered, sandy islands which are swampy near their southern end, and are demarcated by stunted palm trees. The northern end of Anguilla Cays is marked by a beacon, 5 m high. Anguilla Cay is the name of the northern and second largest of the Anguilla Cays. Cotton Cay, the southern Anguilla Cay, is the largest and southernmost of the Anguilla Cays. Between the two is the much smaller Middle Cay. There are also a number of smaller, unnamed cays or rocks[39].

[38] The Nature Conservancy. 2003.
[39] Bruckner, A. 2011. Quick-Look Field Report. Living Oceans Foundation. May 2011. Accessed from the following website: www.sciencewithoutborders.org

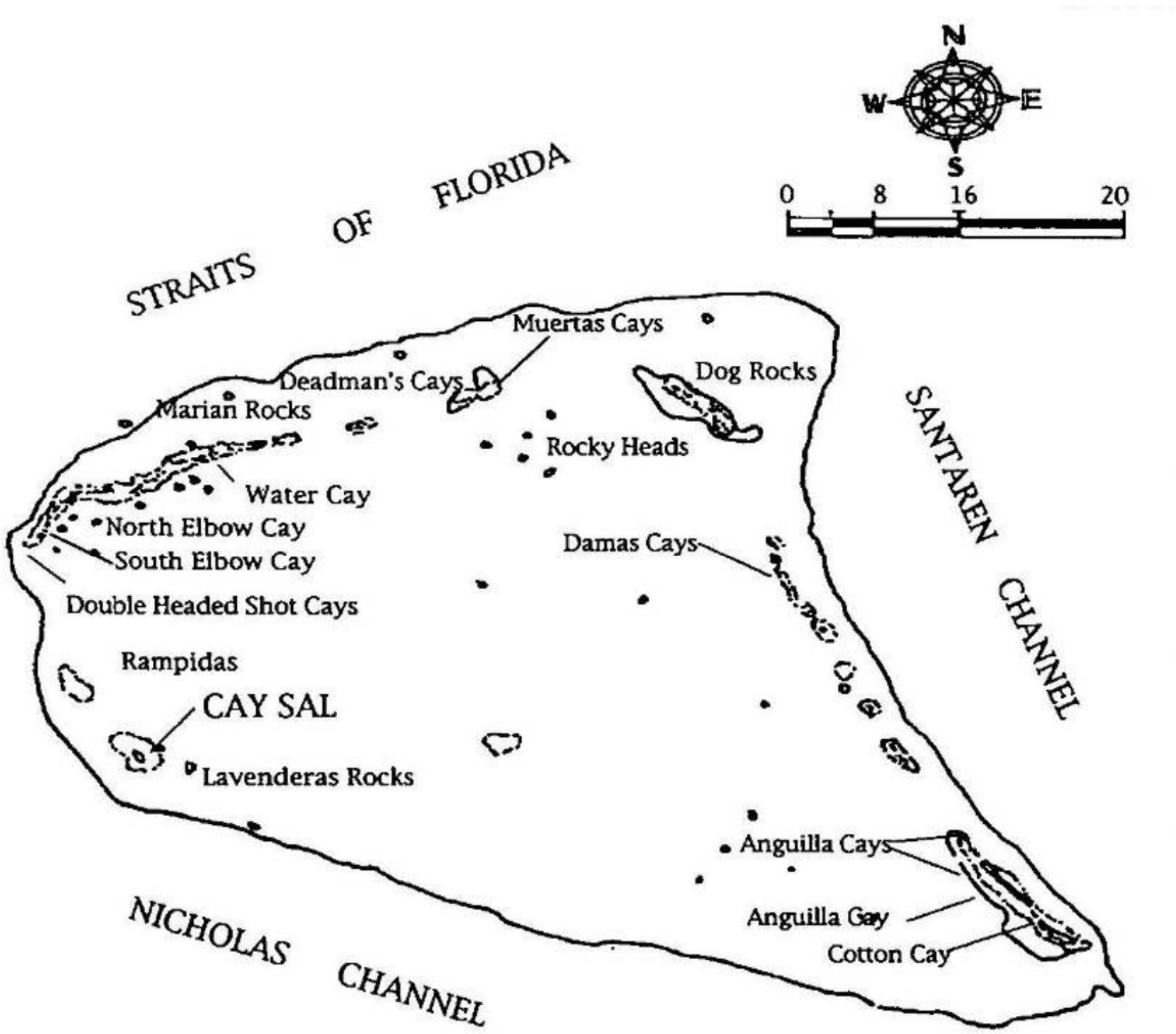

Figure 4-19: Map of Cay Sal Bank
Source: Bradley and Norton, 2011[40]

[40] Bradley, Patricia and Robert Norton. 2011. Maps for an Inventory of Breeding Seabirds of the Caribbean. Accessed from the following website: www.wicbirds.net.

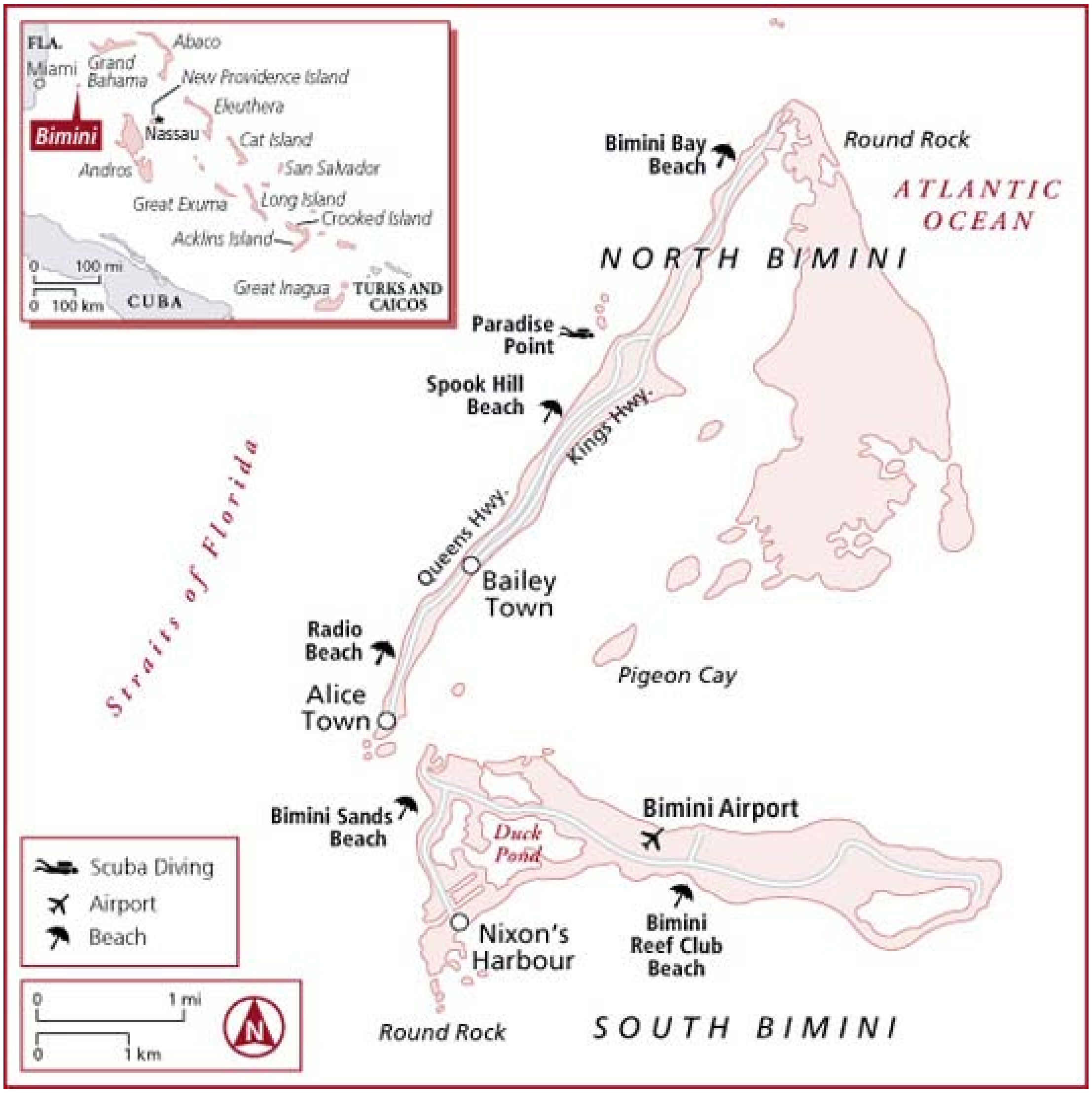

Figure 4-20: Map of Bimini
Source: Bahamas4U.com[41]

Located 50 miles from southern Florida (over 175 miles from the blocks), Bimini actually consists of two small islands – North Bimini and South Bimini as shown in Figure 4-20. Bimini's shoreline is dominated by mangroves and shallow seagrass beds[42]. The warm, clear waters of Bimini flow from the Gulf Stream up onto the Great Bahama Bank.

4.2.1.1 Beaches

No beaches are within Bahamas Petroleum Company's southern license areas, but there are beaches located on Andros Island, within the Cay Sal Bank area and on Bimini. Beaches are found primarily along the east coast of Andros. Beach vegetation includes salt grass (*Distich is spicata*) and inkberry (*Scaevola plumeri*). Beaches provide important habitat for migrating seabirds and nesting habitat for marine turtles.

[41] Bimini Maps. www.bahamas4u.com/biminimaps.html. 2008.

Beaches are found on several of the cays on the Cay Sal bank including the Anguilla Cays, but information is limited on beach type, state and specific locations.

Most beaches in Bimini are found on the west side of North Bimini, stretching from Alice Town to Bailey Town. Bimini's beaches provide nesting sites for loggerhead and hawksbill turtles.

4.2.1.2 Mangroves

Mangrove communities in The Bahamas typically consist of red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*) and buttonwood (*Conocarpus erectus*). These species will occur in zones moving from the sea to land as follows:

- Red mangrove – closest to the sea as the most salt tolerant of the four species;
- Black mangrove – found in areas which are periodically flooded by the tides
- White mangrove – follow black mangrove
- Buttonwood – found in the terrestrial zone of the mangrove.

Mangroves provide habitat for numerous species of birds, fish, mollusks, crustaceans and other invertebrates.

On the west side of Andros, tall, thick mangrove areas are found primarily at the mouths of creeks, especially ones with well-defined channels and at various island sites in creek interior areas. See Appendix C for locations.

Mangroves do not occur on Cay Sal Bank, except for a few areas on Cay Sal Island that are not located near the water.

Found within the salt water mangrove swamp which covers 4 miles of North Bimini is the Healing Hole, a natural spring. It is a pool that lies at the end of a network of winding underground tunnels. During outgoing tides, these tunnels pump cool, fresh water laden with minerals into the pool. Lithium and sulfur are two of the minerals found in the pool[43]. The Healing Hole is purported to have healing powers by those who have swam in it. It is a favorite site to visit for tourists.

Mangroves will not be found in the project area since this area is located in water depths greater than 300 m. However, they are included in this report as they are an important habitat type that is in the area of potential impact.

4.2.1.3 Seagrass Beds

This important benthic habitat is found all along the west side of Andros on the northwest and southwest Great Bahama Bank, Cay Sal Bank, Conch Sound, North Bight, and South Bight (see Figure 4-21). Seagrass beds and macroalgae assemblages play a valuable role by providing food, shelter and serving as nursery grounds for a diversity of commercially exploited species such as:

- fish,
- crabs,
- sea turtles,
- Queen conch;

[43] The Islands of The Bahamas. 2011. About Bimini Island. Accessed from the following website: www.bahamas.com/out-islands/bimini-island. 2008-2011.

- Spiny lobsters, and
- other marine life.

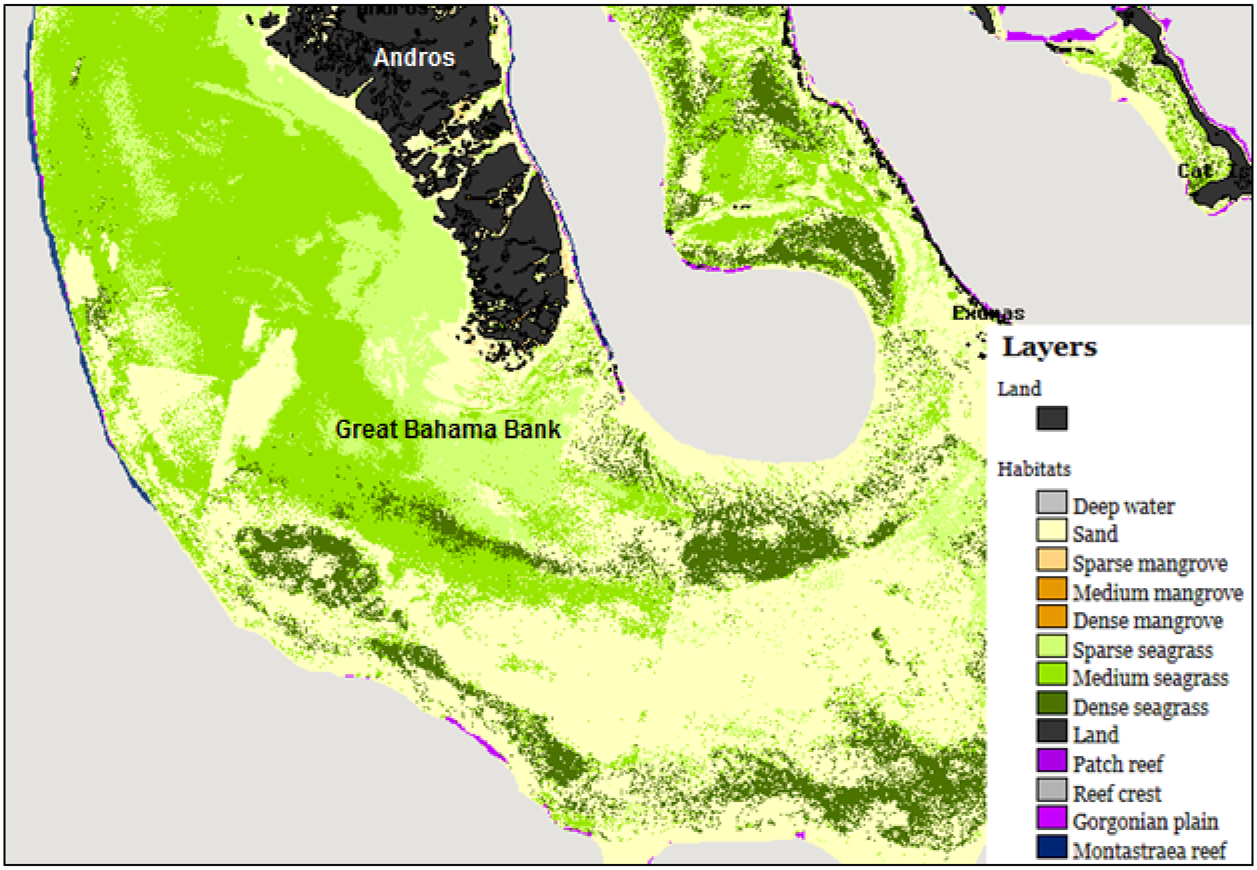

Figure 4-21: Map of Seagrass Distribution on Great Bahama Bank

Source: Adapted from Living Oceans Foundation, 2011[44] [45]

Spiny lobsters also feed on smaller organisms that live in seagrass beds. Seagrasses also stabilize sediments and trap small particles, helping to maintain the clarity of Bahamian waters. When these beds are destroyed, the ocean can become more turbid and less suitable as habitat for some marine organisms.

Goldberg[46] (1983) identified seagrass and algae beds in the Cay Sal Bank. Including shoalweed (*Halodule wrightii*), *Caulerpa* spp., manatee grass (*Syringodium filiforme*), and various species of calcareous chlorophytes. Seagrass found in the north-eastern sector include *Sargassum* spp. Across the bank from Cay Sal to the Damas Cays is an area characterized by turtle grass (*Thalassia testudinum*) which becomes more extensive toward the south-western side. Turtle grass becomes well developed in the lee of larger islands on the bank, particularly Double

[44] Living Oceans Foundation. 2011. GIS Data Viewer. Accessed from the Living Oceans Foundation Website: http://www.livingoceansfoundation.org/

[45] Appendix C includes distribution of seagrass beds from data obtained from the United Nations Environment Program and The Nature Conservancy. Data layers contained in this figure could not be obtained for inclusion in the Appendix.

[46] Goldberg, W. M. 1983. Cay Sal Bank, Bahamas: A Biologically Impoverished, Physically Controlled Environment. Atoll Research Bulletin, No. 271. The Smithsonian Institution. Washington, D.C. USA.

Headed Shot Cays and the Anguilla Cays. Behind the Anguilla Cays, turtle grass grades into a *Halodule* – calcareous green algae zone.

The 2011 Living Oceans Foundation surveys revealed that many of the shallow coral habitats appeared to be biologically impoverished, with little living coral and expansive growth of fleshy seaweeds, also known as macroalgae. Much of the bank benthic area was covered by:

- green, lettuce-like fleshy *Microdictyon* algae,
- brown ruffled *Lobophora* algae, and
- *Sargassum*.

These macroalgae often formed accumulations 10-30cm thick in sandy areas between the reef structures[47].

<u>4.2.1.4 Corals</u>

Corals are ecosystems typically located along coastlines and adjacent to islands, in waters less than fifty meters deep. A multibeam survey completed indicates that there are no deep sea corals in the project area.

The Andros Barrier Reef is the second largest such barrier reef type in the Western Atlantic. It stretches 140 miles along the east coast of Andros Island (see Figure 4-22) with Andros Island acting as a barrier between the reef and the Bahamas Petroleum Company southern license areas. The minimum distance between the proposed drilling location and the Andros Barrier reef is approximately 90 miles (145 km). Coral reefs represent one of the main attractions for the tourism industry in The Bahamas.

Behind the reef crest in the protected waters of the lagoon are found numerous habitats including patch reefs, sand flats, seagrass beds and mangroves. Important commercial species supported by this lagoon area include:

- Spiny lobster (Panulirus),
- Queen conch (*Strombus gigas*),
- Snapper (Lutjanidae), and
- Grunts (Haemulidae).

On the reef structure itself, can be found numerous soft corals or gorgonians including sea fans and sea whips. Hard coral species include:

- Elkhorn (*Acropora palmata*),
- Staghorn (*Acropora cervicornis*), and
- Mountainous star (*Montastrea annularis*).

Classic western Atlantic spur-and-groove reef systems have developed around the outer portions of the Cay Sal Bank. The Living Oceans research team also observed unusual coral and sponge patches within the bank, each differing in structure and species assemblages. One area, at depths of 23-30 ft. (~7-8 m), consisted of small coral bommies with many species of reef building corals and dense, colorful sponge assemblages[48].

[47] Bruckner, 2011.
[48] Bruckner, 2011.

These coral reefs are important to the fishing communities and are a major contributor to the livelihood of persons in The Bahamas.

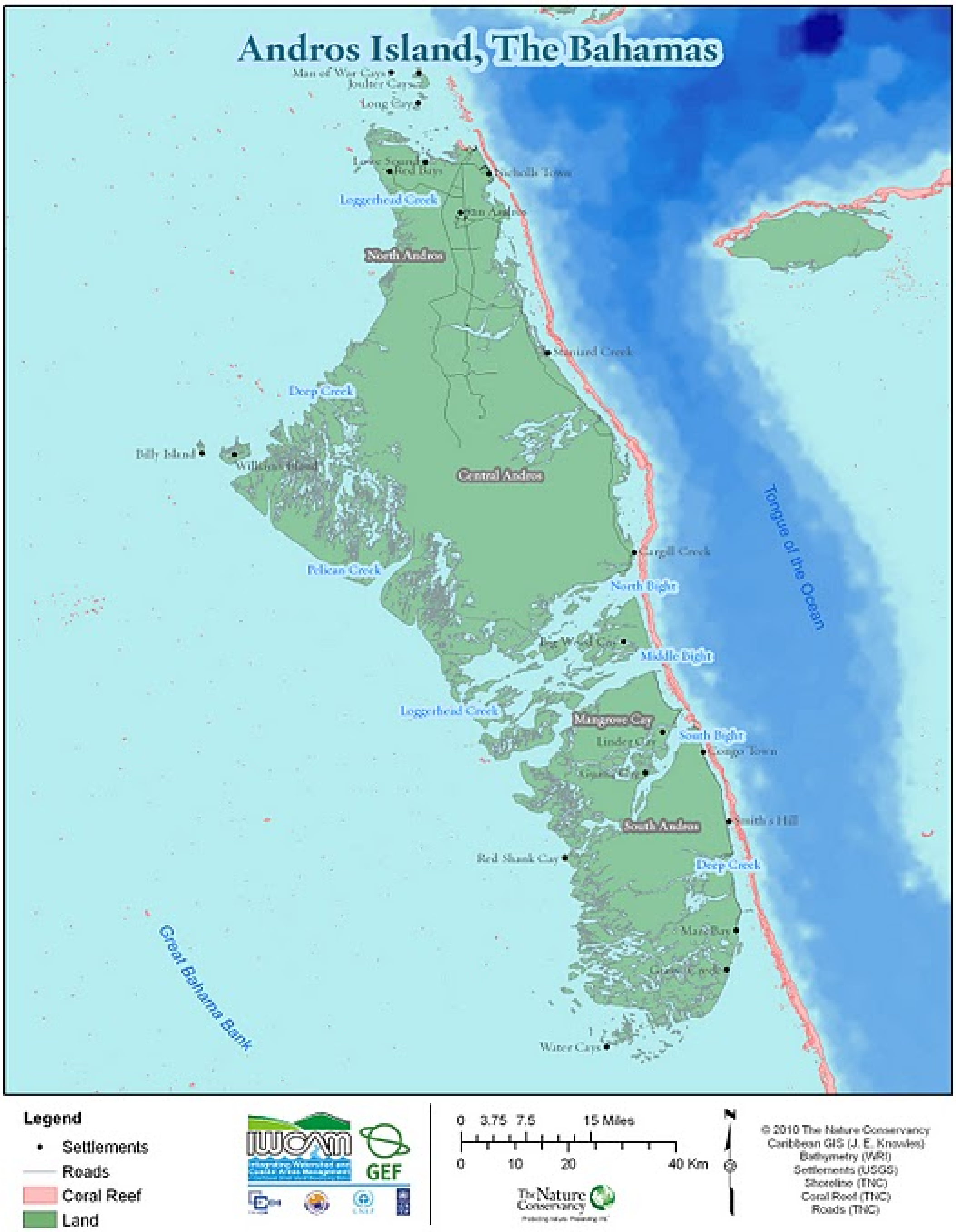

Figure 4-22: Andros Barrier Reef
Source: The Nature Conservancy, 2010[49]

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[49] Knowles, J.E. 2010. The Nature Conservancy, Northern Caribbean Program. Andros Map, Integrated Watershed and Coastal Area Management Project. Nassau, The Bahamas.

4.2.1.5 Blue Holes

Blue holes can be found both inland and in shallow waters on the banks of Andros (Figure 4-23). These holes are the result of carbonate deposition and dissolution cycles, which occurred due to the repeated changes in sea level during the glacial and interglacial periods. There is a clear stratification of distinct biogeochemical layers, which includes the freshwater lens above and the salt water below. The greatest density of blue holes in the world is found in South Bight, Andros. Rare and highly specialized species are found in these blue holes including cave fish and species of shrimp.

There are numerous blue holes on the Cay Sal Bank. Those that have been explored and documented include Big Hole[50], Sistine Chapel and Silversides. Big Hole is 1,600 ft. (0.5 km) in diameter and of unknown depth. Sharks have been seen in this blue hole as well as reef fish and spiny lobsters.

Figure 4-23a: Blue Hole in Andros
Source: Baggett, 2008[51]

[50] Brinkerhoff, B. 2010. The Blue Holes of Cay Sal Bank, Advanced Diver Magazine. Accessed at the following website: http://www.advanceddivermagazine.com/articles/caysal/blueholes.html

[51] Baggett, J. 2008. Journey into the Great Blue Hole. Accessed at the following website: www.jaunted.com.

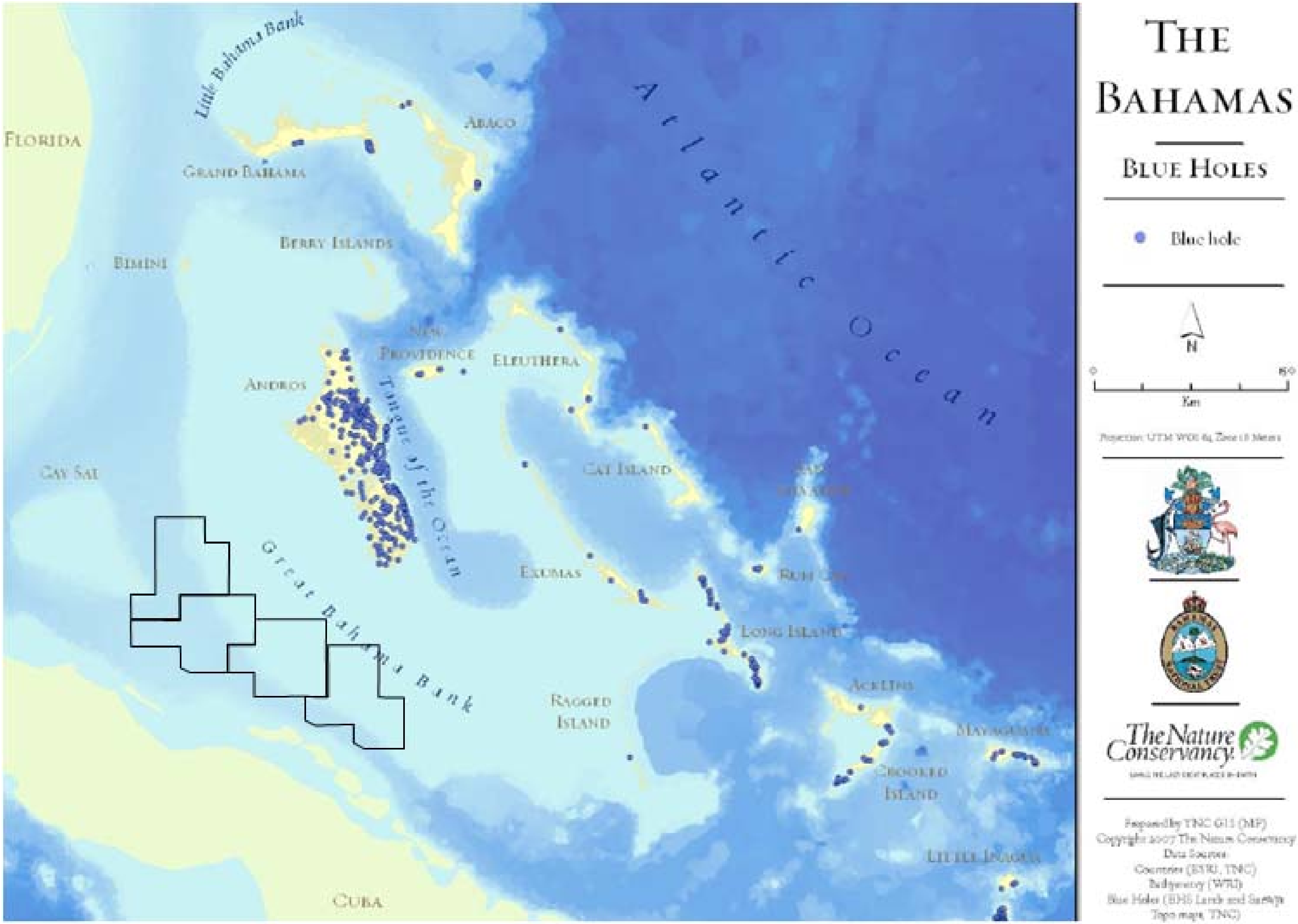

Figure 23b: Map of Blue Holes in The Bahamas[52]

[52] The Nature Conservancy. 2007. Ecological Gap Assessment.

4.2.2 Marine Life

4.2.2.1 Plankton

Many reef organisms have a planktonic phase as a part of their life cycle. Spiny lobster larvae can spend up to nine months drifting in the pelagic zone while Queen conch larvae can exist as plankton for three to four weeks. Plankton form the base of the food chain in the marine environment with phytoplankton (microscopic marine plants) being eaten by zooplankton (microscopic marine animals) and small fish, and these in turn are eaten by larger fish and organisms.

4.2.2.2 Crustaceans and Mollusks

Substantial conch grounds are found in the Conch Sound area of Andros as well as the North Bight and South Bight areas. Queen conch has a significant impact on the marine benthic composition through their feeding and movement activities. Maintaining natural densities of adult conch (Figure 4-24) may be critical to the continued health of eelgrass habitats in general, as well as an important component of the habitat quality of juvenile conchs.

Figure 4-24: Photo of Queen Conch
Source: BEST Commission, 2001[53]

South Andros is important habitat for spiny lobster (*Panulirus argus*) (Figure 4-25).

[53] BEST Commission. 2001. Bahamas Environmental Handbook.

Figure 4-25: Photo of Spiny Lobster
Source: Les Fruits de Mer, 2009[54]

White land crabs (*Cardisoma guanahumi*) (Figure 4-26) are found on the island of Andros feeding in burrows among the mangroves and in low-lying broadleaf coppice. Black land crabs (*Gecarcinus ruricola)* are also found in Andros.

Figure 4-26: Photo of White Land Crab[55]

4.2.2.3 Other Invertebrates
Other invertebrates found around Andros include sea urchins and sponges.

[54] Les Fruits de Mer. 2010. Accessed from the following website: www.lesfruitsdemer.org.
[55] SEV Consulting Group Limited. 2011.

4.2.2.4 Fish

The west side of Andros support highly productive mangrove fish assemblages and important areas for several species including bonefish and tarpon as well the endangered sawfish. The Rapid Ecological Assessment (REA) of the west side of Andros completed in 2006[56] characterized bonefish populations in the area to be in good condition. Other fish species found in Andros include grouper, snapper, grunts, triggerfish, squirrelfish, jacks and numerous species of sharks. There are a number of grouper spawning aggregations near the Andros barrier reef.

4.2.2.5 Turtles

Four species of sea turtles inhabit The Bahamas' coastal waters, namely the green turtle (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*) and the leatherback turtle (*Dermochelys coriacea*). All of these species are listed as endangered or critically endangered in the 2007 International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species, with the leatherback turtle and the hawksbill turtle considered critically threatened[57].

The west side of Andros is important habitat for 3 sea turtles – green turtles, loggerheads and hawksbills. Sea turtle populations observed in The Bahamas are significant. Given their migratory nature, these turtles are of regional significance to the wider Caribbean[58].

Green turtles (Figure 4-27) primarily reside in Bahamian waters and there are beaches throughout the country where they nest. Important habitats for these turtles include coral reefs, seagrass beds and floating seaweed. Green turtles establish grazing plots in seagrass beds of turtle grass (*Thalassia testudinum*). Turtles may hide in floating seaweed and feed there for long periods of time. They also feed on algae found on coral reefs. Green turtles are reported to nest in Abaco and Inagua. Principal threats to these turtles in The Bahamas are harvesting for their meat and shells, ingestion of marine debris and degradation of their habitat. Hawksbill and loggerhead turtles are similarly threatened.

Figure 4-27: Photograph of a Green Turtle
Source: Arauz, 2010[59]

[56] The Nature Conservancy. 2006. Rapid Ecological Assessment, The West Side of Andros, The Bahamas: Report of Scientific Findings.
[57] www.iucnredlist.org
[58] The Nature Conservancy. 2003.

Important habitat for the hawksbill turtle includes shallow coral reefs and mangrove estuaries for juveniles. Adults nest on tropical beaches and also forage in shallow reefs and floating seagrass, particularly sargassum. They also feed on seagrass, *Syringodium filiforme*. It is in marine estuaries and on coral reefs that the hawksbill finds its principal food source: sponges. Documented hawksbill nesting sites are found in the southern Bahamas on the island of Inagua, which is outside of the project area. Figure 4-28 is a photo of a hawksbill turtle.

Figure 4-28: Photograph of a Hawksbill Turtle
Source: Caloyianis, 2011 [60]

The juvenile loggerhead population observed in the waters around the west side of Andros is the only known aggregation of juvenile loggerheads in The Bahamas. Loggerheads (Figure 4-29) are also known to nest on sandy beaches on the Cay Sal Bank.

[59] Arauz, P. 2010. The Green Turtle. Accessed from the following website: challengeblog2.blogspot.com. 2010.
[60] Caloyianis, N. 2011. Hawksbill Sea Turtle, National Geographic. Accessed from the following website animals.nationalgeographic.com. 1996-2011.

Figure 4-29: Photograph of a Loggerhead Turtle
Source: Skerry, 2011[61]

Leatherback turtles (*Dermochelys coriacea*) are thought to migrate through Bahamian waters as this is a truly pelagic turtle species and there have also been reports of nesting on Abaco[62]. Data on leatherbacks in The Bahamas is limited[63]. Figure 4-30 is a photo of a leatherback turtle.

Figure 4-30: Photograph of a Leatherback Turtle
Source: Theleatherbackseaturtle.com, 2011[64]

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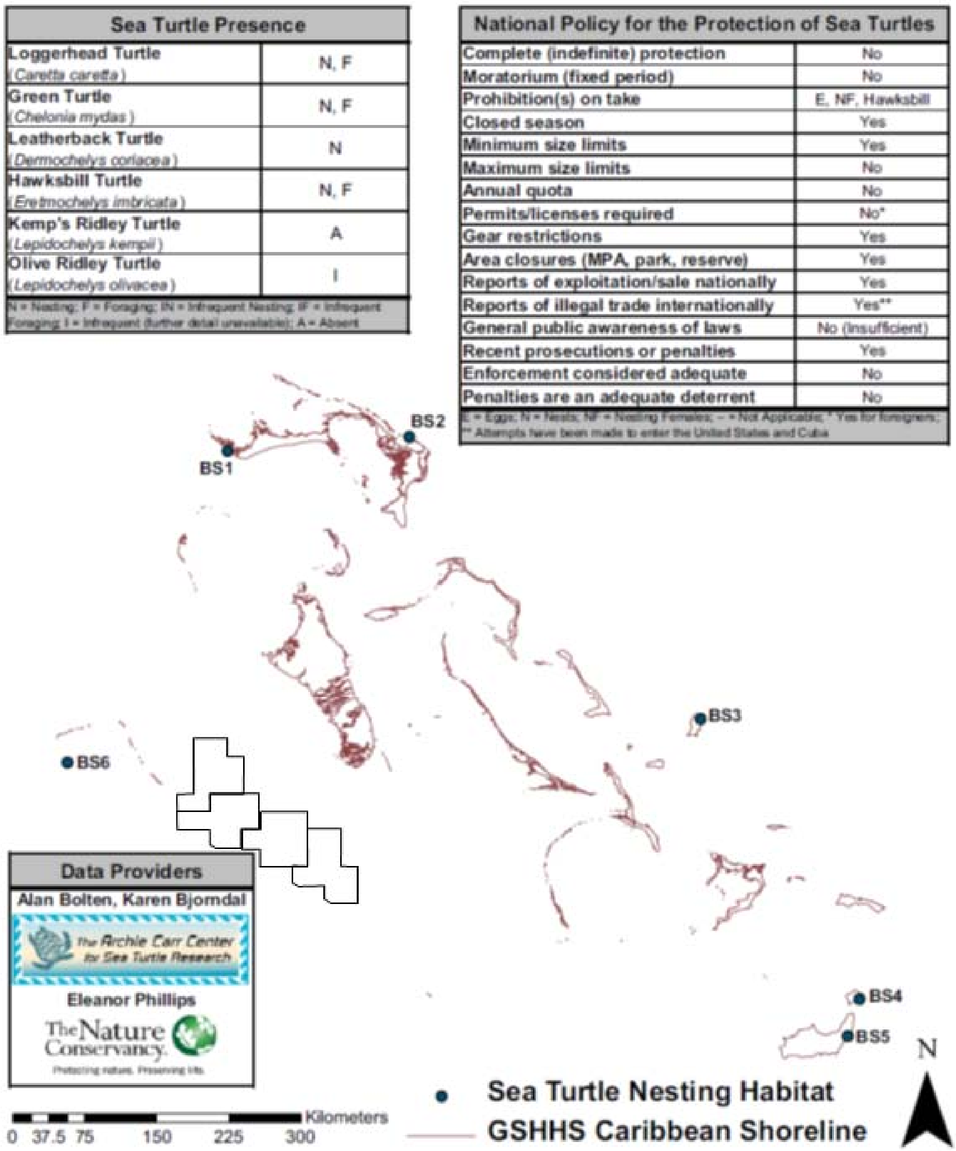
[61] Skerry, B. J. 2011. Loggerhead Sea Turtle, National Geographic. Accessed from the following website animals.nationalgeographic.com. 1996-2011.

[62] Dow, W., Eckert, K., Palmer, M. and P. Kramer. 2007. An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region: WIDECAST Technical Report No. 6, 2007. Accessed from the OBIS-SEAMAP website: http://seamap.env.duke.edu/seamap2.5/widecast/references/Dow_et_al_2007.pdf.

[63] UNEP/WCMC. October 2003. Report on the Status and Conservation of the Leatherback Turtle.

Figures 4-31 and 4-32 show nesting habitat for marine turtles in The Bahamas.



Sea Turtle Presence	
Loggerhead Turtle (*Caretta caretta*)	N, F
Green Turtle (*Chelonia mydas*)	N, F
Leatherback Turtle (*Dermochelys coriacea*)	N
Hawksbill Turtle (*Eretmochelys imbricata*)	N, F
Kemp's Ridley Turtle (*Lepidochelys kempii*)	A
Olive Ridley Turtle (*Lepidochelys olivacea*)	I
N = Nesting; F = Foraging; IN = Infrequent Nesting; IF = Infrequent Foraging; I = Infrequent (further detail unavailable); A = Absent	

National Policy for the Protection of Sea Turtles	
Complete (indefinite) protection	No
Moratorium (fixed period)	No
Prohibition(s) on take	E, NF, Hawksbill
Closed season	Yes
Minimum size limits	Yes
Maximum size limits	No
Annual quota	No
Permits/licenses required	No*
Gear restrictions	Yes
Area closures (MPA, park, reserve)	Yes
Reports of exploitation/sale nationally	Yes
Reports of illegal trade internationally	Yes**
General public awareness of laws	No (Insufficient)
Recent prosecutions or penalties	Yes
Enforcement considered adequate	No
Penalties are an adequate deterrent	No
E = Eggs; N = Nests; NF = Nesting Females; – = Not Applicable; * Yes for foreigners; ** Attempts have been made to enter the United States and Cuba	

Figure 4-31: Sea Turtle Nesting Habitat in The Bahamas
Note: Approximate block boundaries shown in black
Source: Dow, et al., 2007[65]

[64] The Leatherback Sea Turtle. 2011. Accessed from the following website www.theleatherbackturtle.com.
[65] Dow, et al., 2007

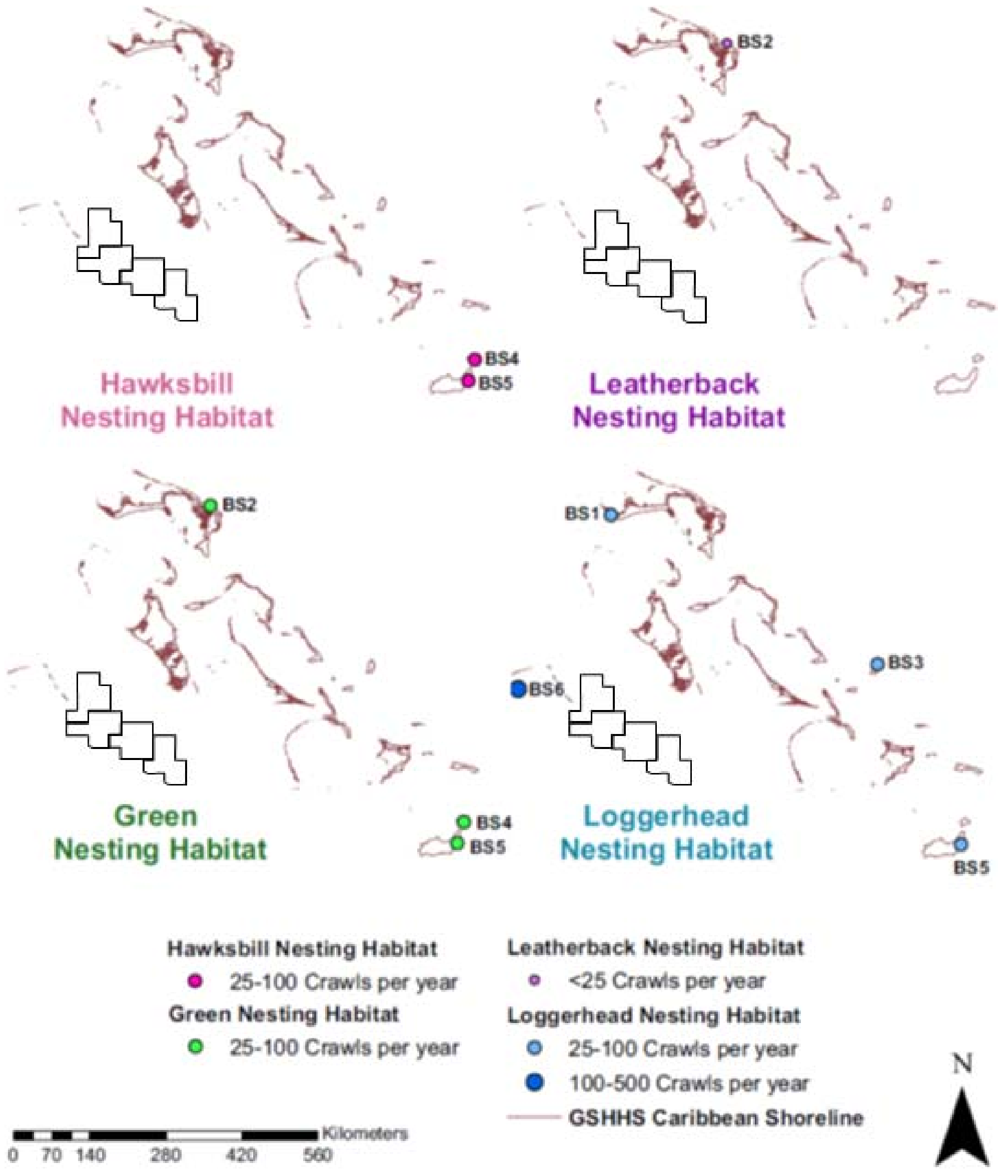


Figure 4-32: Nesting Habitat for Four Species of Sea Turtles in The Bahamas

Note: Approximate block boundaries shown in black

Source: Dow, et al., 2007

4.2.2.6 Marine Mammals

According to the IUCN (2011) the Bahama Islands are home to at least 27 marine mammals with the most commonly encountered species being the sperm whales, the short-finned pilot whales, the dense-beaked whale, the Risso's Dolphin and the Atlantic spotted dolphin.

The Tongue of the Ocean provides important deep water habitat for marine mammals. Species traversing this area include Cuvier's beaked whale, Blainville's beaked whale, minke whales, manatees, and spotted dolphins[66].

Marine mammals sited off Bimini include Atlantic bottlenose dolphins and Atlantic spotted dolphins.

In the 2010 field season, the Bahamas Marine Mammal Research Organization (BMMRO) reported seeing 15 species of marine mammals in The Bahamas. Results of these sightings are shown in Table 4-7. No information of calving areas or migration routes was identified for The Bahamas. BMMRO scientists collected the majority of these sightings data during surveys conducted off Andros and Abaco Islands, but some of the sightings data were gathered from reports from the public from throughout The Bahamas. The nearest locations were on the opposite side of Andros Island from the project area, approximately 100 miles (160 km) northeast.

[66] Andros Island Conservation Assessment. The Nature Conservancy. 2006.

Table 4-7: Marine Mammal Sightings in The Bahamas, 2010

Common name	Scientific name	No. sightings	No. of animals seen
Blainville's beaked whale	*Mesoplodon densirostris*	25 (3)	84 (6)
Gervais' beaked whale	*Mesoplodon europaeus*	6	18
Unknown Mesoplodon species	*Mesoplodon sp.*	1	2
Cuvier's beaked whale	*Ziphius cavirostris*	15	39
Unknown Ziphiid		1	2
Sperm whale	*Physeter macrocephalus*	14 (1)	69 (1)
Dwarf sperm whale	*Kogia sima*	21	78
Pygmy sperm whale	*Kogia breviceps*	4	4
Unknown Kogia species	*Kogia sp.*	2	3
Killer whale	*Orcinus orca*	1 (1)	4 (2)
Short-finned pilot whale	*Globicephala macrorhynchus*	1 (1)	25 (12)
Melon-headed whale	*Peponocephala electra*	8	1160
Atlantic bottlenose dolphin – coastal ecotype	*Tursiops truncatus*	97 (14)	523 (36)
Atlantic spotted dolphin	*Stenella frontalis*	5 (1)	202 (26)
Pan-tropical spotted dolphin	*Stenella attenuata*	1	1
Fraser's dolphin	*Lagenodelphis hosei*	1	50
Humpback whale	*Megaptera novaeangliae*	(1)	(2)
Unknown cetacean		9	52
West Indian manatee – Florida subspecies	*Trichechus manatus latirostrus*	2	3
Total	15 Species	214 (22)	2319 (85)

Note: Numbers in parentheses are data provided by the general public. Numbers not in parentheses are those collected by the scientists working as a part of the BMMRO team.
Source: Bahamas Marine Mammal Research Organization, 2011[67]

4.2.2.7 Birds

The diversity and number of seabirds in The Bahamas exceed that of any other country in the Wider Caribbean.

North Andros has a resident non-breeding flock of West Indian flamingos (*Phoenicopterus ruber ruber*) that varies in size from approximately 100 to over 1,000 individuals from year to year. The flamingo is the national bird of The Bahamas. The lake system north of Wide Opening that is more saline than other lake systems on the west side of North Andros appears to be an important resting area for flamingos.

Andros also provides important seabird habitat for:

- White Tailed Tropicbird (*Phaethon lepturus*),
- Audubon Shearwater (*Puffinus lherminieri*),
- Bridled Tern (*Sterna anaethetus*)
- Sooty Tern (*Onychoprion fuscata*), and

[67] Bahamas Marine Mammal Research Organisation. 2010 Preliminary Field Report to Bahamas Department of Fisheries.

- Brown Noddy (*Anous stolidus*)[68].

All the birds listed above are considered resident species of The Bahamas.

There are 31 Important Bird Areas (IBAs) in The Bahamas (Figure 3-33). The North Atlantic Abaco Cays IBA (BS005) and Cay Sal IBA (BS025) stand out as supporting the largest numbers of seabirds, while Great Inagua IBA (BS039) is home to the largest congregation of waterbirds[69]. The Bahamian IBAs appear to provide habitat to neotropical migrants during spring and fall migration periods. Drilling rigs in the Gulf of Mexico have been found to provide habitat to migrating birds.[70] It is conceivable that this could also be the case for the proposed drilling program.

Figure 4-33: Location of Important Bird Areas in The Bahamas
Note: Approximate block boundaries shown in black
Source: Moore, et al., 2009

The closest IBA in The Bahamas to the BPC license blocks is Cay Lobos (BS033), located approximately 80 miles (~128 km) southeast of the first proposed drill site. Cay Lobos is on the southern edge of the Great Bahama bank, approximately 20 miles north of Cayo Romano, Cuba. A part of The Bahamas, Cay Lobos has IBA bird species including:

- Roseate Tern (*Sterna dougallii*),

[68] The Nature Conservancy. 2007. Andros Island Conservation Assessment.
[69] Moore, P. & Gape, L. 2009 Bahamas. Pp 71 – 78 in C. Devenish, D. F. Díaz Fernández, R. P. Clay, I. Davidson & I. Yépez Zabala Eds. Important Bird Areas Americas - Priority Sites for Biodiversity Conservation. Quito, Ecuador: Birdlife International (Birdlife Conservation Series No. 16).
[70] Russell, R.W. 2005. Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.

- Least Tern (*Sternula antillarum*), and
- Bridled Tern (*Onychoprion anaethetus*).

All three species are of least concern under the IUCN categorization. Most of the data for this site is historical, having been collected by a lighthouse keeper for the period of 1899 – 1901[71].

4.2.3 Protected and Sensitive Resources

4.2.3.1 Protected and Sensitive Areas

The closest Bahamian protected areas are located on Andros Island, which is northeast of the license areas. The Central Andros National Parks (Figure 4-34) comprise 286,080 acres and were established in 2002[72]. The Central Andros National Parks consist of five areas:

1. West Side National Park – Located approximately 100 miles (~160 km) north-northeast from the first proposed well site, is critical habitat for conch and bonefish as well as a feeding area for West Indian flamingos;
2. Northern Marine Park (Andros Barrier Reef National Park) – Located approximately 140 miles (~225 km) north-northeast from the first proposed well site, protects one area of the Andros Barrier reef;
3. Southern Marine Park (Andros Barrier Reef National Park) – Located approximately 130 miles (~210 km) north-northeast from the first proposed well site, protects another area of the Andros Barrier reef;
4. Blue Holes National Park – Located approximately 130 miles (~210 km) north-northeast from the first proposed well site, protects the highest concentration of blue holes in The Bahamas; some of these holes contain rare species of fish and shrimp as well as Lucayan artifacts and acres of pine and coppice forests;
5. Crab Replenishment National Park – Located approximately 130 miles (~210 km) north-northeast from the first proposed well site, protects habitat for sustaining land crab population.

The Central Andros National Parks are managed by the Bahamas National Trust (BNT) which was established by an Act of Parliament in 1959. It is a non-governmental, non-profit organization, mandated with the development and management of the National Parks System of The Bahamas.

[71] Birdlife International.2011. Important Bird Areas factsheet: Cay Lobos. Accessed from the following website: www.birdlife.org/datazone/sitefactsheet.
[72] Bahamas National Trust (BNT). 2009. Accessed from the BNT website: www.bnt.bs.

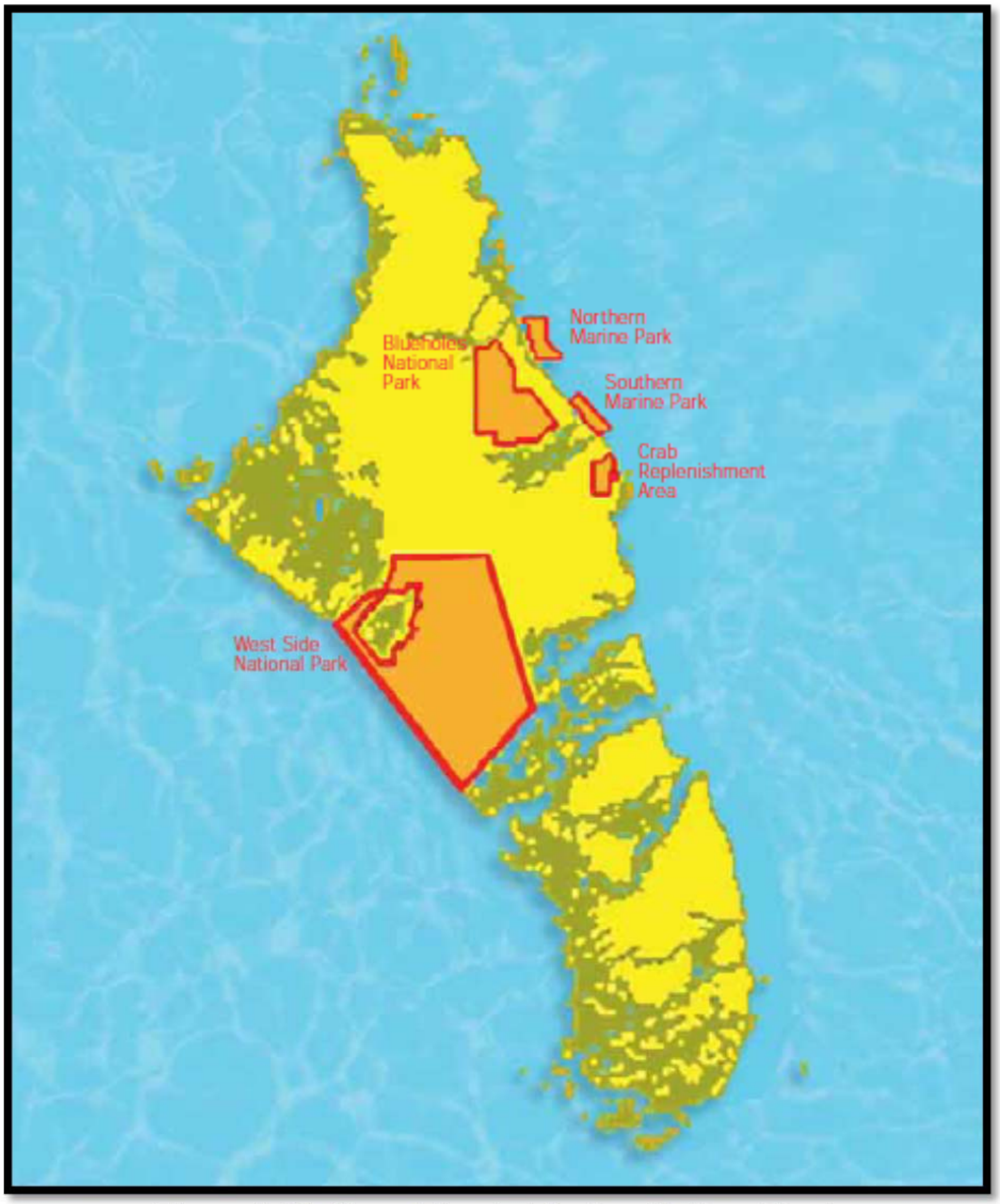


Figure 4-34: Map of Central Andros National Parks
Source: BNT, 2009

In addition to the protected areas on Andros, the following wild bird reserves are located off the southeast shore of Andros (Figure 4-35):

- Washerwomans Cut Cays Wild Bird Reserve (IUCN Category IV)
- Grassy Creek Cays and Rocks Wild Bird Reserve (IUCN Category IV)
- Big Green Cay Wild Bird Reserve (IUCN Category IV)

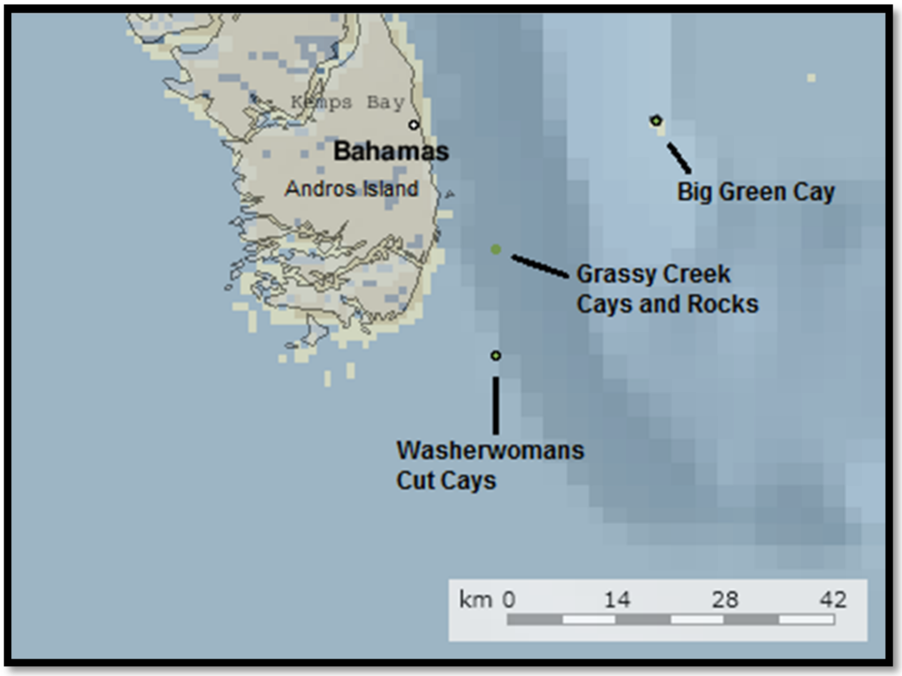


Figure 4-35: Protected Areas Offshore Southeast Andros Island
Source: Adapted from IUCN/Birdlife International/ Conservation International/UNEP/WCMC, 2011[73]

The North Bimini Marine Reserve was established as a no-take area in December 2008 (Figure 4-36). The reserve protects critical mangrove habitat as well as a lemon shark nursery. Species found in the reserve include the Nassau grouper and Bimini boa. Activities that are allowed in the reserve are crabbing and catch-and-release bonefishing.

[73] IUCN/Birdlife International/Conservation International/UNEP/WCMC. 2011. Integrated Biodiversity Assessment Tool. Accessed from the IBAT Website: https://www.ibatforbusiness.org/.

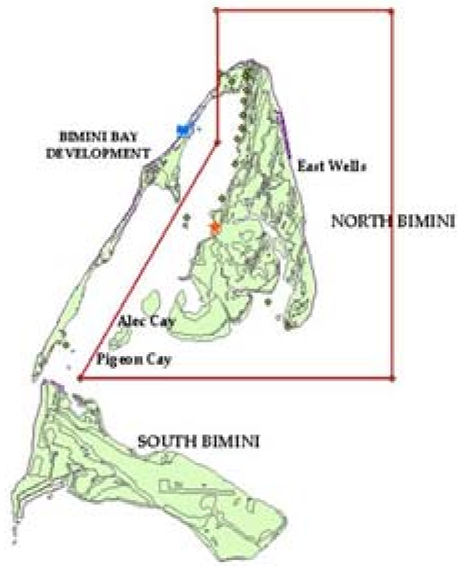


Figure 4-36: North Bimini Marine Reserve
Source: Bimini Biological Field Station, 2004[74]

4.2.3.2 Threatened and Endangered Species

Table 4-8 below outlines the endangered species found in The Bahamas.

Table 4-8: Endangered Species found in The Bahamas

Common Name	Scientific Name	IUCN Classification
Mammals		
Humpback whale	*Megaptera novangliae*	No information available
Northern Right whale	*Eubalaena glacialis*	Endangered
Ingraham's hutia	*Geocapromys ingrahami*	Vulnerable
West Indian Manatee	*Trichechus manatus*	Vulnerable
Birds		
West Indian Flamingo	*Phoenicopterus ruber ruber*	No information available
West Indian Tree Duck	*Dendrocygna arborea*	Vulnerable
Sharp-shinned Hawk	*Accipter striatus*	Least concern
Red-tailed Hawk	*Buteo jamaicensis*	Least concern
Marsh Hawk	*Cicrus cyaneus*	No information available
Osprey	*Pandion haliaetus*	Least concern
Peregrine Falcon	*Falco peregrinus*	Least concern
Merlin	*Falco columbarius*	Least concern
American Kestrel	*Falco sparverius*	Least concern
Bahama Parrot	*Amazona leucocephala bahamensis*	Near threatened
Barn Owl	*Tyto alba*	Least concern
Burrowing Owl	*Speotyto cunicularia*	Least concern
Cuban Emerald Hummingbird	*Chlorostilbon ricordii*	Least concern
Bahama Woodstar Hummingbird	*Calliphlox evelynae*	Least concern
Ruby-throated Hummingbird	*Archilochus colubris*	Least concern

[74] Bimini Biological Field Station. 2011. Bimini MPA. Accessed from the following website: www6.miami.edu/sharklab/aboutbimini_biminimpa.html. 2004

Common Name	Scientific Name	IUCN Classification
Rufous Hummingbird	*Selasphorus rufus*	Least concern
Reptiles		
Bahamian Boa Constrictor	*Epicrates spp.*	No information available
Pygmy Boa Constrictor	*Trophidophis canus*	No information available
Bahamian Rock Iguana	*Cyclura spp.*	Critically endangered
Cat Island & Eleuthera Island Terrapin	*Trachemys terrapen*	Vulnerable
Inagua Terrapin	*Trachemys stejnegeri malonei*	No information available
American Crocodile	*Crocodylas acutus*	Vulnerable
Marine Turtles		
Leatherback Turtle	*Dermochelys coriacea*	Critically endangered
Loggerhead Turtle	*Caretta caretta*	Endangered
Hawksbill Turtle	*Eretmochelys imbricata*	Critically endangered
Green Turtle	*Chelonia mydas*	Endangered
Molluscs		
Queen Conch	*Strombus gigas*	No information available
Corals		
Black Corals	*Anthipatharia spp.*	No information available
Stony Corals	*Scleractinia spp.*	No information available
Branch Corals	*Acropora spp.*	Critically endangered (Staghorn and Elkhorn)
Brain Coral	*Platygyra spp.*	Least concern – Near threatened
Brain Coral	*Favia spp.*	Least concern – Near threatened
Brain Root Coral	*Labophylia spp.*	No information available
Birds Nest Coral	*Seriatopora spp.*	No information available
Blue Coral	*Heliopora spp.*	No information available
Boulder star coral	*Montastraea annularis*	Endangered
Brain Trumpet Coral	*Euphylia spp.*	Near threatened - Vulnerable
Cactus Corals	*Pavona spp.*	Least concern - Vulnerable
Cauliflower Corals	*Stylophora spp.*	Least concern
Finger Coral	*Porites porites*	Least concern
Great star coral	*Montastraea cavernosa*	Least concern
Lettuce Corals	*Pectinia spp.*	Near threatened - Vulnerable
Merulina Corals	*Merulina spp.*	Least concern
Yellow Five Corals	*Milleporidae spp.*	No information available
Organpipe Corals	*Tubiparidae spp.*	No information available
Brown Stem Cluster Corals	*Pocillopora spp.*	Least concern - Vulnerable
Feather Corals	*Polyphylia spp.*	No information available
Plants		
Cacti	*Cactaceae spp.*	No information available
Aloes	*Aloe spp.*	No information available
Cycads	*Cycadaceae spp.*	No information available
Euphorbias	*Euphorbia spp.*	No information available
Orchids	*Orchidaceae spp.*	No information available
Zamia	*Zamiaceae spp.*	No information available
Lignum vitae	*Guaiacum sanctum*	Endangered
Lignum vitae	*Guaiacum officinale*	Endangered

Common Name	Scientific Name	IUCN Classification
Mahogany	*Swietenia mahagoni*	Endangered
Fish		
Atlantic Goliath Grouper	*Epinephelus itajara*	Critically endangered
Nassau Grouper	*Epinephelus striatus*	Endangered
Mutton Snapper	*Lutjanus analis*	Vulnerable
Bahamas Blind Cavefish	*Lucifuga spelaeotes*	Vulnerable
Queen Triggerfish	*Balistes vetula*	Vulnerable
Silky Shark	*Carcharhinus fulciformes*	Near threatened
Blacktip Shark	*Carcharhinus limbatus*	Near threatened
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Vulnerable
Caribbean Reef Shark	*Carcharhinus perezi*	Near threatened
Sandbar Shark	*Carcharhinus plumbeus*	Vulnerable
Bahamas Ghost Shark	*Chimaera bahamaensis*	Unknown
Tiger Shark	*Galeocerdo cuvier*	Near threatened
Nurse Shark	*Ginglymostoma cirratum*	Unknown
Lemon Shark	*Negaprion brevirostris*	Near threatened
Whale Shark	*Rhinocodon typus*	Vulnerable
Scalloped Hammerhead	*Sphyrna lewini*	Endangered
Smalltooth Sawfish	*Pristis pectinata*	Critically endangered
Largetooth Sawfish	*Prisitis perotteti*	Critically endangered
Graysby	*Cephalopholis cruentata*	Least concern
Coney	*Cephalopholis fulva*	Least concern
Rock Hind	*Epinephelus adscensionis*	Least concern
Red Hind	*Epinephelus guttatus*	Least concern
Spanish Hogfish	*Bodianus rufus*	Least concern
Cherubfish	*Centropyge argi*	Least concern
Queen Angelfish	*Holocanthus ciliaris*	Least concern
Rock Beauty	*Holocanthus tricolor*	Least concern
Gray Angelfish	*Pomacanthus arcuatus*	Least concern
French Angelfish	*Pomacanthus paru*	Least concern
Four-eye Butterflyfish	*Chaetodon lapistratus*	Least concern
Reef Butterflyfish	*Chaetodon sedentarius*	Least concern
Banded Butterflyfish	*Chaetodon striatus*	Least concern
Dolphinfish	*Coryphaena hippurus*	Least concern
Blue Runner	*Caranx crysos*	Least concern
Palometa	*Trachinotus goodei*	Least concern
African Pompano	*Alectis ciliaris*	Least concern
Wahoo	*Acanthocybium solandri*	Least concern
King Mackerel	*Scomberomorus cavalla*	Least concern
Atlantic Spanish Mackerel	*Scomberomorus maculatus*	Least concern
Keeltail Needlefish	*Platybelone argalus*	Least concern
Harlequin Bass	*Serranus tigrinus*	Least concern
Creolefish	*Paranthias furcifer*	Least concern
Rainbow Parrotfish	*Scarus guacamaia*	Unknown
Princess Parrotfish	*Scarus taeniopterus*	Least concern
Queen Parrotfish	*Scarus vetula*	Least concern
Greenblotch Parrotfish	*Sparisoma atomarium*	Least concern
Redband Parrotfish	*Sparisoma aurofrenatum*	Least concern
Redtail Parrotfish	*Sparisoma chrysopterum*	Least concern
Stoplight Parrotfish	*Sparisoma viride*	Least concern
Puddingwife	*Halichoeres radiates*	Least concern
Yellowhead Wrasse	*Halichoeres garnoti*	Least concern

Common Name	Scientific Name	IUCN Classification
Bluehead Wrasse	*Thalassoma bifasciatum*	Least concern
Slippery Dick	*Halichoeres bivittatus*	Least concern
Greenband Wrasse	*Halichoeres bathyphilus*	Least concern
Yellowcheek Wrasse	*Halichoeres cyanocephalus*	Least concern
Rainbow Wrasse	*Halichoeres pictus*	Least concern
Green Razorfish	*Xyrichtys splendens*	Least concern
Rosy Razorfish	*Xyrichtys martinicensis*	Least concern
Pearly Razorfish	*Xyrichtys novacula*	Least concern
Shortfin Pipefish	*Cosmocampus elucens*	Least concern
Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	Least concern
Bonnethead Shark	*Sphyrna tiburo*	Least concern

Source: GEF, 2011; IUCN, 2011; Hunmann and DeLoach, 2002 [75] [76] [77]

The Andros rock iguana (*Cyclura cychlura cychlura* – Figure 4-37) found in North and South Andros is an endangered species listed on the International Union for Conservation of Nature (IUCN) Red List. This is a large iguana with population estimates of less than 5,000 individuals. Habitats include tropical dry forests, pine barrens, coppice and sandy beach strands. Here they feed on a variety of fruits, flowers and leaves including those of the black mangrove and cocoplum.

Figure 4-37: Photo of Andros Rock Iguana

Source: The Nature Conservancy, 2003[78]

The West Indian flamingo is considered a rare and endangered species and is listed in Appendix II of the Convention on International Trade of Endangered Species of Wild Flora and Fauna (CITES). Other endangered species include the sawfish, green, loggerhead, leatherback and hawksbill turtles.

[75] GEF. 2011. Full-Sized Project on Sustainability of Marine Protected Areas in The Bahamas. Accessed from the following website: www.thegef.org;

[76] IUCN 2011. Red List of Threatened Species. Accessed from the following website: www.iucnredlist.org/apps/redlist. 2011.

[77] Humann, P and N. DeLoach. 2002. Reef Fish Identification – Florida, Caribbean and Bahamas. 3rd Edition, 2002. New World Publications: Jacksonville, Florida.

[78] The Nature Conservancy, 2003.

Figure 4-38: Photo of West Indian Flamingos in the Inagua National Park[79]
Source: BNT, 2009

The Bimini boa (Epicrates striatus fosteri) is protected under Bahamian law and is endemic to Bimini.

Though they look like sharks, sawfishes (see Figure 4-39) are actually a type of ray. They possess a long flattened toothed saw, thus their name. Two species found in the western Atlantic Ocean include the largetooth sawfish (*Pristis perotteti*) and the smalltooth sawfish (*Pristis pectinata*). Sawfish feed on crabs, shrimp and other bottom-dwelling animals as well as small schooling fishes. They are found in a wide range of habitats including bays, seagrass beds, mud bottoms and along mangrove shorelines. Threats to sawfish include commercial fishing gear in which they can become entangled. They are sometimes caught as by-catch but have minimal commercial value for fishermen. Smalltooth sawfish are found in the waters off Andros and Bimini.

[79] BNT, 2009

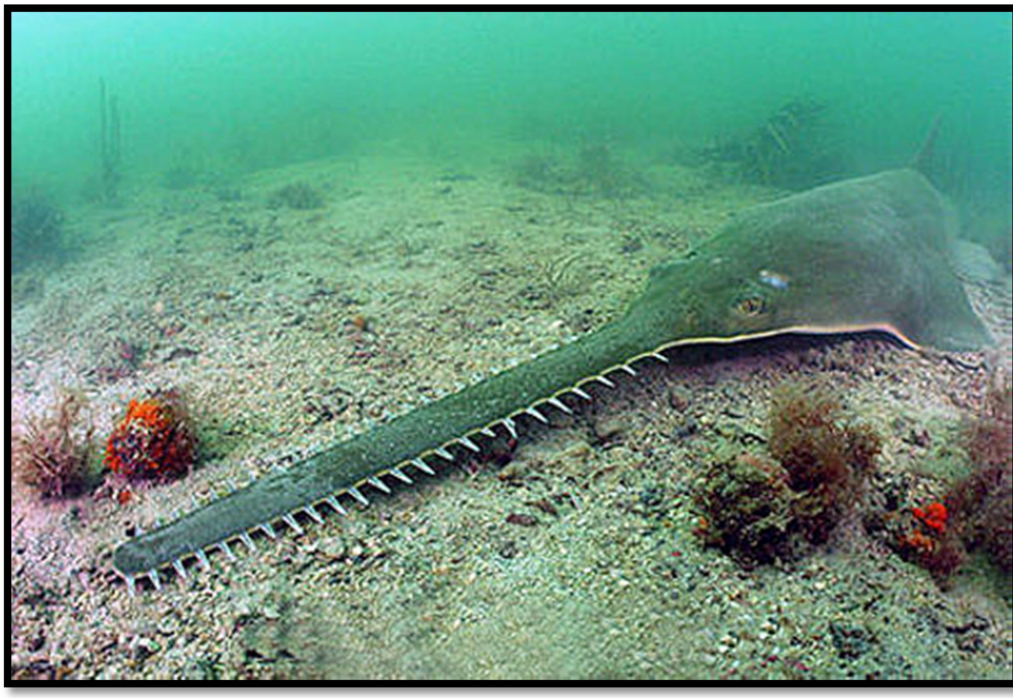


Figure 4-39: Photo of Sawfish
Source: Elasmoworld, 2011 [80]

4.2.3.3 Commercially and Culturally Significant Species
Commercially and culturally significant species found in the project area of influence include:
- Queen conch
- White and black land crabs

Queen conchs are both culturally and economically important in The Bahamas. Conch supports both commercial and subsistence fisheries, by providing a nutritious and relatively inexpensive food source. They are also collected for their beautiful pinkish shells which are sold as souvenirs. Due to the decline of Queen conch populations throughout the Caribbean, it is now listed on Appendix II of CITES. Appendix II lists species that are not threatened presently with extinction, but may become threatened unless trade of such species is subjected to strict regulations. This protection, however, is limited to conch shells. Any manufactured product (e.g., conch fritters) is not protected, and fishery products (e.g., frozen or fresh conch meat), is not covered under CITES. The Bahamas Government does not currently provide a catch limit or closed season for Queen conch, only minimum size limits.

Land crabs are an important economic and consumptive resource for the people of Andros. During spawning season, Androsians come out in the hundreds to catch crabs as they run across the roads on their way to the sea. It is estimated that about 715 households make around $2,000 each selling land crabs in New Providence.

[80] Elasmoworld. Sawfish. 2011. Accessed from the following website: www.elasmoworld.org/sawfish.html.

4.3 Socioeconomic Conditions

4.3.1 Overview of Communities, Employment and other Demographic Conditions

The project is proposed to take place approximately 80 miles (~130 km) offshore to the southwest of Andros Island.

According to the most recent census (2010), the total population of The Bahamas is estimated at approximately 353,658[81]. This represents a growth rate of 16.5% when compared to the 2000 figures. The Bahamian economy is based on tourism and employs directly and indirectly almost half of the archipelago's workforce. Other contributors to the economy are banking, construction, manufacturing, agriculture and fisheries. Agriculture and fisheries contribute 2.12% of the GDP (gross domestic product) of The Bahamas. The government's policy reserves the Bahamian fishing Industry for Bahamian Nationals, fishing vessels must be 100% Bahamian owned. The majority of the population in the potential impact area is involved in agriculture and fisheries. While project activities are only to take place offshore, these activities may potentially affect the on-shore socioeconomic environment on Andros Island and Bimini which fall within the potential impact area.

Andros Island currently supports a small population of 7,400. The people of Andros remain closely connected to the land and sea, which serves as the basis of the local economy and culture.

Predominant industries in Andros include sponging, fishing, crabbing, fly-fishing, tourism, basket weaving, and woodcarving. Economic sectors on the island are mainly related to agriculture, tourism, fishing and general development, with some employment by the Government of The Bahamas and the Water and Sewage Company. The number of visitors to Andros is typically 10,000 per year, with a mean of 85,000 visitor nights from 2006-2008. There are 34 registered hotels (393 hotel rooms)[82].

Residents of Andros have become adept at finding a high quality of life, based largely on the utilization of natural resources. People benefit directly in many varied ways from the flora and fauna, from extraction of crabs, sponge, fish, wood and palm for crafts, medicine and fruits from the forest, as well as water from the ground. They also benefit indirectly in terms of income and employment from nature based tourism, such as guided fishing and diving or visiting blue holes.

The Atlantic Undersea Testing and Evaluation Centre (AUTEC) Base is located in Fresh Creek; it is one of the world's busiest underwater testing facilities. AUTEC's range systems provide underwater and in-air tracking for weapons firing platforms and targets using a variety of acoustic beacons and sensors. The evidence or drop suggests that exposure to intense underwater sound in some settings may cause certain marine mammals to strand and eventually die. Some reports have associated strandings with mid-frequency active military sonars and most have involved beak whales[83].

The Androsia factory also located in Fresh Creek produces batik with unique local designs.

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81 Department of Statistics, 2010. National Census of The Bahamas. Government of The Bahamas. Nassau, Bahamas.

82 The Nature Conservancy. 2010. An Economic Valuation of the Natural Resources of Andros Island, Bahamas.

83 NOAA National Marine Fisheries Services Office of Protected Resources. 2011. Behavioural Response Study on Andros Island, Bahamas. Silver Springs, Maryland.

Other settlements on the island are San Andros, Nicholls Town, Lowe Sound, Staniard Creek, Mangrove Cay, Driggs Hill, Kemps Bay, Long Bay Cays, The Bluff, Deep Creek, Little Creek, Pleasant Bay, Mars Bay, Smith's Hill, Black Point, Behring Point, Cargill Creek, Calabash Bay, Love Hill and Stafford Creek.

Bimini Island has a population of approximately 2,000. Predominant industries in Bimini include sportfishing and tourism. It is the closest Bahamian island to the United States and the majority of tourists are Americans. Visitors to the island in 2009 were 50,144[84]. Major resorts in Bimini include the Bimini Bay Resort and Marina and the Bimini Big Game Club Outpost Resort and Marina.

There are a number of historic landmarks in Bimini including the Bimini Road, several sunken Spanish galleons and Sapona, a freighter wreck from World War I.

Settlements in Bimini include Alice Town, Bailey Town, Port Royal and North Bimini.

4.3.2 Fishing

Bahamians depend on marine resources for food, recreation and employment. The fishing industry employs over 9,300 people (7% of the workforce), as well as an estimated 3,800 part-time fishers, 23 vendors, 11 processors and 18 exporters. These numbers have remained largely unchanged since 2000. Fisheries are subsidized through duty free concessions on fishing equipment. Most of the commercial fishing in The Bahamas takes place on the shallow banks – Great Bahama, Little Bahama and Cay Sal. These banks collectively provide about 45,000 square miles of relatively productive shallow fishing grounds[85]. The Great Bahama Bank and Cay Sal Bank have the possibility of being impacted.

The three main important commercial fisheries in The Bahamas are[86]:

- Crawfish (Spiny lobster) – Landings in the Bahamas are the fourth largest in the world. In 2007, crawfish accounted for 29% of total fishery product landings by weight and 89% of total fishery exports by value (US$71 million).
- Queen Conch – Less than a quarter of the conch catch is typically exported, so estimates are inaccurate because the rest is traded in local markets for which reliable data - is not available. Populations have been severely depleted. Total conch exports in 2008 amounted to 159 mt with a value of $2.0 million.
- Scalefish – This category includes species of grouper, snapper, jacks, grunts, hogfish, triggerfish and others. In 2008, scalefish landings totaled 1,333 mt and represented 9.4% of the total value of all fishery product landings. Snappers accounted for 20.7% of all scalefish landings (valued at US$4.6 million).

The deepwater fishing industry is not well-developed in The Bahamas due to higher costs and requirements for specialized equipment and technology. As fishermen attempt to diversify their catch, interest is increasing.

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[84] Tourism Today. 2011. Accessed from the following website: www.tourismtoday.com/home/statistics/stop-overs

[85] The Bahamian Commercial Fishing Industry (BREEF) 2006. Accessed from the following website www.breef.org.

[86] BREEF, 2006.

Andros is known as the bonefishing capital of the world. A report in 2009 reported 80 bone fishing guides in Andros and estimated there were 64,441 angler nights on Andros (12,643 guided) and that anglers spent an estimated $374 per night (compared to $364 for general tourists)[87]. The sand flats are world-renown for fly fishing and occur on the entire north, south and west coast of the island. Bonefishing is also done within the tidal creeks, cuts and bights which run straight through the island.

Nearshore fishing activities are common along the east coast of Andros.

Bimini is known for big game fishing for species such as:

- Blue marlin (*Makaira nigricans*),
- Bluefin tuna (*Thunnus thynnus*),
- Wahoo (*Acanthocybium solandri*) and
- Swordfish (*Xiphias gladius*).

Fishing sites in or near Bimini include Moselle Shoal, Three Sisters Rock, and Great Isaac Rock. The sand flats in Bimini also have an abundance of bonefish and permit (a type of jack). Bonefishing also occurs on the neighbouring Great Bahama Bank. Charter boats also take tourists out to fish for grouper, snapper and barracuda[88].

4.3.3 Mariculture

There are no mariculture activities currently occurring at the project site or off the coasts of Andros and Bimini. The Cape Eleuthera Institute is conducting a study of offshore cage aquaculture of cobia (*Rachycentron canadum*), but problems have been encountered with sharks congregating at the research sites, attacking the cages and eating the cobia. The study has not moved to the commercial stage, but research continues in collaboration with the University of Miami Rosentiel School of Marine and Atmospheric Science[89].

4.3.4 Tourism/Recreation

There are two principal types of tourism in The Bahamas - cruise ship and overnight. Since 2000, an average of 4.5 million tourists visited The Bahamas each year[90]. Of these, about 1.5 million are overnight visitors and the remaining ones stay a few days on a cruise ship docked in a port. Almost half these visitors had incomes greater than US$100,000.[91] Eighty-one per cent were from the USA, 8% from Canada and 6% from Europe. Overnight visitors stayed an average of 6.6 nights, typically either 5.6 nights in Nassau or 9.5 nights in the out islands. Overnight visitors spent an estimated total of $2.02 billion in aggregate in 2007 and a mean of $1,175 per visit.

Two hundred and fifty-eight thousand (258,000) visitors went to the Family Islands in 2008, spending 2.4 million visitor nights. Thirty-seven per cent of Family Island visitors had chosen The Bahamas due to the beaches, followed by 24% for sporting activities (e.g. snorkeling, fishing, diving, and sailing). Mean expenditure for Family Island overnight visitors was $1,396

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87 BREEF, 2006.

88 The Islands of The Bahamas. 2011. Fishing. Things to do on Water in Bimini. Accessed from the following website: www.bahamas.com/out-islands/bimini-islamd/fishing. 2008 - 2011.

89 Cape Eleuthera Institute. 2011. Offshore Aquaculture. Accessed from the following website: www.ceibahamas.org.

90 Ministry of Tourism. 2011. Accessed from the following website: www.bahamas.gov.bs

91 B$1 = US$1.

per trip in 2007 or US$402 million in aggregate (20% of all tourism expenditure). This includes all those who stayed with friends or on boats and therefore spent nothing on accommodation. Of this, 39% was spent on accommodation, for which the mean price was US$253 per night, 16% on food and drink and 4% on sporting activities. The number of visitors to the Family Islands continues to rise each year and could reach 3 million by 2024, given current growth of 2.8% per year.

The number of visitors to Andros is typically 10,000 per year, of whom 90% are from the US, 5% are from Europe and 3% are from Canada. A mean of 85,000 visitor nights were spent in Andros from 2006-2008. Sixty-six percent of visitors came in on commercial flights and 26% on private planes. Fifty percent of visitors stay in hotels, 12% with friends, 10% on private boats, 5% in rental properties and 5% in their own second homes. There were 34 registered hotels and 393 hotel rooms in Andros in 2008 (12% of all the out-island hotels). Sixty-seven per cent of visitors to Andros were repeat visitors.

Bimini is considered one of the world's best dive destinations with dive sites including the Bimini Road with depths of up to 4,000 feet. Other dive sites include coral reefs, several sunken Spanish galleons, a World War I freighter wreck and the concrete hull of the SS Sapona[92]. As mentioned previously, tourists also engage in sportfishing in the waters and shallow banks off Bimini.

4.3.5 Shipping

The Bahamas Petroleum southern licenses are located offshore and are in the vicinity of three shipping channels (Figure 4-40):

- Nicholas Channel
- Santaren Channel
- Old Bahama Channel (most utilized of the three).

The Old Bahama Channel (see Figure 4-41 for cross section) of is a strait located between Cuba and the Great Bahama Bank, with a small portion of the channel intersecting the Bahamas Petroleum's southern license areas. This channel is connected at its north-western extremity to the Florida Straits by two arms, enclosing Cay Sal Bank (see Figure 4-5). These two arms comprise the Santaren Channel to the north and the Nicholas Channel to the south. The Old Bahama Channel terminates on the east between Cape Maysi in Cuba and the Bahamian island of Inagua. However, it can also be considered to include the Mona Passage which separates Hispaniola and Puerto Rico. The narrowest portion of the Old Bahama Channel is between 22° and 23° north latitude, where its width rarely exceeds twelve miles. The Old Bahama Channel is used as an alternate shipping route when shipping crude or petroleum to and from the Middle East and Mexico, but is frequently avoided during the hurricane season[93].

[92] The Islands of The Bahamas. 2011.
[93] UNEP. 2009. Caribbean Island Oil Pollution Response and Cooperation Plan. IMO/UNEP, Curacao, Netherland Antilles.

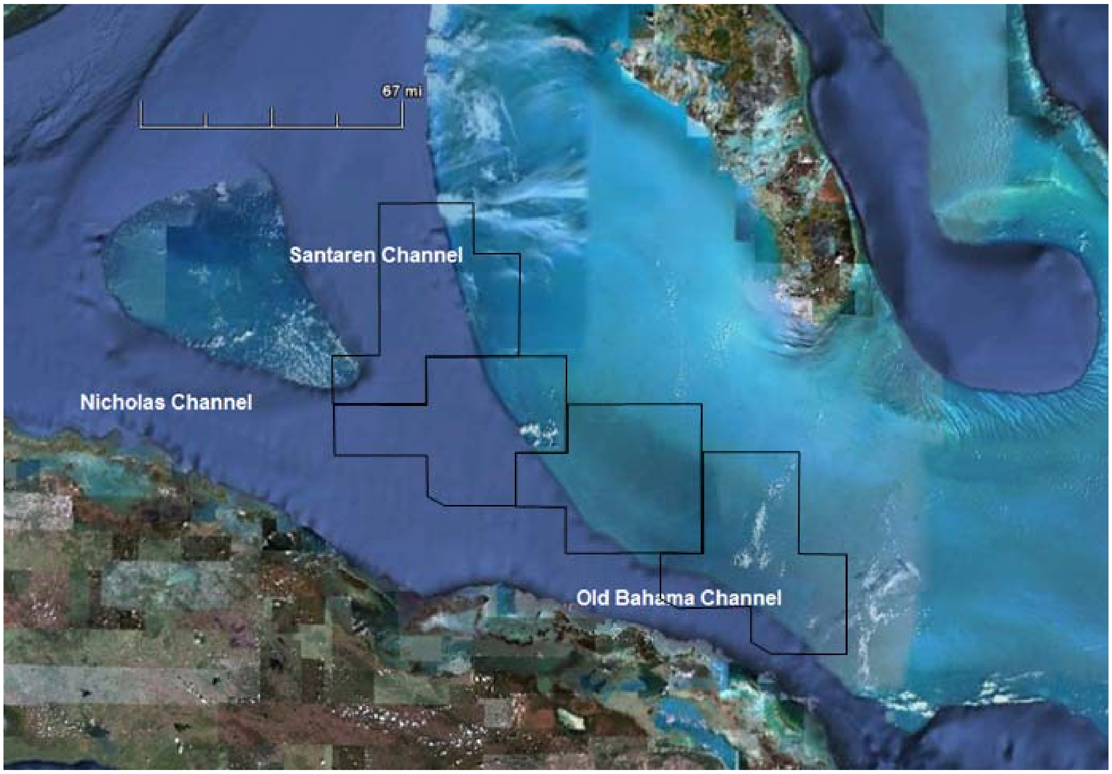

Figure 4-40: Shipping Channels near Bahamas Petroleum Company's Southern Licenses
Note: Approximate block boundaries shown in black
Source: Modified from Google Earth

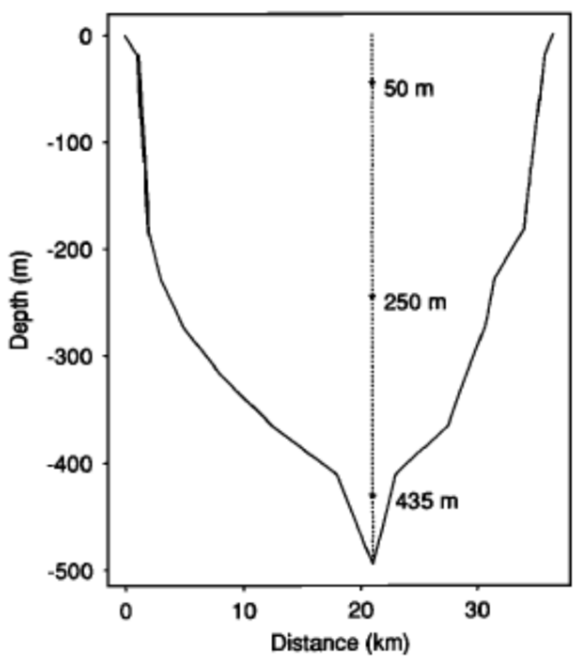

Figure 4-41: Cross section of Old Bahama Channel
Note: Cross section taken at 22° 44.5'N and 78° 31.8'W
Source: Atkinson, 1995[94]

[94] Atkinson, 1995.

Ship registration is a relatively new business in The Bahamas, yet the country has grown from less than one million gross tons to be the world's fifth largest fleet in little more than a decade. Since the passing of the Merchant Shipping Act of 1976, more than 1,500 vessels, representing over 25 million gross tons, have chosen to register in The Bahamas. Many of the most respected international ship-owning companies fly the Bahamian flag, including Exxon International, Maersk Line, Teekay Shipping, and Chevron. Some of the luxury vessels registered include the ships of Norwegian Cruise Lines and Holland-America Cruises; others are cargo steamers, frigates, freighters, tankers and tugboats[95].

Established on July 1, 1995, The Bahamas Maritime Authority (BMA), with its headquarters in London, is a semi-autonomous, Government-owned corporation, specifically designed to be responsive to the needs of the maritime market place. While the BMA will be self-funding from revenues generated from within, the Government has allocated US$1 million 'seed money' to expedite a number of enhancements to present operations. Guided by advice from leading shipowners, the BMA is increasing staff, streamlining registry procedures, and instituting improvements in support systems.

Despite the fact that many vessels and numerous tankers (destined for BORCO and South Riding Point oil storage and transhipment facilities) travel through The Bahamas, there have only been two collisions and zero reported oil spill accidents since 1996.

4.3.6 Infrastructure and Services

The project site is offshore in a remote location where there is no infrastructure or services available but infrastructure and services exist on Andros and Bimini Island which are in the vicinity of the project area.

Infrastructure and services on the island of Andros include:

- Roads - constructed by the Ministry of Public Works
- Potable water - provided by the Water & Sewerage Corporation or private wells
- Telecommunications - provided by the Bahamas Telecommunications Corporation
- Cable television and Internet - provided by Cable Bahamas
- Electricity - provided by the Bahamas Electricity Corporation
- Medical clinics - managed and operated by the Department of Public Health
- Docks/ports - public docking facilities are managed by the Port Department and Local Government; Government docks, ports and private docking facilities occur at Andros Town, Frozen Cay, Morgan’s Bluff, Drigg’s Hill and Standiard Creek
- Airports - small airports are located in the settlements of Andros Town, Clarence A. Bain, Congo Town, and San Andros

There are no hospitals on Andros or Bimini Island. Persons have to be flown to Grand Bahama, New Providence or the United States if they require hospitalization.

The cays located in the Cay Sal Bank area are not inhabited by people therefore no infrastructure exists.

[95] The Bahamas’ Shipping Registry http://www.geographia.com/bahamas/investment/shipng01.htm

A subsea cable runs along the outer edge of the Great Bahama Bank, through the license blocks (Figure 4-42).

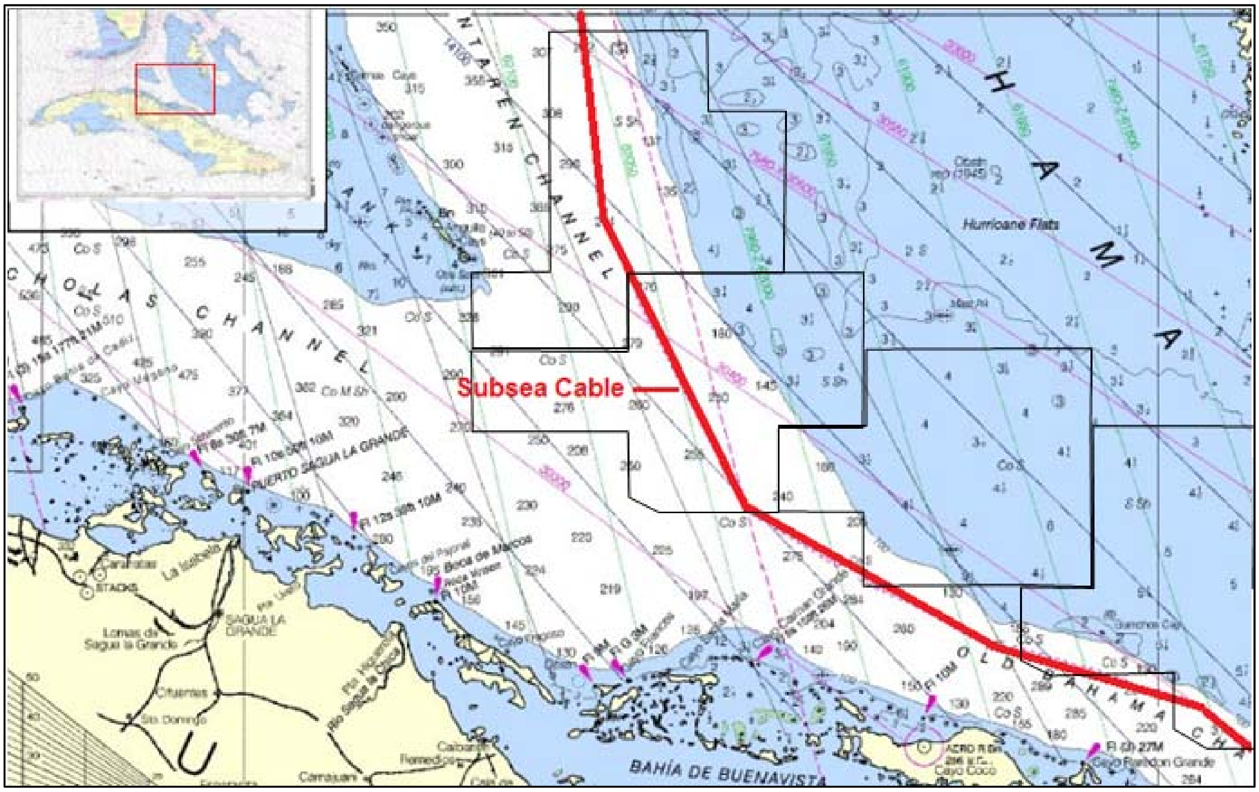

Figure 4-42: Subsea Cable in the Licence Blocks
Note: Approximate block boundaries shown in black
Source: NOAA, 2011. [96]

4.3.7 Archaeological and Historical Resources

In 1992, Captain Herbert Humphreys Jr. and the crew of the research vessel, Beacon recovered an elephant tusk form the circa 1543 shipwreck of the Bronze Cannon on the Great Bahama Bank[97].

[96] National Oceanic and Atmospheric Administration (NOAA). 2011. Modified from the NOAA website: http://www.charts.noaa.gov/OnLineViewer/11013.shtml
[97] www.spanishmainantiques.com

Figure 4-43: Elephant Tusk found on Bronze Cannon Shipwreck on the Great Bahama Bank

Source: Spanishmainantiques.com[98]

Artefacts of broken pottery, trade pipes, household goods, fashion accessories and toys have been collected over a decade (1989-present) from a naturally eroding segment of beach face due south of Forfar Field Station, leeward of Calabash Cay, South Blanket Sound in Andros. The collection consists of more than 1,500 pieces. Most of the artifacts appear to be of English origin, ranging in dates from 1780 to 1890. Investigations suggest that the site may have been a temporary trading centre and launch pad for the final leg of the American Civil War era blockade runners, utilized by the Confederacy, Great Britain and Androsians[99]. This area would not be impacted by the project as they are located on the east side of Andros Island away from the project site.

Lucayan (first known inhabitants of The Bahamas) skeletons and artifacts, including canoes, have been found in inland blue holes on Andros.

The Bimini Road, also referred to as the Bimini Wall, is an underwater rock formation that is 0.5 miles long near North Bimini. The Road is comprised of flat-laying limestone blocks of various shapes. There has been much debate amongst scientists and divers about the origin of these blocks. There is also debate about the age of this rock formation with estimates ranging from 1,900 to 3,500 years[100].

4.4 Cuba and Florida

Bahamas Petroleum Company's southern blocks are approximately 25 miles (40 km) from the Cuban shoreline and approximately 120 miles (195 km) from south-eastern coast of Florida, USA. Also, as described in Chapter 2, Bahamas Petroleum Company could potentially utilize a shore base in Louisiana, USA which would involve transportation of supply vessels between port and the drilling location(s) through the Gulf of Mexico. While the focus of this baseline remains the Bahamian coast adjacent to the Blocks, it is important to note that the Cuban and USA coasts could be affected (i.e. supply boat collision or oil spill).

[98] www.spanishmainantiques.com.

[99] An Investigation into the Origin, Historical and Sedimentological Significance of Archaeological Artifacts, South Blanket Sound, Andros Island, Bahamas. Abbie Wischmeyer and Lawrence A. Wiedman. University of Saint Francis. Proceedings of the 10th Symposium on the Natural History of The Bahamas. 2005

[100] Davaud, E. and A. Strasser.1984. Progradation, Cementation, Erosion, Recent Diagenetic and Sedimentary Evolution in a Carbonate Coastal Environment, Bimini, Bahamas. Eclogae Geologicae Helvetiae. Vol 77, No. 3, p. 449-468. 1984.

An overview of the coastal sensitivities of Cuba and Florida can be found below. A detailed sensitivity map is provided in Appendix C.

4.4.1 Beaches

White sand beaches and tourist hot spots can be found along much of the northern coast of Cuba adjacent to Bahamas Petroleum Company's blocks, including: Vardero Beach, Cayo Coco and Playa Santa Lucia.[101] [102]

Beaches also line the Florida coastline adjacent to the Blocks. Southern Florida beaches include Boca Raton, Pompano Beach, Miami Beach, Key Largo, Marathon, Key West, among others.[103]

In addition to tourism, the Cuban beaches south of the Eneas, Donaldson and Cooper blocks, and most of southern and eastern Florida Peninsula are important turtle nesting grounds (see Appendix C).

4.1.1.1 Sea Turtle Nesting Sites

Green, hawksbill and loggerhead turtle nesting sites are found on the northern coast of Cuba and the eastern coast of Florida. Leatherback nesting habitat is found all along the eastern coast of Florida, but there have been no observations of leatherback nesting on the northern coast of Cuba. Figures 4-44 through 4-47 are regional maps of nesting habitat for these four marine turtle species.

[101] Destination 360. 2011. Accessed from the following website: http://www.destination360.com/caribbean/cuba/cuba-beaches-map

[102] Captivating Cuba. 2011. Accessed from the following website: http://www.captivatingcuba.com/cuba/top_five_beaches/index.html

[103] Destination 360. 2011. Accessed from the following website: http://www.destination360.com/north-america/us/florida/map-of-florida-beaches

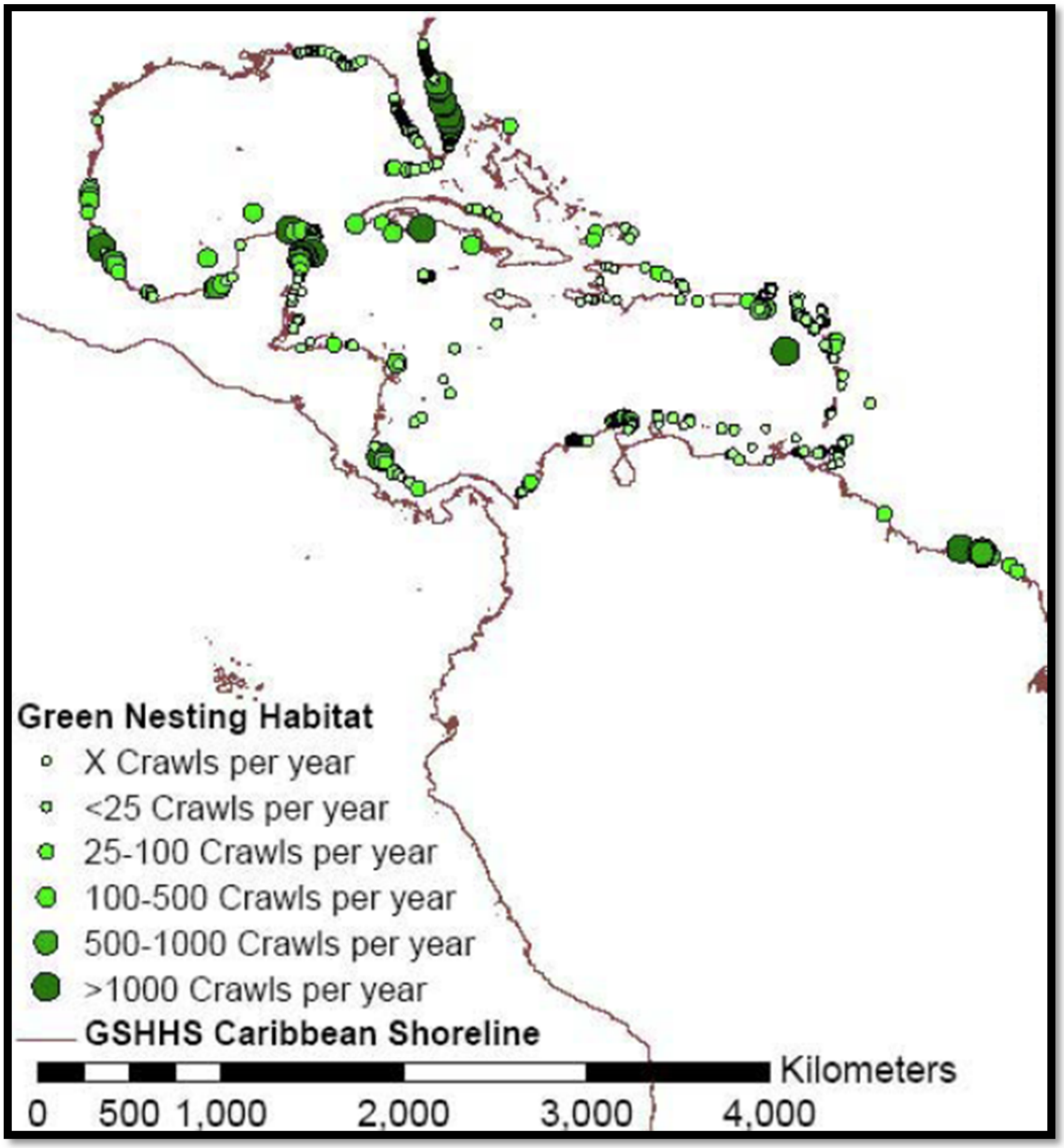

Figure 4-44: Green Turtle Nesting Sites in the Caribbean
Source: Dow, et al., 2007

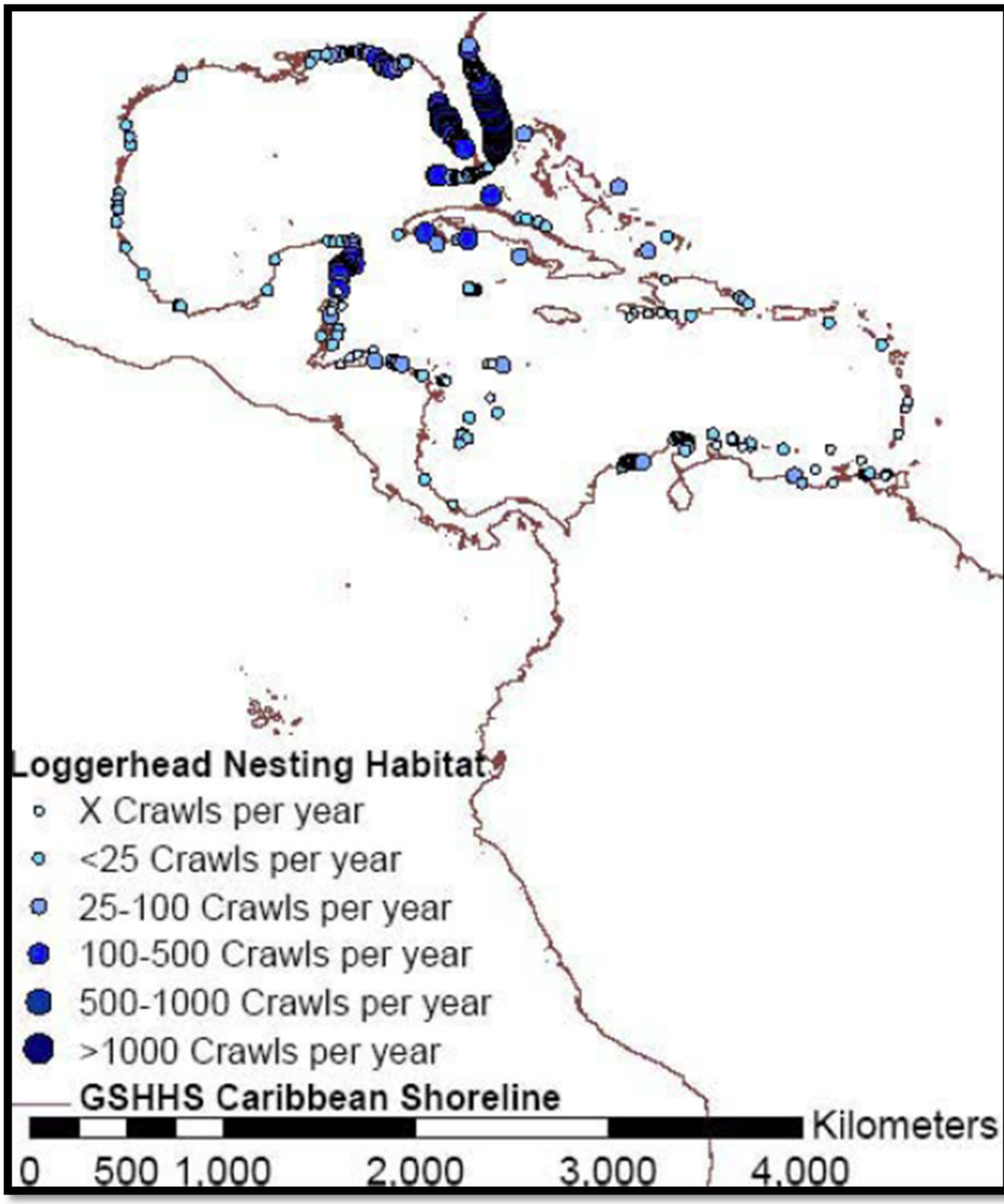

Figure 4-45: Loggerhead Nesting Sites in the Caribbean
Source: Dow, et al., 2007

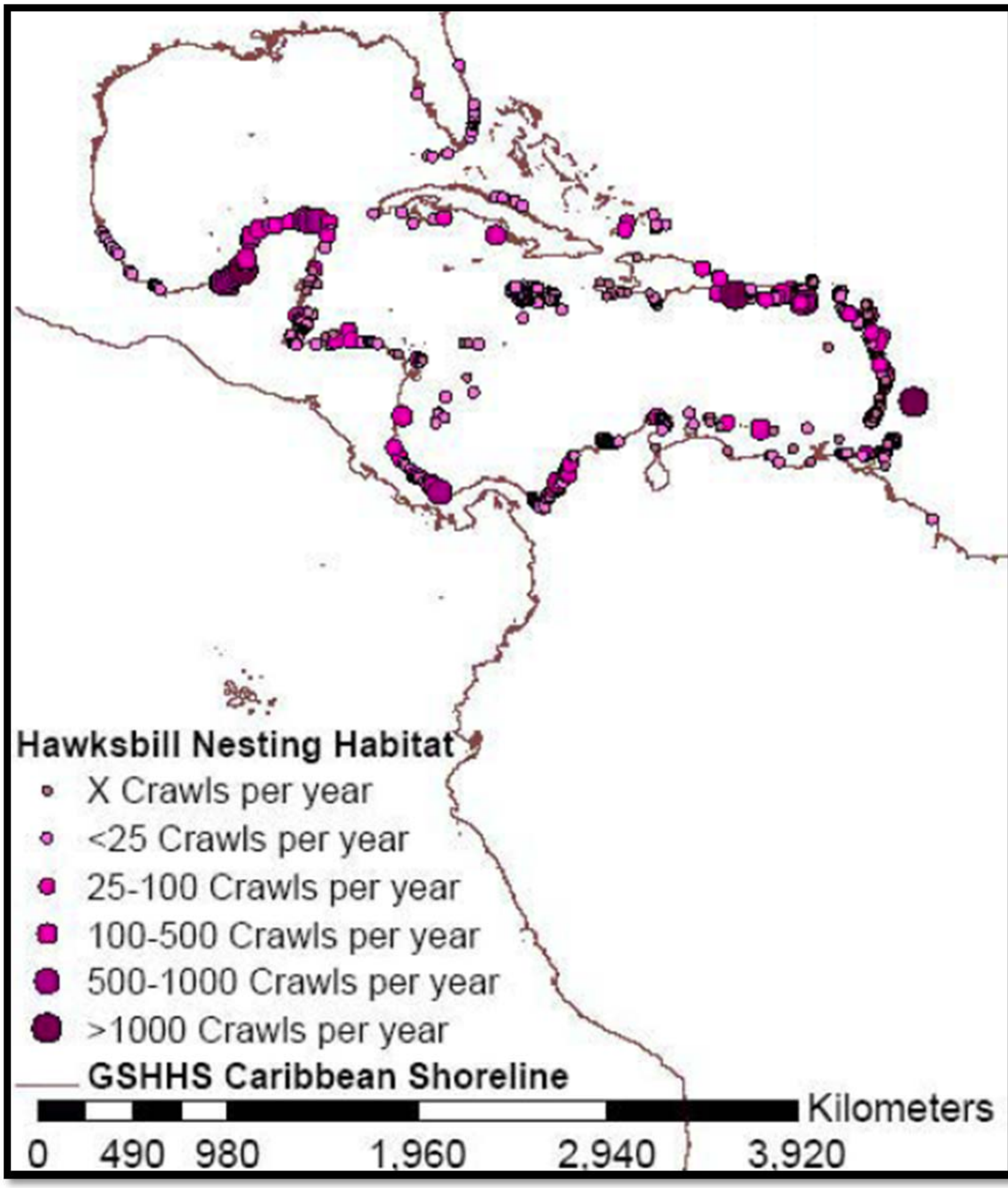

Figure 4-46: Hawksbill Nesting Sites in the Caribbean
Source: Dow, et al., 2007

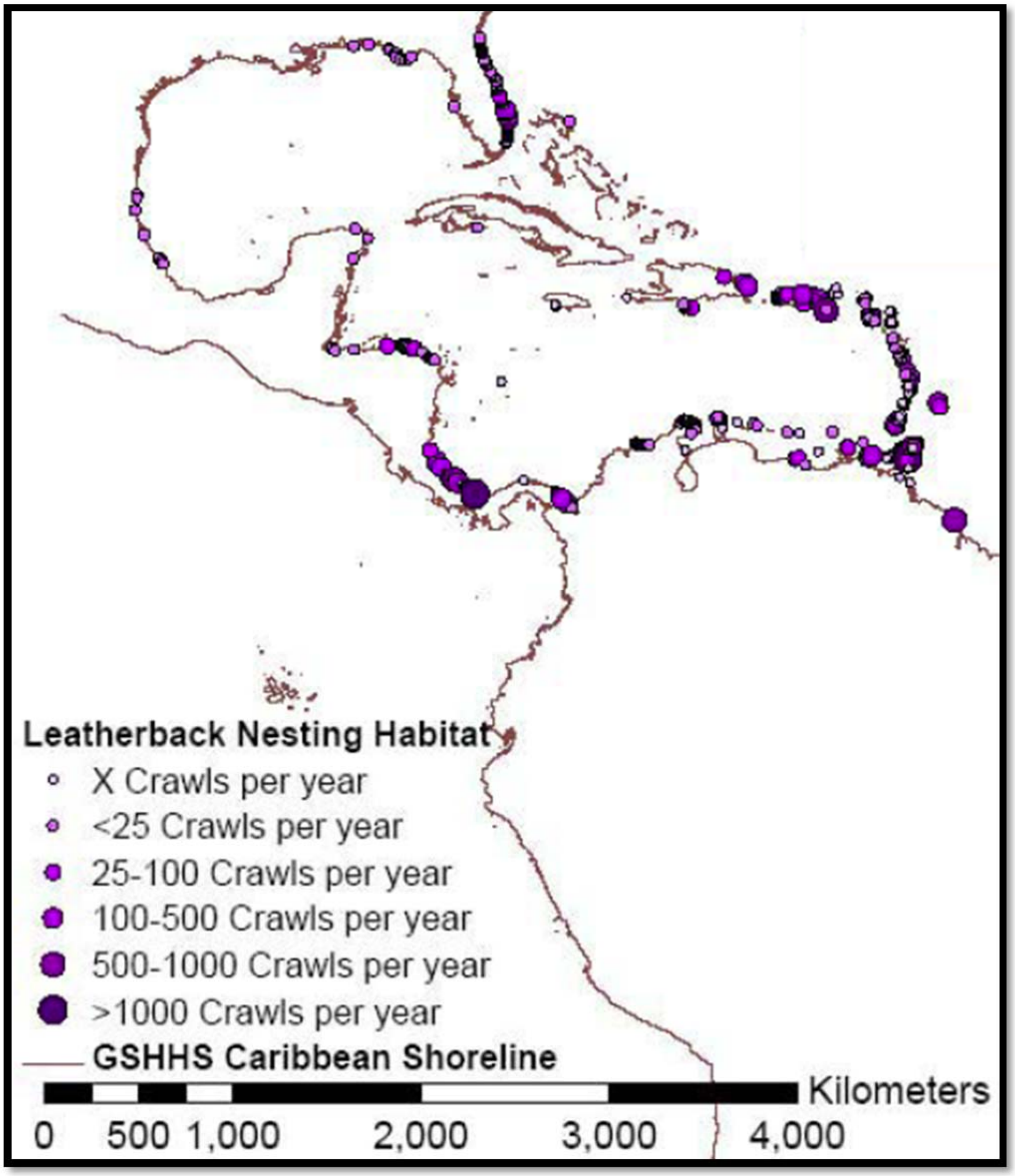

Figure 4-47: Leatherback Nesting Sites in the Caribbean
Source: Dow, et al., 2007

4.4.2 Mangroves

Mangroves can be found consistently along the Cuban coastline south and southwest of Bahamas Petroleum Blocks, especially within the Cuban archipelagos (i.e. Archipelago de Sabana and Archipelago de Camaguey). Numerous protected areas with mangrove ecosystems are located in these archipelagos, including two Ramsar Wetlands of International Importance:

Buenavista and Gran Humedal del Norte de Ciego de Ávila.[104] These areas are described further in Section 4.4.6.

Everglades National Park lies on the westward tip of the Florida Peninsula. This area contains the largest mangrove ecosystem in the western hemisphere and is a significant breeding ground for wading birds, reptiles and threatened species such as the manatee.[105]

4.4.3 Seagrass Beds

The distribution of seagrass beds is generally consistent with the distribution of mangroves. Seagrass beds are concentrated within the northern Cuba archipelagos, southwest of the Blocks, and throughout much of southern and south-western Florida (see Appendix C).

4.4.4 Corals

A fringing coral reef runs along almost the entire northern coast of Cuba, including the areas adjacent to Bahamas Petroleum Company Blocks. Similarly, coral reefs are also found consistently from Ft. Lauderdale to Key West (see Appendix C).

4.4.5 Blue Holes

Blue holes are present along the north side of Cuba; however, locations could not be identified.

4.4.6 Protected and Sensitive Areas in Cuba and Southern Florida

No protected areas occur within the Bahamas Petroleum Company's license areas, but some are located within the vicinity of the project site in Cuba and Florida, as shown in Figure 4-48. There are numerous protected areas along these adjacent shores (shaded in blue).

In 1959, the first proposal was made for a national system of protected areas (Sistema Nacional de Areas Protegidas, SNAP) in Cuba. Created in 1995, the Centro Nacional de Areas Protegidas (CNAP) is responsible for the planning and management of the overall national system of protected areas. The system currently consists of 105 protected areas and there are 253 proposed areas. Threats to protected areas in Cuba include habitat destruction and degradation, hunting, invasive species, illegal trade in plants and animals, and pollution.

Cuba's network of 28 Important Bird Areas (IBAs) have been created to protect 69 key bird species including 24 threatened species, 11 restricted-range species, 48-biome-restricted species and 16 congregatory waterbird and seabird species. Key IBAs along the northern coast of Cuba in closest proximity (approximately 25 miles) to the blocks:

- **Cayeria Centro-Oriental de Villa Clara** (**CU008)** – This IBA is located in the Sabana-Camaguey Archipelago. It supports globally significant breeding colonies of Laughing Gull (*Larus atricilla*) and Royal Tern (*Sterna maxima*). It is also a wintering site for the near threatened Piping Plover (*Charadrius melodus*). This area is also designated as a wildlife refuge, national park and biosphere reserve. The critically endangered eared hutia (*Mesocapromys auritis*) is endemic to a cay within this IBA. The most diverse coral reef of the Sabana-Camaguey Archipelago is also found here.

[104] The Ramsar Convention on Wetlands. 2002. The Annotated Ramsar List: Cuba. Accessed from the following website: http://www.ramsar.org/cda/en/ramsar-pubs-annolist-anno-cuba/main/ramsar/1-30-168%5E16473_4000_0__

[105] United Nations Educational, Scientific and Cultural Organization. 2011. Everglades National Park. Accessed from the following website: http://whc.unesco.org/en/list/76

- **Gran Humedal del Norte Ciego de Avila** (**CU012)** – This IBA is located in the northeastern portion of Ciego de Avila province. It supports globally significant populations of West Indian Whistling Duck, Piping Plover and the near threatened Sandhill Crane (*Grus Canadensis nesiotes*). The endangered Cuban Sparrow (*Torreornis inexpectata varonai*) is an endemic species found here. This area is also designated as an ecological reserve, wildlife refuge and Ramsar site. It provides habitat for the vulnerable American crocodile (*Crocodylus acutus*) as well as hutia and the Cuban ground iguana.

- **Cayos Romano-Cruz-Megano Grande** (**CU015) –** This IBA is located at the eastern end of the Sabana-Camaguey Archipelago off the north coast of the Cuban mainland. It supports a great diversity and density of waterbirds, including the Roseate Spoonbill (*Platalea ajaja*) and White Ibis (*Eudocimus albus*). This area is also designated as a managed resources protected area and faunal refuge. It provides habitat for an endemic snail and 151 Cuban endemic plants of which 23 are threatened.

Protected areas on the Cuban coastline closest to the Blocks (approximately 25 miles south) are shown in Figure 4-49 and 4-50. The protected areas in this region include two RAMSAR Wetlands of International Importance:

- Humedal del Norte de Ciego de Ávila
- Buenavista (Also a United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and the Biosphere Reserve)

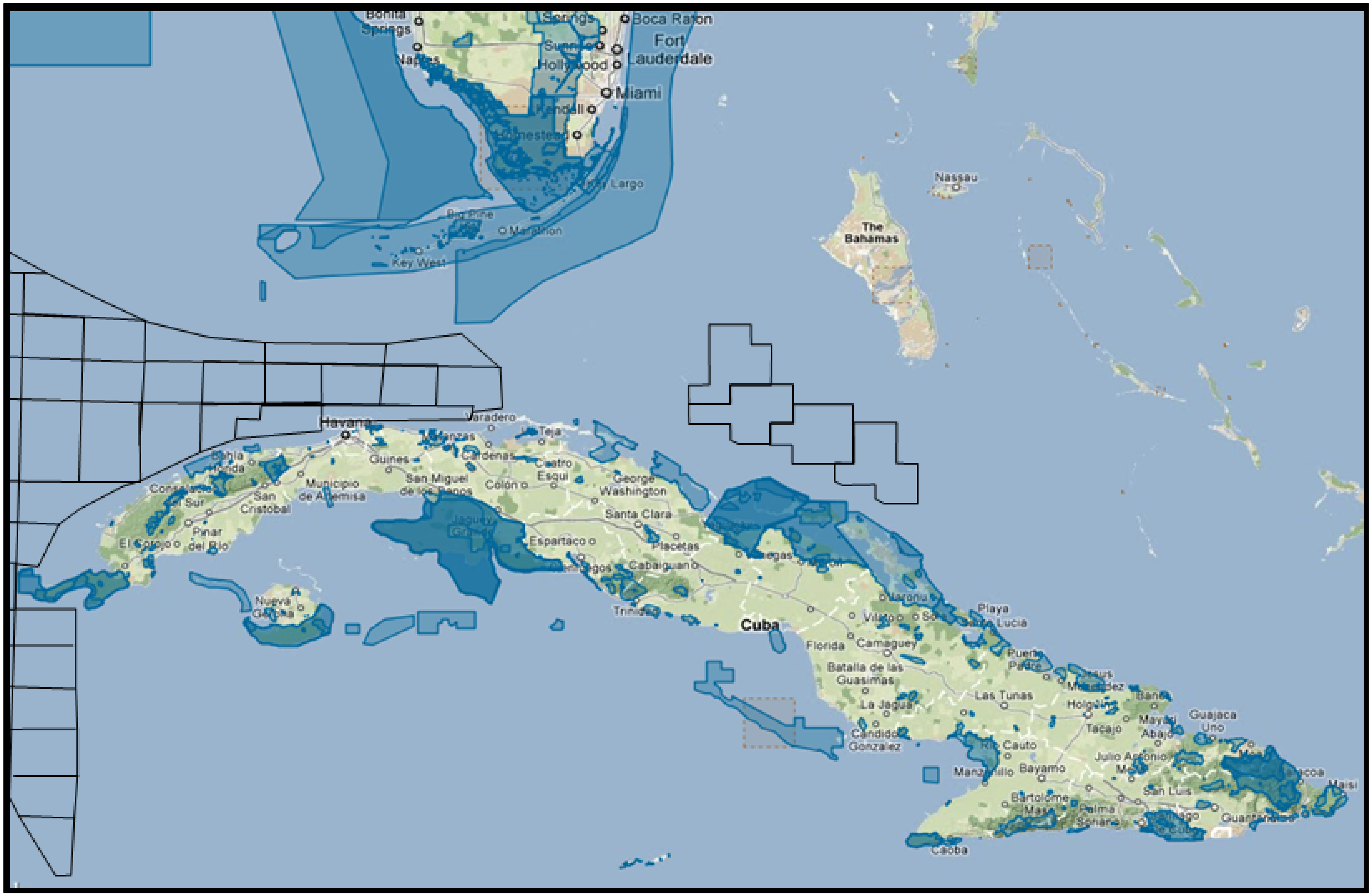

Figure 4-48: Protected Areas Adjacent to the Project Area

Note: Approximate block boundaries shown in black

Source: Adapted from UNEP, 2011[106]

[106] UNEP. 2011. World Data Base on Protected Areas. Accessed from the Protectedplanet website: www.protectedplanet.net

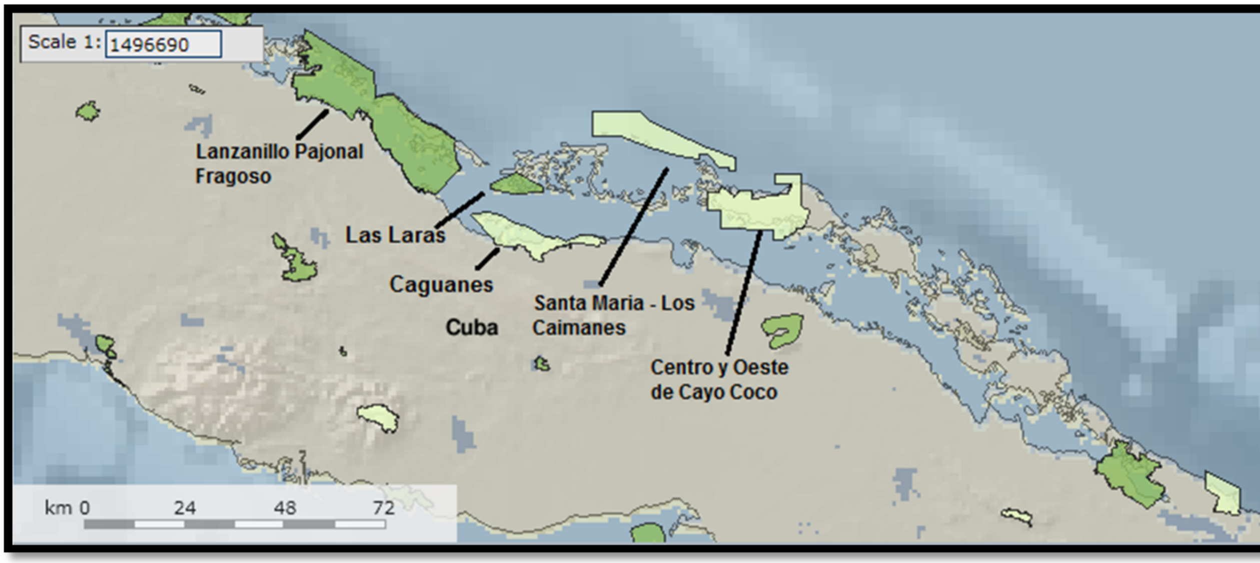

Figure 4-49: Protected Areas (IUCN Category I-IV) on the Central Cuban Coast South of the Blocks

Note: Categories I-II in light green, Categories III- IV in dark green

Source: Adapted from IUCN/Birdlife International/ Conservation International/UNEP/WCMC, 2011

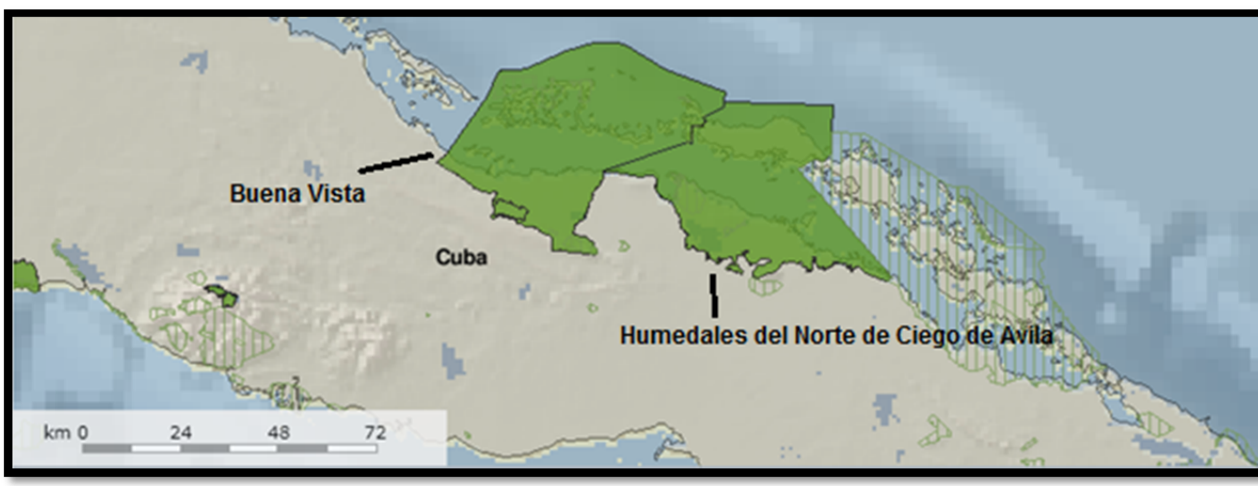

Figure 4-50: Protected Areas (IUCN Category V-VI) on the Central Cuban Coast South of the Blocks

Note: Categories V-VI in dark green, Category "unknown" cross-hatched

Source: Adapted from IUCN/Birdlife International/ Conservation International/UNEP/WCMC, 2011

Both Buena Vista and Humedales del Norte de Ciego de Avila are RAMSAR Wetlands of International Importance.

The south-eastern coast of Florida and Florida Keys are within the area of influence for the project. Important protected and sensitive areas for Florida are described below.

Protected and Sensitive Areas in Southern Florida include:

- **Florida Keys National Marine Sanctuary**[107]

Designated on November 16, 1990, this Sanctuary is one of 14 marine protected areas that comprise the US National Marine Sanctuary System. Administered by NOAA and jointly managed with the State of Florida, Florida Keys National Marine Sanctuary protected 2,900 square nautical miles of ocean surrounding the Florida Keys. It runs south of Miami westward to encompass the Dry Tortugas, but excludes the Dry Tortugas National Park. The shoreward boundary of the Sanctuary is the mean high water mark. Nationally significant marine resources protected here include a barrier reef, extensive seagrass beds, mangrove-fringed islands and more than 6,000 species of marine organisms. Historical artifacts including shipwrecks and treasures are also found in the Sanctuary.

The Sanctuary is divided into five types of marine zones – ecological reserve, sanctuary preservation areas, wildlife management areas, existing management areas and special use areas. This zoning enables protection and preservation of highly sensitive parts of the Sanctuary while allowing activities, like swimming and snorkeling, which are compatible with resource protection.

- **Biscayne National Park**[108]

Biscayne National Park is 172,000 acres, consisting of four primary ecosystems – mangrove forest, Biscayne Bay, northernmost island of the Florida Cays and a portion of a barrier reef. The Park is home to many threatened and endangered species. Threatened species include including the Eastern indigo snake (*Drymarchon corais couperi*), staghorn coral (*Acropora cervicornis*) and loggerhead turtle (*Caretta caretta*). Endangered species include the Schaus' swallowtail butterfly (*Heraclides aristodemus ponceanus*), Key Largo woodrat (*Neotoma floridana smalli*), smalltooth sawfish (*Pristis pectinata*) and Kemp's ridley turtle (*Lepidochlys kempii*).

- **Dry Tortugas National Park**[109]

Almost 70 miles west of Key West lay a cluster of seven islands called the Dry Torgtugas. These islands along with the surrounding shoals and waters as well as coral reefs and sandy beaches comprise the Dry Tortugas National Park. The coral and seagrass communities are among the most vibrant in the Florida Keys. The Sooty Tern (*Sterna anaethetus*) finds its only regular nesting site in the United States in this Park. Large sea turtles nest on the Park's protected beaches. Threatened species found here include the elkhorn coral (*Acropora palmata*), Loggerhead turtle (*Caretta caretta*), Roseate Tern (*Sterna dougallii dougallii*) and Piping Plover (*Charadrius melodus*). Endangered species found in the Park include West Indian manatee (*Trichechus manatus*), Green turtle (*Chelonia mydas*), Leatherback turtle (*Dermochelys coriacea*) and Humpback whale (*Megaptera novaeangliae*).

A Research Natural Area (RNA) was established in the Park in 2007. It is a 46-square mile no-take, no-anchor ecological preserve for species affected by fishing and loss of habitat, including grouper, snapper and grunts. The RNA provides opportunities for boaters, divers, snorkelers and researchers to explore and study this area.

[107] National Park Service, U.S. Department of the Interior. 2011. Accessed from the USDOI website: www.floridakeys.noaa.gov

[108] National Park Service, U.S. Department of the Interior. 2010. Accessed from the USDOI website: www.nps.gov/bisc.

[109] National Park Service, U.S. Department of the Interior. 2010. Accessed from the USDOI website: www.nps.gov/drto.

- **Everglades National Park**[110]

Established in 1947, the Everglades National Park is 1.5 million acres of diverse habitat. The boundaries of the Park comprise one-fifth of the entire Everglades ecosystem. The Park is also designated as a World Heritage Site, International Biosphere Reserve and Wetland of International Importance under the Ramsar Convention. Habitats found in the Park include pineland, mangroves, freshwater marl prairie and cypress. Threatened species found here include the Arctic Peregrine Falcon (*Falco peregrinus tundrius*) and American alligator (*Alligator mississippiensis*). Engendered species found in the Park include Snail Kite (*Rostrhamus sociabilis*), Florida panther (*Felis concolor coryi*) and Hawksbill turtle (*Eretmochelys imbricata*).

The Florida Keys Complex[111] consists of four wildlife refuges – National Key Deer, Crocodile Lake, Great White Heron and Key West. The Complex covers more than 416,000 acres of land and open water, protecting 22 federally listed threatened and endangered species as well as other native wildlife.

Other protected areas within the project's area of influence include:

- **Big Cypress National Preserve**[112]

This 720,000-acre site was established as a National Preserve in 1974. It borders the Everglades National Park and was created to protect the water quality, natural resources and ecological integrity of the Big Cypress Swamp. The Reserve is dominated by a wet cypress forest and hosts an array of flora and fauna including the endangered Florida Sandhill Crane (*Grus canadensis pratensis*).

- **Canaveral National Seashore**[113]

Situated on a barrier island, Canaveral National Seashore is 24 miles of the longest stretch of undeveloped public beach on the east coast of Florida. Over one million people visit this park every year. Threatened and endangered species that are protected here include the Loggerhead turtle (*Caretta caretta*), Bald Eagle (*Haliaeetus luchocephalus leucocephalus*) and Right whale (*Balaena glacialis*). Adjacent to the Merritt Island National Wildlife Refuge, both areas combine to offer important habitat for water and wetland-dependent bird species including the endangered wood stork (*Mycteria americana*) and Florida scrub jay (*Aphelocoma coerulescens*).

Other National Wildlife Refuges in Florida's southeast region include St. John's, Archie Carr, Pelican Island, Hobe Sound, and Loxahatchee.

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[110] National Park Service, U.S. Department of the Interior. Accessed from the USDOI website: www.nps.gov/ever. 2011

[111] U.S. Fish & Wildlife Service. 2002. Florida Keys National Wildlife Refuges. Accessed from the USFWS website: www.fws.gov/southeast/pubs/nkdgen.pdf.

[112] National Park Service, U.S. Department of the Interior. 2011. Accessed from the USDOI website: http://www.nps.gov/bicy/index.htm. 2011.

[113] National Park Service, U.S. Department of the Interior. 2011.

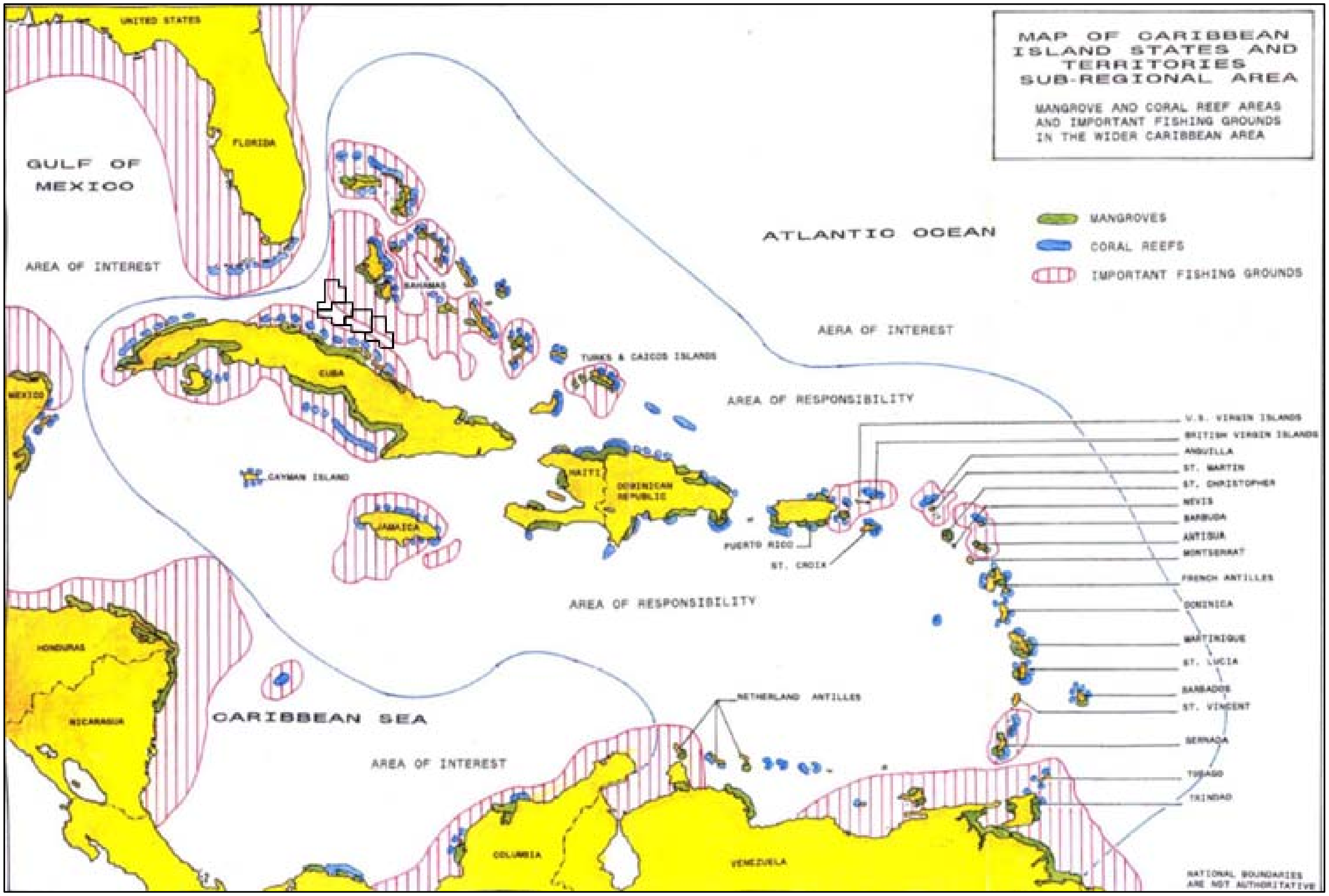

Figure 4-51: Sensitivity Map
Source: UNEP, 2009[114]

[114] United Nations Environment Program (UNEP), Regional Activity Center / Regional Marine Pollution Emergency Information and Training Center- Wider Caribbean Region. 2009. Caribbean Island Oil Pollution Response and Cooperation Plan.

4.5 Data Gaps

To properly evaluate the quality and quantity of existing information and to subsequently identify potential data gaps for the physical/chemical, biological, and socioeconomic environment for the study area, a data evaluation process was conducted. Based on this review, the following data gaps were identified:

- Marine mammal calving areas and migration routes
- Data on leatherback turtles for The Bahamas
- Sea turtle foraging and migration routes, particularly on the west side of Andros
- Specific locations of sub-marine holes in The Bahamas and Cuba

The impact assessment rankings and proposed mitigation measures provided in Chapters 5 and 6 assume that there are marine mammals and endangered sea turtles in the study area. None of these gaps represented a great enough impediment to prevent the EIA team from performing a reasonable evaluation of potential project impacts or proposing appropriate mitigation measures to address the potential impacts identified for the drilling program.

Submarine blue holes in the project area will be identified in the site specific survey report that will be included in the Site Specific Environmental Management Plan.

5. Impact Identification and Evaluation

Chapter 2 of this EIA described the proposed activities to be performed during Bahamas Petroleum Company's exploratory drilling program offshore The Bahamas in the Bain, Cooper, Donaldson and Eneas Blocks. Chapter 4 presented relevant aspects of the existing physical, biological and socioeconomic environment in the study area and specific sensitivities in the area. This chapter considers the potential impacts the proposed activities could have on the existing environment. Specifically, this chapter describes the following:

5.1 Methodology
5.2 Sources of Impact
5.3 Identification of Potential Impacts
5.4 Evaluation of Potential Impacts
5.5 Data Gaps and Uncertainties

In the specific case of this project the following factors should be taken into consideration:

- The project is an exploratory activity;
- Final well locations are still undecided;
- The duration of the drilling activity is temporary (up to 5 months per well); and,
- While the drilling locations are not known, the geographical scope of this EIA is limited to drilling activities located beyond the 300 m bathymetric line, away from mangroves, seagrass beds and coral reefs and no activities are planned closer to shore.

5.1 Methodology

5.1.1 Analysis of Impacts

To identify potential impacts, the EIA team used a methodology that incorporates lessons learned and oil and gas industry best practices from sources such as the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Finance Corporation (IFC). This methodology has been applied consistently by the EIA Team on dozens of oil and gas exploration program EIAs worldwide and is based on a two-tier impact screening process, as shown in Figure 5-1, that:

1) Evaluates all hypothetical impacts for oil & gas projects, then
2) Evaluates potential impacts that are only applicable to the proposed project.

For example, the EIA Team applied the same methodology for:

1. Two exploratory drilling programs offshore Colombia: The projects were adjacent to coral reefs and numerous protected areas offshore Cartagena, a historical city highly dependent on cruise ships and other tourist activity.
2. Exploratory drilling program offshore Kenya: The project was located adjacent to the Kiunga marine protected area, a park that includes a chain of over 50 calcareous offshore islands.
3. Exploratory drilling program offshore Palawan Island, Philippines: The project was located adjacent to pristine coral reef structures in a marine area with contentious uses by indigenous people, mariculture and fishermen. The area is part of the coral triangle and represents key breeding habitat for critically endangered sea turtles.

<u>5.1.1.1 Tier 1 - Evaluation of Hypothetical Impacts</u>

Tier 1 screening evaluation commenced with consideration of a wide range of hypothetical impacts that may be faced by the oil and gas industry in various offshore exploration and production programs. The range of hypothetical impacts considered is based on the experience of the EIA team as well as a variety of oil and gas industry guidelines. Using this list, the Project Team applied a set of simple criteria and/or questions to distinguish possible impacts related to the specific activities proposed from the global list of hypothetical impacts. Criteria-based screening questions used for this first tier screening evaluation were:

- Are there sensitive resources relative to a hypothetical impact present in or around the study area? (For example, are there archaeological resources present?)
- Could the proposed activities reasonably have any influence in altering the present state (positively or negatively, and directly or indirectly) of conditions relative to the hypothetical impact? (For example, could the proposed activities result in any change to socioeconomic conditions in communities along the coast?)
- Could the proposed activities reasonably be impacted by the conditions in the affected environment that may represent hazards? (For example, could severe weather conditions influence the project activities or other possible impact areas, such as increasing a risk of water quality or ecological damage from an oil spill?)

Having evaluated the global list and considered other possible impacts to physical, biological and/or socioeconomic conditions, based on the team's experience in evaluating offshore exploration and production programs, a list of possible impacts was determined. These are reported in Section 5.3.

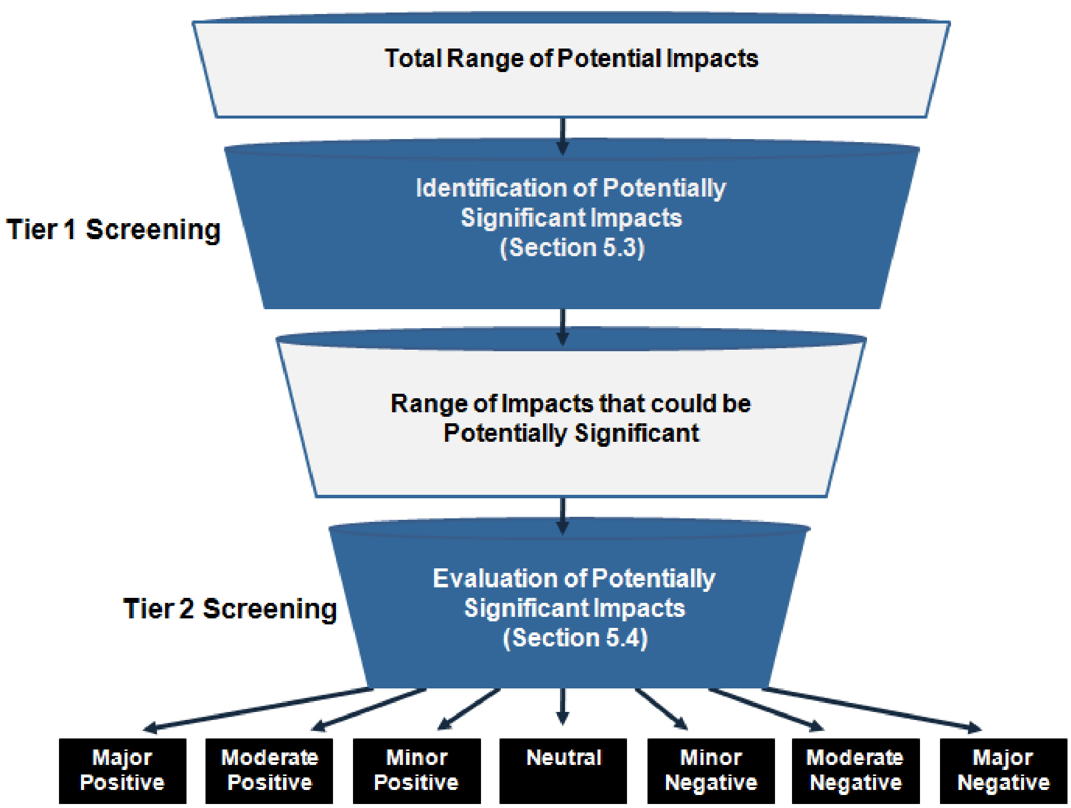

Figure 5-1: Impact Screening Technique Using 2-Tier Significance Criteria

5.1.1.2 Tier 2 - Evaluation of Potential Impacts

Once the Tier 1 screening was complete, a series of more specific (Tier 2) impact significance criteria were used to evaluate the severity and likelihood of the possible impacts and to characterize them in terms of the type of impacts expected. This Tier 2 evaluation took into consideration:

- Nature of the impact: an evaluation of the interaction with the impacted receptor (evaluation described for each impact in Section 5.4)
- Intensity: an evaluation of the reversibility of the impact
  - Reversible impacts are temporary and the affected resource (i.e. marine fauna, water quality, etc.) is expected to return to pre-impact conditions within three to five years
  - Irreversible impacts have permanent affects (i.e. destruction of submerged archaeological resources) that will not return to pre-impact conditions for an extended period of time (>five years), if ever
- Scope: an evaluation of the physical extent of the impact
  - Localized impacts are limited to a small, defined area (i.e. generally within 1 kilometer of the drill site or supply vessel)
  - Dispersed impacts affect widespread areas, the extent of which are potentially unknown (i.e. in the event of a large oil spill)
- Duration: an evaluation of the length of the impact
  - Short-term impacts are either non-continuous or last up to approximately four to six months
  - Medium-term impacts last approximately six months to approximately one or two years
  - Long-term impacts last longer than two years
- Likelihood: an evaluation of how probable the impact is for the proposed activities (likelihood criteria are defined in Table 5-2)

Based on an evaluation of the nature, intensity, scope and duration of impact, an overall consequence level was assigned. Significance criteria used to evaluate the possible impacts in Tier 2 are listed in Table 5-1, and criteria used to rate the likelihood of those impacts occurring in this project are presented in Table 5-2.

The evaluation of potential impacts is reported in Section 5.4, including a discussion of the potential cumulative and transboundary impacts.

Table 5-1: Impact Significance Criteria

Consequence Level	Significance Criteria
Major (3)	Widespread modification of extraordinary severity in seabed or marine life forms or economic resources (e.g., fishing), lasting more than one year
Moderate (2)	Local modification of measurable severity in seabed forms or marine life forms or economic resources, lasting from a few months to up to one year before recovery; or more widespread modification of lesser severity.
Minor (1)	Localized, relatively isolated change in physical environment or economic resources, lasting only a few days to a few months before recovery, with no observable residual effects; impacts less significant than exerted by nature.
Negligible (0)	Little or no change in physical environment, conditions consistent with background conditions.

Table 5-2: Impact Likelihood Criteria

Likelihood Level	Significance Criteria
Probable (3)	Impact or event can reasonably be expected to result from project, occurs routinely in similar operations.
Occasional (2)	The impact or event has occurred in similar operations in this country/ region, or conditions could allow the impact/event to occur in the program.
Seldom (1)	The impact or event has occurred once or twice in the industry (worldwide), but conditions in this program are unlikely to allow the impact/event to occur.
Improbable (0)	The impact or event has never before occurred.

Using a standard, semi-quantitative assessment technique, the team applied a matrix to rate the overall impact significance by comparing the severity ranking with the likelihood ranking. This matrix is presented in Figure 5-2. This methodology allows the partitioning of the potential impacts by impact categories: high, medium and low. These categorizations facilitate the identification of the proposed activities that are likely to generate significant impact and the environmental elements that could be most affected. As shown in Figure 5-2, each impact category has distinct environmental management requirements, with:

- High: requiring alternative approach/design and mitigation to minimize potential impacts;
- Medium: requiring mitigation; and
- Low: requiring no mitigation other than common safeguards, but acknowledging that the Project Team still needs to proceed with care.

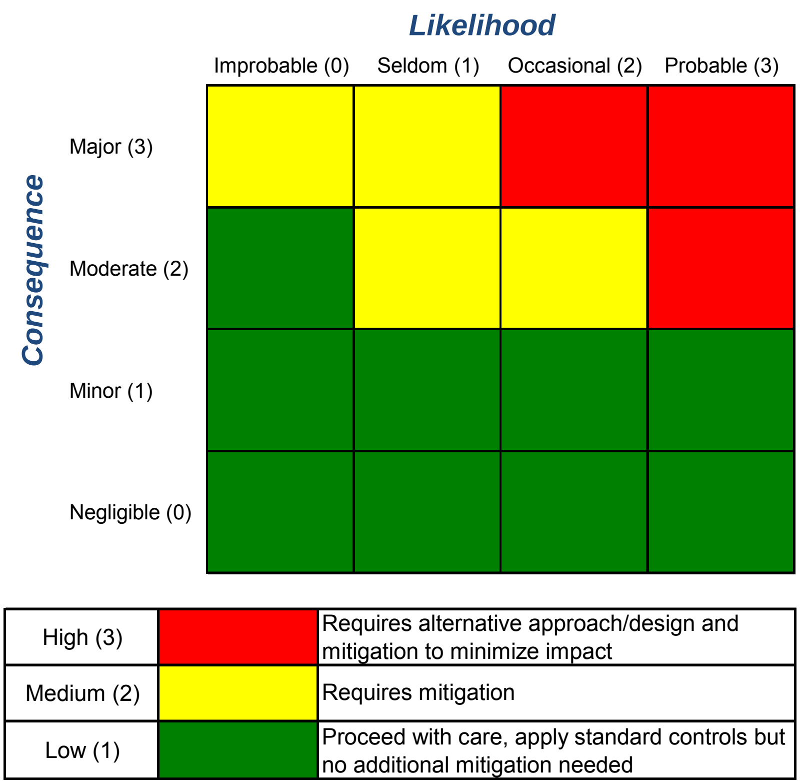

Figure 5-2: Impact Evaluation Matrix

Results of the Tier 2 impact evaluation are presented in Section 5.4 and environmental management and mitigation requirements are detailed in Chapter 6.

5.2 Sources of Impact

Chapter 2 described the activities proposed as part of the exploratory drilling program. These activities are defined according to the following phases of the program:

1. Mobilization and Rigging-up
2. Drilling
3. Appraisal (if needed)
4. Decommissioning and Abandonment

In addition, there are activities that occur in each of the above phases that can be discussed together for the purposes of evaluating potential impacts. For example, the generation, grinding, and discharge of food waste will occur throughout all Project phases. These types of activities are categorized and discussed in Phases 5 and 6, rather than being repeated throughout all phases. Phases 5 and 6 are:

5. Vessel operations
6. Ancillary activities (aspects of the design and preoperational phases that could cause potential impacts, such as purchasing goods and services)

Analysis of the work proposed in each of these program elements reveals specific activities that could result in impacts. These activities, referred to as potential “sources of impact” (also known as “aspects” or “factors”), are highlighted in Sections 5.2.1 – 5.2.6 below.

Please refer to Chapter 2 for a detailed description of all proposed activities.

5.2.1 Mobilization and Rigging-up (Phase 1)

Potential sources of impact identified in this phase are:

A. Loading fuel and other materials onto the drilling rig
B. Attaching transponders and/or anchors to the sea floor[1]

Additionally, there are recurrent activities listed under “Vessel Operations” and “Ancillary Activities” below.

5.2.2 Drilling (Phase 2)

Potential sources of impact identified in this phase are:

A. Operation of the drilling rig
B. Storage and use of potentially hazardous materials
C. Use and consumption of natural resources (fuel, sea water, fresh water, etc.)
D. Penetration of and drilling through the seafloor
E. Generation and disposal of drill cuttings
F. Generation of air emissions
G. Generation of noise
H. Generation of vibration
I. Generation of light source
J. Physical presence of, and exclusion zone around, the drilling rig
K. Generation, storage, and disposal of drilling fluids

[1] During the rig selection process, Bahamas Petroleum Company will give preference to those that do not require anchors.

L. Generation, treatment and discharge of drilling related wastewater

Additionally, there are recurrent activities listed under “Vessel Operations” and “Ancillary Activities” below.

5.2.3 Appraisal (Phase 3)

Potential sources of impact identified in this phase are:

A. Generation of air emissions
B. Generation, treatment and disposal of formation fluids
C. Use of hazardous liquids

Additionally, there are recurrent activities listed under “Vessel Operations” and “Ancillary Activities” below.

5.2.4 Decommissioning and Abandonment (Phase 4)

Potential sources of impact identified in this phase are:

A. Well suspension or abandonment
B. Loading fuel and other materials used in the drilling rig
C. Removing transponders and/or anchors from the sea floor

Additionally, there are recurrent activities listed under “Vessel Operations” and “Ancillary Activities” below.

5.2.5 Vessel Operations (Phase 5)

Potential sources of impact identified in association with this category are:

A. Movement of support vessels and drilling rig
B. Storing fuel and other hazardous liquids on vessels, and refueling operations
C. Generation, storage, transport and disposal of solid waste
D. Generation, grinding, and discharge of food waste
E. Generation, treatment and discharge of wastewater
F. Generation of air emissions
G. Generation of noise

Additionally, there are recurrent activities listed under “Ancillary Activities” below.

5.2.6 Ancillary Activities (Phase 6)

Potential sources of impact identified in association with this category are:

A. Demand for public services
B. Purchasing goods and services to support the program
C. Presence of oil and gas drilling in-country
D. Use of foreign workers

5.3 Identification of Potential Impacts

As noted in Section 5.1, the EIA team used Tier 1 screening criteria to identify the possible impacts of proposed activities described in Chapter 2. To do so, the team considered the possible effects of each potential source of impact identified in Section 5.2 on the baseline environmental and socioeconomic conditions of the affected environment as described in Chapter 4.

The results of this screening revealed an inventory of possible impacts affecting various aspects of the physical, biotic, and social environment. Table 5-3 presents those impacts that have passed the Tier 1 screening as possible impacts that could result from the project activities (impact sources described above in Sections 5.2.1 – 5.2.6).

The impacts numbering system in Table 5-3 is set up to assign a unique identifier to each impact. Using the first impact listed as an example, impact 1A1 may be interpreted as follows:

- First number (1) = project phase (i.e. mobilization and rigging-up, drilling, etc.)
- First letter (A) = source of potential impact; letters are added sequentially with the addition of sources
- Second number (1) = potential impact; number increases sequentially when there is more than one potential impact associated with the same source (i.e. "loading and storing fuel and other materials used in rigging the drilling rig" might potentially generate two impacts, numbered "1A1" and "1A2")

In Table 5-3, each potential impact has also been assigned an impact consequence and likelihood "score" or rating according to the Tier 2 screening, and based on these score a significance ranking has been assigned according to Figure 5-2. The ranking methodology and evaluation of potential impacts are discussed in Section 5.4. All potential impacts with a medium significance ranking (no impacts were ranked high) will require mitigation to minimize potential impacts. Mitigation measures for each medium level impact in Table 5-3 are discussed in Chapter 6.

Table 5-3: Identification and Evaluation of Potential Impacts

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Duration	Overall Consequence Level and Score	Likelihood Level and Score	Significance
Mobilization and Rigging-up (Phase 1)										
1A1	Loading fuel and other materials onto the drilling rig	Marine water quality	Degradation of water quality from an accidental spill of fuel or other hazardous materials	5.4.1.1	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
1A2	Loading fuel and other materials onto the drilling rig	Marine fauna	Potential mortalities or oiling of marine fauna (fish, plankton, mammals, sea birds, or sea turtles) as a result of an accidental fuel or other material spill	5.4.1.2	Reversible (at the habitat level)	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
1B1	Attaching transponders and/or anchors to the sea floor	Marine fauna	Damage to potentially sensitive benthic organisms and their habitat from attaching transponders and/or anchors to the sea floor	5.4.1.2	Reversible	Localized	Medium-term	**Minor (1)**	**Seldom (1)**	**Low**
1B2	Attaching transponders and/or anchors to the sea floor	Submerged Archaeological Resources	Potential damage to archeological resources resulting from attaching transponders and/or anchors to the sea floor	5.4.1.3	Irreversible	Localized	Long-term	**Moderate (2)**	**Improbable (0)**	**Low**
1B3	Attaching transponders and/or anchors to the sea floor	Marine water quality	Potential degradation of water quality resulting from sediment disruption from attaching transponders and/or anchors to the sea floor	5.4.1.1	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
1B4	Attaching transponders and/or anchors to the sea floor	Sediments	Disruption of sea floor sediments from attaching transponders and/or anchors to the sea floor	5.4.1.4	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
See also Vessel Operations (Phase 5) and Ancillary Activities (Phase 6)										

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
Drilling (Phase 2)										
2A1	Operation of the drilling rig	Marine water quality	Degradation of marine water quality due to potential accidental oil spill (loss of well control)	5.4.2.1	Reversible	Dispersed	Medium -term	**Major (3)**	**Seldom (1)**	**Medium**
2A2	Operation of the drilling rig	Marine fauna	Potential accidental oiling and/or mortality of marine fauna resulting from an oil spill (loss of well control)	5.4.2.3	Reversible (at habitat level)	Dispersed	Medium -term	**Major (3)**	**Seldom (1)**	**Medium**
2A3	Operation of the drilling rig	Sensitive shoreline features	Potential accidental oil spill reaching shoreline fouling habitat (loss of well control)	5.4.2.4	Reversible	Dispersed	Medium to long-term	**Major (3)**	**Seldom (1)**	**Medium**
2A4	Operation of the drilling rig	Seafloor sediments	Degradation of seafloor sediments from accidental oil spill (accumulation on the sea floor)	5.4.2.6	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
2A5	Operation of the drilling rig	Local economy / communities	Potential accidental oil spill impacting fish or reaching fishing areas and/or tourism areas, limiting income of the local communities (loss of well control)	5.4.2.8	Reversible	Dispersed	Medium -term	**Major (3)**	**Seldom (1)**	**Medium**
2A6	Operation of the drilling rig	Submerged Archaeologic-al Resources	Potential damage to submerged archaeological resources (e.g., possible shipwrecks) near well site	5.4.2.9	Irreversible	Localized	Long-term	**Moderate (2)**	**Improbable (0)**	**Low**
2A7	Operation of the drilling rig	Local economy / communities	Potential damage to subsea telecommunications infrastructure	5.4.2.8	Reversible	Dispersed	Medium -term	**Major (3)**	**Improbable (0)**	**Medium**

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
2B1	Storage and use of potentially hazardous materials	Marine water quality	Degradation of water quality from accidental spill of potentially hazardous materials	5.4.2.1	Reversible	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
2B2	Storage and use of potentially hazardous materials	Marine fauna	Degradation harm to marine fauna as a result of accidental release or spill of fuel or other hazardous materials	5.4.2.3	Reversible (at the habitat level)	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
2C1	Use and consumption of natural resources	Environment	Extraction and use of natural resources	5.4.2.10	Reversible	Localized	Short-Term	**Negligible (0)**	**Probable (3)**	**Low**
2D1	Penetration of and drilling through the seafloor	Benthos	Disruption of sediments surrounding location of drill bit	5.4.2.6	Reversible	Localized	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
2E1	Generation and disposal of drill cuttings	Sea floor sediments	Degradation of the quality of seafloor sediments from discharge of drill cuttings	5.4.2.5	Irreversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2E2	Generation and disposal of drill cuttings	Marine water quality	Degradation of marine water quality from discharge drill cuttings	5.4.2.2	Reversible	Dispersed	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2E3	Generation and disposal of drill cuttings	Benthos	Degradation of benthic habitat resulting from discharge of drill cuttings and physical smothering.	5.4.2.5	Reversible	Dispersed	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2F1	Generation of air emissions	Air quality	Degradation of air quality from combustion fuels used in mechanized equipment needed to support drilling	5.4.2.7	Reversible	Dispersed	Short-term	**Minor (1)**	**Probable (3)**	**Low**

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
2G1	Generation of noise	Marine fauna	Potential disruption to marine fauna (esp. marine mammal) behavior due to generation of noise (both above sea level and sub-marine noise)	5.4.2.3	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	Low
2H1	Generation of vibration	Marine fauna	Disruption of marine fauna (esp. benthos) from vibration caused by drilling and associated activities	5.4.2.3	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	Low
2I1	Generation of light source	Marine fauna	Potential disruption to marine fauna (esp. sea turtle) behavior due to lighting	5.4.2.3	Reversible	Dispersed	Short-term	**Minor (1)**	**Occasional (2)**	Low
2I2	Generation of light source	Local economy	Potential aesthetic impact of rig due to lighting	5.4.2.8	Reversible	Dispersed	Medium -term	**Negligible (0)**	**Occasional (2)**	Low
2J1	Physical presence of, and safety zone around, the drilling rig	Local economy	Potential disruption of fishing (industrial and artisanal) and shipping activities resulting from avoidance of the drilling rig from the safety zone	5.4.2.8	Reversible	Localized	Medium -term	**Minor (1)**	**Probable (3)**	Low
2K1	Generation, storage, and disposal drilling fluids	Marine water quality	Degradation of marine water quality from discharge of drilling fluids	5.4.2.2	Reversible	Dispersed	Short-term	**Minor (1)**	**Probable (3)**	Low
2L1	Generation, treatment and discharge of drilling related wastewater	Marine water quality	Potential degradation of marine water quality from liquid wastes (i.e. deck drainage and bilge water) discharged at sea	5.4.2.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	Low

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
2L2	Generation, treatment and discharge of drilling related wastewater	Marine Fauna	Potential harm to marine fauna from operational discharges	5.4.2.3	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
See also Vessel Operations (Phase 5) and Ancillary Activities (Phase 6)										
Appraisal (Phase 3)										
3A1	Generation of air emissions	Air quality	Generation of light, noise, heat, smoke and greenhouse gasses from flaring	5.4.3.1	Reversible	Dispersed	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
3A2	Generation of air emissions	Local communities	Generation of air emissions from flaring impacting local communities	5.4.3.1	Reversible	Dispersed	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
3B1	Generation, treatment and disposal of formation fluids	Marine water quality	Potential degradation of marine water quality from discharge of treated produced water to the ocean	5.4.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
3B2	Generation, treatment and disposal of formation fluids	Marine water quality	Potential degradation of marine water quality from flaring fallout (un-combusted materials)	5.4.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
3B3	Generation, treatment and disposal of formation fluids	Marine Fauna	Potential harm to marine fauna from discharge of produced water and fallout from un-combusted materials during flaring	5.4.3.3	Reversible	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
3C1	Use of hazardous liquids	Marine water Quality	Potential Degradation of marine water quality from spill of completion chemicals	5.4.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Improbable (0)**	**Low**
See also Vessel Operations (Phase 5) and Ancillary Activities (Phase 6)										

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Duration	Overall Consequence Level and Score	Likelihood Level and Score	Significance
Decommissioning and Abandonment (Phase 4)										
4A1	Well suspension or abandonment	Sediments	Disruption of sea floor sediments during well plugging and abandoning operations	5.4.4.1	Reversible	Localized	Short-term	**Negligible (0)**	**Probable (3)**	**Low**
4A2	Well suspension or abandonment	Marine water quality	Potential degradation of water quality resulting from accidental release of formation fluids into the marine environment	5.4.4.2	Reversible	Dispersed	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
4A3	Well suspension or abandonment	Marine fauna	Potential disruption of benthic species during well suspension and abandonment operations	5.4.4.3	Reversible (at the habitat level)	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
4B1	Loading fuel and other materials used in the drilling rig	Marine water quality	Degradation of water quality from accidental spill of fuel or other hazardous materials	5.4.4.2	Reversible	Dispersed	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
4B2	Loading fuel and other materials used in the drilling rig	Marine fauna	Potential mortalities or oiling of marine fauna (fish, plankton, mammals sea birds, or sea turtles) as a result of an accidental fuel or other material spill	5.4.4.3	Reversible (at the habitat level)	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
4C1	Removing transponders and/or anchors from the sea floor	Sediments	Disruption of sea floor sediments during removal of transponders and/or anchors	5.4.4.1	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
4C2	Removing transponders and/or anchors from the sea floor	Marine water quality	Potential degradation of water quality resulting from sediment disruption during removal of transponders and/or anchors	5.4.4.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
4C3	Removing transponders and/or anchors from the sea floor	Marine fauna	Damage to benthic organisms and their habitat from removal of transponders and/or anchors	5.4.4.3	Reversible (at the habitat level)	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
See also Vessel Operations (Phase 5) and Ancillary Activities (Phase 6)										
Vessel Operations (Phase 5)										
5A1	Movement of support vessels and drilling rig	Marine water quality	Potential degradation of marine water quality due to an accidental fuel or other materials spill.	5.4.5.1	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
5A2	Movement of support vessels and drilling rig	Marine fauna	Potential harm to marine fauna (fish, plankton, mammals, sea birds, or sea turtles) as a result of an accidental fuel or other material spill	5.4.5.3	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
5A3	Movement of support vessels and drilling rig	Marine fauna	Potential damage to marine fauna from contact with hull or propeller (esp. sea turtles)	5.4.5.3	Reversible	Localized	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
5A4	Movement of support vessels and drilling rig	Sensitive shoreline features (estuaries, beaches, lagoons)	Potential degradation of sensitive coastal feature habitat due to an accidental fuel or other material spill	5.4.5.4	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
5A5	Movement of support vessels and drilling rig	Local economy / communities	Potential accidental oil spill impacting fish and potentially reaching and fouling fishing/mariculture areas (vessel fuel tank rupture at sea)	5.4.5.4	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Dura-tion	Overall Consequ-ence Level and Score	Likelihood Level and Score	Signifi-cance
5A6	Movement of support vessels and drilling rig	Local economy / communities	Potential disruption of fishing activities (industrial and artisanal) and shipping routes resulting from increased marine traffic and movement of vessels of "limited maneuverability"	5.4.5.7	Reversible	Dispersed	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
5B1	Storing fuel and other hazardous liquids on vessels, and refueling operations	Marine water quality	Potential degradation of water quality due to accidental spill of fuel or other materials at the drill site or at port	5.4.5.1	Reversible	Dispersed	Medium -term	**Moderate (2)**	**Seldom (1)**	**Medium**
5C1	Generation, storage, transport and disposal of solid waste	Marine water quality	Potential degradation of water quality due to accidental release of solid waste to the marine environment	5.4.5.1	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
5D1	Generation, grinding and discharge of food waste	Marine water quality	Potential degradation of marine water quality in the immediate vicinity around pipe discharge point	5.4.5.2	Reversible	Localized	Short-term	**Negligible (0)**	**Probable (3)**	**Low**
5E1	Generation, treatment and discharge of wastewater	Marine water quality	Potential degradation of marine water quality from liquid wastes (grey water, deck drainage, etc.) discharged at sea	5.4.5.2	Reversible	Localized	Short-term	**Negligible (0)**	**Probable (3)**	**Low**
5F1	Generation of air emissions	Air quality	Degradation of local air quality due to the emission of exhausts from combustion engines (program vessels and machinery) and cumulative addition to global greenhouse gas levels	5.4.5.5	Reversible	Dispersed	Short-term	**Minor (1)**	**Probable (3)**	**Low**

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	See Section	Intensity	Scope	Duration	Overall Consequence Level and Score	Likelihood Level and Score	Significance
5G1	Generation of noise	Local communities	Disruption of local community lifestyles from generation of noise from passing helicopters	5.4.5.6	Reversible	Localized	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
5G2	Generation of noise	Marine Fauna	Potential disruption to marine fauna (esp. marine mammal) behavior due to generation of noise from supply vessel movement	5.4.2.3	Reversible	Dispersed	Short-term	**Minor (1)**	**Probable (3)**	**Low**
See also Ancillary Activities (Phase 6)										
Ancillary Activities (Phase 6)										
6A1	Demand for public services	Local economy / communities	Potential strain to agencies from oversight of project	5.4.6.1	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
6B1	Purchasing goods and services to support the program	Local economy / communities	Potential benefit to employment and economy	5.4.6.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
6C1	Presence of oil and gas drilling in country	Local economy/ communities	Detailed knowledge about the environment	5.4.6.2	Irreversible	Dispersed	Long-term	**Minor (1)**	**Probable (3)**	**Low**
6D1	Use of foreign workers	Local economy / communities	Potential social conflicts due to the presence of foreign workers	5.4.6.3	Reversible	Dispersed	Short-term	**Negligible (0)**	**Occasional (2)**	**Low**
6D2	Use of foreign workers	Local economy / communities	Potential public health impacts from introduction of foreign employees	5.4.6.4	Reversible (at the population level)	Dispersed	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**

5.4 Evaluation of Potential Impacts

The possible impacts addressed in Section 5.3 were identified through the Tier 1 screening criteria described in Section 5.1.1. Tier 2 criteria were then used to evaluate and categorize the possible impacts. This evaluation resulted in assigning a "score" or rating of impact consequence (negligible, minor, moderate, major) and likelihood (improbable, seldom, occasional, probable) in order to define the overall impact significance rating (low, medium, or high). Impacts were also characterized in terms of other qualifying criteria, including:

- Positive or negative
- Reversible or irreversible
- Localized or dispersed
- Short or long term

Any impacts rated as low are considered acceptable and do not require mitigation beyond the operational and environmental controls that are already part of the standard methods used in performing offshore drilling programs.

5.4.1 Mobilization and Rigging-up

Impacts of mobilization and rigging-up are described below. Most of the potential impacts are related to:

- Loading/unloading of materials needed to support the drilling operations such as fuel, drilling fluids and other supplies that could damage marine resources
- Attaching transponders and/or anchors to the sea floor if an anchored rig is utilized.

Given that any spill of hazardous liquids during this stage of the process would be limited to small volumes, the potential impacts to various marine resources are generally rated as low. This rating is further supported by the fact that support vessels will be present with the capability to respond quickly in the event of a spill. If uncontrolled, even a small to medium spill could degrade marine water quality and potentially harm flora and fauna in the area covered by the spill. These considerations have been taken into account in the establishment of consequence and likelihood ratings.

5.4.1.1 Potential Degradation of Marine Water Quality

Potential Impact from Accidental Spill of Fuel or Other Hazardous Material (1A1) – As stated above, the potential to damage marine water quality during the mobilization phase would occur from uncontrolled releases of hazardous liquids (e.g., spills of fuel or hazardous materials or wastes) while loading materials (especially bunkering of fuel oil to the drilling rig or handling of oil / drilling fluid additive drums).

A study of chemical spills of offshore oil and gas activities by Boehm et al. reviewed the types and volumes of chemicals used in United States Gulf of Mexico outer continental Shelf[2]. The study determined that while a number of these chemicals exhibit hazardous characteristics, such as corrosivity or toxicity, two chemicals in particular could potentially impact the marine

[2] Boehm, P., D. Turton, A. Raval, D. Caudle, D. French, N. Rabalais, R. Spies, and J. Johnson. 2001. Deepwater Program: Literature Review, Environmental Risks of Chemical Products Used in Gulf of Mexico Deepwater Oil and Gas Operations; Volume I: Technical Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-011. 326 pp.

environment if spilled - zinc bromide and ammonium chloride. Most other chemicals are either nontoxic or used in small quantities. Zinc bromide and ammonium chloride are both used for well treatment or completion and therefore are needed at the drill site for only a short period of time. Thus, the risk of a spill for these chemicals is very small. Further, Bahamas Petroleum Company will strive to use only environmentally friendly fluids. Initial assessments suggest it should be possible to avoid the use of "heavy brines" (i.e. zinc bromide and ammonium chloride) as the reservoir is not expected to be under high pressure. However, impact likelihood rankings were assigned using the "Precautionary Principle" and do not take this into consideration (i.e. likelihood rankings assume use of heavy brines is possible). The consequence of this impact is at most moderate and the likelihood is seldom, so the impact rating is **medium**, requiring mitigation to manage the risk (C = 2, L = 1, and thus I = medium). In each of these cases, the resulting water quality impacts would be negative, direct, localized, reversible and short-term.

Potential Degradation of Marine Water Quality from Disruption of Seafloor Sediments (1B3) – Securing the drilling rig will require attaching transponders and/or anchors to the sea floor. Disturbance of sediments is less with transponders, and Bahamas Petroleum Company will give preference to rigs utilizing dynamic positioning (no anchors would be required). This will cause a temporary disruption of sediments that will suspend in the water column near the sea floor. The consequence of this activity could have a minor impact to water quality as the sediments would quickly settle. The likelihood of this would be probable. The overall impact is **low** (C = 1, L = 3, and thus I = low). This impact would be negative, direct, reversible, localized and short-term.

5.4.1.2 Potential Harm to Marine Fauna

Impacts to Marine Fauna in phase 1 relate to the potential degradation of marine quality resulting from the spill of fuel or other hazardous materials, as well as attaching transponders and/or anchors to the sea floor. Specifically, these include:

- Potential impact to fish from degradation of marine quality
- Potential impact to plankton from degradation of marine quality
- Potential impact to marine mammals and sea turtles from degradation of marine quality
- Potential impact to birds from degradation of marine quality
- Potential impact to sensitive benthic organisms from placement of transponders and/or anchors on the sea floor

Potential Impact to Fish (1A2) - Impacts to fish would be limited to the potential disruption of habitat as a result of an accidental release of oil or other hazardous liquid to the marine environment. As noted by IPIECA, "Wild fish swim away from oil spills and long-term effects on local populations are avoided. However, fish moving back into an area following a spill may take some time to recover".[3] A spill during phase 1 would likely be small and response capabilities would be present to manage a potential spill. Therefore, this potential impact would be negative, direct, localized, reversible (at the habitat level) and short term. The possibility of fish coming in contact with a spill during this phase would be seldom and the consequence would be minor, therefore the impact rating assigned is **low** (C = 1, L = 1, and thus I = low).

Potential Impact to Plankton (1A2) – The potential impacts to plankton from rigging-up and mobilization activities are similar to those as described above for fish. The only difference is that certain species of plankton inhabit the water surface and would be unable to avoid contact with

[3] International Petroleum Industry Environmental Conservation Association (IPIECA). 2008. Oil Spill Preparedness and Response: Report Series Summary 1990-2008. Retrieved from the IPIECA Website: http://www.ipieca.org .

any oil or hazardous liquid accidently spilled. This potential impact would be localized, reversible (at the habitat level) and short term. Given the ability of crew to contain small spills and the abundance of plankton throughout the marine environment the consequence of a small spill would be minor and the likelihood would be seldom, resulting in a rating of **low** (C = 1, L = 1, and thus I = low). This potential impact would be negative, direct, localized, reversible (at the habitat level) and short term.

Potential Impact to Marine Mammals and Sea Turtles (1A2) – Potential impacts of the mobilization activities to marine mammals and sea turtles are considered unlikely. Like fish, whales, dolphins and sea turtles are highly mobile and likely to avoid drill sites because of the noises generated (see Section 5.4.5.6). The likelihood that there would be an oil spill or significant water quality degradation and that these species would surface in the area of such an impact is extremely low. The impact on marine mammals and/or sea turtles as a result of mobilization activities would be negative, direct, localized, reversible (at the habitat level) and medium term (given the reproductive rates of these species). The potential impact of an accidental spill or leak contacting a marine mammal or sea turtle would be minor, the likelihood of this scenario occurring is seldom, resulting in a **low** impact (C = 1, L = 1, and thus I = low).

Potential Impact to Birds (1A2) – Potential impacts of the mobilization activities to birds are considered unlikely. As with marine mammals above, the likelihood that there would be an oil spill during mobilization and that sea birds would come into contact with such a spill is low. Any impact to birds as a result of mobilization activities would be negative, direct, localized, reversible (on the habitat level) and short term (given the reproductive rates of these species). The potential impact of an accidental spill or leak contacting a bird would be minor, the likelihood of this scenario occurring is seldom, resulting in a **low** impact (C = 1, L = 1, and thus I = low).

Potential Impact to Benthic Organisms (1B1) – During mobilization, deep water benthic communities are more likely to be impacted if a moored drilling rig is used. Should a dynamically positioned rig be used, the impacts on deepwater benthic communities will be negligible as only the transponders (rather than anchors) will have contact with the seafloor.

Benthic organisms may be smothered or disrupted by attaching transponders and/or anchors to the seafloor, resulting in a very localized and reversible impact on benthic communities in the study area. Impacts from attaching transponders to the sea floor would be minimal, although scouring of the sea floor from anchoring could have a more significant impact (i.e. scour up to 30 m per anchor[4]). The presence of potentially sensitive benthic organisms such as deep sea corals or chemosynthetic organisms in the study area is unknown. A survey of the sea floor at each well site will be conducted as a standard control measure to ensure that the spud location can be adjusted to avoid any sensitive features or subsea hazards. The consequence of placing anchors and/or transponders on the seafloor is expected to have minor impact to benthos and seldom likelihood. The overall impact is **low** (C = 1, L = 1, and thus I = low) and would be negative, direct, reversible and medium-term.

5.4.1.3 Potential Disruption of Submerged Archaeological Resources (1B2)

Attachment of transponders and/or anchors to the seafloor near the drill site during mobilization and rigging-up could possibly disrupt any shipwrecks or other submerged archaeological

[4] Hudson, J.H., Shinn, E.A, and D.M. Robbin. 1982. Effects of Offshore Oil Drilling on Philippine Reef Corals. Bulletin of Marine Science, 32(4):890-908, 1982.

resources that might exist in this area. A survey of the sea floor at each well site will be conducted as a standard control measure to ensure the spud location can be adjusted to avoid any shipwrecks or other submerged archaeological resources that might exist in this area. The likelihood that one might be located in or near the exact locations in which transponders and/or anchors are placed is very low. The level of damage that might be caused to such a resource could be moderate, but the likelihood is improbable and therefore the overall impact rating is **low** (C = 2, L = 0, thus I = low). This impact would be negative, direct, irreversible and long-term.

5.4.1.4 Potential Disruption of Seafloor Sediments (1B4)
Securing the drilling rig will require attaching transponders and/or anchors to the sea floor. This will cause a temporary and minor disruption of sediments in the immediate area around the anchor/transponder point. This potential impact would be negative, direct, localized, reversible and short-term. The consequences of these impacts is expected to be minor with a probable likelihood, leading to a **low** impact rating (C = 1, L = 3, and thus I = low).

5.4.2 Drilling

Potential impacts of the drilling phase are evaluated below. The most significant (based on the combination of likelihood and consequence) are those related to:

- An accidental spill of oil, drilling fluid or other hazardous fluids (especially loss of well control) considering both the physical and social environment
- The discharge of drill cuttings
- The social impacts associated with noise and potential disruption of fishing and marine traffic

Given that standard controls will be in place, none of the identified potential impacts were ranked as high - all are either low or medium. Regardless, certain impact mitigation actions should be taken and integrated into the exploratory drilling program to mitigate and minimize these impacts to the lowest practicable levels.

The most significant potential environmental impacts from offshore drilling operations are typically those associated with accidental events such as oil spills, particularly large spills from a loss of well control or blowout. Blowouts occur when drilling penetrates gas/oil/water pockets that are under such high pressure that the back-pressure of the escaping gas overpowers and ruptures well control equipment, resulting in the free flow of oil and gas from the reservoir, through the well to the surface, until the well is brought back under control. Personnel are trained to recognize signs of high pressures and measures are in place to control unexpected pressures during drilling in order to prevent blowouts. Everyone from the level of Derrickman and above on the rig must undergo training (typically a 1 week intensive course) and certification in “Well Control”. - This includes the onshore engineering and supervisory team. Each has to have certification resulting from a mandatory exam every 2 years known as the IWCF (International Well Control Forum). Pass mark for the exam is at least 85%. Persons without the certification or who fail renewals are not allowed to work in a position of significance relating to the drilling operation. Blowouts occurring in offshore well drilling are very rare, but they do occur when there are simultaneous failures of the many technical and operational procedure/training controls in place. Other causes of well control loss are external, for example storms, ship collisions, fires or earthquakes. Potential impacts can range from minor to major depending on the magnitude of the blowout and location of the rig.

The rate of blowouts in the oil and gas industry is very low (0.0048 blowouts per well drilled offshore in the US Outer Continental Shelf between 1996-2009) because of the common use of blowout preventers (BOPs) and rigorous health and safety standards, policies and procedures that are focused on incident prevention.[5] Further, the probability of a blow-out in The Bahamas is expected to be less as the well characteristics are different (reservoirs are expected to be under less pressure in the Bahamas compared to the Gulf of Mexico). While it can never be guaranteed until the actual structure itself is drilled, good indications can be inferred from historical data. Study of the previous wells drilled in The Bahamas near the proposed well site suggest that the reservoirs could be at such a low pressure that reservoir fluids may need to be pumped from the reservoir to the surface using a downhole pump. This means that oil or other liquids may be too heavy and therefore not be able to flow to the surface (although if gas is present it will) reducing the probability of a blowout. While the reservoir pressure is expected to be below what is normally found in the Gulf of Mexico, impact likelihood rankings were assigned using the "Precautionary Principle" and do not take this into consideration (i.e. the likelihood rankings related to blowouts are the same as in a high-pressure environment). Despite the fact that blowouts resulting in spills are rare events, should they occur, they would likely result in environmental and social consequences.

The evaluation rankings for impacts relating to potential oil spills are based on oil spill trajectory models conducted for the preliminary well site. Bahamas Petroleum Company contracted The University of Miami, Rosentiel School of Marine and Atmospheric Science (RSMAS) to perform oil spill modeling. The complete report, titled "*Transport and Fate of Oil Particles Released in The Bahamas*"[6] is included as Appendix A. The report describes the oil and spill characteristics used in the modeling (such as oil composition, release characteristics, oceanographic conditions, location of spill, etc.) and expected interactions of oil spilled to the marine environment, including differences between a surface and seabed release.

The University of Miami/RSMAS oil spill module is an application of the Connectivity Modeling System (CMS) that produces probabilistic simulations of particle dispersion in the ocean over multiple scales. For the study of transport and fate of oil particles, the CMS couples and merges three components:

1. A Geographic Information System (GIS) module (representing coastal marine and land habitat and used to record landfall of oil particles on the shoreline or deposited on the coral reefs).
2. The hydrodynamic model (describes the physical environment in which oil particles evolve)
3. The oil module (simulates the geochemical processes directly affecting oil particles)

The GIS module includes unique details for this study area, based on extensive previous studies; it provides an effective means for quantifying the impact of possible oil particle landings on specific locations of the sensitive coastal habitat (including Marine Protected Areas between 25 and 175 miles away), at any selected scale. The hydrodynamic models provide estimates of the currents, which move the oil particles, but they also provide density fields (temperature and

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[5] Abbot, J. Measuring OCS Performance. US Department of Interior (DOI), Bureau of Ocean Energy Management, Regulation and Enforcement. Retrieved from the DOI Website: http://www.boemre.gov/perfmeas/index.htm

[6] Kourafalou, V., Paris, C., Kang, H. and M. Le Henaff. 2011. Transport and Fate of Water Particles Released in The Bahamas (Unpublished). Bahamas Petroleum Company Final Report September 2011. Miami, Florida.

salinity), which affect the oil buoyancy in the water column, as well as the oil degradation process. The oil spill module describes the chemical properties and behavior of the crude oil in seawater, including evaporation and biodegradation. Individual particles are described by a droplet size value, and a density value. Oil characterization and simulation attributes are shown in Table 5-4.

Table 5-4: Oil Characterization and Simulation Attributes

Model Parameter	Scenario 1	Scenario 2
Discharge Point	Topside (sea surface)	Well head (sea floor)
Discharge Rates	2,400 m^3 / day (15,000 bbl / day)-Medium	1,600 m^3/day (10,000 bbl/day)- Low 3,200 m^3 /day (20,000 bbl/day)-High
Oil Type	High Sulfur Crude	High Sulfur Crude
Location[7]	23°00’15.0340”N 78°46’54.0242”W	23°00’15.0340”N 78°46’54.0242”W

Source: Kourafalou, et al., 2011

Much of the oil found and produced in Cuba is of high sulfur content and is found in a similar environment to The Bahamas. Therefore, Bahamas Petroleum chose to use the worst case scenario for the oil type which was High Sulfur Crude.

For purposes of this analysis, the study domain was divided into 7 coastal polygon groups (Figure 5-3). A long-term simulation of 7-year duration (from January 2, 2004 to December 31, 2010) was performed, where oil particles are released once a day, so the daily variability in the ocean and atmosphere conditions is present. The goal of this simulation is to describe the evolution of an oil spill in any condition during the 2004-2010 period. This period includes seasonal variations, but also more rapid changes, like the changes in the ambient current, typically the Florida Current, as well as the effects of hurricanes, especially in the intense 2005 season. Hence, the statistics extracted from that simulation, in terms of oil presence at the surface or along the coast, and time to reach the coasts, represent the largest variability in the conditions in which an oil spill may take place.

The probability of coastline oiling is determined by calculating the percentage of particles landed on each polygon out of the total released particles over the 7-year model duration. Table 5-5, Table 5-6 and Table 5-7 summarize the shoreline oil statistics, grouped by the seven coastal groups, for the surface spill (medium flow rate), sea bottom spill (low flow rate) and sea bottom spill (high flow rate), respectively.

The flow rates assumed for the modeling were based on the reservoir properties seen in the five wells drilled in The Bahamas, a comparison to producing analogs in the Bay of Campeche, Mexico and the likely size pipe anticipated in the whole at the reservoir. The open hole drill stream test in the Doubloon Saxon well calculates out to a flow rate of 927 barrels of fluid per day (BFPD). The 13 Cretaceous carbonate reservoirs reviewed have a medium flow rate of 5840 barrels of oil per day (BOPD) and an average of 8400 BOPD (further discussion is presented in Appendix D: Ryder Scott Competent Persons Report, 2011). Bahamas Petroleum Company increased the rates for the spill modeling to ensure the high side case was accounted for and in case higher pressures were encountered due to the depth of the well.

[7] Additional modeling will be completed if the well location is located further than 5-7 kilometers from this location. See Attachment 1 of Appendix A for an explanation of how the 5-7 kilometer distance was determined. No wells are expected in waters less than 200m depth.

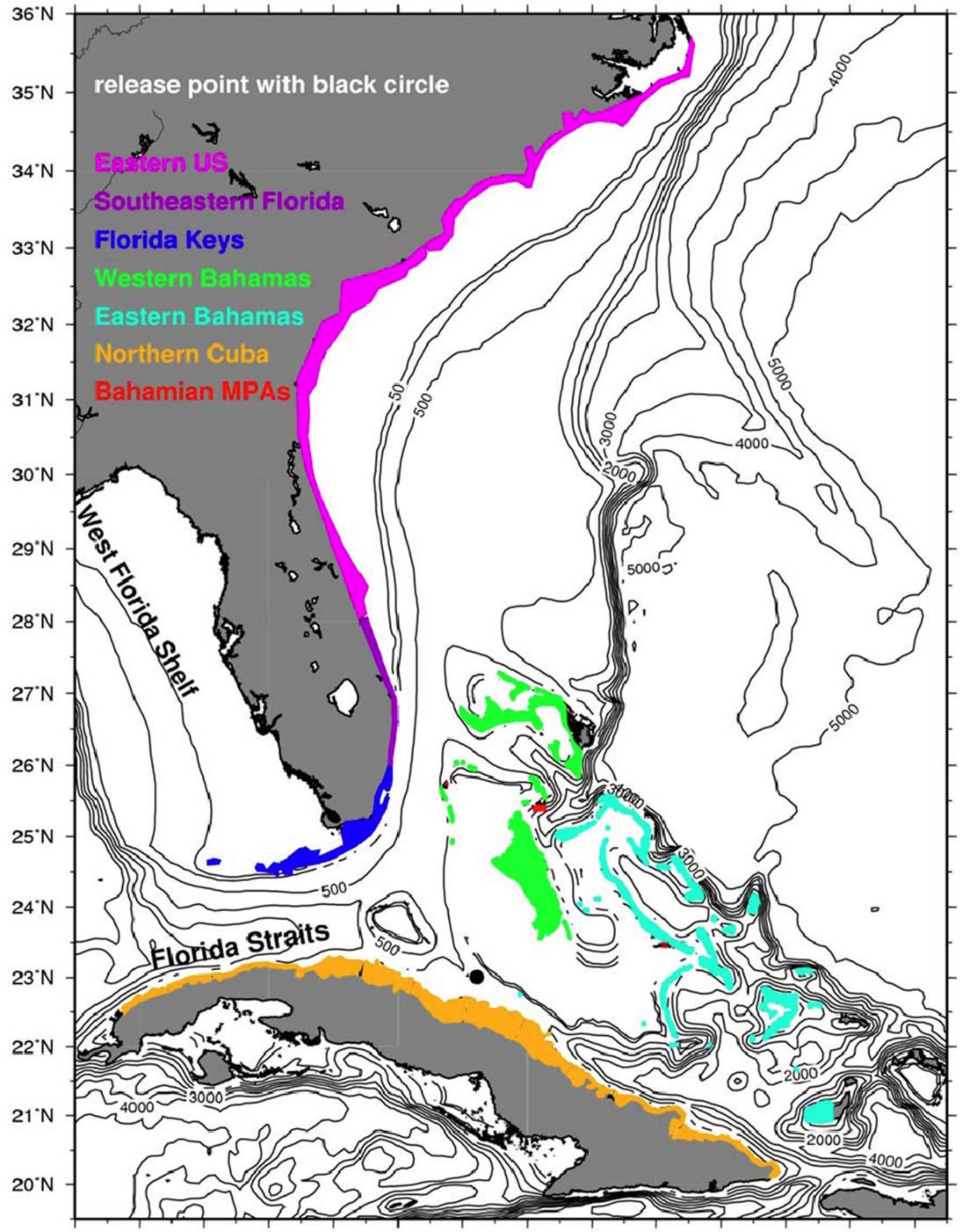

Figure 5-3: Extended Study Domain and Coastal Groups

Source: Kourafalou, et al., 2011[8]

[8] Kourafalou, et al., 2011

Table 5-5: Probability of Coastal Oiling for the Sea Surface Spill 2,400 m^3 / day (15,000 bbl/day)

Group Number	Group Name	%
1	Eastern US	0.05
2	Southeastern Florida	0.09
3	Florida Keys	0.04
4	Western Bahamas	0.07
5	Eastern Bahamas	0.16
6	Northern Cuba	46.44
7	Bahamian Marine Protected Areas (MPA)	0.00
Total		**46.9**

Source: Kourafalou, et al., 2011

Table 5-6: Probability of Coastal Oiling for a Spill at the Sea Floor 1,600 m^3/day (10,000 bbl/day)

Group Number	Group Name	%
1	Eastern US	0.03
2	Southeastern Florida	0.04
3	Florida Keys	0.02
4	Western Bahamas	0.14
5	Eastern Bahamas	0.12
6	Northern Cuba	34.98
7	Bahamian MPAs	0.00
Total		**35.3**

Source: Kourafalou, et al., 2011

Table 5-7: Probability of Coastal Oiling for a Spill at the Sea Floor 3,200 m^3 /day (20,000 bbl/day)

Group Number	Group Name	%
1	Eastern US	0.02
2	Southeastern Florida	0.03
3	Florida Keys	0.01
4	Western Bahamas	0.29
5	Eastern Bahamas	0.11
6	Northern Cuba	27.26
7	Bahamian MPAs	0.00
Total		**27.7**

Source: Kourafalou, et al., 2011

The data presented in Table 5-5, Table 5-6 and Table 5-7 above are also shown graphically in Figure 5-4, Figure 5-5 and Figure 5-6.

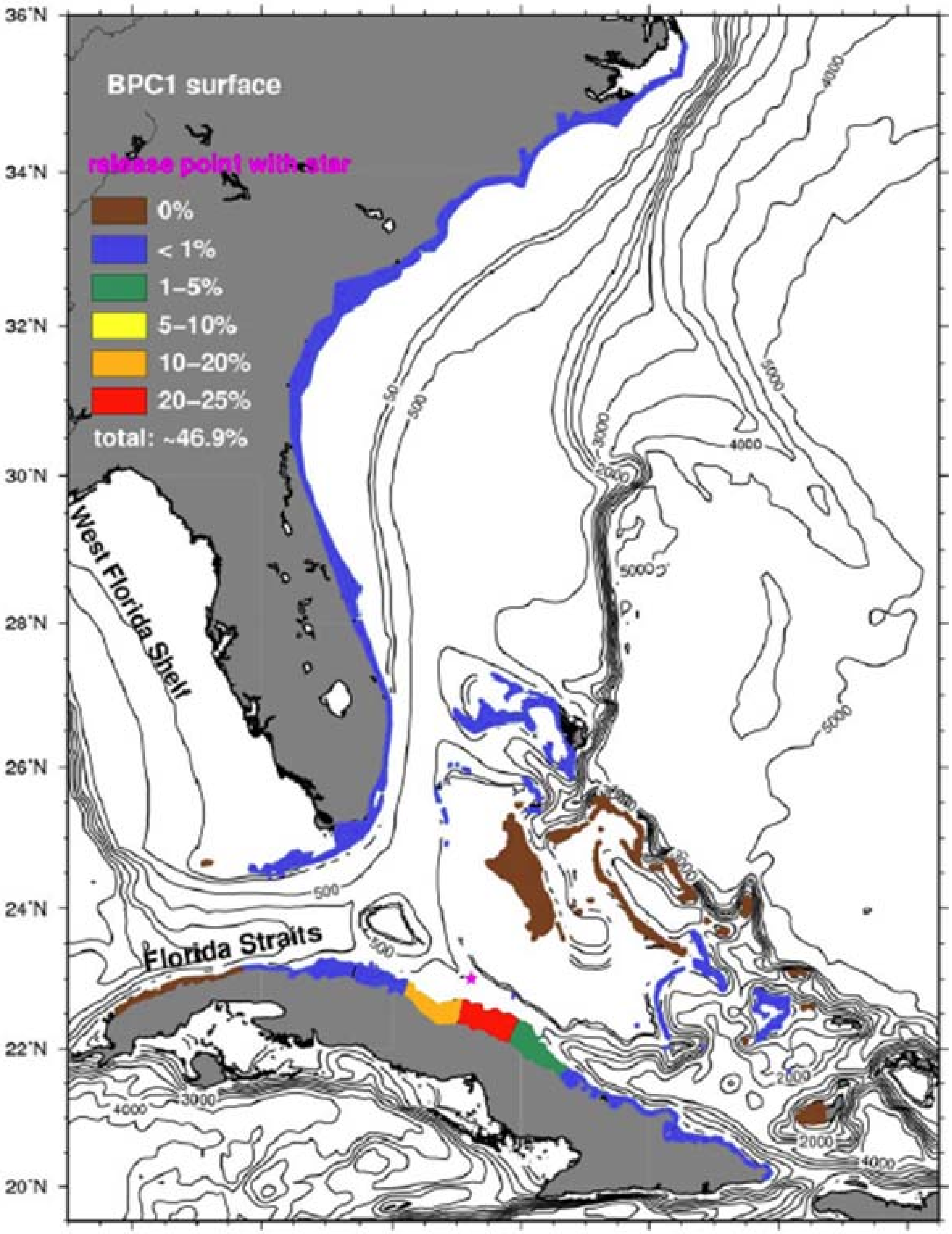

Figure 5-4: Probability of Coastline Oiling from a Spill at Sea Surface (2,400 m^3 / day)
Source: Kourafalou, et al., 2011

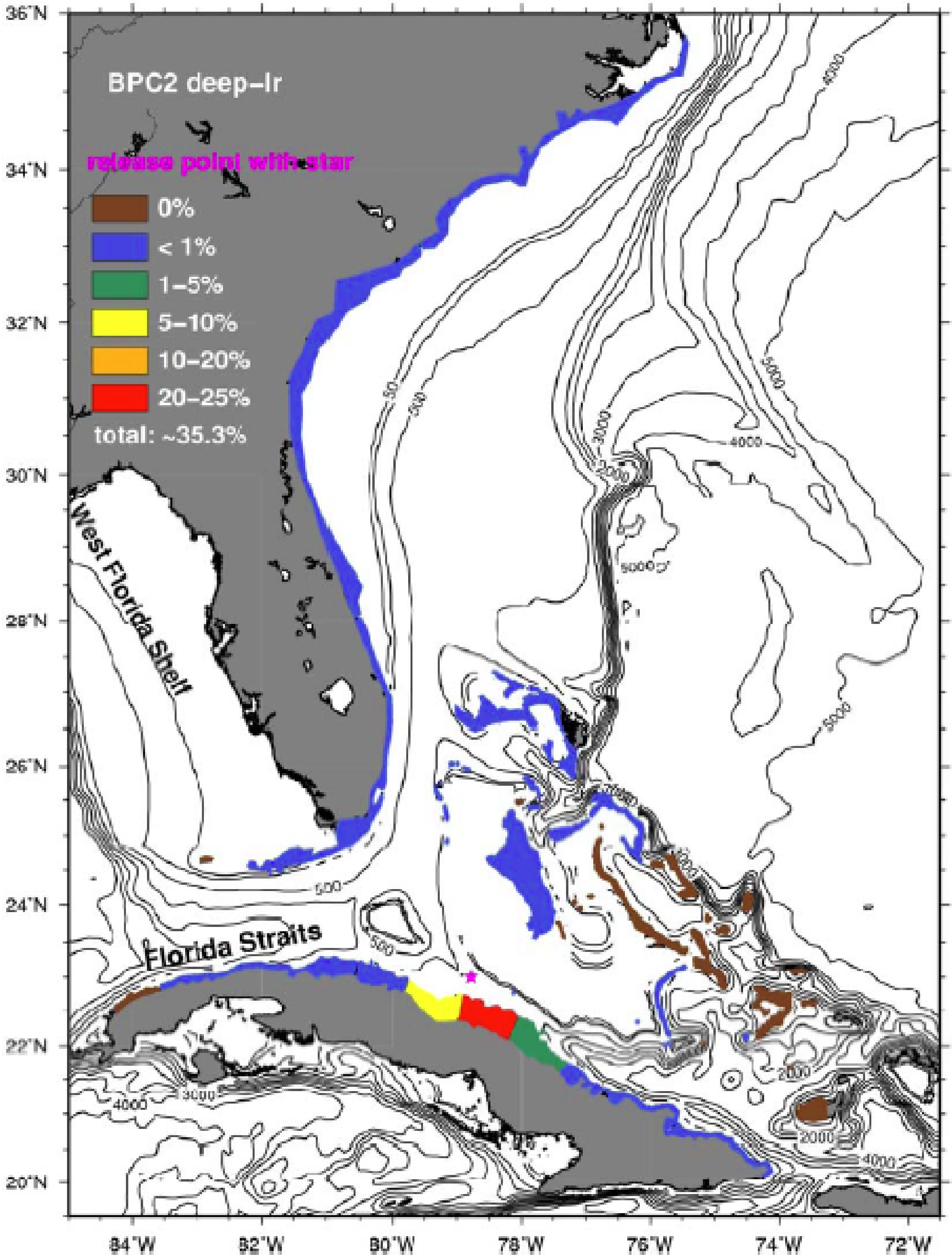

Figure 5-5: Probability of Coastal Oiling from a Spill at the Sea Floor (1,600 m^3/day)
Source: Kourafalou, et al., 2011

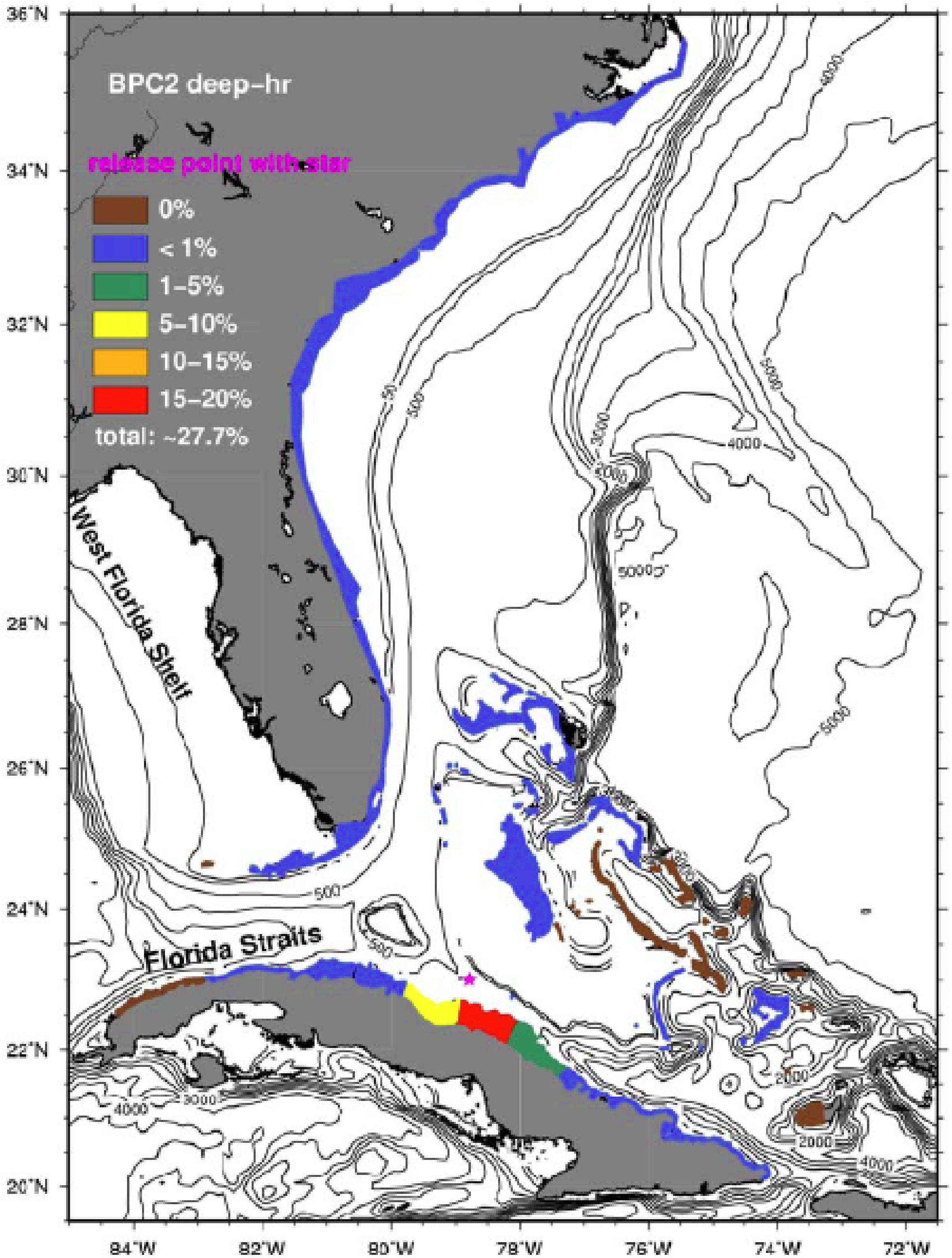

Figure 5-6: Probability of Coastal Oiling from a Spill at the Sea Floor (3,200 m^3 /day)
Source: Kourafalou, et al., 2011

Minimum time for oil landfall is shown in Figure 5-7, Figure 5-8 and Figure 5-9.

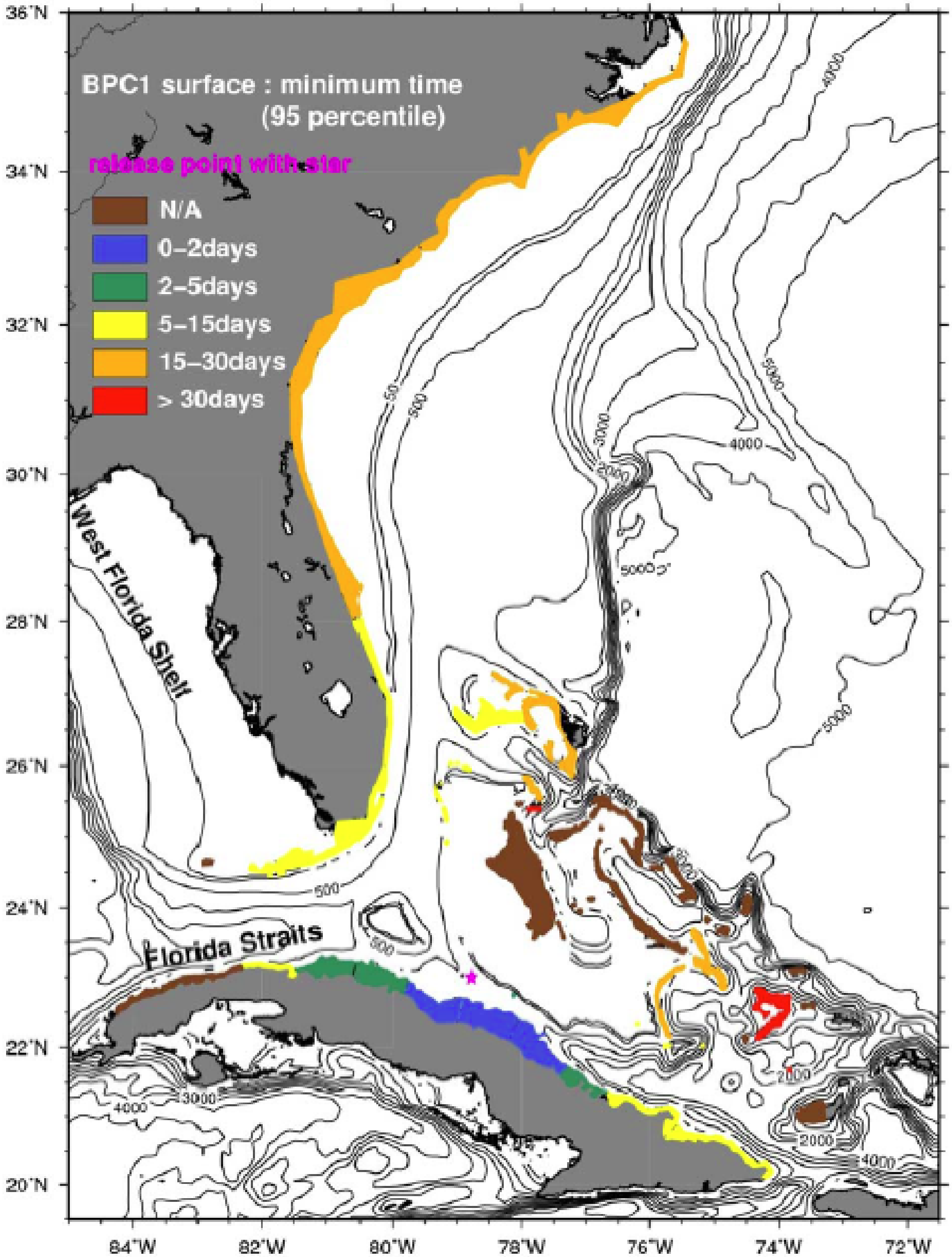

Figure 5-7: Minimum Time to Oil Landfall from a Spill at the Sea Surface (2,400 m^3 / day)

Source: Kourafalou, et al., 2011

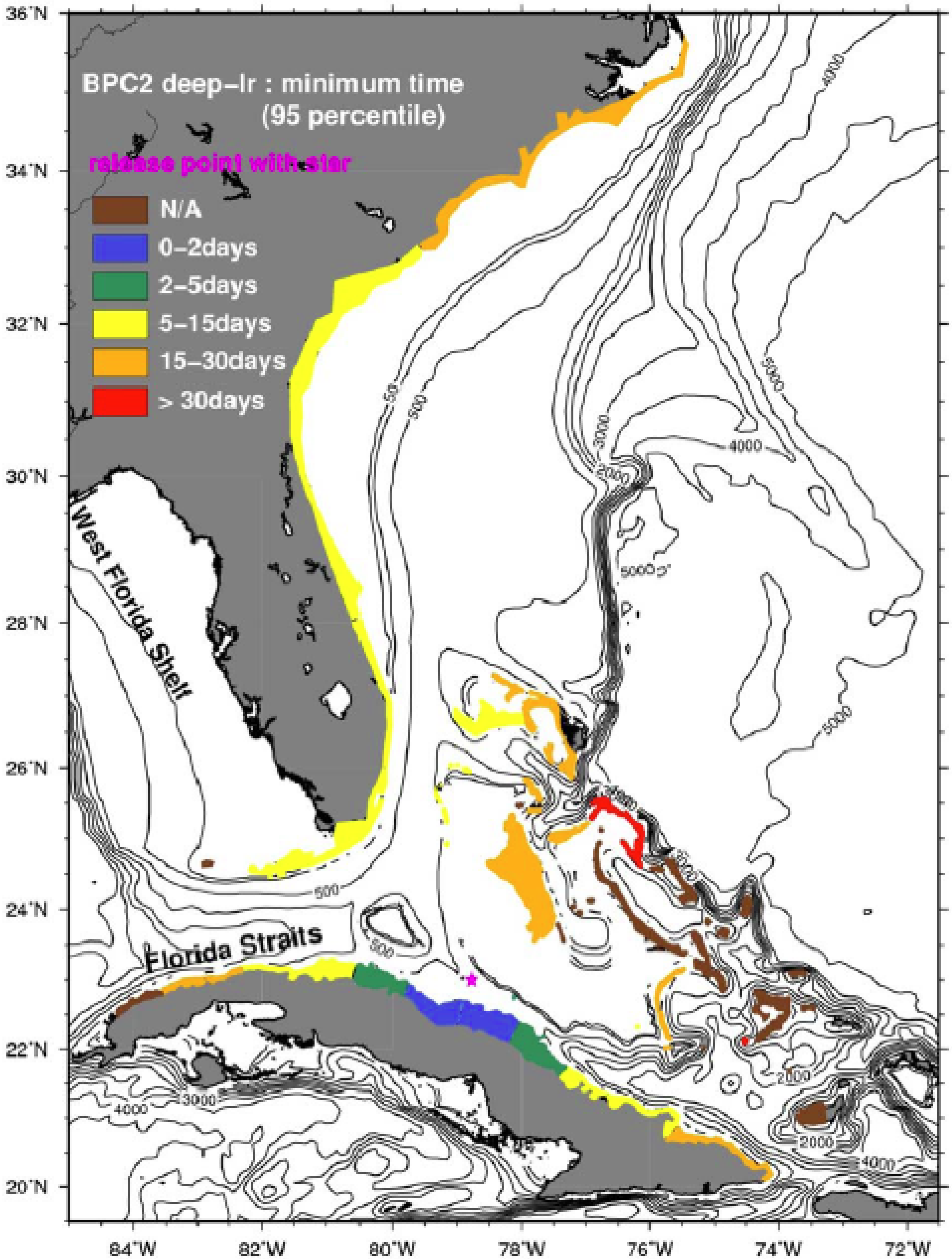

Figure 5-8: Minimum Time to Oil Landfall from a Spill at the Sea Floor (1,600 m^3/day)
Source: Kourafalou, et al., 2011

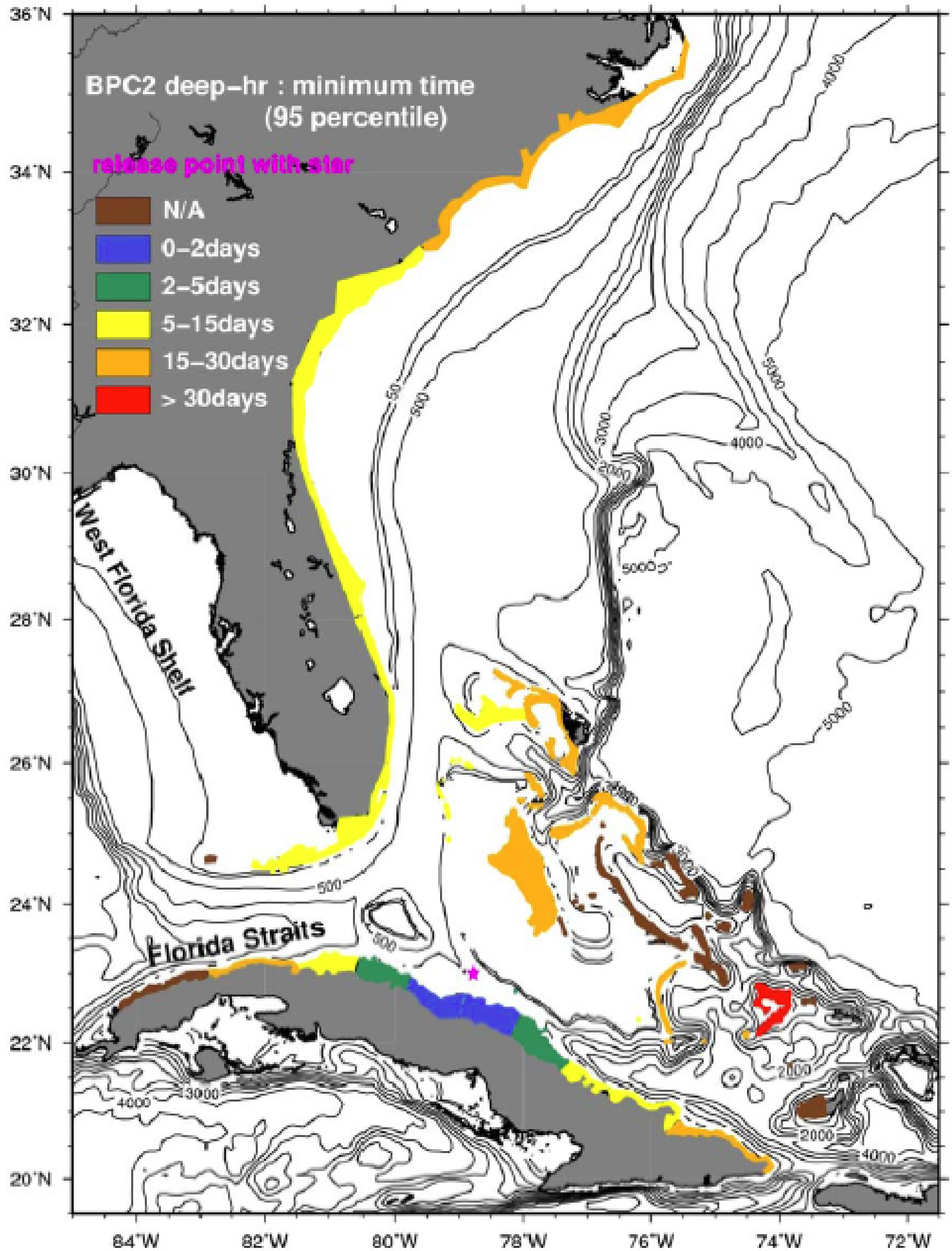

Figure 5-9: Minimum Time to Oil Landfall from a Spill at the Sea Floor (3,200 m^3/day)

Source: Kourafalou, et al., 2011

The probability of the maximum extent of oil sheen on the sea surface after a 60 day spill (model run for a total of 90 days from beginning of spill) is shown in Figure 5-10, Figure 5-11 and Figure 5-12.

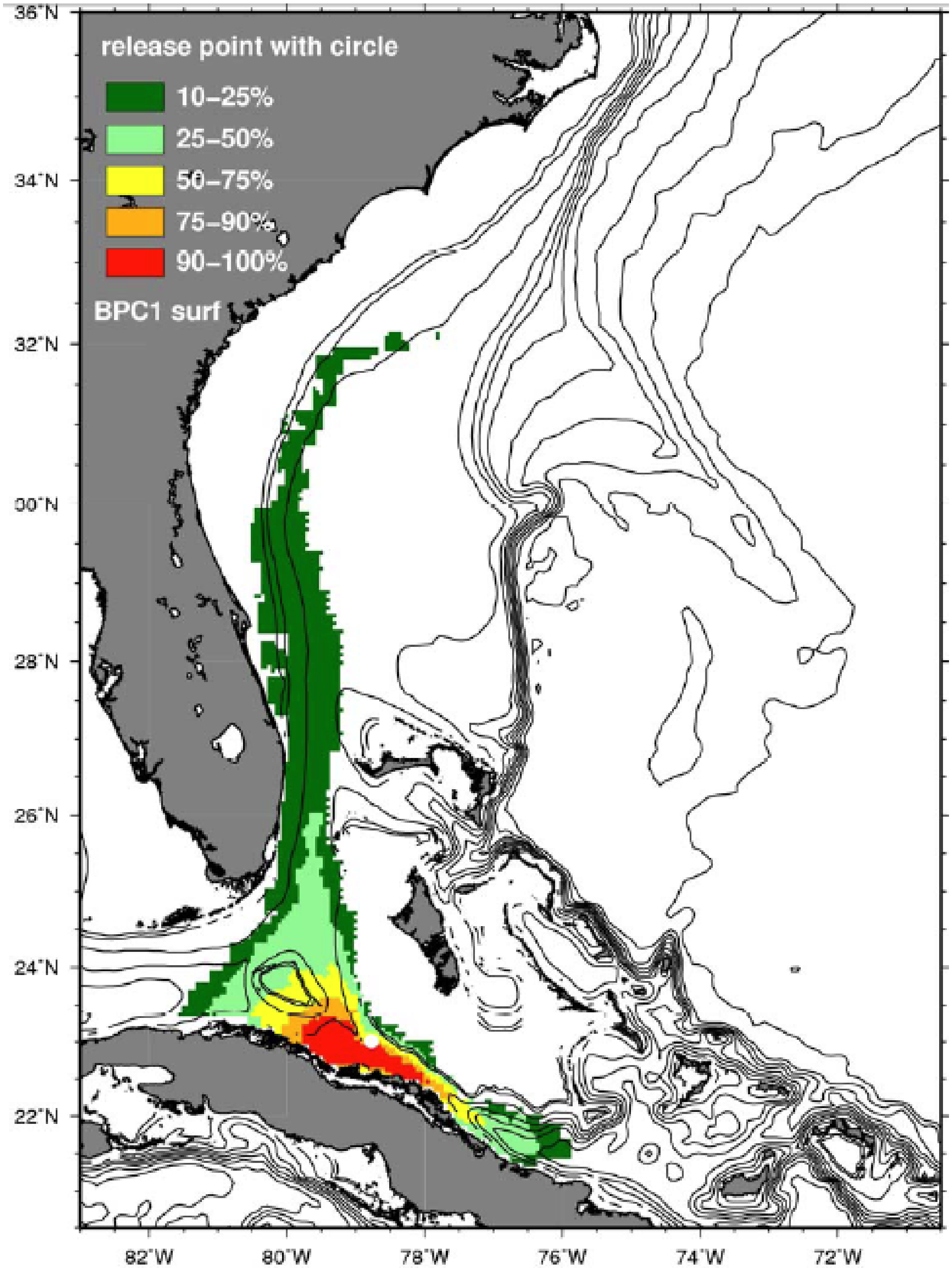

Figure 5-10: Probability of the Maximum Extent of Oil Sheen on the Sea Surface after a 60 Day Spill at the Sea Surface (2,400 m^3/day)

Source: Kourafalou, et al., 2011

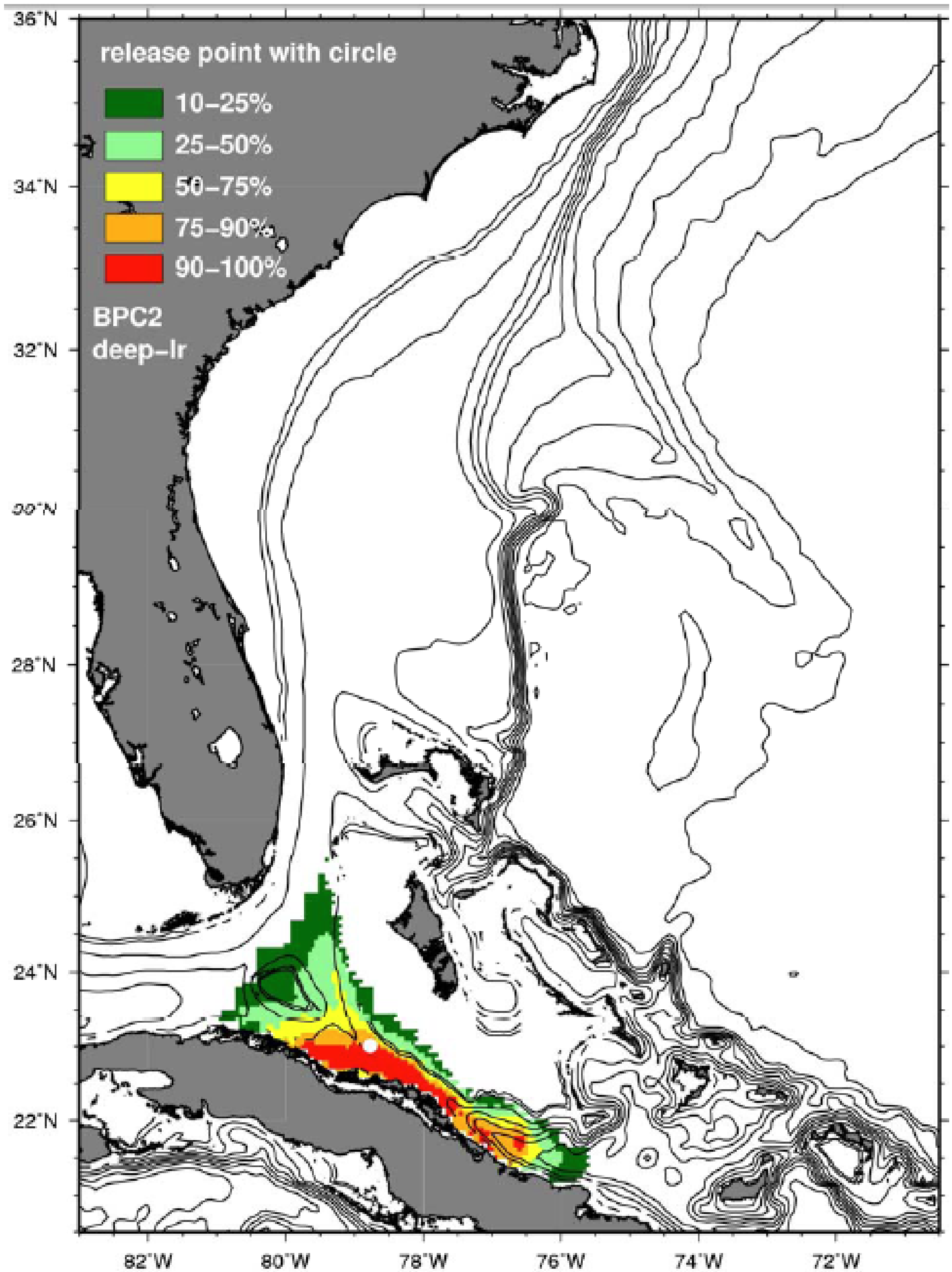

Figure 5-11: Probability of the Maximum Extent of Oil Sheen on the Sea Surface after a 60 Day Spill at the Sea Floor (1,600 m^3/day)
Source: Kourafalou, et al., 2011

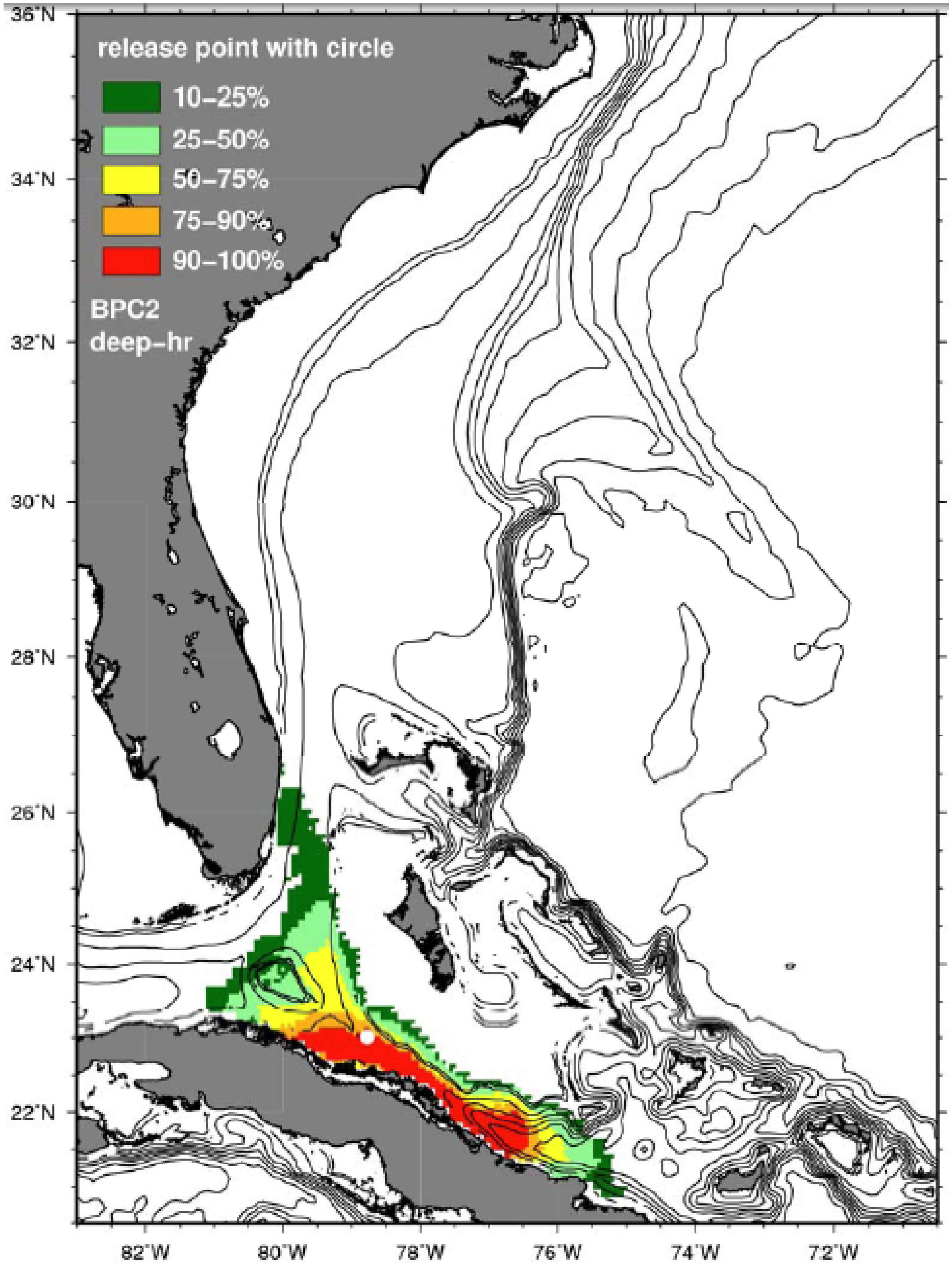

Figure 5-12: Probability of the Maximum Extent of Oil Sheen on the Sea Surface after a 60 Day Spill at the Sea Floor (3,200 m^3/day)
Source: Kourafalou, et al., 2011

The oil spill modeling results indicate that oil released from a loss of well control in the proposed drilling program could potentially reach shorelines of The Bahamas, Cuba and the United States if there is no intervention. The estimated release rates used in the modeling were based on the anticipated permeability from the principal reservoir zones identified by logs in the Doubloon Saxon well which are expected to be present within the seismic-delineated closures, assuming a reasonable net thickness of hydrocarbon bearing zone is completed in a given well. The modeled spill trajectories were highly influenced by the bathymetry of the region. Modeled oil dispersion tended to flow with the currents in the deeper waters and less towards the shallow waters, such as Great Bahama Bank.

Evaluation of the consequences of an oil spill has to take into consideration not only the potential physical damage but also the potential social/economic impacts and, in this case, possible political complications that could result.

As noted in Section 4.4, potentially affected shoreline contains sensitive and protected features such as mangroves, estuarine communities, fishing grounds and beaches. These areas provide habitat for endangered species, breeding grounds for vital commercial species and support livelihoods for local communities, recreation activities and ecotourism. Because the potential consequence of an oil spill fouling this area could be major, defining the amount of time for a spill to reach these areas is critical in determining the impact rating and required mitigation measures. The projected minimum time to shoreline impact varies depending on the location but is less than 2 days to northern Cuba for all scenarios modeled.

Impacts related to oil spills are evaluated by resource type (i.e. water quality, marine fauna, etc.), along with other impacts below.

5.4.2.1 Potential Degradation of Marine Water Quality – Accidental Oil Spills (2A1, 2B1)

Hydrocarbons released to the marine environment can result from well blowouts or other accidental events. Hydrocarbons spilled into seawater are subject to physical, chemical, and biological processes that change their composition and potential impact to the environment. A conceptual model of the fate of hydrocarbons entering the marine environment is shown in Figure 5-13. Hydrocarbon composition and toxicity will change over time in a process known as 'weathering'. The importance of various weathering [9] [10] components is shown in Figure 5-14.

[9] Burns et al., 2000
[10] Neff et al., 2000

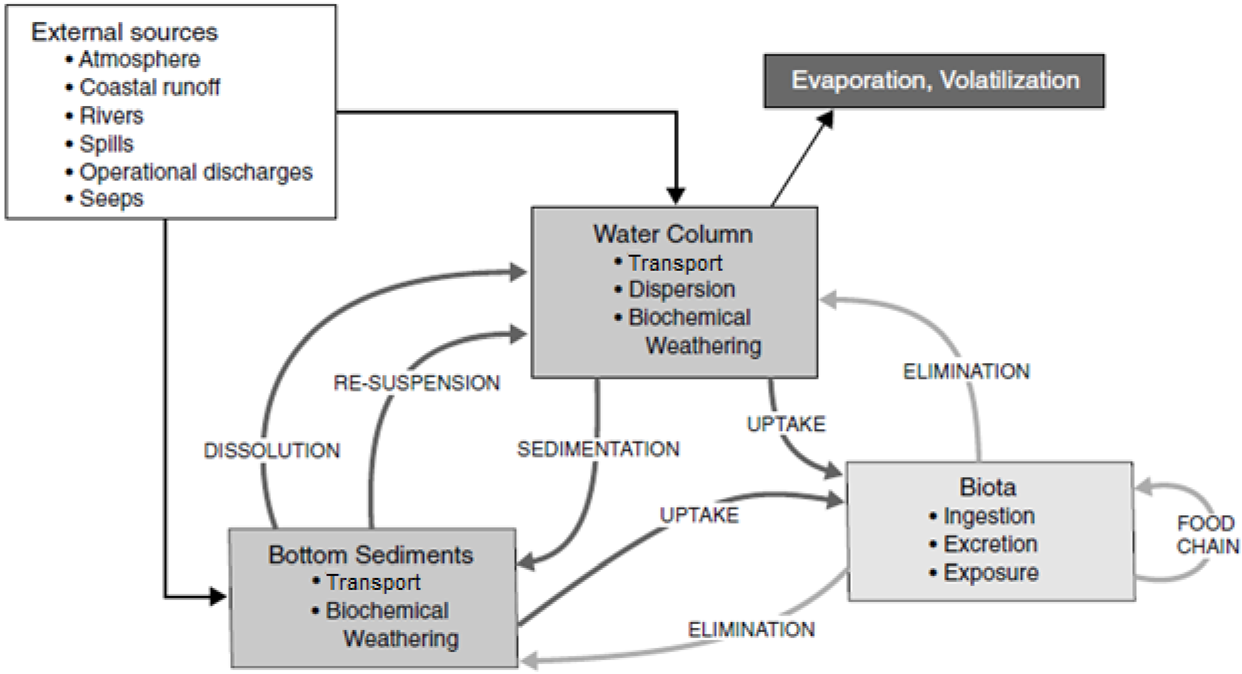

Figure 5-13: Conceptual Model of the Fate of Hydrocarbons in the Marine Environment
Source: Committee on Oil in the Sea, 2003. [11]

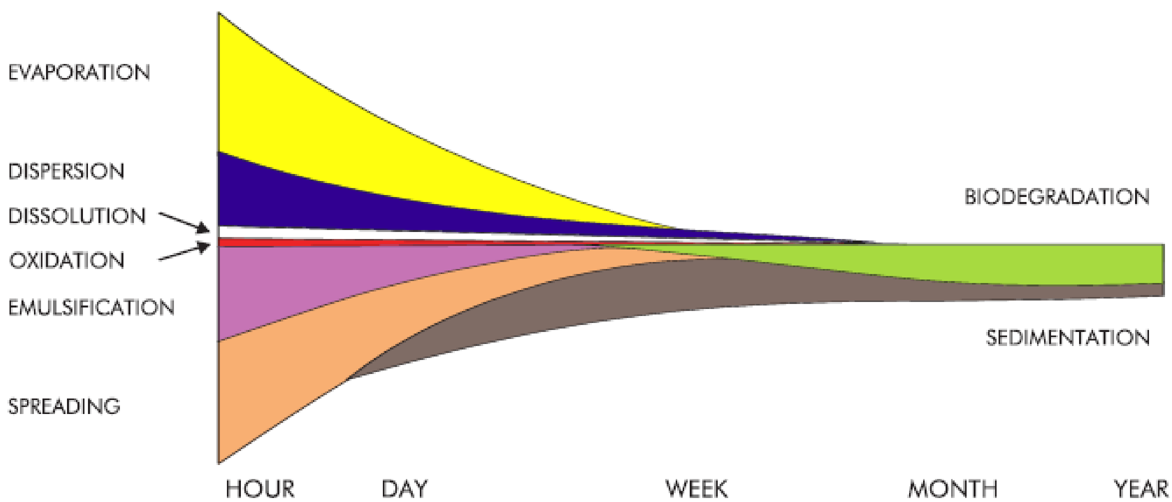

Figure 5-14: Importance of Weathering Components to Crude Oil Spilled into the Marine Environment over Time
Note: Width of each band indicates importance
Source: International Tanker Owner Pollution Federation Limited (ITOPF), 2011[12]

[11] Committee on Oil in the Sea: Inputs, Fates, and Effects. 2003. Oil in the Sea III: Inputs, Fates, and Effects. The National Academies Press: Washington DC.
[12] International Tanker Owner Pollution Federation Limited (ITOPF). 2011. Technical Information Paper No. 2: Fate of Marine Oil Spills. Accessed from the ITOPF Website: http://www.itopf.com/marine-spills/fate/weathering-process/documents/tip2.pdf

Without mitigation, a worst case scenario oil spill could cause hydrocarbons to be dissolved or entrained in the water column and/or sea surface. The consequence could have moderate to major impacts to water quality; however, the likelihood of this occurring is considered seldom. Standard industry controls that will be in place to minimize the impact likelihood include careful well design including blowout preventers and other elements to manage risks of blowouts, and an emergency response plan to help respond to a spill quickly and to provide equipment and resources to manage a spill. Response activities will be aligned with the Caribbean Island Oil Pollution Response and Cooperation Plan and The Bahamas Oil Spill Contingency Plan. The consequences of these impacts would be direct, negative, dispersed, reversible (at the habitat level) and medium term. The overall impact to the environment of this activity is **medium**, requiring mitigation to manage the risk (C = 2-3, L = 1, and thus I = medium). Multiple mitigation and management activities will be implemented to limit oil spill impacts; these actions are described in Chapter 6.

As described in Section 5.4.1.1, the drilling process involves storage and use of potentially hazardous materials (impact category 2B1). However, such chemicals are only used in small quantities. A spill of hazardous liquids during drilling could result in temporary degradation of marine water quality, but Bahamas Petroleum Company expects to avoid the use of hazardous fluids to the extent possible. Such an impact would be minor and the likelihood seldom; resulting in a **low** impact rating (C = 1, L = 1, and thus I = low). This impact (2B1) could also be considered a higher, moderate consequence with a lower, improbable likelihood. This would also result in a low impact rating.

5.4.2.2 Potential Degradation of Marine Water Quality – Drilling Discharges (2E2, 2K1, 2L1)[13]

Offshore drilling involves sources of impact to marine water quality other than a potential oil spill. In addition to the uncontrolled release described above, there are also controlled releases, such as discharge of:

- Drill cuttings
- Water based drilling mud and fluids (if needed), and
- Other routine discharges (i.e. deck drainage).

As potential hydrocarbon formations are expected to be low-pressure, Bahamas Petroleum Company expects to drill the wells mainly with seawater although a water based drilling fluid cannot be ruled out at this stage. All previous wells drilled in The Bahamas utilized the same technique. If needed, Bahamas Petroleum Company might use periodic sweeps of water based drilling mud/fluids (WBM) to clean the well bore. WBMs are relatively cheap compared to other mud types and are generally considered to be relatively benign drilling muds. Bahamas Petroleum Company does not expect to utilize synthetic based drilling fluids (SBM), but these could be used for operational or safety reasons if unexpected formations or pressures are encountered. Bahamas Petroleum Company will not utilize oil or diesel based muds. Due to the absence of a riser system during the drilling of the uppermost portions of a well, drill cuttings and muds will be discharged directly to the seabed. This discharge to sea is standard industry practice, even in the most environmentally sensitive areas and is largely accepted by environmental protection authorities globally. Once the riser is installed cuttings and any drilling fluids used will be brought to the surface, cleaned and cuttings discharged over board assuming they meet pre-agreed limits of contaminants. Any cuttings not meeting these pre-agreed limits and will be stored on-board for shipping and disposal in approved land fill sites.

[13] Routine discharges are discussed in Phase 5, Vessel Operations

Discharge of drill cuttings and WBM (if needed) will cause a short term and localized degradation of marine water quality in the direct vicinity of the drill site. WBMs are water-soluble and would be suspended in the water column temporarily. Discharged cuttings will quickly settle to the sea floor. Measurements of plumes of exploratory drilling rigs in the Gulf of Mexico showed less than 10 PPM of suspended solids 24 meters from the discharge pipe and at 100 m concentrations were near background levels.[14] Most suspended solids tend to settle out within 200 m from the discharge point, but thin accumulations can be found 1 km or more depending on the water depth and current speeds. [15]

If SBM are required, no SBM or cuttings containing SBM would be discharged to sea. Due to the increased cost of SBMs and environmental considerations, SBMs would be recovered to the rig for recycling.

Discharges of cuttings will cause a localized (generally less than 200 m radius from well) increase in water turbidity and minor changes in water quality. Oil on cuttings will be measured by a trained lab technician on the drilling rig prior to discharge. Bahamas Petroleum Company will follow good international industry practice and limit oil on cuttings to less than 1%. As no cuttings associated with SBM will be discharged, the only source of oil would be contaminants from hydrocarbon bearing zones. Drilling fluid pressure will exceed the reservoir pressure (“overbalanced”); therefore formation fluids returning with the drill cuttings would likely be limited. These impacts are rated as minor given the volume of the surrounding ocean environment where localized temperature increase and low level pollution can be quickly absorbed.[16] The consequence of discharge of cuttings and fluids to water quality is minor, and the likelihood is occasional (for WBM) or probable (for cuttings), resulting in an impact rating of **low** (C = 1, L = 2-3, and thus I = low). This impact would be negative, direct, reversible and short-term.

Bilge water and drainage from machining and engineering areas are likely to contain hydrocarbons and/or chemicals. Waters from these areas will be separated from clean water drainage and routed to the oily water treatment system. Overboard discharge from the oily water treatment system will be monitored periodically to ensure the system is efficiently removing oil prior to discharge. Liquid waste resulting from rainfall, rig washing, deck washings, tank cleaning operations, and runoff from curbs and gutters will also be passed through the oil/water separator. Spillage of drilling fluids would be collected in the deck drainage system on the drilling rig and treated prior to discharge.

Discharge from the oil water treatment system is common for marine activities and is regulated by MARPOL 73/78, Annex I requirements. MARPOL requires all such discharges to have less than 15 mg/l of oil concentration. Similarly, any water required for storage displacement (ballast water) would meet MARPOL requirements and standard controls will be implemented to prevent

[14] Shinn, E. A., J. H. Hudson, D. M. Robbin, and C. K. Lee. 1981. Drilling mud plumes from offshore drilling operations-implications for coral survival. Pages 471-496 in R. A. Geyer, ed. Marine environmental pollution I: hydrocarbons. Elsevier/North Holland.

[15] Neff, J. 2005. Composition, Environmental Fates, and Biological Effect of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: A Synthesis and Annotated Bibliography. Prepared for Petroleum Environmental Research Forum (PERF) and American Petroleum Institute (API). Retrieved from the PERF website: http://www.perf.org/pdf/APIPERFreport.pdf

[16] Motu, U.E and L. Pinturier. 2008. Zero Harmful Impact from Drilling Discharges: Where are the Limits? Society of Petroleum Engineers International Conference on Health, Safety and Environment in Oil and Gas Production; Nice, France.

the introduction/spread of harmful aquatic organisms. The drilling process will also require cooling water. Typical cooling water systems on modern rigs utilize ‘closed loop’ systems that do not require discharge of heater water to the marine environment.

Most operational discharges are diluted and dispersed in the ocean waters at the point of discharge. The impact to the environment is minimized by following international requirements (i.e. MARPOL) and other industry practices. The likely impacts on water quality resulting from routine drilling discharges will be adverse, reversible, short term and dispersed. The consequence of these potential disturbances is minor, and the likelihood probable, resulting in an impact rating of **low** (C = 1, L = 3, and thus I = low).

5.4.2.3 Potential Harm to Marine Fauna

In the rigging-up and mobilization phase, potential impacts were identified to marine fauna from various sources of water quality degradation. During drilling, the primary potential source of water quality degradation would be an accidental oil spill.

Potential Impact to Fish from Oil Spill (2A2) - An accidental oil spill caused by loss of well control could impact marine habitat and lead to localized mortalities of sensitive species directly impacted by a spill. The severity of the impact depends on the type of marine organism and the size of the spill. Most of the oil that would be spilled to the marine environment from a subsea well in the unlikely event of a release would float on the water’s surface, but some components may also sink to the seabed or become suspended in the water column.

In the event oil becomes suspended in the water column:[17]

> *“[Fish] may come into direct contact and contaminate their gills; the water column may contain toxic and volatile components of oil that may be absorbed by their eggs, larvae, and juvenile stages; and they may eat contaminated food. Fish that are exposed to oil may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion, a variety of biochemical and cellular changes, and reproductive and behavioral responses. Chronic exposure to some chemicals found in oil may cause genetic abnormalities or cancer in sensitive species. If chemicals such as dispersants are used to respond to a spill, there may be an increased potential for tainting of fish and shellfish by increasing the concentration of oil in the water column.”*

However, Hjermann et al. report that because dispersed and dissolved oil typically leaves the water column rapidly following even a large spill, mainly through evaporation, dilution, and microbial degradation, marine pelagic fish rarely are exposed to high enough concentrations of toxic fractions of oil for long enough to result in high levels of lethal and sub-lethal effects.[18] This potential impact would be negative, direct, dispersed, reversible (at the habitat level) and medium term. Potential impacts to fish from oil spill could have moderate effects on the potentially affected organisms, but the likelihood of a spill is seldom, resulting in a **medium** impact (C = 2, L = 1, and thus I = medium). Mitigation is required to manage the risk.

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[17] United States Environmental Protection Agency (US EPA), Office of Emergency and Remedial Response, Oil Program Center. 1999. Understanding Oil Spills and Oil Spill Response. Retrieved from the US EPA website: http://www.epa.gov/oem/docs/oil/edu/oilspill_book/chap5.pdf

[18] Hjermann, D.Ø., A. Melsom, G.E. Dingsør, J.M. Durant, A.M. Eikeset, L.P. Røed, G. Ottersen, G. Storvik, and N.C. Stenseth. 2007/. Fish and Oil in the Lofoten-Barents Sea system: Synoptic Review of the Effect of Oil Spills on Fish Populations. Mar. Ecol. Prog. Ser. 330:283-299.

Potential Impact to Plankton, Fish Eggs and Larvae from Oil Spill (2A2) – Plankton, fish eggs and larvae are also abundant in the marine environment. These organisms passively float in the currents, some at the sea surface. A large hydrocarbon spill could cause a die-off of these organisms in the affected area causing a moderate to major environmental consequence with a likelihood of seldom, resulting in a **medium** impact (C = 2/3, L = 1, and thus I = medium). Mitigation is required to manage the risk. This impact would be negative, direct and medium term but reversible given the fast reproductive rates and widely distributed abundance of these species.

Potential Impact to Marine Mammals and Sea Turtles from Oil Spill (2A2) – Species of marine mammals and sea turtles could be affected by oil spills through various pathways: surface contact, inhalation, ingestion, and baleen fouling.[19] Although marine mammals and sea turtles live and/or migrate through the study area, they are much less common than fish or plankton and are able to avoid potential spills. In the event that marine mammals are directly exposed, "...oil can result in temporary eye problems. Ingestion of oil can result in digestive tract bleeding and in liver and kidney damage. Ingestion of oil is of greater concern for species that groom themselves with their mouth... ".[20]

Sea turtles are particularly vulnerable as they lack avoidance behavior, indiscriminately feed in convergence zones (sub-sea plumes are likely to be carried to these regions), and take large pre-dive inhalations. "Oil effects on turtles include increased egg mortality and developmental defects, direct mortality due to oiling in hatchlings, juveniles, and adults; and negative impacts to the skin, blood, digestive and immune systems, and salt glands."[21] Further, sea turtles are known to nest along adjacent coastlines[22], and potential oiling of these beaches could reduce sea turtle reproduction rates.

Considering the rarity of many marine mammals and sea turtles, mortality of even a few individuals would be considered a moderate to major consequence, resulting in a **medium** impact requiring mitigation to manage the risk (C = 3, L = 1, and thus I = medium). This potential impact would be negative, direct, dispersed, and reversible (at the habitat level) and medium term (given the reproductive cycles of these species).

Potential Impact to Pelagic and Inshore Seabird Species from Oil Spill (2A2) – Chronic and acute oil pollution is recognized as a significant threat to both pelagic and inshore seabird species. The International Bird Rescue Center describes how seabirds can be impacted by oil spills to water bodies:[23]

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[19] Geraci, J.R. 1990. Physiologic and Toxic Effects on Cetaceans. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea Mammals and Oil: Confronting the Risks. San Diego, CA: Academic Press, Inc. Pp. 167-197.

[20] United States Environmental Protection Agency (US EPA), Office of Emergency and Remedial Response, Oil Program Center.

[21] Shigenaka et. al. 2003. Oil and Sea Turtles: Biology, Planning and Response. National Oceanic and Atmospheric Administration, Office of Response and Restoration. 2003. http://response.restoration.noaa.gov

[22] Dow, W., Eckert, K., Palmer, M. and P. Kramer. 2007. The Wider Caribbean Sea Turtle Conservation Network and The Nature Conservancy. WIDECAST Technical Report No. 6: An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region. Beaufort, North Carolina. 267 pages.

[23] International Bird Rescue Center (IBRC). 2008. How Oil Affects Birds. Retrieved from IBRC Website: http://www.ibrrc.org/oil_affects.html

The majority of deaths attributable to oil pollution amongst seabirds are due to the physical properties of the oil and damage to the water repellent properties of the birds' plumage. This allows water to penetrate, decreasing buoyancy and leading to sinking and drowning. Additionally, thermal insulation capacity is reduced requiring greater use of energy to combat cold. Instinctively, the bird tries to get the oil off its feathers by preening, this results in the animal ingesting the oil. This ingestion can cause severe damage to the bird's internal organs. The focus on preening overrides all other natural behaviors; including feeding and evading predators, making the bird vulnerable to secondary health problems such as severe weight loss, anemia, predation and dehydration.

The area in which drilling will occur is far from shore; however there are extensive areas of estuarine marshes and mangroves along the adjacent coastlines. There are a number of wild bird reserves located southeast of Andros and two RAMSAR Wetlands of International Importance (Buena Vista and Humedales del Norte de Ciego de Avila) are located on the Cuba coast, approximately 25 miles (~40 km) south of the well site. Worst case oil spill trajectory modeling shows oil making shoreline impact with the Cuban coast near these areas within 2 days. These areas are of particular importance to wading and other shoreline species. This potential impact would be negative, direct, temporary dispersed, reversible (at the habitat level) and medium term. This impact could have a major consequence if sensitive areas are affected, but the likelihood would be seldom resulting in a **medium** impact. Mitigation is required to manage the risk (C = 3, L = 1, and thus I = medium).

Potential Harm to Marine Fauna from Fuel or other Hazardous Material Spill during Storage (2B2) – Drilling involves storage and use of potentially hazardous materials. The largest quantity of hazardous material stored is fuel oil (up to approximately 28,000 bbls). Other potential hazardous materials include brine, base oil, drilling fluid and additives, paint thinner, adhesives and other chemicals used in small quantities.

All hazardous materials will be stored in appropriate containers and stowed as necessary to avoid release to the marine environment due to exposure to wind, rain or other event. Storage areas containing hazardous liquids will contain secondary containment (such as bunded areas and/or closed loop drainage systems) in the event of a spill. Given the typical quantities used and container sizes, any spill to the marine environment would likely be relatively small (<1 barrel). Further, both the support vessels and the drilling rig will be equipped and personnel prepared for immediate response. The impact of fuel or other hazardous material spill to marine fauna is similar to those described in Section 5.4.1.2. While a spill could cause localized mortality to plankton and benthos (if the substance sinks to the bottom) in the area, fish, sea turtles, marine mammals and sea birds are likely to avoid the area resulting in limited harm. Accidental releases described above could have minor consequences to marine fauna with a likelihood of seldom, resulting in a **low** impact (C = 1, L = 1, and thus I = low). This impact would be reversible (at the habitat level) localized and short-term.

Potential Impact to Marine Fauna from Noise and Vibration (2G1, 2H1) – Studies of the effects of underwater sound on marine life are generally concerned with anthropogenic sounds that overlap in frequencies with the hearing range of marine organisms. An exception is the case of very loud sounds, where peak sound pressure is the important factor.

According to Richardson, et al. and Gales, drilling operations often produce noise that includes strong tonal components at low frequencies, including infrasonic frequencies in at least some cases. [24] [25] Drillships are noisier than semisubmersibles. Rigs using thrusters to maintain position generate more radiated sound than fixed installations. Sound and vibration paths to the water are predominantly through either the air or the risers. Underwater noise ranges from about 20 to 40 dB above background levels within a frequency spectrum of 30-300 hertz (Hz) at a distance of 30 m from the source. These levels vary with rig/platform type and water depth.

Impacts to plankton, benthos, and fish would be negligible. Such noise may interfere with or mask the sounds used and produced by marine mammals and sea turtles and thereby interfere with their natural behavior. [26] [27] [28] [29] [30] [31] [32]

Vibrations will be caused by the drilling rig from the use of internal combustion engines, electric motors, pumps, pulling drill strings and other rotating/moving equipment. It is possible that these vibrations could have a temporary effect on benthic and pelagic life. Vibrations will be minimized by equipment being maintained in good condition.

A number of impacts, ranging from interference with the detection of biologically relevant sound signals, to behavioral disturbance, hearing loss and in the worst cases injury and death have been attributed to underwater sound.[33] However, sound generated during drilling operations does not appear to be a significant source.[34] The consequence of these effects on marine fauna are considered minor and the likelihood is probable, thus resulting in a **low** impact (C = 1, L = 3, and thus I = low). Such impacts would be negative, direct, localized, reversible and short term.

Impacts of noise from vessel operations are discussed in Section 5.4.5.3.

Potential Impact to Marine Fauna from Light (2I1) - Normal drilling operations will be carried out on a continuous 24-hour basis, requiring adequate work space lighting for a safe work

[24] Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. San Diego, CA: Academic Press.
[25] Gales, R.S. 1982. Effects of Noise of Offshore Oil and Gas Operations on Marine Mammals - an Introductory Assessment. Technical Report 844. Naval Ocean Systems Center, San Diego, CA.
[26] Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the Giant Sea Turtle, Chelonia mydas. In: Proceedings of the National Academy of Sciences. 64(3):884-890.
[27] Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine Turtle Reception of Bone-conducted Sound. Journal of Auditory Research 23:119-125.
[28] Moein Bartol, S., J.A. Musick, and M.L. Lenhardt. 1999. Auditory Evoked Potentials of the Loggerhead Sea Turtle (Caretta caretta). Copeia 1999:836-840.
[29] Lenhardt, et al., 1983
[30] Lenhardt, et al., 1983
[31] O'Hara, J. and J.R. Wilcox. 1990. Avoidance Responses of Loggerhead Turtles, Caretta Caretta, to Low Frequency Sounds. Copeia 1990(2):564-567.
[32] McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine Seismic Surveys - a Study of Environmental Implications. APPEA Journal 2000:692-708.
[33] OSPAR Commission. 2009. Overview of the Impacts of Anthropogenic Underwater Sound in the Marine Environment.
[34] NCE. 2007. Review of Existing and Future Potential Treatments for Reducing Underwater Sound from Oil and Gas Industry Activities, Report 07-001, prepared for Oil & Gas UK Joint Industry Project on E&P Sound and Marine Life, pp185

environment during night operations. The lighting will occur at a location where there ordinarily is no light at night, except perhaps for the temporary transition of fishing and other vessels. The drilling location(s) will be at least 15 miles (~ 24 km) from the nearest shoreline and offshore rigs are typically only visible for ten miles. [35] The new source of light could attract both airborne and seaborne wildlife, especially sea turtles, fish and birds. [36] [37] [38] [39] [40] [41] [42] Sounds generated by the drilling rig are expected to deter marine mammals from approaching the drilling rig; Therefore, they are unlikely to be affected by the lighting.

The likelihood that drilling rig lighting could have a measurable (moderate consequence) impact to marine fauna is negligible. Instead, the impact of lighting is rated for disruption rather than mortality, resulting in a minor consequence, occasional likelihood, and low overall impact rating (C = 1, L = 2, and thus I = low). This potential impact would be negative, direct, dispersed, reversible and short term (over the life of the project).

Potential Impact to Marine Fauna from Operational Discharges (2L2) – As discussed in Section 5.4.2.2, exploration drilling results in numerous routine discharges during operation, such as: drill cuttings, water based drilling fluids (if required), deck drainage, macerated food, etc. Most operational discharges are diluted and dispersed in the marine environment at the discharge point. The impact to the environment is minimized through International requirements (i.e. MARPOL) and other industry practices. Studies have shown that impacts to marine life exposed to operational discharges have sub-lethal affects.[43] [44] [45] The likely impacts on marine life

[35] Geological Survey of Alabama (GSA). 1998. Governor's Report: Options for Development of Potential Natural Gas Reserves from Central Gulf of Mexico, Mobile Area Blocks 826 and 829.
[36] Russell, R.W. 2005. Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.
[37] Owens, D. 1983. Oil and Sea Turtles in the Gulf of Mexico: A Proposal to Study the Problem. In: Keller, C.E. and J.K. Adams, eds. Proceedings, Workshop on Cetaceans and Sea Turtles in the Gulf of Mexico: Study Planning for Effects of Outer Continental Shelf Development. Prepared by the U.S. Dept. of the Interior, Fish and Wildlife Service, for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Pp. 34-39.
[38] Witherington, B.E. and R.E. Martin. 1996. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Florida Marine Research Institute Technical Report TR-2, Florida Dept. of Environmental Protection. 73 pp.
[39] Witherington, B.E. 1997. The Problem of Photopollution for Sea Turtles and Other Nocturnal Animals. In: Clemmons, J.R. and R. Buchholz, eds. Behavioral Approaches to Conservation in the Wild. Cambridge, MA: Cambridge University Press. Pp. 303-328.
[40] Chan, E.H. and H.C. Liew. 1988. A Review on the Effects of Oil-based Activities and Oil Pollution on Sea Turtles. In: Proceedings, 11th Annual Seminar of the Malaysian Society of Marine Sciences. Pp. 159-167.
[41] Owens, 1983
[42] Witherington and Martin, 1996
[43] American Petroleum Institute (API). 1989. Effects of Offshore Petroleum Operations on Cold Water Marine Mammals: A Literature Review. Washington, DC: American Petroleum Institute. 385 pp.
[44] National Research Council (NRC). 1983. Drilling Discharges in the Marine Environment. Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment. Marine Board; Commission on Engineering and Technical Systems; National Research Council. Washington, DC: National Academy Press.
[45] Kennicutt II, M.C., ed. 1995. Gulf of Mexico Offshore Operations Monitoring Experiment, Phase I: Sublethal Responses to Contaminant Exposure, Final report. U.S. Dept. of the Interior, Minerals

resulting from routine drilling discharges will be adverse, reversible, short term and localized. The consequence of these potential disturbances is minor, and the likelihood probable, resulting in an impact rating of **low** (C = 1, L = 3, and thus I = low).

5.4.2.4 Potential Degradation of Sensitive Shoreline Features – Oil Spill (2A3)

As described in Chapter 4, there are a number of areas of coastal sensitivities along the adjacent shorelines. For example, there are mangroves, estuaries, sea grass beds, popular beaches, protected areas, endangered sea turtle nesting sites, and other features important to biodiversity and ecosystem services. Loss of well control can occur, although very infrequently (Section 5.4.2.1). Spill modeling scenarios performed assumed a worst case spill. Even in a worst case, coastal oiling of most of The Bahamas was unlikely (<1%). However, the modeling shows that a spill has the potential to reach sensitive coastal features of Cay Sal and Northern Cuba. Cuba is particularly vulnerable and oil reaches shores within 2 days (see spill modeling results Section 5.4.2).

Given the distance from shore, existing response capabilities could be mobilized to help limit the potential impact of an oil spill to these sensitive areas. Nonetheless, the possibility exists that the proposed drilling could result in a blowout that would not be able to be contained before fouling the coastline. The likelihood of this impact is best characterized as seldom. However, damage to even small sections of sensitive coastal features could have major consequences. Therefore, the impact rating for this category of impact is **medium** (C = 3, L = 1, and thus I = medium). This impact would be negative, direct, reversible and medium to long-term.

5.4.2.5 Impact to Benthic Habitat – Cuttings Discharge to the Sea Floor (2E1, 2E3)

While the dispersion of cuttings discharged during drilling depends on a number of factors (water depth and currents, in particular), studies have shown that most settle within 200 m of the well site.[46] Bahamas Petroleum Company plans to drill the wells primarily with sea water, and water based muds if needed. Most of the components of the water based fluids have low toxicity with the exception of some trace metals. Barium is the major element in the mud because of the high barite level, but trace amounts of chromium, copper, cadmium, mercury, lead, and zinc are also present. A study of chronic impacts from oil and gas activities [47] determined that metals from discharges, including mercury and cadmium, were generally localized to within 150 m of the structure, although significant elevations of all these metals except chromium were observed within 500 m of Gulf of Mexico drilling sites.[48]

Use of synthetic based muds (SBMs) is not planned, and SBMs would not be discharged in the unlikely event that they are required for the drilling program. Discharge of drill cuttings to the sea floor could have a minor consequence to the quality of seafloor sediments. The likelihood of impacts to the sea floor sediments is probable. Such impacts would be negative, direct, localized, irreversible and short-term. Therefore, the overall impact to the environment of this activity is **low** (C = 1, L = 2, thus I = low).

Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0045. 709 pp.

[46] Neff, J. 2005.

[47] Kennicutt II, 1995.

[48] Boothe, P.N. and B.J. Presley. 1989. Trends in Sediment Trace Element Concentrations around Six Petroleum Drilling Platforms in the Northwestern Gulf of Mexico. In: Engelhardt, F.R., J.P. Ray, and A.H. Gillam, eds. Drilling Wastes. New York: Elsevier Applied Science Publishers, Ltd. Pp. 3-20.

Discharged cuttings could smother any benthic organisms present that are unable to move from the area. Recovery of macrofauna and other benthic species depends on the thickness of the accumulation and the characteristics of the receiving environment (water depth, temperature and currents).[49]

It is unknown if deep water coral reefs and/or chemosynthetic communities are located near the drilling sites. A study of the effects of cuttings discharges on coral found little impact to growth rates of head corals compared to pre-drilling rates.[50] However, diver observations found a 70-90% reduction in foliose, branching and table-like corals within a 115 x 85 meter ellipse.

Bahamas Petroleum Company will review detailed seafloor mapping and imagery prior to drilling to avoid potential seafloor hazards and sensitivities that might be observed and cuttings will not be discharged to an area of seafloor occupied by a high biodiversity of sensitive benthic communities.

Discharge of drill cuttings to the sea floor could possibly have a moderate consequence impact to benthic communities if sensitive features are located nearby. However, given the controls in place and the localized nature of the cuttings dispersion, the likelihood of this occurring is seldom. Such impacts would be negative, direct, dispersed, reversible and medium term. Therefore, the overall impact to the environment of this activity is **medium**, requiring mitigation to manage the risk (C = 2, L = 1, thus I = medium).

In addition to discharge of cuttings, excess cement used to secure well casings will be deposited on the sea floor during installation of top whole sections (before the marine riser is installed). The amounts of cement are expected to be minimal and will have effects similar to those of cuttings described above (localized smothering).

5.4.2.6 Impact to Benthic Habitat – Disruption of Sediments on the Sea Floor (2D1, 2A4)

The sea floor will be penetrated by drilling at the well locations. The rotation of the drill bit and installation of casing will disrupt sediments at and immediately around the drilling sites and create a very localized and temporary increase in turbidity. This increase in sedimentation and turbidity could adversely impact benthic life forms that cannot move away quickly to avoid the impact. Bahamas Petroleum Company will review detailed seafloor mapping and imagery prior to drilling to avoid potential seafloor hazards and sensitivities that might be observed, and this could help avoid disruption to unusual seafloor features and associated benthic communities that might be more rare or biodiverse than are found elsewhere on the seafloor. This potential impact would be localized, reversible and short term. The consequence of this disturbance is minor, and the likelihood is occasional, resulting in an impact rating of **low** (C = 1, L = 2, and thus I = low).

In addition, a subsea well blow-out could result in the precipitation and accumulation of heavy elements of the oil released (for example, tar balls) on the sea floor. Such impacts could cause localized smothering of benthos and/or contamination of seafloor sediments. This potential impact would likely affect a more expansive area around the well than the sediment disruption

[49] International Association of Oil and Gas Producers (OGP). 2003. Environmental Aspects of the Use and Disposal on Non Aqueous Drilling Fluids Associated with Offshore Oil and Gas Operations: Report No. 342. Retrieved from OGP Website: http://www.ogp.org.uk/pubs/342.pdf

[50] Hudson, J.H., Shinn, E.A, and D.M. Robbin. 1982. Effects of Offshore Oil Drilling on Philippine Reef Corals. Bulletin of Marine Science, 32(4):890-908, 1982.

from drilling, and would have a medium term effect. The consequence of this disturbance is moderate, and the likelihood is seldom, resulting in an impact rating of **medium**, requiring mitigation to manage the risk (C = 2, L = 1, thus I = medium).

5.4.2.7 Degradation of Air Quality (2F1)

Estimated air emissions to be produced from the drilling program are described in Section 2.6.3. Air emissions will be generated from on board equipment such as pumps, generators and diesel engines needed to support the drilling activities. If drilling identifies the presence of hydrocarbons, well testing is planned. During well testing, gas and oil will be flared (burned). Due to recent advances in burner technology, flaring burns at very high (>98%) efficiency.[51] All emissions produced would be temporary, disperse rapidly in the ocean environment and be located away from the public. Standard procedures will be followed to protect the health and safety of the workforce.

In 2009, The Bahamas generated 5,236,000 metric tons of CO_2 emissions.[52] A typical exploration well (not including flaring) produces approximately 2,000 metric tons of CO_2 equivalent per well, mostly from diesel-driven electrical generators and equipment. Drilling of each well would contribute approximately 0.038% to the annual emissions of The Bahamas, plus flaring. World CO_2 emissions from consumption of fossil fuels in 2007 were 2.93914×10^{13} metric tons. [53] Compared to global CO_2 emissions, emissions from drilling of an individual well is negligible. The IFC requires clients to report emissions for projects that generate over 25,000 metric tons per year. Once the rig is chosen, well specific estimates based on US EPA AP-42 emission factors and rig specifications for PM, SO_X, NO_X, VOC, CO, CO_2 and CH_4 and would be provided in the well-specific EMPs. However, it's difficult to provide estimates for flaring, if any, because the period of flaring and composition of the feed are highly variable. Contents and quality of the materials flared will be recorded. Actual emission values can be calculated from this data.

Such an impact would be negative, direct, easily dispersed, reversible and short term. The consequence of any such impact is minor, and the likelihood probable. Therefore, the overall impact rating is **low** (C = 1, L = 3, and thus I = low).

5.4.2.8 Potential Disruption of Fishing and Other Economic Activities

Potential disruptions to fishing and other economic activities were evaluated both near the drill site and near coastal areas.

Potential Disruption to Fishing and Shipping near Drill Site (2J1) – In accordance with international safety practices, a safety zone will be established for up to a 1 km radius around the drilling rig, within which fishermen and other mariners will not be allowed to pass. As described in Chapter 2, offshore fishing in The Bahamas is concentrated in the shallow waters of Grand Bahama Bank and Little Bahama Bank. Bahamas Petroleum Company is proposing to

[51] United States Environmental Protection Agency (EPA). 1996. AP-42, Emission Factors, Section 13.5 - Industrial Flares.

[52] Energy Information Administration. 2011. International Energy Statistics. Accessed from the Energy Information Administration website: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8

[53] International Energy Agency (IEA). 2010. CO_2 Emissions from Fuel Combustion Highlights. Accessed from the IEA website: http://www.iea.org/co2highlights/co2highlights.pdf

drill only in deep water areas. Therefore, interruptions to fishing vessels near the drilling sites are expected to be minimal.

The deep water portions of the blocks are part of Old Bahama Channel (between Grand Bahama Bank and Cuba) and the Santaren Channel (between Great Bahama Bank and Cay Sal Bank). The drilling rig and exclusion zone could interfere with shipping vessels and/or pose a slight risk for collision[54]. A collision with the drilling rig could cause a loss of well control or other significant spills of hazardous materials to the marine environment. Impacts of a blowout are discussed above. The potential intersection with shipping activities may require minor alteration of ship routes, but only to an added distance of up to one kilometer. The drilling contractor and support vessels will follow good international industry practices for notifying mariners and port authorities, establishing an exclusion zone, using markings/lighting and observing marine navigation rules in accordance with the International Maritime Organization's COLREGs standards. Given the controls in place, the impact of the drilling rig on shipping routes is expected to be minor. The likelihood of this impact is probable, leading to a **low** (C = 1, L = 3 and thus I = low). This impact would be negative, direct, localized, reversible and medium-term.

Potential Disruption to Fishing in Near-shore Waters and Tourism (2A5) – Potential oil spills from drilling operations in the license area could reach fishing grounds and cause a disruption to industrial fishing boats, artisanal fishermen and other activities. As noted previously, an oil spill could cause some fish mortality due to direct oiling, reduction in fertility and/or ingestion of oil contained in the water column. Further, fishermen may not be able to realize economic benefit from fishing in the area after a spill because of the potential for their fishing gear to be oiled or the catch to be tainted.[55]

Further, an average of 4.5 million tourists visits The Bahamas each year and tourism is a critical component of the Bahamian economy.[56] Oil spills reaching shore or near shore areas could foul beaches and waterways that are attractive to tourists. A large spill could also lead to canceled bookings based on a perceived impact to The Bahamas in general. The spill modeling results show that even without intervention there is less than a 1% chance of oil reaching shore in The Bahamas and 0% in most areas. The United States, Norway and Brazil are a few examples of countries where fishing and tourism coexist with significant oil and gas exploration and production activities. Under normal circumstances, the proposed drilling operations are not likely to have an impact on tourism and fishing as drilling will be far from shore and temporary. The project will be located in deepwater away from areas utilized by tourists and most fishermen.

These potential impacts would be negative, direct, dispersed, reversible and medium term. Oil spill impacts to the local economy could have a major consequence, but such a consequence would have a seldom likelihood, resulting in a **medium** impact (C = 3, L = 1, and thus I = medium). Therefore, mitigation will be required to manage the risk.

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[54] Hill, P., Crabtree, S., and R. M[c]Donnell. 1999. Collision Avoidance for Deepwater Floating Systems: Report of the NOSAC Subcommittee. Offshore Technology Conference, 3 May-6 May 1999, Houston, Texas

[55] IPIECA, 2008

[56] Ministry of Tourism www.bahamas.gov.bs

Potential Disruption to Aesthetic Appeal of Viewshed (2I2) – A study by the Geological Survey of Alabama on aesthetic impacts of fixed structures in the Gulf of Mexico suggests that rigs located more than 10 mi offshore would not be visible from shore under most circumstances. [57] The exploratory wells are expected to be greater than 15 miles (~24 km) from the nearest shoreline and at least 25 miles (~40 km) from the nearest inhabited land, and thus lighting from this operation is not likely to be visible from shore. Additionally, wells will only be located in deep water, away from coral reefs and other tourist attractions. Thus, risk of a social / aesthetic impact would have negligible consequence and occasional likelihood, for an overall **low** social impact rating (C = 0, L = 2, and thus I = low). This impact will be negative, direct, and short-term.

*Potential Damage to Subsea Telecommunications Infrastructure (*2A7*)* – A telecommunications cable runs along the Santaren Channel and Old Bahama Channel in the west – southwest borders of the Blocks in an area where wells could potentially be drilled (Figure 4-41). Damage to the sub-sea cable due to drilling activities could affect telecommunications services to a broad region. The cost and time to fix such a cable could be expensive and time consuming. The consequence of damage to the cable could be considered major. However, Bahamas Petroleum Company will study the sea floor at and around the drill sites prior to drilling to ensure no hazards or sensitivities are present so the likelihood of this impact is improbable, resulting in a **medium** impact rating (C = 3, L= 0, and thus I=low). Therefore, mitigation will be required to manage the risk. This impact will be negative, direct, reversible, dispersed and medium-term.

5.4.2.9 Damage to Submerged Archaeological Resources (2A6)

The potential for impact on possible submerged archaeological resources in the drilling phase is the same as described in the mobilization phase. The extent of damage that could be caused to such a resource would be greater if impacted by the drilling rather than anchor or transponder placement, but the likelihood would still be improbable. This is because there are no known submerged resources in the area and because the drilling will be preceded by a remote operated vehicle seabed survey that would detect and allow avoidance of such a submerged resource. The consequence would be minor to moderate, and thus the overall impact rating would be **low** (C = 2, L = 0, and thus I = low). This impact would be direct, negative, localized, irreversible, and long-term.

5.4.2.10 Use and Extraction of Natural Resources (2C1)

Chapter 2 describes the types and estimated quantities of natural resources to be consumed during the proposed drilling program. Of these, fuel and water consumption are the most significant. Sea water used during drilling is expected to be returned to the marine environment. The drilling rig could also desalinate sea water for consumption and domestic uses, the amount of which will depend on the specific drilling rig selected. Brine discharged rates range from 10 – 100 tonnes per day – specific estimates will be included in the well-specific EMPs once the rig has been selected.

Some potable water could be purchased from vendors in The Bahamas.

A typical drilling rig can hold 3,975 m^3 (25,000 bbl) of fuel oil, 795 m^3 (5,000 bbl) potable water plus additional multi-purpose storage tanks. Additional fuel will be purchased at port. Given the plan to desalinate seawater and the wide availability of fuel, the impacts of natural resource use

[57] Geological Survey of Alabama (GSA). 1998.

can be considered negligible with a probable likelihood, therefore resulting in a **low** impact (C = 0, L = 3, and thus I = low). This potential impact would be localized, reversible and short term.

5.4.3 Appraisal

If hydrocarbons are identified during the well logging that is performed during drilling, Bahamas Petroleum Company plans to conduct well testing to assess the characteristics of the well and fluids. Potential impacts of appraisal are related to flaring of associated gases and discharge of treated, produced water.

5.4.3.1 Potential Degradation of Air Quality from Flaring Emissions (3A1, 3A2)

During appraisal, natural gas will be separated from formation fluids and flared (burned) at the drill rig. Efficient flaring generates mainly water vapor and carbon dioxide. Efficient combustion in the flame depends on achieving good mixing between the fuel gas and air, and on the absence of liquids. Testing by the U.S. Environmental Protection Agency has shown that combustion efficiencies of a well-designed and operated flare are often greater than 98%.[58] Bahamas Petroleum Company will include mandatory use of modern “green burners” in the drilling contractor bidding instructions. Even with efficient combustion flaring will emit carbon dioxide which will contribute to global levels of greenhouse gases.

Waste gases containing methane, hydrogen, CO, and ammonia usually burn without smoke. Waste gases containing heavy hydrocarbons such as paraffins, olefins, and aromatics, cause smoke.[59] The fuel gas would primarily be composed of methane so smoke and soot should be limited.

Flaring will also generate a light source in an environment that is typically dark and noise in an area that is quiet. As described in Section 5.4.2, generation of noise and light could impact marine life passing close to the drilling rig.

The amount of flaring will depend on the length of the well tests, gas / oil ratio of the reserves and rate of well production. Bahamas Petroleum Company will follow good international industry practices for flaring, the wells will be located in an offshore environment away from sensitive receptors, flaring will be temporary, if at all, and the period of any testing will be kept to an absolute minimum. The consequence of this impact is considered minor and the likelihood occasional, resulting in a **low** impact rating (C = 1, L = 2, and thus I = low). This impact would be direct, negative, reversible, dispersed and short-term.

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[58] International Association of Oil and Gas Producers (OGP). 2000. Flaring & Venting in the Oil & Gas Exploration & Production Industry: An Overview of Purpose, Quantities, Issues, Practices and Trends. Report No. 2.79/288.

[59] United States Environmental Protection Agency (EPA). 1995. AP-42: Compilation of Air Pollutant Emission Factors

5.4.3.2 Potential Degradation of Marine Water Quality

Potential Degradation of Marine Water Quality from Discharge of Produced Water (3B1) – Produced water is a by-product of oil and gas extraction from underground reservoirs that is separated from the hydrocarbons on the drilling rig. After separation, produced water will be transferred to a produced water treatment system where it is filtered, cleaned and cooled prior to discharge to sea. The proportion of produced water varies depending on the reservoir characteristics. However, the well tests can be very short, sometimes no more than a few hours at a time with the well flowing. Further, produced water can be limited by avoiding perforation of the drill casing in water producing zones. As such, produced water volumes are likely to be minimal.

Bahamas Petroleum Company will treat any produced water following International Finance Corporation (IFC, a member of the World Bank Group) guidance - maximum oil content of 42 mg/l, and such that the 30 day average does not exceed 29 mg/l) [60] - before discharging produced water to the sea.

Toxicity studies on produced water discharges have shown that the concentrations of toxic chemicals in most produced waters are well below the test species 96 hour LC50 (lethal concentration for 50% of the individuals tested over a 96 hour period) indicating that acute toxicity is unlikely beyond the immediate vicinity of the discharge[61].

The consequence of discharging produced water to the marine environment could be moderate, but given the ability of Bahamas Petroleum Company to avoid water producing zones the likelihood is seldom. This is best characterized as a **medium** impact rating (C=2, L=1 and I=medium), requiring mitigation to manage the risk.

Potential Degradation of Marine Water Quality from Flaring Fallout (3B2) – In addition to air emissions, flaring can generate carbon particles (soot), unburned hydrocarbons, carbon oxide, and other partially burned and altered hydrocarbons. The quantities of hydrocarbon emissions generated relate to the degree of combustion. Flames extinguished by weather, intermittent flow or low heat-content gas, or improper fuel-air mixing can result in lower burn efficiencies (i.e. soot, unburned hydrocarbons, etc.).[62]

Unburned hydrocarbons and other fallout entering the sea can degrade marine water quality. However, modern burner systems (for example, Schlumberger's EverGreen system[63]) can produce 'fall-out free and smokeless combustion' of well testing gasses and liquids. Bahamas Petroleum Company will include mandatory use of modern "green burners" in the drilling contractor bidding instructions. The use of good international industry practices for flaring should minimize fallout, but introduction of even small amounts of hydrocarbons into the marine environment could be considered to have a moderate consequence. The likelihood of this

[60] International Finance Corporation. 2007. Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development.
[61] GESMAP. 1993. Impact of Oil Related Chemicals and Wastes on the Marine Environment. IMO/FAO/UNESCO/WMO/IAEA/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution.
[62] Fernandez, R. 2008. Successful Application of Gas Utilization Technologies. Global Forum on Venting and Flaring Reduction and Natural Gas Utilization.
[63] Schlumberger. 2011. EverGreen Burner. Accessed from the Schlumberger website: http://www.slb.com/services/characterization/testing/surface_testing/evergreen_burner.aspx

impact is seldom, resulting in a **medium** impact (C=2, L=1 and I=medium) requiring mitigation to minimize the risk. This impact would be direct, negative, reversible, localized and short-term.

Potential Degradation of Marine Water Quality from Well Completion (3C1) – If hydrocarbons are identified during well logging, the well would need to be completed in order to be tested. Well completion incorporates the steps taken to transform a drilled well into a producing well. These steps include casing, cementing, perforating, gravel packing and installing a production tree. In order to complete the well completion fluids such as weighted brines or acids, methanol and glycols and other chemical systems are used. As described in Section 5.4.1.1, these chemicals can exhibit hazardous characteristics, such as corrosivity and/or toxicity. However, these chemicals are used in small quantities and are carefully managed. Work-overs of the well will not be required. Based on expected normally pressured well characteristics Bahamas Petroleum Company believes it can avoid hazardous completion fluids such as zinc bromide.

In the event that completion fluids are released to the marine environment, the resulting water quality impacts would be negative, direct, localized, reversible and short-term. The consequence of this impact could be moderate; however, the likelihood is improbable resulting in an impact rating of **low** (C = 2, L = 0, and thus I = low). This ranking could also be considered to have a minor consequence with seldom or occasional likelihood, but this ranking would also be considered low (C = 1, L = 1 - 2, and thus I = low).

5.4.3.3 Potential Harm to Marine Fauna (3B3)

A study of chemical spills of offshore oil and gas activities by Boehm, et al. reviewed the types and volumes of chemicals used in United States Gulf of Mexico outer continental Shelf.[64] The study determined that most chemicals are either nontoxic or used in small quantities. Zinc bromide and ammonium chloride are both used for well treatment or completion and therefore are not in continuous use; thus, the risk of a spill for these chemicals is very small. Further, Bahamas Petroleum Company does not expect to use these or other “heavy brines” as previously drilled wells in The Bahamas were normally pressured.

While such spills could impact marine water quality the consequence of such a spill on marine fauna is minor and the likelihood seldom. This results in a **low** impact rating (C=1, L=1, thus C=low). This impact would be negative, reversible, localized and short-term.

5.4.4 Decommissioning and Abandonment

The activities associated with decommissioning and abandonment are similar to those of rigging-up and mobilization, and therefore, the impacts are also similar. The main concerns include potential damage to marine water quality and marine life from a spill of hazardous liquids or other material. However, in this phase the drilled wells also need to be suspended or abandoned. This process involves steps to isolate the hydrocarbon bearing formations and capping the wells. During this process there will be a disruption of sea floor sediments immediately around the well head and increased turbidity that could impact benthic species.

5.4.4.1 Disruption of Sea Floor Sediments (4A1, 4C1)

After the drilling is complete and well characteristics have been determined, the drilled well will need to be suspended or abandoned (depending on the results). This process involves isolating the production zones from the seabed with cement plugs and mechanical barriers to prevent the

[64] Boehm, et. al. 2001.

potential flow of hydrocarbons to the surface. In addition, removal of the transponders and/or anchors will temporarily disrupt seafloor sediments and benthos. This potential impact would be negative, direct, localized, reversible and short term. The consequences of these impacts are expected to be minor with a probable likelihood, leading to a **low** impact rating (C = 1, L = 3, and thus I = low).

5.4.4.2 Potential Degradation of Marine Water Quality

Impacts in this phase will be similar to phase 1 (mobilization and rigging-up) relating to potential impacts from uncontrolled releases and water quality impacts caused by disruption of seafloor sediments.

Potential Degradation of Marine Water Quality from Release of Formation Fluid D (4A2) – Some release of formation fluid (i.e. water and petroleum in from the reservoir) to the ocean environment near the wellhead is possible during suspension and abandonment. However, controls are in place to manage this, therefore the likelihood of fluids release would be minimal. The consequence of this activity on the marine environment would be minor, and the likelihood is seldom. Therefore the overall impact is **low** (C = 1, L = 1, and thus I = low). This impact would be negative, direct, dispersed, reversible and short-term.

Potential Degradation of Marine Water Quality from Fuel or other Hazardous Material Spill (4B1) – As described in Section 5.4.1.1, loading and storing fuel and other hazardous materials during decommissioning and abandonment could result in uncontrolled releases. The consequence of such spills is at most moderate and the likelihood is seldom, so the impact rating is **medium**, requiring mitigation to manage the risk (C = 2, L = 1, and thus I = medium). This impact would be negative, direct, dispersed, reversible and short-term.

Potential Degradation of Marine Water Quality from Disruption of Seafloor Sediments (4C2) – As described in Section 5.4.3.1, sediments will be temporarily disrupted from well abandonment/suspension and when removing the transponders and/or anchors. The consequence of this activity could have a minor impact to water quality, and the likelihood of this would be probable. The overall impact is **low** (C = 1, L = 3, and thus I = low). This impact would be negative, direct, localized, reversible and short-term.

5.4.4.3 Potential Harm to Marine Fauna

Two main sources of impact to marine fauna were identified in the decommissioning and abandonment phase and are similar to those described for mobilization and rigging-up. These include accidental release of fuel or other hazardous material and impacts to benthic organisms from removing disruption of seafloor sediments during well abandonment and/or removal of transponders and/or anchors. Accidental releases of hazardous liquids are also possible during well suspension or abandonment.

Potential Harm to Marine Fauna from Fuel or other Hazardous Material Spill (4B2) – Similar to Section 5.4.1.2, a potential spill of fuel or other hazardous materials could occur during decommissioning and abandonment. However, such a spill (particularly during loading) would be relatively small and probably identified and contained/dispersed quickly. Further, both the support vessels and the drilling rig will be equipped and personnel prepared for immediate response. Some release of formation fluid to the ocean environment near the wellhead is also possible during suspension and abandonment. Accidental releases described above could have minor consequences to marine fauna with a likelihood of seldom, resulting in a **low** impact (C = 1, L = 1, and thus I = low). This impact would be negative, direct, reversible (at the habitat level), localized and short-term.

Potential Disruption to Benthos from Disruption of Sea Floor Sediments (4A3, 4C3) – As described in Section 5.4.3.1, seafloor sediments will be temporarily disrupted during well abandonment/suspension and during removal of transponders and/or anchors. These activities could smother or disrupt benthos, causing a very localized and reversible (on the habitat level) impact. The consequence of these activities could have a negligible to minor impact to benthos, although the likelihood of this activity would be seldom. This impact would be negative, direct, reversible (at the habitat level) and short-term. The overall impact is **low** (C = 0-1, L = 1, and thus I = low).

5.4.5 Vessel Operations

As discussed above, impacts related to vessel operations include activities that will be conducted throughout phases 1-4. For example, these include impacts relate to housing approximately 200 people at sea and movement of the drilling rig and support vessels. Potential impacts related to oil spills from drilling are discussed in Section 5.4.2. This section discussed oil spills that could be caused by transport of the drilling rig to and from the well sites, as well as support vessels traveling to and from port. Similarly, discharges related to drilling were discussed above, whereas gray and black water discharges, and management of other household wastes will be discussed in this section. Most of the possible impacts of vessel operations are rated as low and do not require further mitigation beyond normal controls that will be in place.

<u>5.4.5.1 Potential Degradation of Marine Water Quality – Accidental Spills (5A1, 5B1, 5C1)</u>

Degradation of water quality resulting from operational activities could result from potential fuel or other material spills.

Fuel spills could occur during storage or refueling or due to a collision at sea that is sufficiently severe to rupture a fuel tank or line on a vessel. From 1995 to 2001, there were 56 vessel collisions in the Gulf of Mexico related to oil and gas exploration.[65] The activity in the Gulf of Mexico is much higher than the proposed program. Most collisions were a result of service vessels colliding with platforms or vessel collisions with risers. Approximately 10 percent of vessel collisions with platforms in the Gulf of Mexico outer continental shelf caused diesel spills. The expected fuel storage capacity of support vessels is approximately 900 m^3 (240,000 gallons) (plus additional storage capacity of other hazardous liquids).

[65] United States Minerals Management Service. 2003. Gulf of Mexico OCS Oil and Gas Lease Sales 189 and 197, Eastern Planning Area, Final Environmental Impact Statement.

In the last 5 years there have only been two reported vessel collisions in The Bahamas, both by pleasure boaters.[66] Despite the numerous tankers that frequent the oil storage and trans-shipment facilities at BORCO and South Riding Point in Grand Bahama, there were no reported incidents from oil related vessel collisions in The Bahamas.

An oil spill while fuelling would likely cause a measurable but short term and reversible degradation of water quality around the point of the spill and, if severe, could spread to surrounding waters.

The cause of such a spill would have to be a collision with another vessel, structure, or shallow feature of such a strong impact that it is capable of puncturing or tearing the steel hull of one of the vessels at the area where fuel is stored.

Diesel fuel is lighter than other oils, and thus quickly disperses and evaporates on the surface of water. Thus, while the impact of such a spill on marine water quality would certainly cause a measurable degradation of water quality, it would be a short term and reversible impact.

Spills of industrial solid waste (trash, building materials, recyclables, etc.) could occur also, although these materials could be retrieved (if floating), and have a localized impact. For these reasons, the consequence of oil spill or release of solid waste on marine water quality is classified as moderate. While the quantities of fuel and other hazardous liquids stored on the drilling rig are larger than quantities stored on support vessels, the chances of a drilling rig tank rupture are less probable. Without mitigation in place, the likelihood of a moderate level spill that will have the impacts described above at either the dock or in open ocean is seldom. Therefore the overall pre-mitigation impact rating is **medium**, requiring mitigation to manage the risk. (C = 2, L = 1, and thus I = medium). These impacts could be considered reversible, dispersed and have short to medium term duration.

5.4.5.2 Potential Degradation of Marine Water Quality – Discharge of Macerated Food and Treated Effluent (5D1, 5E1)

Each of the vessels working on the program will discharge macerated food and treated wastewater effluent to the ocean in accordance with MARPOL standards[67]. Treatment and disposal of sanitary wastes (include all black [sewage] and grey water [showers and washing facilities]) varies between drilling rigs, however wastewater from the drilling rig will be treated and discharged directly to the sea in accordance with MARPOL. Vessels that require ballast water discharge will follow international standards to avoid introduction of invasive species. Each ship will have a Ballast Water Management Plan to ensure the stability of the vessel and conform with international standards, such as exchanging ballast water at least 200 nautical miles from shore and in waters over 200 meters deep, if required. Plans will be vetted and audited as part of the contracting process and spot audits might be carried out during operations. There will be a qualified Ballast Control Operator 24 hours a day onboard to ensure stability all times. This will be managed particularly during fluids transfer on/off the vessel during bad weather.

[66] Rolle, D. 2011. Personal communication with The Bahamas Maritime Authority.

[67] These include a requirement that vessels certified to carry 15 or more people have an operating wastewater treatment facility, that treated wastewater may not be discharged within three nautical miles of shore, and that untreated wastewater may not be discharged within 12 nautical miles of shore.

Support vessels accompanying the drilling rig will not have wastewater treatment facilities onboard, but will discharge wastewater in accordance with the vessel's wastewater plans. This practice is consistent with what is done by other small vessels (including, for example, fishing vessels) that have been operating in the study area, and is consistent with MARPOL standards. Neither the food nor the treated wastewater discharges nor the small amount of untreated wastewater discharge from the support vessels will contain high levels of pollutants, and each of these waste streams will disperse quickly in the open marine environment. As a result, the impact will be consistent with natural conditions, resulting in a consequence classification of negligible. The likelihood that these discharges will occur is probable (certain), and therefore the overall impact rating is **low** (C = 0, L = 3, and thus I = low). This potential impact would be reversible, localized and short term (although it would be repeated over the life of the project).

If untreated or inadequately treated wastewater were to be accidentally discharged in the near-shore environment, either due to equipment failure or operator error from support vessels while passing to and from the port, the resulting consequence on sensitive coastal features could be minor with a likelihood of seldom, resulting in a **low** overall risk ranking. In the worst case, a moderate consequence to near shore marine ecosystems and habitat from an untreated sewage release would have to be considered to have an improbable likelihood, still resulting in a **low** overall impact ranking.

5.4.5.3 Potential Harm to Marine Fauna

Potential impacts to marine fauna resulting from vessel operations are related to a potential spill of diesel fuel or other hazardous liquids, physical impact from vessel hull or propellers and generation of noise from support vessel operations. Specifically, these impacts include:

- Potential Impact to Fish from Oil Spill
- Potential Impact to Plankton, Fish Eggs and Larvae from Oil Spill
- Potential Impact to Marine Mammals and Sea Turtles from Oil Spill
- Potential Impact to Pelagic and Seabird Species from Oil Spill
- Potential Disruption of Marine Fauna from Noise Generated by Support Vessels
- Potential Mechanical Impact to Marine Fauna

Potential Harm to Marine Fauna – Spill of Fuel or other Hazardous Liquids (5A2) – A significant spill of diesel fuel or other hazardous liquid from vessel collision and tank rupture or spill while refueling could impact marine fauna. Individuals within this category of organisms, including fish, marine mammals, turtles and plankton, could be impaired if they were to come into direct contact with spilled fuel or other hazardous liquids. No harm to benthos is expected during this phase. Except in the case of plankton, only localized impact to a small number of species could be expected before the released diesel fuel rises to the surface and is dispersed or evaporated to ambient conditions. Plankton communities in the direct vicinity of the spill would likely suffer more damage and some die-off as these organisms inhabit the surface and upper levels of the water column. Due to the measurable but potentially dispersed and reversible[68] effect of a diesel fuel spill on pelagic organism habitat, the consequence of this impact is categorized as moderate. The likelihood of a spill is seldom. Therefore the overall pre-mitigation impact rating is **medium** (C = 2, L = 1, and thus I = low).

Potential Impact to Marine Fauna from Noise from Supply Vessels (5G2) – As discussed in Section 5.4.2.3, human-made sounds from drilling related activities may affect the ability of

[68] At the habitat level vs. the individual level.

marine fauna to communicate and to receive information about their environment. Ambient noise in the ocean between the frequency bands of 20Hz to 300Hz is dominated by shipping noise. [69] [70] Figure 5-15 depicts shipping and other anthropogenic activities compared to noise created by natural sources, including marine fauna.

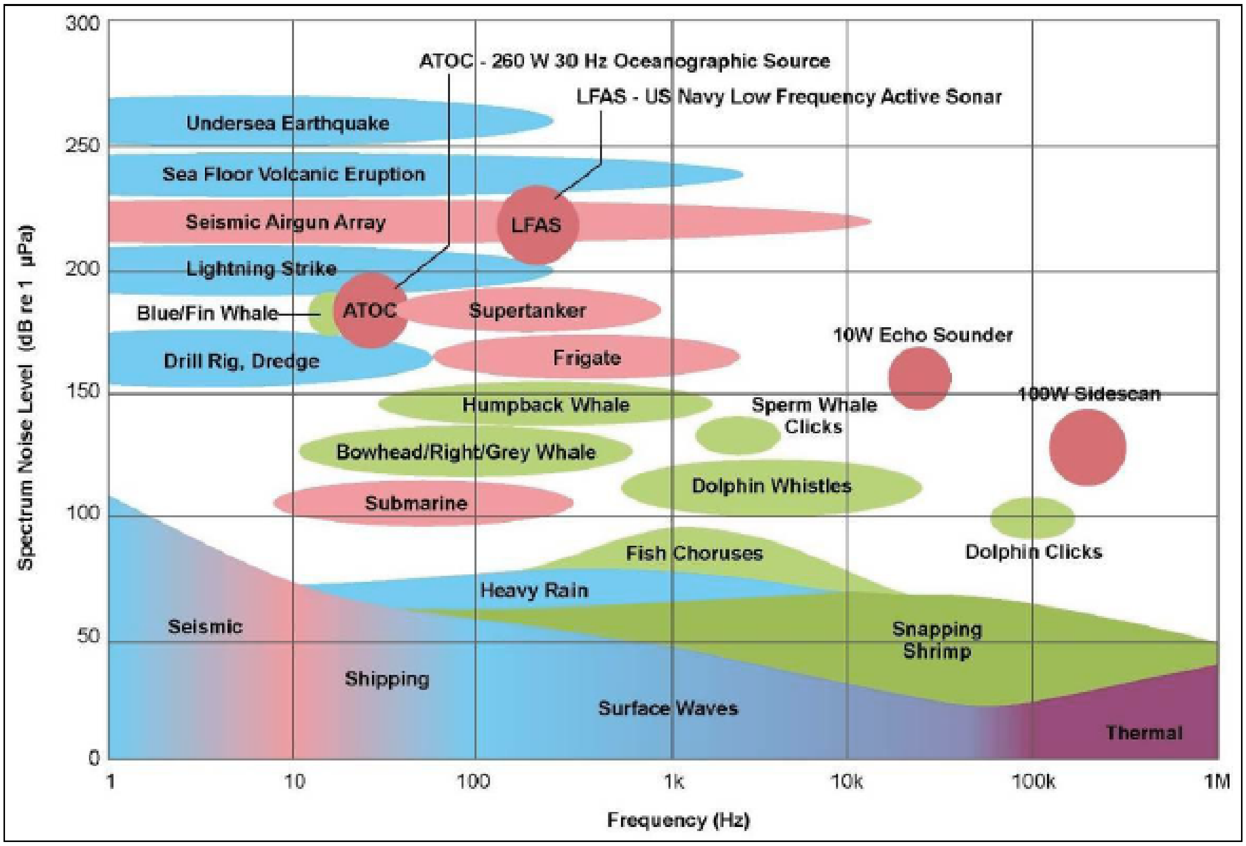

Figure 5-15: Comparison of Frequency and Noise Level of Anthropogenic and Natural Ocean Sounds

Source: Adapted from Richardson, et al., 1995[71] [72]

Impacts to plankton, benthos, and fish would be negligible. Noise generated by the drilling program may add to current ambient ocean noise and interfere with or mask the sounds used

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69 Wyatt, R. 2008. Review of Existing Data on Underwater Sounds Produced by the Oil and Gas Industry. Submitted to Joint Industry Programme on Sound and Marine Life. Accessed from the soundandmarinelife.org website: http://www.soundandmarinelife.org/Site/Products/Seiche_Aug08.pdf .

70 U.S. Department of Interior, Bureau of Ocean Energy Management. 2011. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017, Draft Environmental Impact Statement. Accessed from the BOEM website: http://www.boem.gov/uploadedFiles/BOEM/5-Year/2012-2017/PEIS/Combined_2012-2017_OCS_Oil_and_Gas_Leasing_Draft_Programmati.pdf

71 Adapted from Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA, 576 pp

72 Recent data from the Oil and Gas UK Joint Industry Programme on Sound and Marine Life confirms the data depicted in this graphic.

and produced by marine mammals and sea turtles and thereby interfere with their natural behavior.[73]

However, the additional one to three trips per week by supply vessels to port will only produce limited sound disturbance as the vessels are continuously moving. Further, one to three trips to port per week is insignificant compared to the existing vessel traffic in the area from pleasure boats, cruise ship traffic and shipping traffic. As such, the consequence of these effects on marine fauna are considered minor. The likelihood of impact is probable, thus resulting in a **low** impact (C = 1, L = 3, and thus I = low).

Potential Mechanical Impact to Marine Fauna (5A3) – Increased traffic from support vessels involved in survey, service, or shuttle functions could increase the probability of collisions between vessels and marine fauna. Harm to plankton, fish and benthos at the habitat scale would be negligible, but collisions with marine mammals and/or sea turtles could cause major wounds or fatalities to individuals. [74] [75] [76] Debilitating injuries may have negative effects on a population through impairment of reproductive output.

The consequence of this impact (at the habitat scale) could be moderate given that species affected could be endangered and the likelihood would be seldom, resulting in a **medium** overall impact rating (C = 2, L = 1, and thus I = low) and requiring mitigation. This impact would be direct, negative, reversible, localized and medium term (at the species level).

5.4.5.4 Potential Degradation of Sensitive Shoreline Features – Spill of Fuel or other Hazardous Liquid (5A4, 5A5)

As described in Chapter 4, coastal sensitivities exist along the adjacent shorelines. For example, there are popular beaches, protected areas, endangered sea turtle nesting sites, and other features important to biodiversity and ecosystem services. Fuel spills could occur either from an accident while refueling or due to a collision at sea that is sufficiently severe to rupture a fuel tank or line on a vessel. Refueling near shore would only occur at the port facilities where nearby coastlines are developed and lack sensitive shoreline features. However, a supply vessel collision could potentially occur near sensitive areas. Diesel fuel is lighter than crude and much would likely disperse in the ocean environment and/or evaporate before reaching shore. However, even small quantities could cause both ecological and economic harm. While the effect of a spill reaching these resources would be considered a moderate consequence, the likelihood that a fuel tank rupture would occur near these areas is seldom, resulting in a **medium** impact (C = 2, L = 1, and thus I = medium). The impact would be negative, direct, reversible, dispersed and medium-term.

[73] Bowles, A.E. 1995. Responses of Wildlife to Noise. In: Knight, R.L. and K.J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence through Management and Research. Washington, DC: Island Press. Pp. 109-156.

[74] Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions Between Ships and Whales. Marine Mammal Science 17:35-75.

[75] Kraus, S.D. 1990. Rates and Potential Causes of Mortality in North Atlantic Right Whales (Eubalaena glacialis). Marine Mammal Science 6:278-291.

[76] Waring, G.T., D.L. Palka, K.D. Mullin, J.H.W. Hain, L.J. Hansen, and K.D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 1996. NOAA Tech. Memo. NMFS-NE-114.

5.4.5.5 Degradation of Air Quality (5F1)
Estimated air emissions are shown in Section 2.6.3 and air quality impacts related to drilling are described in Section 5.4.2.7. Air emissions generated during vessel operations will be produced from vessel engines, helicopters and from other combustion fueled equipment. Most of these emissions will be produced offshore and will be dispersed quickly. The emissions from helicopters passing over coastal sections of the study area will have a barely measurable, dispersed, short term and quickly reversible impact on air quality. The consequence of any such impact is negligible to minor, and the likelihood is probable. Therefore, the overall impact rating is **low**. (C = 0-1, L = 3, and thus I = low)

Cumulative impacts of green-house gas emissions are discussed in Section 5.4.7.1.

5.4.5.6 Disruption of Local Communities from an Increase in Noise (5G1)
Engines in the support vessels and helicopters being used for the drilling program will generate noise, as will the rotation of the helicopter blades.

Service vessels transmit noise through both air and water. The intensity of noise from service vessels is roughly related to ship size, laden or not, and speed. Sounds from support boats range from 120 to 160 dB at 400-7,000 Hz.[77] Commercial vessel noise is a dominant component of manmade ambient noise in the ocean. [78]

Noise generated from helicopter and service-vessel traffic is transient in nature and extremely variable in intensity. This sound would generally be brief as these sources are typically moving between the drill site and port/shore.

As these vessels pass through coastal areas between the drilling rig and port, the noise could disrupt people who live, work and recreate in these areas. The consequence of this impact is minor and the likelihood is occasional, for an overall impact level of **low** (C = 1, L = 2, and thus I = low). The impact would be negative, direct, reversible and short-term.

5.4.5.7 Disruption of Fishing, Commercial, and Recreational Marine Vessel Traffic (5A6)
The drilling program is expected to cause a minimal increase in marine vessel traffic to the study area resulting from movement of the drilling rig and transport of personnel and supplies from the support vessels. When possible, these vessels will operate within designated navigation channels, and the supply vessels and drilling rig will navigate in accordance with international marine safety and traffic standards (e.g., COLREGS). Nevertheless, the increase in marine traffic could potentially disrupt commercial or recreational vessels in the area and increase the risk of vessel collisions. This potential impact would be dispersed, reversible and short term (although repeated over the life of the project). The consequence of this impact is categorized as negligible to minor, and the likelihood that such a conflict could occur is occasional. Therefore, the overall impact rating is **low** (C = 1, L = 2, and thus I = low).

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[77] U.S. Dept. of Commerce. National Marine Fisheries Service. 1984. Endangered; Species Act, Section 7 Consultation – Biological Opinion. Attachment C. In: Science Application, Inc., Revised Draft Environmental Impact Statement/Report, Technical Appendix 8, Marine Biology for Santa Ynez Unit/Las Flores Canyon Development and Production Plan. 34 pp.

[78] Jasny, M. 1999. Sounding the Depths: Supertankers, Sonar and the Rise of Undersea Noise. National Resources Defense Council, March 1999. 75 pp.

5.4.6 Ancillary Activities

Possible impacts resulting from ancillary activities are limited to impacts related to the increase in demand for supporting services onshore and the indirect effects of those activities.

5.4.6.1 Demand for Public Services (6A1)

The supporting services of the drilling activities will generate a demand for review, public vetting, approval and monitoring by officials of the Government of The Bahamas including the BEST Commission and other agencies involved in reviewing and approving the EIA, as well as marine navigation authorities. However, this demand will be localized, short-term and reversible. Thus, the consequence is categorized as minor, the likelihood is probable, and the overall impact rating is **low** (C = 1, L = 3, and thus I = low). The cumulative impacts relating to the increase in demand of public services of this project in combination with other projects in the area is addressed in Section 5.4.7.1.

5.4.6.2 Impact on Employment and Economy

Potential Positive Impact of Drilling Activities on the Local Economy (6B1) – The proposed drilling activities will have a limited positive impact on the local economy. Given the complex nature of offshore drilling activities, highly specialized and experienced crews of workers are needed on the rigs to ensure timely, well communicated and safe completion of drilling activities. Based on the special skill sets required for the project, Bahamas Petroleum Company may indirectly involve 10 additional Bahamians / Companies in addition to the 3 currently on staff. In addition to a limited number of permanent jobs for Bahamas Petroleum Company staff, the drilling activities will require the provision of boats, food, accommodation, flights (fixed wing and helicopter), emergency services, construction materials and other goods and services that could create new jobs. Local goods and service providers will be selected whenever possible and could involve 20-50 persons. Exploration drilling programs are temporary so the activity would be limited to a few months. This potential impact would be localized, reversible and short term. Any positive impact generated would be categorized as having a minor consequence and a probable likelihood. Therefore, the overall impact rating is **low**. (C = 1, L = 3, and thus I = low). The impact would be reversible, dispersed and short-term.

The impact assessment rating is based on this stage of the hydrocarbon exploration and production process only (a 1 or 2 well drilling campaign). If commercial reserves are identified the impact to the local economy could be significant , both in terms of education, job creation (300-500 positions), infrastructure and revenue to the government.

Acquisition of Detailed Knowledge about the Environment (6C1) – The acquisition of detailed environmental and technical studies (i.e. multibeam survey, site specific surveys, etc.) will be implemented as part of project operations and would provide detailed knowledge about the environment that would otherwise be unknown. Detailed seabed surveys may highlight areas of interest (e.g. shipwrecks) or environmental impact (e.g. status of coral habitats) that otherwise would have been studied. This potential impact would be dispersed, irreversible and long term. The consequence of this impact is categorized as minor and the likelihood is probable. Therefore, the overall impact rating is **low** (C = 1, L = 3, and thus I = low).

5.4.6.3 Potential Social Conflicts with Foreign Workers (6D1)

As described above, due to the complex nature of offshore drilling activities, highly specialized and experienced crews of workers will be needed on the rig. These employees will work on a rotation, either 14 or 28 days at a time. Crew changes will likely involve helicopter flights from the drilling site(s) to a regional airport on Andros Island. Most of the workers will then take a chartered flight to the Lynden Pindling Airport in Nassau and take connecting flights home. Some workers may stay in The Bahamas during their time off. Considering that an average of 4.5 million tourists visit The Bahamas annually the impact to local health and safety from less than 200 additional visitors is considered negligible. However, local residents may have high expectations for job creation from oil and gas activities and the numbers and types of jobs created at this stage (exploration) might disappoint. Thus the likelihood ranking is occasional, resulting in a **low** impact (C = 0, L = 2, and thus I = low). The impact would be reversible, dispersed and likely short-term.

5.4.6.4 Potential Public Health Impacts from Interaction between Foreign Workers and Local Population (6D2)

Drilling crew typically work on either a 14 or 28 day rotation schedule. Between shifts, workers will likely return to their home country (i.e. United States) using pre-arranged travel that would likely include a 2-3 hour stop-over in Congo Town prior to flights to Nassau then home. If, however, workers remain in The Bahamas between shifts there is a possibility that the introduction of foreign workers could increase the spread of sexually transmitted diseases (STDs). All workers will be required to undergo a medical screening prior to arriving in The Bahamas as a condition of their employment and the project is only expected to last a few months. Therefore, the likelihood of spread of STDs due to project activities is considered seldom. However, introduction of even one case of a serious STD (i.e. HIV/AIDS) would be considered a moderate consequence, resulting in a **medium** impact and will require mitigation to reduce the risk (C = 2, L = 1, and thus I = medium). This impact would be reversible (at the population level), dispersed and short-term.

5.4.7 Potential Cumulative and Transboundary Impacts

5.4.7.1 Potential Cumulative Impacts

The EIA Project Team also evaluated the potential cumulative environmental and social impacts that could result from the proposed project activities in combination with current actions and reasonably expected future developments in the area. Bahamas Petroleum Company currently holds the only active licenses in The Bahamas, although additional license applications are pending. Early exploration activities are also currently underway off western Cuba.

It is currently unknown if commercially exploitable hydrocarbons are present in Bahamas Petroleum Company blocks or other areas in the region. Further, if commercially exploitable reserves are found Bahamas Petroleum Company would complete another EIA prior to any future production activity. Given the uncertainty of future oil and gas activities in The Bahamas and subsequent opportunity to conduct more detailed cumulative impacts analysis once more details are known, discussion of potential cumulative impacts in this study is brief.

Several minor cumulative effects were identified: increased contribution to global greenhouse gas emissions from burning of combustible fuels in ship motors, process equipment and flaring; increased contribution to ambient ocean noise from supply vessels and drilling rig; potential to increase demand for public services and potential for additional socioeconomic impacts.

Cumulative Impacts of Greenhouse Gas (GHG) Emissions – The primary GHGs to be emitted during the proposed drilling program are CO_2 and CH_4. The major sources of GHG emissions include:

- Main power generation systems on the drilling rig which are used to generate electricity

- On board equipment such as pumps, generators and diesel engines needed to support the drilling activities
- Supply boats and helicopters
- Flaring of gas on the drilling rig during well testing and/or due to upset, maintenance and emergency conditions during operations. No continuous flaring of hydrocarbon gases during normal operations is planned.

In 2009, The Bahamas generated 5,236,000 metric tons of CO_2 emissions.[79] A typical exploration well (not including flaring) produces approximately 2,000 metric tons of CO_2 equivalent per well. Drilling of each well would contribute approximately 0.038% to the annual emissions of The Bahamas, plus flaring. The amount of emissions from flaring varies depending on the volume of hydrocarbons flared (if any) and the amount of carbon in the feed. World CO_2 emissions from consumption of fossil fuels in 2007 were 2.93914 X 10^{13} metric tons. [80] Compared to global CO_2 emissions, emissions from drilling of an individual well is negligible. Emissions from downstream activities are not included in the listed sources of greenhouse gas emissions.

If commercially exploitable hydrocarbons are found, another EIA would need to be completed prior to development. This subsequent report would evaluate the cumulative impact of downstream activities, such as: producing, transporting and refining the hydrocarbons.

Cumulative Impacts to Marine Environment from Addition of Submarine Noise

The project will require mobilization of a drilling rig to/from the drill sites and transport of materials and crew from shore to the drill sites. Noise from these activities would be similar to those created by other small vessels potentially in the study area, such as fishing and recreational vessels. Large shipping vessels are also likely to pass through the study area, and dominate the ambient noise in the ocean between the frequency bands of 20Hz to 300Hz. [81] [82]

Currently, Bahamas Petroleum Company plans to utilize one or two platform supply vessels (PSV), with each making approximately one to three trips per week between the shore base and drilling location. If Port Fourchon, Louisiana is selected as the supply base there will be one trip per week per PSV, two to three trips per week per PSV if Freeport is selected. The cumulative impact of this level of addition activity is expected to have a negligible impact to the cumulative ambient ocean noise.

Potential Cumulative Impacts of Demand for Infrastructure and Services

As described above, the Project will require review, public vetting, approval and monitoring by government officials. Because there are no other offshore oil exploration and production programs proceeding or planned at present in The Bahamas, the cumulative effect of this demand for government personnel with knowledge of offshore exploration operations is expected to be limited. Likewise, the project preparation and other activities may generate an increased demand for service from marine navigation authorities and other government authorities. However, the consequence of these cumulative impacts is considered minor.

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[79] Energy Information Administration. 2011. International Energy Statistics. Accessed from the Energy Information Administration website: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8

[80] International Energy Agency (IEA), 2010.

[81] Wyatt, R. 2008.

[82] U.S. Department of Interior, Bureau of Ocean Energy Management. 2011.

If commercially exploitable hydrocarbons are found, development, production and downstream components (refining and marketing) would likely create a significant demand for new petroleum related infrastructure such as pipelines, storage tanks and related support industries. This new industry could create significant economic and growth but could also increase demand for local port infrastructure, as well as local roads, offices, waste facilities and other supporting infrastructure and services. If commercially exploitable hydrocarbons are found, the subsequent EIA to be completed prior to production would review these cumulative impacts.

Potential Other Cumulative Socioeconomic Impacts
The Project will be completed quickly (3-5 months per well). It will be performed by skilled workers offshore and will not involve much interaction with communities in The Bahamas, with the exception of temporary housing of off-duty workers and supply vessel and helicopter/fixed wing interaction with other sea users. The Project by itself is not likely to have significant adverse or beneficial socioeconomic impacts, however over time and in conjunction with additional exploration projects there is the potential for benefits to local businesses. If productive hydrocarbon reserves are identified, then exponentially more significant socioeconomic impacts are likely to be realized and should be studied in the subsequent production EIA, if necessary.

5.4.7.2 Potential Transboundary Impacts
The two potential transboundary impacts identified included:
1. Potential disruption of fishing, shipping and other current uses from increased vessel traffic
2. Potential harm to marine water quality, marine fauna, sensitive coastal resources, and local economies (especially fishing) in the event of a major loss of well-control (i.e. blow-out)

Supply vessels could be traveling to and from the United States to support this drilling program. Transboundary supply vessel traffic would be negligible (1 to 2 trips per week) as the additional traffic would not be noticeable when compared to existing traffic and oil and gas activities in the Gulf of Mexico.

In the very unlikely event of a potential well blow-out there could be transboundary impacts to marine water quality, marine fauna, sensitive coastal resources, and local economies (especially fishing) in Cuba and/ or the United States. As noted previously, historically poor communication between Cuba and The Bahamas and United States increases the need for pre-planning and response readiness – both by operators in the region and the national governments. Recent meetings between Caribbean countries and the United States provide a basis for some optimism that national oil spill strategies can be strengthened.[83] With regard to the proposed project, mitigation measures that address potential transboundary impacts are warranted. These will be described in Chapter 6.

5.5 Data Gaps and Uncertainties

In completing the impact assessment, relevant uncertainties and gaps identified are those related to project details described in Chapter 2 (including Project alternatives) and Chapter 4. None of these gaps represented a great enough impediment to prevent the EIA team from performing assessment reasonable evaluation of potential project impacts or proposing

[83] Bolstad, E. 2011. "Oil Drilling Off Cuba Prompts Talks in the Region". Published December 12, 2011. Accessed from the Miami Herald Website: http://www.miamiherald.com/2011/12/12/2543744/oil-drilling-off-cuba-prompts.html

appropriate mitigation measures to address the potential impacts identified for the drilling program. Bahamas Petroleum Company plans to submit well specific Environmental Management Plans for each well that will identify site specific sensitivities and re-evaluate impacts and mitigation if they are different from the above.

6. Environmental Management Plan

6.1 Introduction

This chapter presents the environmental mitigation and management measures considered for the Project. As described in Chapter 5, the EIA team used a methodology for impact evaluation that assessed the consequence and likelihood of each event to determine an overall significance rating of high, medium or low. These impact categories are used to determine the required level of mitigation. A "low" category indicates a potential impact that is at an acceptable level given that standard operating procedures and best practices will be applied. A "medium" category is a potential impact that requires mitigation in order to bring the potential impact down to a low level. Finally a "high" category represents a major or moderate consequence or probable likelihood and requires either an alternative approach or design, or a mitigation measure that will minimize the potential impact. Figure 6-1 shows the Impact Categories.

High (3)		Requires alternative approach/design and mitigation to minimize impact
Medium (2)		Requires mitigation
Low (1)		Proceed with care, apply standard controls but no additional mitigation needed

Figure 6-1: Impact Categories and Management Requirements

All the impacts identified for the Project were found to be of low or medium level significance. There were no high level impacts identified. Adherence to environmental operating procedures described in this report, in conjunction with adherence to the site specific Environmental Management Plan (which would be submitted under separate cover prior to drilling each well) will keep potential environmental impacts to a minimum.

Bahamas Offshore Petroleum Limited ("Bahamas Petroleum Company") Health, Safety and Environmental (HSE) Policy and standard practices and procedures are described in Section 6.2. These policies, practices or procedures apply to all potential impacts identified, even those that are low. Controls for low level impacts and mitigation measures for medium level impacts are presented in Section 6.3.

6.2 Health, Safety and Environmental Management

Bahamas Petroleum Company has a strong HSE Policy (provided in Section 3.6) which will apply to the project. In addition, a number of plans will be in place to protect the health and safety of employees and the public and minimize impacts to the environment.

For each well, Bahamas Petroleum Company or the operator will develop the following to manage HSE aspects of the project:

- Emergency Response Plan (including definition of response to hurricanes)
- Oil Spill Contingency Plan (including Blow-out)
- Waste Management Plan
- Health and Safety Plan
- Public Notification and Consultation Plan

Overviews of these actions are discussed below and full versions of the plans will be submitted with the well-specific Environmental Management Plan prior to drilling each well. Bahamas

Petroleum Company or the operator will ensure the project and all sub-contractor activities are in compliance with the actions described.

6.2.1 Emergency Response Plan

Bahamas Petroleum Company or the operator will develop an Emergency Response Plan (ERP) to respond in a safe, rapid, effective, and efficient manner to potential incidents that might result from project activities. Emergency response operations are designed to directly address all emergency situations and their consequences, and establish command and control over the incident scene, ensure the safety of responders, develop plans of action, and facilitate communications.

Emergency situations to be addressed in the ERP include:

- Well control problems (kick during drilling, blowout, etc.)
- Spills (oil spills, chemical spills, etc.)
- Fire and/or explosion (well, facility, etc.)
- Personnel (injuries, fatalities, missing person, etc.)
- Evacuations (medical, from a remote site, etc.)
- Natural disasters (hurricane, earthquake, etc.)
- Toxic releases (storage tank release or explosion, H_2S or SO_2 gas release, etc.)
- Transportation – personnel or equipment (down aircraft, vessel collision, etc.)
- Security (kidnap/extortion, piracy, etc.)
- Media/public relations (could result from any of the incidents above)
- Bahamas Petroleum Company property loss (numerous incident categories above)
- Public impacts (environmental impacts, injury, public or private property damage, etc.)

Response procedures for the emergency situations above will be included in the ERP.

<u>6.2.1.1 Roles and Responsibilities</u>

The ERP will designate roles and responsibilities of all emergency response personnel in an easy to use format (checklists). Internal communication protocol between Bahamas Petroleum Company employees will be provided, including an organizational chart and clear contact information for each party. The ERP will also list the contact information and protocol for third parties such as government agencies, local and regional support. Some contact details in the ERP will not become available until just prior to mobilization to the Site. Therefore, it is standard practice to verify and update the ERP within 1-2 weeks before mobilization to ensure all resources and procedures listed are current and correct.

A management team will be available 24-hours a day to help ensure that resources are mobilized to respond to an incident.

<u>6.2.1.2 Incident Response Training and Preparedness</u>

Bahamas Petroleum Company or the operator will conduct incident response and management training for all emergency response personnel. Incident response training will include the following topics:

- Notification procedures/requirements for facility operations, internal response organization, national and local agencies, contractors, and the information required for those organizations
- Communication system used for the notifications and response
- Information on the products stored, used, or transferred including familiarity with the material safety data sheets, special handling procedures, health and safety hazards, spill and firefighting procedures

- Potential incident scenarios and response procedures
- The operational capabilities of the contractors to respond to different types of incidents and how to manage these
- The Incident Management System that will be used to manage responses
- Human impact and media relations
- Resources at risk

In addition to training, the Bahamas Petroleum Company or the operator will conduct exercises and drills on emergency responses to ensure familiarity with roles and responsibilities and location specific environmental and social sensitivities. Results of the drills will be documented and reviewed to identify gaps and limitations. Based on these findings, the emergency response strategy for the drilling campaign will be updated if needed. An emergency response drill will be conducted as part of the start-up meetings to be performed with the crew of the drilling rig and support vessels prior to initiating drilling.

6.2.2 Oil Spill Contingency Plan

The drilling rig and support vessels will be outfitted with the necessary safety and emergency response equipment to manage all potential emergencies. Of particular concern is ensuring equipment and response capabilities are in place to manage oil spills. Bahamas Petroleum Company or the operator will develop an Oil Spill Contingency Plan (OSCP) to ensure that appropriate resources can be mobilized rapidly to provide an effective response to any spill whether considered Tier 1, Tier 2 or Tier 3 (as described in Chapter 2).

Tier 3 spill events are extremely rare but have the potential to cause widespread damage, affecting many people and overwhelming the capabilities of local, regional and even national resources. Bahamas Petroleum Company or the operator will maintain communication with a qualified international oil spill response organization that will be available 24-hours per day for a Tier 2 and/or 3 spills and will be capable of deploying internationally recognized best practices and technologies. These include:

- Dispersant and application equipment
- In-situ burn equipment
- Containment boom and anchoring equipment
- Mechanical recovery / skimming systems
- Temporary and intermediate storage and pumps
- Command, control and communications equipment
- Beach clean-up equipment
- Other support supplies

The OSCP will describe the following:

- Regional shoreline sensitivities, including sensitivity mapping
- Local support infrastructure (i.e. ports, airports, etc.)
- Oil spill risk scenarios and oil spill trajectory modeling
- Available oil spill response equipment (both on-board and onshore)
- External spill response support, including integration with national and regional oil spill response plans (i.e. Caribbean Island Oil Pollution Response and Cooperation Plan and The Bahamas Oil Spill Contingency Plan) and 3rd party contractors (i.e. Clean Caribbean and Americas)
- Notification procedures, communication systems, organizational structure and other items described in the ERP

The resources described above and Bahamas Petroleum Company's careful planning will help ensure that sensitive coastal resources, tourist activities and local fishing activities are protected in the unlikely event of a large unexpected spill.

6.2.3 Waste Management Plan

Oil and gas drilling programs produce various types of solid and liquid waste, and managing these wastes is an integral part of operating a successful drilling program that minimizes environmental and social impacts. Bahamas Petroleum Company or the operator will develop a project-specific waste management plan to ensure that all wastes for the drilling activities are properly managed in accordance with applicable laws and regulations, company policies and international standards relevant to the offshore oil and gas industry.

The following general categories of wastes are anticipated to be generated from the project at this time:

- Domestic solid waste, e.g. waste from living accommodations, offices, warehouses and workshops, such as office supplies, paper, wood, ashes, bottles, cans, Styrofoam, plastics, aluminum, glass, household batteries, incandescent light bulbs, and incidental food scraps
- Industrial solid waste, e.g. packaging material, oily rags construction materials, rubber, bulk scrap metal, drums and containers, industrial batteries, compressed gas cylinders, drill cuttings, etc.
- Medical waste, e.g. bandages, dressings, surgical waste, human tissue, hypodermic needles, medical laboratory waste, etc.
- Domestic liquid wastes, e.g. sewage (black water) and, waste water from showers, sinks, laundries, and canteen or kitchen wastewater from dishwashing and food grinding (grey water).
- Industrial liquid wastes e.g., waste oil (any used or spent petroleum liquid) cooking oil, sludges, oily filtrate, grease, paint, waste chemicals, drilling fluids, washdown water, etc.
- Air emissions: e.g. air emissions from the combustions of fuels in engines, generators, turbines and process equipment, marine vessels and flaring (if needed)

The Waste Management Plan will include:

- Waste streams and sources, including expected volumes
- Waste minimization and recycling opportunities, including:
  - Substitution of suitable products that are less toxic and less hazardous
  - Consideration of alternative approaches that could avoid the generation of waste altogether
  - Identification of potential beneficial reuse or recycling opportunities
- Disposal options for each waste stream
- Identification of appropriate waste management facilities that meet local requirements
- Recordkeeping practices, including manifest and waste tracking forms
- Permits or other required agency approvals
- Auditing, training and reporting

6.2.4 Health and Safety Plan

Offshore oil and gas drilling activities pose health and safety risks to employees, contractors and the public, if not managed properly. Bahamas Petroleum Company will work with the drilling contractor to develop a Health and Safety Plan (HASP) to manage safety concerns. The HASP will include:

- Identification of health and safety hazards
- Measures to minimize hazards

- Risk categorization
- EHS procedures, training and other controls and risk reduction measures (e.g. personal protective equipment, training, management programs, etc.) to protect workers and the public.

In addition, the following safety measures will be in place:
- Limitations to Project Site Access
- Program for Maintenance and Monitoring Site Integrity
- Compliance with International Rules or Codes of Practice

6.2.4.1 Limitations to Project Site Access

The drilling rig is considered a vessel with restricted maneuverability under the Convention on International Regulations for Preventing Collisions at Sea (COLREGs) rules established by the United Nations International Marine Organization (IMO). Under these rules, other vessels are required to give way and pass at safe distances to the rig. Industrial fishing vessels and other vessels may pass safely near the study area. There will be a safety zone of 1 km established around the drilling site to protect the health and safety of members of the public. Due to the offshore location of the project, artisanal fishing boats are not expected to be near the project site; however, members of the local fishing communities will be informed in advance of the Project and about the safety zone.

Bahamas Petroleum Company will inform maritime authorities prior to rig mobilization regarding detailed routes, rig locations, exclusion zones and scheduling plans through established means of communication. Notification to mariners would be provided by the following methods:
1. VH Channel 16
2. Notifications published in the local media (i.e. ZNS, community announcements, and the community page) and provided to local government

The drilling rig captain will monitor nearby vessel movements and provide warnings by radio and other means (including deploying a support vessel) to notify and redirect other vessels if needed.

6.2.4.2 Program for Maintenance and Monitoring Site Integrity

During drilling there will be daily maintenance inspections of equipment to ensure they are maintained in good order. Standard procedures for refueling, handling and managing wastes and monitoring discharges will be followed to ensure protection of the environment.

On completion of drilling, the drilling contractor will perform a survey of the seafloor immediately around (within 100-150 meters of) the drill site using a Remotely Operated Vehicle (ROV) to observe any impacts to the sea floor from the drilling activities including the discharge of cuttings.

6.2.4.3 Compliance with International Rules or Codes of Practice

A variety of international standards will apply to the drilling operations, including operational integrity, safety and environmental standards of API[1] as well as safety and environmental guidelines issued by the International Oil and Gas Producers Forum (OGP – www.ogp.org.uk) and the International Petroleum Industry Environmental Conservation Association (IPIECA – www.ipieca.org).

[1] Formerly the American Petroleum Institute, API maintains over 500 standards covering all aspects of the oil and gas industry (http://www.api.org/) including standards for the protection of health and safety.

In addition, three international treaties are particularly important to the project that relate to maritime traffic, vessel collision prevention and environmental protection. These are COLREGs (1972), MARPOL (1973/1978) and SOLAS (1974). Many of the standard controls oil and gas companies implement were developed to meet these international standards, see Section 3.2 for more details on these key treaties. Rules for implementing each of these agreements have been developed and are administered by the IMO. The Bahamas is one of 166 IMO member countries.

6.2.5 Public Notification and Consultation Plan

The Bain, Cooper, Donaldson and Eneas Blocks are located at the southwest edge of the Great Bahama Bank, north of Cuba. The well locations have not been finalized, but Bahamas Petroleum Company expects they will be located in water depths of approximately 1,650 ft. (~500 m). The proposed location of the first well is in the Donaldson Block, approximately 80 miles (~130 km) from Andros Island and 25 miles (~40 km) from the nearest Cuban islands.

Bahamas Petroleum Company and/or the operator will ensure the necessary precautions are used during their drilling program to minimize and prevent impacts and to safeguard socioeconomic sensitivities, while ensuring there are opportunities for the public to be informed of and ask questions about the proposed operations. Therefore, if required by the government, Bahamas Petroleum Company will develop a Public Notification and Consultation Plan (PNCP). The PNCP will include:

- Project background
- Engagement objectives
- Engagement process
- Engagement activities

The objectives, methods, and scope of Bahamas Petroleum Company's engagement will vary depending on the stakeholder group.

6.3 Mitigation Practices

When evaluating proposed mitigation measures for potential impacts, the EIA team focused on medium level impacts and recommended measures (in addition to those described in Section 6.2) that once applied will reduce the level of these medium impacts to low. The majority of medium level potential impacts are associated with "accidental" events, primarily spills (as opposed to routine events like air emissions that are known to occur).

The mitigation measures recommended are based on the EIA Team's experience on similar assignments worldwide and international guidance documents such as the IPIECA SIA Guidelines for the Oil and Gas Industry and World Bank Group Environmental, Health, and Safety Guidelines.[2] [3] International Finance Corporation (IFC, the private sector arm of the World Bank) calls for EIAs to propose "feasible and cost effective measures that may reduce potentially significant adverse environmental impacts to acceptable levels".[4]

[2] International Petroleum Industry Environmental Conservation Association (IPIECA). 2004. Social Impact Assessment Guidelines for the Oil and Gas Industry. Accessed from the IPIECA Website: http://www.ipieca.org/sites/default/files/publications/sia.pdf

[3] International Finance Corporation (IFC). 2007. Environmental, Health and Safety Guidelines. Accessed from the IFC Website: http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines

[4] IFC. 2011. Performance Standards on Social & Environmental Sustainability. Accessed from the IFC Website: http://www.ifc.org/ifcext/sustainability.nsf/Content/EnvSocStandards

While low level impacts do not require mitigation, Table 6-1 summarizes standard controls that will be implemented to ensure the impacts are minimized. Table 6-2 presents the mitigation measures required to reduce the medium level impacts to low, and Table 6-3 presents the mitigation measures in an Environmental Management Plan.

Table 6-1: Standard Controls to Manage Low Level Impacts

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Controls
1A2	Loading fuel and other materials onto the drilling rig	Marine fauna	Potential mortalities or oiling of marine fauna (fish, plankton, mammals, sea birds, or sea turtles) as a result of an accidental fuel or other material spill	Low	• Standard operating procedures (SOPs) for loading/bunkering • Emergency Response Plan • Oil Spill Contingency Plan (Additional mitigation listed in Table 6-2)
1B1	Attaching transponders and/or anchors to the sea floor	Marine fauna	Damage to potentially sensitive benthic organisms and their habitat from attaching transponders and/or anchors to the sea floor	Low	• High resolution multi beam survey prior to securing the drilling rig • Remote operated vehicle site survey prior to spudding
1B2	Attaching transponders and/or anchors to the sea floor	Submerged Archaeologic-al Resources	Potential damage to archaeological resources resulting from attaching transponders and/or anchors to the sea floor	Low	• High resolution multi beam survey prior to securing the drilling rig • Remote operated vehicle site survey prior to spudding
1B3	Attaching transponders and/or anchors to the sea floor	Marine water quality	Potential degradation of water quality resulting from sediment disruption from attaching transponders and/or anchors to the sea floor	Low	No controls required
1B4	Attaching transponders and/or anchors to the sea floor	Sediments	Disruption of sea floor sediments from attaching transponders and/or anchors to the sea floor	Low	No controls required
2A6	Operation of the drilling rig	Submerged Archaeologic-al Resources	Potential damage to submerged archaeological resources (e.g., possible shipwrecks) near well site	Low	• High resolution multi beam survey prior to securing the drilling rig • Remote operated vehicle site survey prior to spudding
2B1	Storage and use of potentially hazardous materials	Marine water quality	Degradation of water quality from accidental spill of potentially hazardous materials	Low	• SOPs for hazardous material labeling, storage and transport • Selection of least hazardous materials
2B2	Storage and use of potentially hazardous materials	Marine fauna	Degradation harm to marine fauna as a result of accidental release or spill of fuel or other hazardous materials	Low	• SOPs for hazardous material labeling, storage and transport • Selection of least hazardous materials
2C1	Use and consumption of natural resources	Environment	Extraction and use of natural resources	Low	• Maintenance of equipment

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Signifi-cance	Controls
2D1	Penetration of and drilling through the seafloor	Benthos	Disruption of sediments surrounding location of drill bit	**Low**	No controls required
2E1	Generation and disposal of drill cuttings	Sea floor sediments	Degradation of the quality of seafloor sediments from discharge of drill cuttings	**Low**	• Selection of environmentally friendly drilling fluids
2E2	Generation and disposal of drill cuttings	Marine water quality	Degradation of marine water quality from discharge drill cuttings	**Low**	• Selection of environmentally friendly drilling fluids
2F1	Generation of air emissions	Air quality	Degradation of air quality from combustion fuels used in mechanized equipment needed to support drilling	**Low**	• Maintenance of equipment
2G1	Generation of noise	Marine fauna	Potential disruption to marine fauna (esp. marine mammal) behavior due to generation of noise (both above sea level and sub-marine noise)	**Low**	• Maintenance of equipment
2H1	Generation of vibration	Marine fauna	Disruption of marine fauna (esp. benthos) from vibration caused by drilling and associated activities	**Low**	• Maintenance of equipment
2I1	Generation of light source	Marine fauna	Potential disruption to marine fauna (esp. sea turtle) behavior due to lighting	**Low**	No controls required
2I2	Generation of light source	Local economy	Potential aesthetic impact of rig due to lighting	**Low**	No controls required
2J1	Physical presence of, and safety zone around, the drilling rig	Local economy	Potential disruption of fishing (industrial and artisanal) and shipping activities resulting from avoidance of the drilling rig from the safety zone	**Low**	• Compliance with international navigation protocols (COLREGs) • Communication in advance of the project and during operations
2K1	Generation, storage, and disposal drilling fluids	Marine water quality	Degradation of marine water quality from discharge of drilling fluids	**Low**	• Selection of least hazardous materials • Waste Management Plan
2L1	Generation, treatment and discharge of drilling related wastewater	Marine water quality	Potential degradation of marine water quality from liquid wastes (i.e. deck drainage and bilge water) discharged at sea	**Low**	• Waste Management Plan • Adherence to local and international laws (i.e. MARPOL)

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Signifi-cance	Controls
2L2	Generation, treatment and discharge of drilling related wastewater	Marine Fauna	Potential harm to marine fauna from operational discharges	**Low**	• Waste Management Plan • Adherence to local and international laws (i.e. MARPOL)
3A1	Generation of air emissions	Air quality	Generation of light, noise, heat, smoke and greenhouse gasses from flaring	**Low**	• Minimization of flaring • Use of efficient burners (additional mitigation listed in Table 6-2)
3A2	Generation of air emissions	Local communities	Generation of air emissions from flaring impacting local communities	**Low**	• Minimization of flaring • Use of efficient burners (additional mitigation listed in Table 6-2) • Maintenance of equipment
3B3	Generation, treatment and disposal of formation fluids	Marine Fauna	Potential harm to marine fauna from discharge of produced water and fallout from un-combusted materials during flaring	**Low**	• Minimization of flaring • Use of efficient burners (additional mitigation listed in Table 6-2) • Maintenance of equipment • Avoidance of water producing zones during testing
3C1	Use of hazardous liquids	Marine water Quality	Potential Degradation of marine water quality from spill of completion chemicals	**Low**	• SOPs for hazardous material labeling, storage and transport • Emergency Response Plan • Oil Spill Contingency Plan • Selection of least hazardous materials (Additional mitigation listed in Table 6-2)
4A1	Well suspension or abandonment	Sediments	Disruption of sea floor sediments during well plugging and abandoning operations	**Low**	No controls required
4A2	Well suspension or abandonment	Marine water quality	Potential degradation of water quality resulting from accidental release of formation fluids into the marine environment	**Low**	• Standard operating procedures (SOPs) for well abandonment • Emergency Response Plan • Oil Spill Contingency Plan • Selection of least hazardous materials

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Signifi-cance	Controls
4A3	Well suspension or abandonment	Marine fauna	Potential disruption of benthic species during well suspension and abandonment operations	**Low**	• High resolution multi beam survey prior to securing the drilling rig • Remote operated vehicle site survey prior to spudding
4B2	Loading fuel and other materials used in the drilling rig	Marine fauna	Potential mortalities or oiling of marine fauna (fish, plankton, mammals sea birds, or sea turtles) as a result of an accidental fuel or other material spill	**Low**	• Standard operating procedures (SOPs) for loading/bunkering fuel • Emergency Response Plan • Oil Spill Contingency Plan (Additional mitigation listed in Table 6-2)
4C1	Removing transponders and/or anchors from the sea floor	Sediments	Disruption of sea floor sediments during removal of transponders and/or anchors	**Low**	No controls required
4C2	Removing transponders and/or anchors from the sea floor	Marine water quality	Potential degradation of water quality resulting from sediment disruption during removal of transponders and/or anchors	**Low**	No controls required
4C3	Removing transponders and/or anchors from the sea floor	Marine fauna	Damage to benthic organisms and their habitat from removal of transponders and/or anchors	**Low**	• High resolution multi beam survey prior to securing the drilling rig • Remote operated vehicle site survey prior to spudding
5A6	Movement of support vessels and drilling rig	Local economy / communities	Potential disruption of fishing activities (industrial and artisanal) and shipping routes resulting from increased marine traffic and movement of vessels of "limited maneuverability"	**Low**	• Compliance with international navigation protocols (COLREGs) • Communication in advance of the project and during operations
5D1	Generation, grinding and discharge of food waste	Marine water quality	Potential degradation of marine water quality in the immediate vicinity around pipe discharge point	**Low**	• Waste Management Plan • Adherence to local and international laws (i.e. MARPOL) • Discharge below the sea surface
5E1	Generation, treatment and discharge of wastewater	Marine water quality	Potential degradation of marine water quality from liquid wastes (grey water, deck drainage, etc.) discharged at sea	**Low**	• Waste Management Plan • Adherence to local and international laws (i.e. MARPOL) • Discharge below the sea surface

Impact Identification	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Controls
5F1	Generation of air emissions	Air quality	Degradation of local air quality due to the emission of exhausts from combustion engines (program vessels and machinery) and cumulative addition to global greenhouse gas levels	**Low**	• Maintenance of equipment
5G1	Generation of noise	Local communities	Disruption of local community lifestyles from generation of noise from passing helicopters	**Low**	• Route selection to avoid inhabited areas to the extent feasible
5G2	Generation of noise	Marine Fauna	Potential disruption to marine fauna (esp. marine mammal) behavior due to generation of noise from supply vessel movement	**Low**	• Maintenance of equipment • Minimization of supply vessel trips
6A1	Demand for public services	Local economy / communities	Potential strain to agencies from oversight of project	**Low**	• Communication in advance of the project and during operations
6B1	Purchasing goods and services to support the program	Local economy / communities	Potential benefit to employment and economy	**Low**	• Source locally to the extent feasible
6C1	Acquisition of detailed knowledge about the environment	Local economy / communities	Potential benefit to The Bahamas and its people from increased environmental awareness from studies that would not have been completed without the project	**Low**	No controls required
6D1	Use of foreign workers	Local economy / communities	Potential social conflicts due to the presence of foreign workers	**Low**	• Source locally to the extent feasible

Table 6-2: Recommended Mitigation Measures

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
Mobilization and Rigging-up (Phase 1)						
1A1	Loading fuel and other materials onto the drilling rig	Marine water quality	Degradation of water quality from an accidental spill of fuel or other hazardous materials	**Medium**	Mitigation Practice 1.1-1: Ensure drilling fluid additives or hazardous liquids (e.g., paint and solvent) are labeled and stored in sealed containers with secondary containment of adequate volume to help prevent the discharge of spills and debris into the marine environment.	**Low**
					Mitigation Practice 1.1-2: Develop and be ready to implement oil spill and emergency response procedures for bunkering hazardous liquids / refueling to minimize incidents.	
					Mitigation Practice 1.1-3: Prohibit bunkering / refueling at sea during rough weather or times of limited visibility	
					Mitigation Practice 1.1-4: Adhere to standard operating procedures during refueling to minimize incidents, including the use of drip pans.	
					Mitigation Practice 1.1-5: Ensure that the refueling hoses and check valves are in a good working condition prior to usage.	
					Mitigation Practice 1.1-6: During transfers, maintain effective communication between the supply vessel and the drilling rig during transfer and monitor continuously	
					Mitigation Practice 1.1-7: Ensure all staff is familiar with the procedures required for loading/unloading and storage of fuel and other hazardous materials	
See also Vessel Operations (Phase 5)						

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
Drilling (Phase 2)						
2A1	Operation of the drilling rig	Marine water quality	Degradation of marine water quality due to potential accidental oil spill	**Medium**	Mitigation Practice 2.1-1: Tailor oil spill response preparations to the results of the oil spill trajectory models and sensitive areas along the shoreline most likely to be impacted by a potential oil spill and provide adequate equipment and training to limit impacts from accidental releases on such areas.	**Low**
					Mitigation Practice 2.1.2: Verify that Tier 1 oil spill equipment is available on vessels.	
					Mitigation Practice 2.1-3: Maintain contract with an international oil spill response organization for support in responding to any potential Tier 2 and 3 spills that require outside assistance.	
					Mitigation Practice 2.1-4: Identify extreme weather patterns or other natural hazards that could impact the area and include planning for such events in the emergency response plan.	
					Mitigation Practice 2.1-5: Review oil spill trajectory modeling results and spill response plans with crew prior to start-up of drilling activities.	
					Mitigation Practice 2.1-6: Perform frequent checks of blow out preventer equipment, service according to the scheduled maintenance plan and ensure good operational conditions.	
					Mitigation Practice 2.1-7: All critical pressure test charts (i.e. negative tests, casing test, etc.) will be reviewed by Drilling Engineer/Drilling Supervisor prior to continuing with operations.	
					Mitigation Practice 2.1-8: Coordinate with local officials before drilling commences and maintain communication throughout the project.	

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
2A1 (Continued)	Operation of the drilling rig	Marine water quality	Degradation of marine water quality due to potential accidental oil spill	**Medium**	Mitigation Practice 2.1-9: Communicate with local port, marine navigation and fishing authorities in advance of drilling activities to notify them of the location and schedule of the proposed drilling program and to establish a reliable means of communication between the drilling rig captain, government marine authorities and sea users during the drilling program. The rig will be visible to all traffic by formal “Notice to Mariners” published daily.	**Low**
					Mitigation Practice 2.1-10: Identify government agencies and contact information of appropriate individuals responsible for oil spill preparedness and response in Cuba and include in the Emergency Response Plan.	
					Mitigation Practice 2.1-11: Ensure careful selection of drilling rig type and review of contractor’s historical performance.	
					Mitigation Practice 2.1-12: Conduct a complete mechanical and electrical audit of the drilling rig prior to contracting and acceptance.	
					Mitigation Practice 2.1-13: Review key contractor training and competency systems, and vet key personnel prior to drilling.	
					Mitigation Practice 2.1-14: Ensure all drilling contractor personnel involved in the project (onshore team & offshore personnel above Derrickman) have valid and current International Well Control Forum certification.	
					Mitigation Practice 2.1-15: Perform regular and varied well control drills during operations.	

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
2A1 (Continued)	Operation of the drilling rig	Marine water quality	Degradation of marine water quality due to potential accidental oil spill	**Medium**	Mitigation Practice 2.1-16: Use of effective, real-time data transmission and collection system from drilling equipment.	**Low**
					Mitigation Practice 2.1-17: Give due regard to the intent and spirit of the findings from the Macondo oil spill during planning and operations.	
					Mitigation Practice 2.1-18: Apply continuous oversight and auditing to ensure that appropriate procedures are being followed.	
					Mitigation Practice 2.1-19: Conduct a high resolution multibeam survey prior to securing the rig and a remote operated vehicle survey of sea floor prior to drilling to identify sub-sea hazards and/or seafloor anomalies	
2A2	Operation of the drilling rig	Marine fauna	Potential accidental oiling and/or mortality of marine fauna resulting from an oil spill (loss of well control)	**Medium**	Apply Mitigation Practices 2.1-1 through 2.1-19	**Low**
2A3	Operation of the drilling rig	Sensitive shoreline features	Potential accidental oil spill reaching shoreline fouling habitat (loss of well control)	**Medium**	Apply Mitigation Practices 2.1-1 through 2.1-19	**Low**
2A4	Operation of the drilling rig	Seafloor sediments	Degradation of seafloor sediments from accidental oil spill (accumulation on the sea floor)	**Medium**	Apply Mitigation Practices 2.1-1 through 2.1-19	**Low**

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
2A5	Operation of the drilling rig	Local economy / communities	Potential accidental oil spill impacting fish or reaching fishing areas and/or tourism areas, limiting income of the local communities (loss of well control)	**Medium**	Apply Mitigation Practices 2.1-1 through 2.1-19	**Low**
2A7	Operation of the drilling rig	Local economy / communities	Potential damage to subsea telecommunications infrastructure	**Medium**	Apply Mitigation Practice 2.1-19	**Low**
2E3	Generation and disposal of drill cuttings	Benthos	Degradation of benthic habitat resulting from biodegradation of drill cuttings, sediment toxicity and physical smothering	**Medium**	Mitigation Practice 2.2-1: Preferentially, use water-based muds (WBM) and low toxicity muds. When possible, pass cuttings through solid removal equipment for treatment and mud recovery prior to discharge to the marine environment.	**Low**
					Mitigation Practice 2.2-2: Periodically inspect and maintain drilling fluid circulation system and cuttings treatment system.	
					Mitigation Practice 2.2-3: Prohibit any overboard discharge of synthetic based drilling fluids.	
					Mitigation Practice 2.2-4: No discharge of drill cuttings within 300 meters of coral reefs, seagrass beds, submerged archaeological features or other seafloor sensitivities identified in the well specific Environmental Management Plan.	
See also Vessel Operations (Phase 5)						

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
Appraisal (Phase 3)						
3B1	Generation, treatment and disposal of formation fluids	Marine water quality	Potential degradation of marine water quality from discharge of treated produced water to the ocean	**Medium**	Mitigation Practice 3.1-1: Maximum oil content of produced water discharges must be less than 42 mg/l, and such that the 30 day average does not exceed 29 mg/l	**Low**
					Mitigation Practice 3.1-2: Minimize duration of tests	
3B2	Generation, treatment and disposal of formation fluids	Marine water quality	Potential degradation of marine water quality from flaring fallout (un-combusted materials)	**Medium**	Mitigation Practice 3.2-1: Use industry leading, efficient flare tips ("green burners"), and optimize the size and number of burning nozzles.	**Low**
					Mitigation Practice 3.2-2: Maximize flare combustion efficiency by controlling and optimizing flare fuel/air/steam flow rates to ensure the correct ratio of assist stream to flare stream.	
					Mitigation Practice 3.2-3: Minimize risk of pilot blow-out by ensuring sufficient exit velocity and providing wind guards.	
					Mitigation Practice 3.2-4: Minimize liquid carry over and entrainment in the gas flare stream.	
					Mitigation Practice 3.2-5: Record volumes of Hydrocarbons flared.	
					Apply Mitigation Practice 3.1-2	
Decommissioning and Abandonment (Phase 4)						
4B1	Loading fuel and other materials used in the drilling rig	Marine water quality	Degradation of water quality from accidental spill of fuel or other hazardous materials	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
See also Vessel Operations (Phase 5)						

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
Vessel Operations (Phase 5)						
5A1	Movement of support vessels and drilling rig	Marine water quality	Potential degradation of marine water quality due to an accidental fuel or other materials spill.	**Medium**	Mitigation Practice 5.1-1: Conduct advanced scouting and intermittent soundings prior to establishing dedicated transportation routes between the port and the drilling site where waters are <50m deep to determine if any elevated/shallow features (e.g. rocky shoals or coral outcrops) may be present warranting special precautions.	**Low**
					Mitigation Practice 5.1-2: Adhere to rules of navigation, particularly in the various channels where space may be limited.	
					Apply Mitigation Practices 1.1-1 through 1.1-7	
					Apply Mitigation Practices 2.1-1 through 2.1-19	
5A2	Movement of support vessels and drilling rig	Marine fauna	Potential harm to marine fauna as a result of an accidental fuel or other material spill	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
					Apply Mitigation Practices 2.1-1 through 2.1-19	
					Apply Mitigation Practice 5.1-1	
5A3	Movement of support vessels and drilling rig	Marine fauna	Potential damage to marine fauna from contact with hull or propeller	**Medium**	Mitigation Practice 5.2-1: Reduce speeds when a marine mammal or sea turtle is sighted to: • 13 knots within 2 miles (3.2 km) • 10 knots within 1 mile (1.6 km) • 7 knots within 0.5 miles (0.8 km)	**Low**
					Mitigation Practice 5.2-2: Maintain a safe distance from marine mammals and sea turtles: • 150 ft. (~45 m) from dolphins, porpoises, seals and sea turtles • 300 ft. (~90 m) from whales	

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
5A3 (Continued)	Movement of support vessels and drilling rig	Marine fauna	Potential damage to marine fauna from contact with hull or propeller	**Medium**	Mitigation Practice 5.2-3: No head on approach of marine mammals within 0.5 miles (0.8 km)	**Low**
					Mitigation Practice 5.2-4: Post a look out if within two miles (3.2 km) of a whale	
					Mitigation Practice 5.2-5: Report injury or mortality to sea turtles or marine mammals resulting from boat strike or other project activity	
5A4	Movement of support vessels and drilling unit	Sensitive shoreline features (estuaries, beaches, mangrove, lagoons)	Potential degradation of sensitive coastal feature habitat due to an accidental fuel or other material spill	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
					Apply Mitigation Practices 2.1-1 through 2.1-19	
					Apply Mitigation Practice 5.1-1	
5A5	Movement of support vessels and drilling unit	Local economy / communities	Potential accidental oil spill impacting fish and potentially reaching and fouling fishing/tourism areas (vessel fuel tank rupture at sea)	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
					Apply Mitigation Practices 2.1-1 through 2.1-19	
					Apply Mitigation Practice 5.1-1	
5B1	Storing fuel and other hazardous liquids on vessels, and refueling operations	Marine water quality	Potential degradation of water quality due to accidental spill of fuel or other materials at the drill site or at port	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
					Apply Mitigation Practices 2.1.1 through 2.1-19	
					Apply Mitigation Practice 5.1-1	

e	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Practice	Residual Impact
5C1	Generation, storage, transport and disposal of solid waste	Marine water quality	Potential degradation of water quality due to accidental release of solid waste to the marine environment	**Medium**	Apply Mitigation Practices 1.1-1 through 1.1-7	**Low**
Ancillary Activities (Phase 6)						
6D2	Use of foreign workers	Local economy / communities	Potential public health impacts from introduction of foreign employees	**Medium**	Mitigation Practice 6.1-1: Conduct training to workers regarding Company Policies (i.e. codes of conduct and ethics), local culture and importance of respectful relationships with local communities, and information on avoidance of STDs (such as hygienic practices and low risk behavior).	**Low**

6.4 Residual Impacts

After developing mitigation measures, the impacts were re-evaluated to determine whether the proposed mitigation measures would be effective in bringing all of the “medium” level impacts down to “low” level impacts. In each case, it was determined that when properly and consistently applied, the proposed mitigation measures were determined to bring all potential impacts for the project to a low level.

The most significant potential impacts, degradation of water quality, marine fauna, sensitive shorelines and local economy as a result of a possible oil spill (for example, from a blowout), will be limited by the standard marine navigation and BOP controls in place, experience and training of the personnel, adherence to policies and procedures established in the drilling plan and continuous oversight and auditing and further reduced by the mitigation measures proposed in this chapter. Effective application of the mitigation measures proposed related to oil spill response will be sufficient to ensure the overall impact is maintained at a low (and tolerable) level. Ensuring that these measures and controls are applied effectively and consistently throughout all applicable phases of the project will be critical to achieving the low levels of impacts predicted after mitigation.

Residual impacts after application of mitigation measures are shown in Table 6-2. The Environmental Management Plan presented in Table 6-3 presents indicators for each mitigation measure that represent successful application.

6.5 Environmental Management Plan Implementation and Monitoring

Bahamas Petroleum Company will follow an Environmental Management Plan (EMP) to ensure that mitigation measures and other EHS management activities are properly implemented. For each mitigation measure, the EMP (Table 6-3) presents:

- Schedule of implementation
- Record-keeping requirements
- Indicators of effectiveness
- Responsibilities (for implementing mitigation measures and monitoring their implementation)

In addition to the EMP below, Bahamas Petroleum Company will produce a well specific EMP that will evaluate potential impacts and mitigation that might be required at the given well location based on site specific sensitivities. The well specific EMPs will also include details on standard monitoring that will be conducted (not just those related to mitigation), including procedures and parameters. For example, the following will be monitored:

- Air emissions (equipment, flaring)
- Drilling mud and cuttings (types, chemical additives, mud recovery, cuttings discharge)
- Aqueous discharges (sewage, deck drainage, bilge and ballast water)
- Waste (kitchen, other waste)
- Socioeconomic impacts
- Spills

The well specific EMPs will also describe reporting requirements to ensure compliance with the EMP. If at any point limits look like they will be exceeded, this will be reported and an update to the EMP will be submitted for consideration.

Conformance to the mitigation measures will be monitored at regular intervals throughout the duration of each drilling event (which will last approximately 100-130 days). Examples include:

- Auditing of contractors against bridging document to ensure that the contractor's own EHS requirements, Bahamas Petroleum Company' EHS requirements and mitigation measures are met
- Review of records as needed during drilling (e.g. in the event of an incident) or at the close of the Project

On completion of each drilling event, Bahamas Petroleum Company or the operator will provide a brief report to BEST to summarize the Project activities and success in implementing mitigation measures. The report will include:

- A brief summary of the project schedule and activities
- Presentation of waste management and disposal activities completed
- Presentation of discharge monitoring reports for drill cuttings and other discharges
- Details of any spills or accidents
- Results of surveys performed with ROVs (if environmental sensitivities were encountered or significant impacts identified after drilling was completed)
- Details of encounters with other vessels or encroachments by other vessels within the 1 km safety zone

6.5.1 Implementation Plan

Bahamas Petroleum Company's EHS Manager will be the "owner" of the EMP and responsible for ensuring that the mitigation measures in the EMP are properly implemented. Contractor staff and Contractor EHS Officers will have day-to-day responsibility for ensuring that mitigations involving inspections, monitoring or maintenance are implemented.

Prior to each drilling event performed within the Licenses, Bahamas Petroleum Company or the operator will review this EIA and include a brief addendum for submittal to BEST as part of the well specific EMP.

The EMP presented in Table 6-3 can be used as a stand-alone document and kept on-board Project vessels.

6.5.2 Auditing

Beyond the routine inspection and monitoring activities conducted, audits will be carried out internally by Bahamas Petroleum Company or the operator to ensure compliance with regulatory requirements as well as their own EHS standards and policies. Audits will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be communicated to Bahamas Petroleum Company executive management.

The audit will include a review of compliance with the requirements of the EMP and include, at minimum, the following:

- Completeness of EHS documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping.

Table 6-3: Environmental Management Plan

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
Mobilization and Rigging-up (Phase 1)						
1A1	Mitigation Practice 1.1-1: Ensure drilling fluid additives or hazardous liquids (e.g., paint and solvent) are labeled and stored in sealed containers with secondary containment of adequate volume to help prevent the discharge of spills and debris into the marine environment.	Continuously throughout Phase 1	Maintain inspection reports of material storage. Maintain manifest and disposal documentation. Maintain records of spills.	1) No spills[5] and no disposal of waste chemicals overboard. 2) Number of audits performed 3)Percentage of findings remaining open greater than 24 hours	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 1.1-2: Develop and be ready to implement oil spill and emergency response procedures for bunkering hazardous liquids / refueling to minimize incidents.	Continuously throughout Phase 1	Maintain records of spill and emergency response procedures, communication of procedures to on-board personnel and spill response drills. Maintain records of spills.	No spills during refueling	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 1.1-3: Prohibit bunkering / refueling at sea during rough weather or times of limited visibility	Continuously throughout Phase 1	Maintain records of weather conditions during refueling. Maintain records of spills.	No spills during refueling	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager

5 See International Petroleum Industry Environmental Conservation Association (IPIECA) "Oil and Gas Industry Guidance on Voluntary Sustainability Reporting" for definitions of spills: http://www.ipieca.org/sites/default/files/publications/voluntary_sustainability_reporting_guidance_2010_1.pdf

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
1A1 (Continued)	Mitigation Practice 1.1-4: Adhere to standard operating procedures during refueling to minimize incidents, including the use of drip pans.	Continuously throughout Phase 1	Maintain records of standard operating procedures (SOPs) for refueling and communication of SOPs to crew. Maintain records of spills.	No spills during refueling	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 1.1-5: Ensure that the refueling hoses and check valves are in a good working condition prior to usage.	Continuously throughout Phase 1	Maintain records of refueling, equipment maintenance and inspections. Maintain records of spills.	No spills during refueling	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 1.1-6: During transfers, maintain effective communication between the supply vessel and the drilling rig during transfer and monitor continuously	Continuously throughout Phase 1	Maintain records of standard operating procedures (SOPs) for refueling and communication of SOPs to crew. Maintain records of spills.	No spills during refueling	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 1.1-7: Ensure all staff is familiar with the procedures required for loading/unloading and storage of fuel and other hazardous materials	Continuously throughout Phase 1	Maintain records of training and record spills.	No spills and no disposal of waste chemicals overboard.	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
Drilling (Phase 2)						
2A1	Mitigation Practice 2.1-1: Tailor oil spill response preparations to the results of the oil spill trajectory models and sensitive areas along the shoreline most likely to be impacted by a potential oil spill and provide adequate equipment and training to limit impacts from accidental releases on such areas.	Prior to Phase 2	Maintain records of spill response preparations (e.g. records of communication with response resources, emergency and spill plans, records of drills).	No impact to shoreline in the event of a spill	Contractor EHS Officer	Review level of preparation and records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1.2: Verify that Tier 1 oil spill equipment is in available on vessels.	Prior to and continuously throughout Phase 2	Project Specific EHS plan will note vessel equipment requirements	Successful response in the event of a Tier 1 spill	Contractor EHS Officer	Review by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-3: Maintain contract with an international oil spill response organization for support in responding to any potential Tier 2 and 3 spills that require outside assistance.	Prior to and continuously throughout Phase 2	Records of communication and contract with an international oil spill response organization	Successful response in the event of a Tier 2 or 3 spill	Bahamas Petroleum Company Project Contracting Officer	Review of contract by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-4: Identify extreme weather patterns or other natural hazards that could impact the area and include planning for such events in the emergency response plan	Prior to and continuously throughout Phase 2	Maintain daily records of weather conditions and forecast	Successful response in the event of a spill	Contractor staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-5: Review oil spill trajectory modeling results and spill response plans with crew prior to start-up of drilling activities.	Prior to Phase 2	Records of communication with crew	Successful response in the event of a spill	Contractor EHS Officer	Review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-6: Perform frequent checks of blow out preventer equipment, service according to the scheduled maintenance plan and ensure good operational conditions.	Continuously throughout Phase 2	Maintain records of equipment inspections and pressure tests	No incidents involving BOP	Contractor staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
2A1 (Continued)	Mitigation Practice 2.1-7: All critical pressure test charts (i.e. negative tests, casing test, etc.) will be reviewed by Drilling Engineer/Drilling Supervisor prior to continuing with operations.	Continuously throughout Phase 2	Records of pressure tests	No blowouts	Drilling Engineer/Drilling Supervisor	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-8: Coordinate with local officials before drilling commences and maintain communication throughout the project.	Prior to and periodically during Phase 2	Records of communication	Effective communication in the event of a spill	Bahamas Petroleum Company Country Manager	Verify by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-9: Communicate with local port, marine navigation and fishing authorities in advance of drilling activities to notify them of the location and schedule of the proposed drilling program and to establish a reliable means of communication between the drilling rig captain, government marine authorities and sea users during the drilling program. The rig will be visible to all traffic by formal "Notice to Mariners" published daily.	Prior to Phase 2	Maintain records of communication	No incidents involving fishing or other vessels	Bahamas Petroleum Company Country Manager	Review of records of communication by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-10: Identify government agencies and contact information of appropriate individuals responsible for oil spill preparedness and response in Cuba and include in the Emergency Response Plan.	Prior to Phase 2	Emergency response plan	Successful response in the event of a spill affecting neighboring countries	Bahamas Petroleum Company EHS Manager	Review of oil spill/emergency response preparations by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-11: Ensure careful selection of drilling rig type and review of contractor's historical performance.	Prior to Phase 1	Maintain records of rig and contractor selection	No incidents	Bahamas Petroleum Company Country Manager	Monitor HSE performance during drilling by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-12: Conduct a complete mechanical and electrical audit of the drilling rig prior to contracting and acceptance.	Prior to Phase 1 and during Phase 2	Maintain audit results	Percent findings remaining open greater than 24 hours	Bahamas Petroleum Company EHS Manager	Review audit results and ensure any audit findings are resolved

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
2A1 (Continued)	Mitigation Practice 2.1-13: Review key contractor training and competency systems, and vet key personnel prior to drilling.	Prior to Phase 1	Maintain records of training	Percentage of staff trained according to contractor management system	Bahamas Petroleum Company EHS Manager	Review records by Bahamas Petroleum Company HSE Manager to ensure training is in-line with contractor management system
	Mitigation Practice 2.1-14: Ensure all drilling contractor personnel involved in the project (onshore team & offshore personnel above Derrickman) have valid and current International Well Control Forum certification.	Prior to and Continuously throughout Phase 2	Maintain records of certification by the drilling contractor	Percentage of all applicable staff certified	Bahamas Petroleum Company EHS Manager	Contractor HSE Officer to ensure all certifications are up-to-date
	Mitigation Practice 2.1-15: Perform regular and varied well control drills during operations	Prior to and Continuously throughout Phase 2	Maintain records of drills and findings	Number of drills performed and percentage of drill findings resolved	Bahamas Petroleum Company EHS Manager and Contractor HSE Officer	Conduct periodic drills and monitor compliance of drill findings by Bahamas Petroleum Company EHS Manager
	Mitigation Practice 2.1-16: Use of effective, real-time data transmission and collection system from drilling equipment.	Continuously throughout Phase 2	Maintain records of logs, well tests and other data	Percentage of the time of operation for which real-time data is generated and checked	Drilling Engineer/Drilling Supervisor	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.1-17: Give due regard to the intent and spirit of the findings from the Macondo oil spill during planning and operations.	Prior to Phase 1 and Continuously throughout Phase 2	Records of communication and contract with drilling contractor	Percentage of operations staff with which results are shared and discussed during drilling operations	Bahamas Petroleum Company EHS Manager	Bahamas Petroleum Company HSE Manager to review and apply any new findings of the Macondo oil spill

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
2A1 (Continued)	Mitigation Practice 2.1-18: Apply continuous oversight and auditing to ensure that appropriate procedures are being followed.	Continuously throughout Phase 2	Records of all audits	Number of audits	Bahamas Petroleum Company EHS Manager	Bahamas Petroleum Company EHS Manager to review audit schedule and records
	Mitigation Practice 2.1-19: Conduct a high resolution multibeam survey prior to securing the rig and a remote operated vehicle survey of sea floor prior to drilling to identify sub-sea hazards and/or seafloor anomalies	Conduct multibeam survey prior to securing the rig and remote operated vehicle survey prior to Phase 2	Results of surveys	No incidents or harm to seafloor anomalies	Bahamas Petroleum Company EHS Manager	Bahamas Petroleum Company EHS Manager to review survey results
2A2	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 2	See Impact 2A1			
2A3	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 2	See Impact 2A1			
2A4	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 2	See Impact 2A1			
2A5	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 4	See Impact 2A1			
2A7	Apply Mitigation Practice 2.1-19	Prior to Phase 2	See Impact 2A1			
2E3	Mitigation Practice 2.2-1: Preferentially, use water-based muds (WBM) and low toxicity muds. When possible, pass cuttings through solid removal equipment for treatment and mud recovery prior to discharge to the marine environment.	Continuously throughout Phase 2	Maintain records of muds used (including MSDS sheets), and records of discharge monitoring	No off-spec discharges	Contractor staff	Periodic inspections by Contractor HSE Officer and review of discharge monitoring records by Bahamas Petroleum Company HSE Manager

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
2E3 (Continued)	Mitigation Practice 2.2-2: Periodically inspect and maintain drilling fluid circulation system and cuttings treatment system.	Continuously throughout Phase 2	Maintain records of inspection of cuttings treatment equipment	No off-spec discharges	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.2-3: Prohibit any overboard discharge of synthetic based drilling fluids.	Continuously throughout Phase 2	Maintain records of discharge monitoring	No off-spec discharges	Contractor staff	Periodic inspections by Contractor HSE staff and review of discharge monitoring records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 2.2-4: No discharge of drill cuttings within 300 meters of coral reefs, seagrass beds, submerged archaeological features or other seafloor sensitivities identified in the well specific Environmental Management Plan.	Continuously throughout Phase 2	Identify sensitive features in the well specific Environmental Management Plan	No impact of drill cuttings on sensitive seafloor features	Bahamas Petroleum Company HSE Manager	Bahamas Petroleum Company HSE Manager to review ROV survey prior to securing the rig
Appraisal (Phase 3)						
3B1	Mitigation Practice 3.1-1: Maximum oil content of produced water discharges must be less than 42 mg/l, and such that the 30 day average does not exceed 29 mg/l.	Continuously throughout Phase 3	Maintain records of discharge monitoring	No off-spec discharges	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 3.1-2: Minimize duration of tests.	Continuously throughout Phase 3	Maintain records of communication with Contractor	Test duration does not exceed planned length	Contractor staff	Review by Bahamas Petroleum Company HSE Manager

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
3B2	Mitigation Practice 3.2-1: Use industry leading, efficient flare tips ("green burners"), and optimize the size and number of burning nozzles.	Continuously throughout Phase 3	Well test records	Flare efficiency meets specifications and no oil fallout onto sea surface.	Contractor staff	Review by Contractor HSE Manager prior to well test and periodic inspection by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 3.2-2: Maximize flare combustion efficiency by controlling and optimizing flare fuel/air/steam flow rates to ensure the correct ratio of assist stream to flare stream.	Continuously throughout Phase 3	Well test records	Flare efficiency meets specifications	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 3.2-3: Minimize risk of pilot blow-out by ensuring sufficient exit velocity and providing wind guards.	Continuously throughout Phase 3	Well test records	Flare efficiency meets specifications	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 3.2-4: Minimize liquid carry over and entrainment in the gas flare stream.	Continuously throughout Phase 3	Well test records	Flare efficiency meets specifications	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 3.2-5: Record volumes of Hydrocarbons flared.	Continuously throughout Phase 3	Well test records	Total volume of flares recorded	Contractor staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Apply Mitigation Practice 3.1-2	Continuously throughout Phase 3	See Impact 3B1			
Rigging-down and Demobilization (Phase 4)						
4B1	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 4	See Impact 1A1			

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
Vessel Operations (Phase 5)						
5A1	Mitigation Practice 5.1-1: Conduct advanced scouting and intermittent soundings prior to establishing dedicated transportation routes between the port and the drilling site where waters are <50m deep to determine if any elevated/shallow features (e.g. rocky shoals or coral outcrops) may be present warranting special precautions.	Prior to Phase 2	Designate a defined transportation corridor prior to drilling	No supply vessel traffic outside the defined corridor	Contractor Staff	Periodic inspections by Contractor HSE Officer and review of records by Bahamas Petroleum Company HSE Manager
	Mitigation Practice 5.1-2: Adhere to rules of navigation in the various channels where space may be limited.	Continuously throughout all Phases	Maintain records of near misses	No collisions. Percentage of near misses recorded and reviewed with operators and vessel contractors	Drilling Rig Captain	Review of records by Bahamas Petroleum Company HSE Manager
	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 5	See Impact 2A1			
5A2	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 5	See Impact 2A1			
	Apply Mitigation Practice 5.1-1	Prior to Phase 2	See Impact 5A1			

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
5A3	Mitigation Practice 5.2-1: Reduce speeds when a marine mammal or sea turtle is sighted to: • 13 knots within 2 miles (3.2 km) • 10 knots within 1 mile (1.6 km) • 7 knots within 0.5 miles (0.8 km)	Continuously throughout Phase 5	Record marine mammal or sea turtle strikes and sightings	No marine mammal or sea turtle strikes	Contractor Staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 5.2-2: Maintain a safe distance from marine mammals and sea turtles: • 150 ft. (~45 m) from dolphins, porpoises, seals and sea turtles • 300 ft. (~90 m) from whales	Continuously throughout Phase 5	Record marine mammal or sea turtle strikes and sightings	No marine mammal or sea turtle strikes	Contractor Staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 5.2-3: No head on approach of marine mammals within 0.5 miles (0.8 km)	Continuously throughout Phase 5	Record marine mammal strikes and sightings	No marine mammal strikes	Contractor Staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 5.2-4: Post a look out if within two miles (3.2 km) of a whale	Continuously throughout Phase 5	Record marine mammal strikes and sightings	No marine mammal strikes	Contractor Staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
	Mitigation Practice 5.2-5: Report injury or mortality to sea turtles or marine mammals resulting from boat strike or other project activity	Continuously throughout Phase 5	Record marine mammal or sea turtle strikes and sightings	No marine mammal or sea turtle strikes	Contractor Staff	Review of records by Contractor HSE Officer and Bahamas Petroleum Company HSE Manager
5A4	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 5	See Impact 2A1			
	Apply Mitigation Practice 5.1-1	Prior to Phase 2	See Impact 5A1			

Impact Identification	Mitigation Practice	When to Apply	Record Keeping	Indicator of Effectiveness	Responsible Party	Monitoring
5A5	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
	Apply Mitigation Practices 2.1-1 through 2.1-19	Prior to and Continuously throughout Phase 5	See Impact 2A1			
	Apply Mitigation Practice 5.1-1	Prior to Phase 2	See Impact 5A1			
5B1	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
	Apply Mitigation Practices 2.1.1 through 2.1-19	Prior to and Continuously throughout Phase 5	See Impact 2A1			
	Apply Mitigation Practice 5.1-1	Prior to Phase 2	See Impact 5A1			
5C1	Apply Mitigation Practices 1.1-1 through 1.1-7	Continuously throughout Phase 5	See Impact 1A1			
6D2	Mitigation Practice 6.1-1: Conduct training to workers regarding Company Policies (i.e. codes of conduct and ethics), local culture and importance of respectful relationships with local communities, and information on avoidance of STDs (such as hygienic practices and low risk behavior).	Prior to Phase 1	Maintain records of training	No cases of STDs involving crew	Contractor Staff	Review of records by Bahamas Petroleum Company HSE Manager

Appendix A
Transport and Fate of Oil Particles Released in The Bahamas

Attachment 1	**Response to BEST Commission Comment 39**
Attachment 2	**Response to BEST Commission Comment 69**

FINAL REPORT

Project:

TRANSPORT AND FATE OF OIL PARTICLES RELEASED IN THE BAHAMAS

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EXECUTIVE SUMMARY

A study of hypothetical releases of oil particles at a specific location in the Bahamas has taken place. This study has been executed by the University of Miami under the guidance of the Bahamas Petroleum Company. The objective was to describe the processes influencing the transport of the released oil, in the context of the intense oceanographic variability in the study domain, and to quantify the oil fate under different release scenarios.

A comprehensive modeling approach has been employed, based on the use of a series of nested physical models to represent the circulation resulting from the dynamics of the ocean and atmosphere at high resolution, and the use of an oil spill model able to represent the fate of the oil in the ocean. Several oil spill characteristics have been considered, with oil being released either at depth or at the surface, and with varying flow rates. The effects of these various spills have been studied statistically, based on a long-term simulation of 7 years, and for shorter periods during individual scenarios, able to capture typical features related to specific oceanic or atmospheric conditions.

Based on the long-term statistical study, the evolution of the spreading of oil particles, for the surface and seabed release cases, shows a large influence of the bathymetry of the area surrounding the release point suggested by the Bahamas Petroleum Company. The prevailing winds (generally coming from the East) also play an important role in transport, through wind-driven currents and the wind-induced drift acting on the surface oil slicks. In addition, oceanic currents dominated by the Florida Current – Gulf Stream system impact the transport of oil particles. Oil at the surface was found to initially spread over the Old Bahama Channel. This is bounded by the wide Great Bahama Bank and the narrow Cuban shelf. Consequently, the topographic steering of transport largely favored spreading toward Cuba, preventing most of the oil from reaching the Bahama islands. The study findings suggest that Cuba is by far the coastline that could be most affected by oil landfall. West of the release point, oil at the surface tends to be directed along the Cuban coast, but can also be transported northward. The tendency for northward spreading (following the North-South orientation of the Florida Straits) is associated with the entrainment of the oil by the Florida Current – Gulf Stream system. This entrainment is supported by the northwestward winds, which usually prevail in the wet season. Through the wind-induced drift, this wind pattern tends to push oil away from Cuba toward the oceanic current system and can occasionally lead to the Eastern U.S. and Florida coastlines being impacted. However, such impacts are statistically much smaller than for the Cuba coasts. East of the release point, surface oil is mainly entrained by episodes of eastward surface currents, and is not supported by the dominant westward winds. Hurricanes seem to have a noticeable effect only when they are directly over the zone around the release location.

The surface and the two seabed (low and high flow rates) release cases also allowed the analysis of the effects of the discharge rate and the depth of release. The impact of topography on the displacement of submerged oil before it emerges is stronger than for oil released directly at the surface: continental shelf breaks are a natural guideline for deep currents and deep entrainment of oil, while they shield the shelf areas from oil reaching the coastlines. The difference in the discharge rate between the two seabed release cases suggests that the high rate case has larger areas of high probability of oil presence at the surface.

The total duration of an oil spill is also affected by the depth of the oil release: oil at depth lives longer, since evaporation is more efficient in degrading oil compared to biodegradation. Both processes, evaporation and biodegradation, are slower for heavy oil compounds, which is another determinant aspect to take into account for estimating the duration of an oil spill. The longer lifetime of oil at depth explains how it can be advected away from the source, although deep currents are not as intense as at the surface. Finally, the distribution of oil droplet size is crucial for estimating the presence of oil between surface and depth: since small droplets (smaller than 50 to 60 μm) are too small to reach the surface by buoyancy, they will stay at depth for extended periods of time. Larger particles will eventually reach the surface, where their lifetime is shorter. The oil droplet size distribution is subject to estimate, since it depends on the specific configuration of the oil source. For instance, a large flow rate is associated with a high shear of the initial jet, which results in smaller oil droplets.

The study of individual scenarios confirms the findings from the long-term simulation. In particular, the dynamics of an oil spill originating at the location chosen for this study is essentially driven by the local bathymetry. At the surface, this is especially the case when the spill extends to the east. There, the slick is constrained between Cuba and the Great Bahama Bank, and even after northward wind burst, the slick usually goes back to its initial path. To the west, the surface slick appears less constrained by the topography and is more sensitive the changes in the winds. When extending westward, the surface slick has thus a moderate chance to reach the Florida Current, and some material can then be pushed toward Florida or the Eastern U.S. coast, or to the Western Bahama islands. A surface spill of a few weeks is likely to show episodes of both eastward and westward extension. However, the major part of the oil will affect the Cuban coasts, which are directly facing the source of the oil, and are not protected by a large continental shelf. The dynamics of submerged plumes are also dominated by topography. The submerged plumes usually have a very different evolution and different pathways compared to the surface slicks, for which the dominant surface export is eastward while it is westward at depth. Oil at depth encounters depth varying currents, and is not influenced by the surface wind-induced drift. To the west, submerged oil particles tend to follow the edge of the Great Bahama Bank, which acts as a natural waveguide for exporting submerged oil. When submerged particles are advected to the east, they are also constrained by local topography between the Great Bahama Bank and the Cuban shelf.

Since submerged oil droplets tend to degrade slower than surface evaporation and are not pushed toward the Cuban coast, as is the case at the surface, they are associated with a wide extension of the spill. For the eastward branch, submerged oil can probably be advected as far (or further) compared to the surface, and be possibly upwelled to the surface, subject to potential landfall. For the westward branch, the area over the Cay Sal Bank and the Santaren Channel seems to favor upwelling of submerged oil, and thus could allow surfacing of oil at a location where it can then be advected toward the Gulf Stream. The rather intense northward current at depth along the Great Bahama Bank favors quick export of submerged oil, some of which may eventually surface far from the release point.

As a general conclusion, an oil spill taking place at the location under study is most likely to have a major impact on the Cuban coastlines in the vicinity of the release point. Particular wind conditions may favor the transport of small quantities of oil to the west, where it can eventually be advected by the Florida Current and potentially affect the Florida or Eastern U.S. coasts, or the Western Bahama Islands. However, this likelihood is smaller. In case of a seabed spill, some oil may reach the surface at distance from the initial spill, due to intense deep dynamics along the Great Bahama Bank. This would favor a wide spread of oil, with possible impact on the Cuban coast, and with smaller probability on the Florida or Eastern U.S. coasts, or the Western Bahama Islands.

1. INTRODUCTION

1.1 PHYSICAL SETTING

The coastal areas around the Florida Straits (Fig. A) are characterized by a series of islands along the eastern side (west Bahamas), the south side (Cuba) and the north and western side (Florida Keys, extending to the South Florida mainland). Further north, the Straits feed into the Southeast U.S. Continental Shelf, an area which has been extensively studied from the early 80's, in tandem with studies of the Gulf Stream flowing along the shelf (Lee and Atkinson, 1983; Lee et al., 1984; Kourafalou et al., 1984, among others). Shallow areas in the Straits include the Cay Sal Bank and the Bahamas Banks (Fig. A), while a narrow shelf area extends along the Florida Keys (the Atlantic Florida Keys Shelf). Topography is very complex in this domain, with both steep and gentle shelf break slopes, from the coastal and shelf areas toward the deep interior. A series of islands marks the Bahamian archipelago (Fig. B).

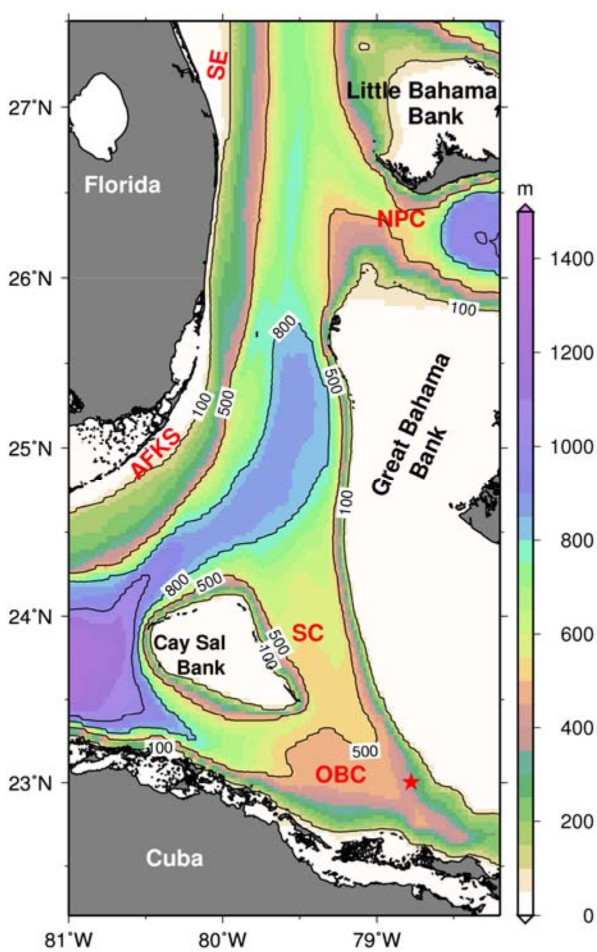

Fig. A:
Topography in the Florida Straits (derived from the bathymetry data used in the hydrodynamic model, see section 2.1a); color scale in meters.

AFKS: Atlantic Florida Keys Shelf; SE: Southeast US Continental Shelf; OBC: Old Bahama Channel; SC: Santaren Channel; NPC: North Providence Channel.

The red star marks the release location for the Southern licenses.

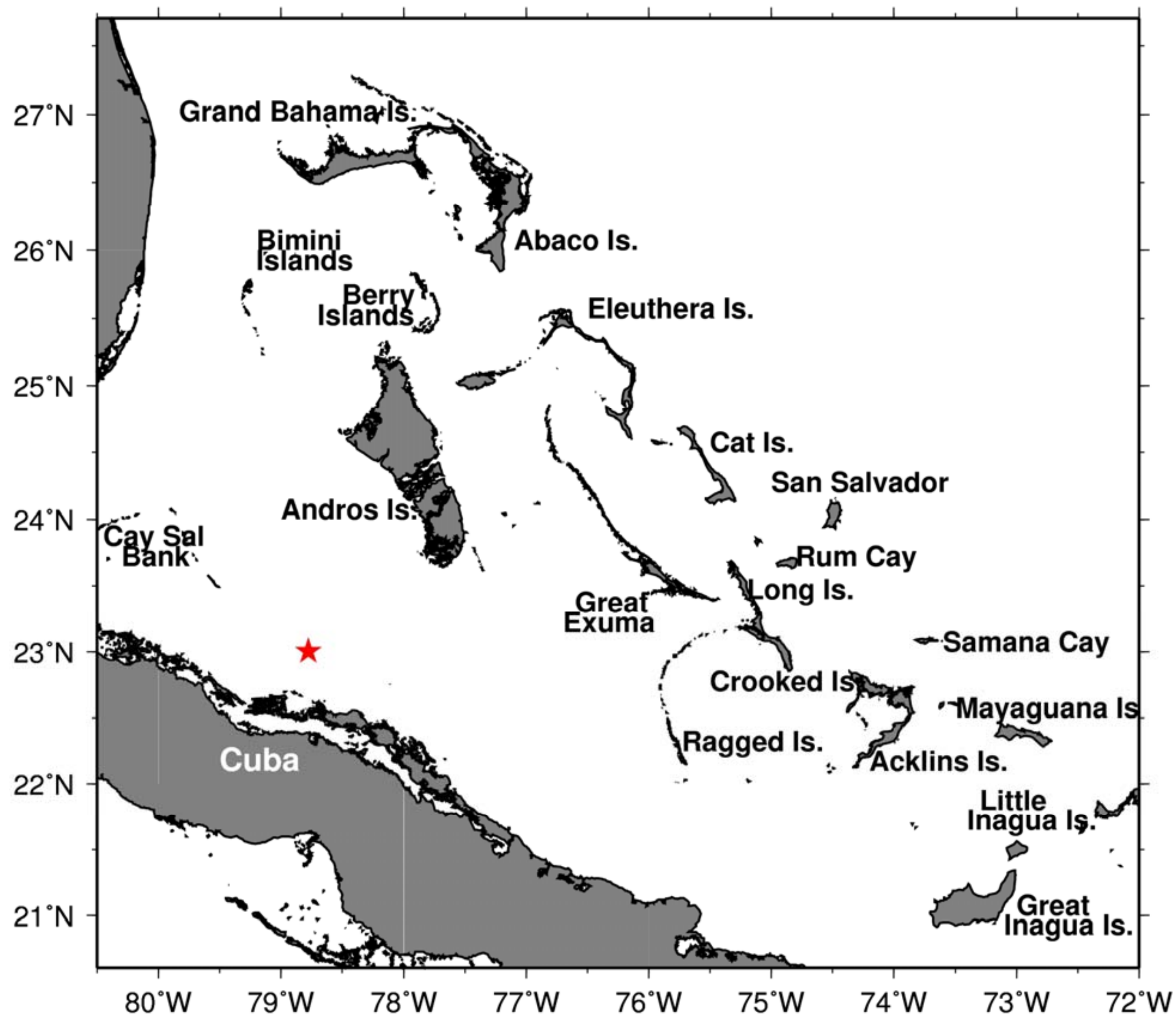

Fig. B: Detail of the study area over the Bahamian archipelago.

1.2 CIRCULATION CHARACTERISTICS

The ocean circulation within the Florida Straits (ie. between the Bahamas, Cuba and South Florida, Fig. A) is dominated by the Florida Current (FC), which originates where the Loop Current (LC) enters the Straits from the Gulf of Mexico. Both the LC and FC are branches of the Gulf Stream, which emerges from the Florida Straits along the Southeast U.S. Continental Shelf and beyond. The FC variability extends over a large range of spatial and temporal scales (Johns and Schott, 1987; Lee and Williams, 1988; Schott et al., 1988; Baringer and Larsen, 2001). Cyclonic, cold-core eddies are established along the northern to northwestern FC edge and travel northward along the continental margin (eventually feeding into the western edge of the Gulf Stream). They have been mainly studied as frontal eddies along the LC/FC system (Vukovich 1988; Lee et al., 1995; Fratantoni et al., 1998). They have been found to provide a connectivity mechanism around the South Florida coastal regions (Lee et al., 2002; Kourafalou et al., 2009), while supporting productivity and larval recruitment (Maul et al., 1984; Lee et al., 1992; Limouzy-Paris et al., 1997; Lee and Williams, 1999; Sponaugle et al., 2005) through upwelling in their core (Kourafalou and Kang, 2011) and retention of drifting materials.

The cyclonic eddies traveling on the north side of the FC in the Straits of Florida have major implications for cross-shelf transport of biological and chemical materials, as detected by drifter studies (Kourafalou et al., 2007). Recirculation within mesoscale eddies along the Keys coastal zone have been proposed as a retention and connectivity mechanism, important for nutrient transport and local recruitment of larvae spawned in the Dry Tortugas or along the outer Reef Tract (Lee et al. 1992; Limouzy-Paris et al., 1997; Hitchcock et al., 2005; Fiechter et al., 2008). Off the Florida Keys, frontal eddies are associated with cross-shelf larval transports (as observed by Limouzy-Paris et al., 1997; Sponaugle et al., 2005 and modeled by Graber and Limouzy-Paris, 1997; Kang et al., 2008), an important mechanism for the replenishment of coral reef fish and for biodiversity in the region (Limouzy-Paris et al. 1994).

Although the above studies have concentrated on the western side of the Gulf Stream, the resulting meandering of the Florida Current has implications on the flows over the Cay Sal Bank and along the northern coast of Cuba and the western Bahamas. Furthermore, the tendency of eddies to retain and transport particles (as has been observed and modeled for fish larvae) is an important attribute for the study of oil particle transport and fate.

The various channels between Cay Sal Bank, the Bahamas islands and Cuba are secondary transport pathways of the ocean circulation in the area. Limited measurements in the study area during the early ‘90s have given some indications of volume transport. In the Northwest Providence Channel, between the Grand and Little Bahama banks (Fig. A), the average transport of sea water was found to be to the West, feeding the Florida Current with 1.2 Sv (1 Sv = 10^6 m^3/s), which is small compared to ~30 Sv for the mean Florida Current transport (Leaman et al., 1995). However, the transport there shows a large variability, between -1 and 3 Sv, due to changes in currents, which means that there is potential for circulation to the East in that channel. South of the Northwestern Providence Channel, the Santaren Channel, between Cay Sal and the Great Bahama Bank, around 24°N, shows a mean transport toward the North of 1.8 Sv an average (Leaman et al., 1995). Similar to the Northwestern Providence Channel, the currents in the Santaren Channel show a large variability, which leads the transport (mainly northward) to sometimes be toward the South. The northward transport observed in the Santaren Channel is for a large part due to the transport observed in the Old Bahama Channel, between Cuba and the Great Bahama Bank, with a mean value of 1.9 Sv toward the West (Atkinson et al., 1995). Measurements in the Old Bahama Channel at 78°31.8’W suggest that deep currents are more stable as compared to the variable surface currents (Atkinson et al. 1995).

The potential linkages among Cuba and neighboring locations have been previously examined with a coupled biophysical model simulating the transport of larvae of harvested snapper species (Paris et al. 2005). Results suggested that the north-central regions of Cuba were strongly connected to the southern Bahamas, specifically to Cay Sal Bank and that a small few weeks lag in particle release representing varying spawning times contributed significantly to high variability in recruitment (number of particles reaching coral reefs) and connectivity patterns.

2. MODEL INFORMATION

2.1 DESCRIPTION OF MODELS USED IN THIS ASSESSMENT

More details on model attributes are given in APP1.

2.1a Hydrodynamic modeling

The "Coastal and Shelf Modeling" lab at the University of Miami/RSMAS specializes in high resolution, nested models on the coastal, shelf and regional scales. The research group has long term expertise with the Hybrid Coordinate Ocean Model (HYCOM), initially developed through a Consortium for Data Assimilative Modeling led by RSMAS. Currently, HYCOM is a community based code applied both in research mode and in real time and operational systems (http://hycom.org).

The high resolution (~900m grid) Florida Straits, South Florida and Keys (FKeyS) HYCOM model has been running continuously since 2004 and has been validated with available satellite and in situ data (Kourafalou and Kang, 2011). The high resolution has allowed details in both shelf and deep regions and the appropriate interactions between coastal and offshore flows. In particular, the meandering of the Florida Current front and the highly variable eddy field (Kourafalou and Kang, 2011) have been successfully simulated. FKeyS-HYCOM has been nested in a hierarchy of larger scale models, where evaluation with observations has taken place (Kourafalou et al., 2009). These include the regional Gulf of Mexico (GoM) HYCOM model and the Atlantic Ocean part of the global HYCOM model.

2.1b Oil spill modeling

The newly developed oil spill module is an application of the Connectivity Modeling System (CMS) from the "Physical-Biological Interactions" lab of the University of Miami/RSMAS that produces probabilistic simulations of particle dispersion in the ocean over multiple scales (Paris et al., 2007). For the study of transport and fate of oil particles, the CMS couples and merges three components: (a) the hydrodynamic model (describes the physical environment in which oil particles evolve); (b) the oil module (simulates the geochemical processes directly affecting oil particles); (c) a Geographic Information System (GIS) module (representing coastal marine and land habitat and used to record landfall of oil particles on the shoreline or deposited on the coral reefs). It should be noted that the GIS module includes unique details for this study area, based on extensive previous studies; it provides an effective means for quantifying the impact of possible oil particle landings on specific locations of the sensitive coastal habitat (including Marine Protected Areas), at any selected scale. The hydrodynamic models provide estimates of the currents, which move the oil particles, but they also provide density fields (temperature and salinity), which affect the oil buoyancy in the water column, as well as the oil degradation process. The oil spill module describes the chemical properties and behavior of the crude oil (DeGouw et al. 2011) in seawater, including evaporation and biodegradation. Individual particles are described by a droplet size value, and a density value. Density values are prescribed from a three-fraction classification of the oil established from known characteristics of High Sulfur crude oil. These fractions describe light, medium and heavy oil. The heavier the oil, the longer it takes to degrade or evaporate. We used distributions of oil droplet ranging from 1-500 microns in diameter. Both the oil density and oil droplet size affect the terminal velocity of oil droplets due to buoyancy, with very small particles staying at depth and those larger than 100 microns rising quickly. Once at the surface, the displacement of oil particles is affected not only by the ocean currents (provided by the physical model), but also by a wind-induced drift, estimated from an atmospheric model.

2.2 PROCEDURES FOR COUPLING OF THE MODELS

The hydrodynamic and oil spill models are integrated components within the Connectivity Modeling System (CMS), which allows the offline coupling of hydrodynamic parameters, oil chemistry and biophysical particle behavior, transport and fate. Details are given in APP1C.

A unique capability of the coupled hydrodynamic and oil module system is that a hierarchy of hydrodynamic models of different resolution can be used. Thus, oil particles may be released within a high resolution hydrodynamic model and, if they are transported away from the limited model domain, they can utilize fields from a larger scale hydrodynamic model.

2.3 OIL SPILL MODEL SIMULATIONS

Two groups of simulations have been performed. “Surface release” includes simulations with oil particles released on the surface. “Seabed release” includes simulations with oil particles released at depth. A detailed analysis was performed to identify the optimal model attributes for the simulations representing the seabed release, see APP1D. For both groups, we distinguish two types of simulations: a long term (2004-2010) simulation with continuous “oil spills” that is used to derive stochastic results (Part 1; section 4 and App. 6) and a series of short term simulations that examine specific scenarios (Part 2; section 5 and App. 7).

2.4 OIL CHARACTERIZATION

The location and characteristics of the oil are given in Table 1 (bopd: barrels of oil per day). Three simulations are designed, attributes in Table 1: surface release study (one rate: medium), seabed release study (two rates: low and high).

Table 1: Oil characterization and simulation attributes

	The Southern licenses (Bahamas Petroleum Company) Surface release study	The Southern licenses (Bahamas Petroleum Company) Seabed release study
Discharge Point	Topside (sea surface)	Well head (seabed)
Discharge Rates	2,400 m^3/day (15,000 bopd) (medium)	1,600 m^3/day (10,000 bopd) (low) 3,200 m^3/day (20,000 bopd) (high)
Oil type	High Sulfur crude oil	High Sulfur crude oil
Location	23°00’15.0340”N 78°46’54.0242”W	23°00’15.0340”N 78°46’54.0242”W

Much of the oil found and produced in Cuba is of high sulfur content and is found in a similar environment to The Bahamas. Therefore, Bahamas Petroleum chose to use the worst case scenario for the oil type which was High Sulfur Crude.

The heavy fractions for the High Sulfur crude oil have a larger part than for other types of crude oil, like the Lousiana crude found in the Northern Gulf of Mexico. Based on results by Yang and Wang (1977) we derived a 3-fraction composition of the oil:

- 42% of "medium" carbon fractions, ranging from 810 to 940 g/m^3, with a half-life of 50hrs
- 18% of "light" carbon fractions, ranging from 710 to 770 g/m^3, with a half-life of 10hrs
- 40% of "heavy" carbon fractions, ranging from 980 to 1010 g/m^3, with a half-life of 250hrs

The estimated release rates were based on the anticipated permeability from the principal reservoir zones identified by logs in the Doubloon Saxon well which are expected to be present within the seismic-delineated closures, assuming a reasonable net thickness of pay zone is completed in a given well. Assuming normal reservoir pressures, the flow rate in a given well is also constrained by the casing size at the producing zone depth, which is currently anticipated to be 5-1/2” diameter. Outside of these basic parameters, anticipated flow rates are basically “best guesses” based on production performance of analogous carbonate reservoirs in similar geological settings, some of which were considered by Ryder Scott in the CPR.

In the following sections, results will be presented with the corresponding threshold values:

- Oil at the sea surface if average thickness is >1µm (dull brown sheen)
- Oil in the water column if average concentration is > 10 ppb, larger than the initially chosen value of 100 ppb, due to rapid dispersion of oil at depth which makes it difficult to describe the dynamics of the submerged plume. Concentration values larger than 1000 ppb are still found at some isolated locations, especially in the vicinity of the source of oil.
- All maximum / minimum cases are based on 95th percentile
- Probability of presence of oil > 10%

2.5 ATMOSPHERIC FORCING

The atmospheric patterns over the Straits of Florida and the exchanges between atmosphere and ocean control the seasonal circulation characteristics. Two general seasons are distinguished in this area (Lee et al., 2002; Kourafalou et al., 2006): “dry” season (November-April) and “wet” season (May-October).

The winds follow a regular seasonal pattern: weak southeasterly (toward the northwest) winds and daily sea breezes in the wet season (especially the summer months); persistent northeasterly (toward the southeast) winds in the fall transition; and the regular passage of cold fronts causing moderate increases in wind speed and a clockwise rotation of wind direction during the dry season (especially in the winter months). In general, the winds have a mean easterly (westward) component (southwestward in the dry season and northwestward in the wet season), being much lighter in the wet season.

During the hurricane season (summer–early fall), the persistent southeasterly tradewind and sea breeze pattern can be interrupted by the passage of tropical storms, often resulting in substantial increases in wind speed.

Statistical analysis of surface meteorological data from C-MAN buoy stations off South Florida (Peng et al., 1999) has shown that point data are representative of the monthly mean wind speed and direction over the Florida Straits, as the fields are fairly coherent and homogeneous. We have selected a characteristic location near the Cay Sal bank and have extracted time series of 3-hourly wind vectors (shown in APP3) from the COAMPS atmospheric data set (description in APP1A).

Figs 3.1-3.4 (APP3) exhibit the seasonal variability, but also episodic events, such as hurricanes.

3. SEASONAL AND INTER-ANNUAL VARIABILITY OF CURRENTS

Seasonal mean currents over the “wet” (May – October) and “dry” (November – April) seasons have been computed from the high resolution hydrodynamic model archives (see section 2.1a and APP1A for model attributes) near surface and at 300m and 500m depth. Plots for all seasonal averages (2004-2010) are given in APP4. The dry season calculations start from the November of the previous year; the dry season of 2004 is not included as it started on November 2003, before the beginning of the model simulations on 1/1/2004.

APP4 exhibits all seasonal plots, showing current direction and speed. The entire study domain (as in Fig. A) is shown, together with a zoom domain around the Old Bahama Channel, surrounding the release location.

As seen in Figs. 4.1-4.13, a strong mean northward flow is evident within the Straits of Florida, namely the Florida Current (FC), the local branch of the Gulf Stream system. The large flows of the FC (reaching 2.5 m/s) overwhelm the scale of the much smaller circulation around the coastal regions and within the channels bordering the Bahamas. Therefore, for clarity, only vectors up to 1 m/s are shown; this does not bear any influence on the discussion of circulation variability.

The northward flow of the FC is evident from the surface to the 500m depth, for all seasons and years. A branch wrapping around the Cay Sal Bank (and then continuing northward) is evident below the surface, guided by the bathymetry around the Cay Sal Bank and within the Santaren Channel. A counter-current is formed near surface, flowing southward in the Santaren Channel, then turning southeastward in the Old Bahama Channel. This flow exhibits some variability between seasons and years and is presented in more detail in Figs. 4.14-4.20. It is generally stronger during the wet seasons (when velocities reach ~60 cm/s). As near surface currents flow southeastward in the Old Bahama Channel, a westward branch develops (toward Cuba).

APP5 exhibits examples of the variability in Florida Current (FC) position on both short and long time scales. Fig. 5.1 (from Kourafalou and Kang, 2011) shows model computed Temperature and current velocity across a section between South Florida and the Bahamas at 25.5^{o}N and over depths from the surface down to 200m, capturing the core of the FC. The dates are close to each other (May 4, May 6, June 2 and June 4, 2004), matching data surveys during these periods and demonstrating that the FC regularly meanders in the Florida Straits. In general, the ability of the model to capture the FC meandering has been successfully evaluated with temperature observations along this section during 12 monthly cruises in 2004 (Kourafalou and Kang, 2011). The FC remains closer to the Florida coast than the Bahamas. When it veers strongly westward, a return (southward) coastal flow along the Bahamas becomes evident (as on June 4, 2004).

Figs. 5.2-5.3 show the changes in Florida Current (FC) position from north to south (latitude variability 23 ^{0}N to 25 ^{0}N at two specific longitudes (81 ^{0}W and 80.5 ^{0}W). The index used for the marking of the FC position is based on the calculation of the 20 ^{0}C isotherm at 150m (as suggested by data based studies, see Lee et al., 1995). The southward spikes at 81 ^{0}W, approaching the latitude of 23.5 ^{0}N indicate periods when the FC is near Cuba. The southward spikes at 80.5 ^{0}W, approaching the latitude of 24 ^{0}N indicate periods when the FC is near the Cay Sal Bank. However, the sharp southward spikes that approach 23 ^{0}N (near day 300 in 2005, day 360 in 2006 and day 120 in 2007) are related to narrow flow regimes branching off the FC.

4. RESULTS AND DISCUSSION, LONG TERM SIMULATION (PART1)

4.0 LONG TERM (2004-2010) SIMULATION

We first employ the hydrodynamic archives for years 2004-2010 to perform three long-term (7-year) simulations with attributes given in Table 1. In these simulations, oil particles are released once a day, so that the daily variability in the ocean and atmosphere conditions is present. The goal of these simulations is to describe the evolution of an oil spill in any condition during the 2004-2010 period. This period includes seasonal variations, but also more rapid changes, like the changes in the ambient current, typically the Florida Current, as well as the effects of hurricanes, especially in the intense 2005 season. Hence, the statistics extracted from these simulations, in terms of oil presence at the surface or along the coast, and time to reach the coasts, represent the largest variability in the conditions in which an oil spill from the study release location may take place. These 7-year simulations are also used to identify periods of specific interest to be investigated in more details in Part 5, based on time series of oil reaching the various coastal zones in the study area (Task 4).

From the three cases that have been modeled, one corresponds to the surface release scenario; two correspond to the seabed release scenarios with two different discharge rates. The discharge rate will affect the partition of oil between large and small oil droplets, and will also determine the depth of separation of the initial jet of mixed oil and gas in individual bubbles and droplets.

The surface case is represented by releasing 1500 oil particles per day. Consistently, seabed high flow rate case is modeled by releasing 2000 oil particles per day, and seabed low flow rate is modeled by releasing 1000 particles per day. In addition, the distribution in oil droplet size is uniform in the case of surface and low flow rate, and not uniform in the case of the high flow rate. High flow rate is associated to a higher shear at the ejection of the oil from the well head, which leads the oil to be atomized in small droplets. This is represented, in our simulation of the high flow rate case, by setting the proportion of oil droplets smaller than 100 μm three times higher than the proportion of oil droplets that are between 100 μm and 500 μm.

It should be noted that the arrival of oil on the shoreline is derived as quantities of oil reaching the detailed coastal polygons, then grouped in larger regions of interest (see APP. 2). Therefore, oil concentrations at the shoreline employ local details and also reflect the composites of oil within the polygon units and under the imposed threshold limitations (see section 2.4). The maps showing shoreline exposure to oil are used for comparing the space distribution of oil making landfall, while the time series of oil landfall are used for identifying events and/or seasons favorable for oiling.

4.1 OIL LANDFALL CALCULATION

The 7-year simulation (from January 2, 2004 to December 31, 2010) is composed of a total of 2,556 individual daily oil spills of 90 days duration each, with a period of 60 days of spill and a period of 30 days of follow-up. We derive a time series of oil landfall on coastline and reef areas by regions of interest, computed as the frequency of daily occurrence scaled by the total number of oil particles released per day (which characterizes the magnitude of the spill). The simulated oil is captured in coastal polygons grouped in seven regions (as shown in Fig. 2.2). The resulting 7-years time series are used to select the worst case scenarios of maximum shoreline area oiled. This is accomplished by identifying times when the probability of landfall is at its maximum.

4.1.1 OIL LANDFALL (surface release - medium discharge rate)

APP6.1 exhibits time series plots of oil landfall for the surface simulations (Fig. D.1.1-Fig. D.1.7) in seven selected regions of the study domain (Fig. 2.2).

The results indicate that landfall is highly variable among regions. The northern coast of Cuba is continuously impacted, receiving about 20-70% of the daily oil discharge (Fig. D.1.1). A seasonal cycle is detected with less coastline oiling during the wet season, in particular during the summer months (Fig. D.1.1). The eastern Bahamas exhibit less frequent hits at a much lesser extent than Cuba, while the western Bahamas are relatively less affected (Figs. D.1.2-D.1.3). The U.S. coastlines are sporadically hit by the oil spills with a magnitude in Florida and the Florida Keys similar to that of the western Bahamas (Figs. D.1.4-D.1.6). There seem to be a reverse seasonal cycle from what we see in Cuba, with maximum oiling occurring during the wet season in the Florida coast (D.1.4).

A long-term event of maximum shoreline area oiled occurs from October 2009 to February 2010 in Cuba (Fig. D.1.1). For the Bahamas, the largest impact of the oil occurred on the coastline of the eastern Bahamas during February of 2007 (Fig. D.1.2). For the U.S., the highest impact occurred on the southeastern Florida coast in September of 2009. In the Florida Keys, May of 2004 exhibits the strongest landfall (Fig. D.1.6). Marine reserves, due to their small size and location, receive relatively low amount of oil, with landfall that appears decoupled from the predictions for the rest of the Bahamas.

4.1.2 OIL LANDFALL (seabed release - low discharge rate)

APP6.2 exhibits time series plots of oil landfall for the deep simulations with low flow rate (Fig. D.2.1-Fig. D.2.7) in seven selected regions of the study domain (Fig. 2.2).

The northern coast of Cuba is impacted at all times (with a minimum in August-September 2008, Fig. D.2.1) and so are the western Bahamian coastlines, but to a significantly much lesser degree of two orders of magnitude (Fig. D.2.3). The eastern Bahamas are subjected to higher but less frequent pulses of coastal oiling, with a decrease in magnitude through the years (Fig. D.2.2). A similar trend holds for the northeastern U.S. coast and a reverse trend holds for Florida and the Florida Keys, with a large event during September-October 2008 (Figs. D.2.4-D.2.6). Again, the Bahamian Marine Reserves receive the least amount of oil landfall due to their small size and location, yet there is an order of magnitude difference between the low and high flow rate simulations, the lower rate being the most impacted (Fig. D.2.7 and Fig. D.2.14). A relatively large event is evident between December 2009 and January 2010 (Fig. D.2.7).

4.1.3 OIL LANDFALL (seabed release - high discharge rate)

APP6.3 exhibits time series plots of oil landfall for the high flow rate (Fig. D.2.8- Fig. D.2.14) in seven selected regions of the study domain (Fig. 2.2).

The magnitude of the total landfall (all regions combined) from the high discharge deep spill is decreased by about 10% from the low flow rate blowout simulation. Again, the northern shore of Cuba is constantly impacted, with daily variations between 15-35% of the total oil discharged and a minimum to less than 10% during October-Novemember 2008 (Fig. D.2.8). The eastern and western Bahamas receive similar magnitude of landfall events, with a large peak in October-Novemeber of 2007, yet such events are more frequent in the western Bahamas (Fig. D.2.9-D.2.10). Oil landfall on the east U.S. coastline appears seasonal, with a peak during the end of the wet season, the highest one occurring in September-October 2004 (Fig. D.2.11). The east coast of Florida and the Florida Keys follow similar trends with the least amount of landfall and a large event in September-October 2008 (Fig. D.2.12-D.2.13). Again, the Bahamian Marine Reserves receive the least amount of oil landfall due to their small size and location, yet there is an order of magnitude difference between the low and high flow rate simulations, the higher rate being the least impacted (Fig. D.2.7 and Fig. D.2.14).

4.1.4 OIL LANDFALL (summary)

The magnitude of the total landfall (all regions combined) from the deep spills is decreased by about 30% and 40 % for the low flow rate (see section 4.1.2) and high flow rate (see section 4.1.3) respectively, compared to the surface spill. The most striking difference between surface and deep spill simulations is the sporadic nature of landfall in the western Bahamas for the surface spills, compared to frequent oiling for both deep simulations in that same region, the magnitude being higher for the high flow rate scenario.

The differences observed between the 3 scenarios may be explained by several factors. One comes from the source of oil, at the surface or at depth. For the deep release cases, part of the oil stays at depth for extended periods, where it has a longer lifetime than at the surface, and moreover can be advected further away compared to oil at the surface, which is pushed toward the coasts by the winds. The latter process explains how the proportion of oil making landfall on the Cuban coasts is higher for the surface release case. Oil at depth can be advected away from the release point and surface due to its own buoyancy or due to dynamical processes (mainly upwelling by eddies). Since currents at depth tend to flow along the bathymetry lines, oil advected to the West will preferably follow the Great Bahama Bank edge, which favors impact on the Western Bahamas region in case of oil surfacing. This process is stressed for the high flow rate, for which the relative proportion of small oil droplets capable of staying submerged for days or weeks is larger.

4.2 PROBABILITY OF COASTLINE OILING

The probability of coastline oiling is determined by calculating the percentage of particles landed on each polygon out of the total released particles over the 7 years from 2004 to 2010.

Prob(i) = (Nparticle(i)/total number of particles)*100.0,

where (i) is polygon number from 1 to 68.

Table 2 summarizes the shoreline oil statistics for the long term simulation over 7 years from 2004 to 2010, grouped by the seven regions of interest. Numbers represent the percentage of particles that landed, out of the total number of released particles, which is NP(total) and is calculated according to the simulation attributes given in section 4.0.

Table 2: Shoreline oil statistics for the long term simulation and for the 3 release cases: surface medium discharge rate (sfc-mr), seabed for low discharge rate (sbd-lr) and seabed for high discharge rate (sbd-hr). See description of MPAs (Marine Protected Areas) in App. 2. NP(total)=3.8 $*10^6$ (sfc-mr); 2.5 $*10^6$ (sbd-lr); 5.1 $*10^6$ (sbd-hr).

Group Number	Group name	sfc-mr(%)	sbd-lr (%)	sbd-hr(%)
1	Eastern US	0.05	0.03	0.02
2	Southeast Florida	0.09	0.04	0.03
3	Florida Keys	0.04	0.02	0.01
4	Western Bahamas	0.07	0.14	0.29
5	Eastern Bahamas	0.16	0.12	0.11
6	Northern Cuba	46.44	34.98	27.26
7	Bahamian MPAs	0.00	0.00	0.00
TOTAL		46.9	35.3	27.7

4.2.1 Surface release – medium discharge rate

The probability of coastline oiling for the surface release simulation is given in APP6.4, Fig. D.4; see Fig. B for island names.

There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. Some islands coastlines (from Long Island, Crooked Island, to Ragged Island, and around Acklins Island) in Eastern Bahamas have small probability of less than 0.1%. High probability is shown along the northern Cuban coast, especially southeast of the spill site between 79.0^{o}W and 78.2^{o}W with 24.23% of the total released particles, and southwest of the spill site between 79.8^{o}W and 79.0^{o}W with 17.77% while no particles landed in the far western region (west of 82.2^{o}W) of the northern Cuban coast (Fig. D.4).

Table 2 summarizes the shoreline oil statistics for the long term surface release simulation over 7 years from 2004 to 2010 grouped by the seven regions of interest. The Northern Cuba shoreline has a maximum probability 46.44%. Eastern U.S., Southeast Florida, Florida Keys and Western Bahamas have small probability of less than 0.1%. Especially, there is no particle landed in shorelines around Andros in the Western Bahamas. Eastern Bahamas has 0.16% probability. Bahamian MPAs has 0% probability (9 particles landed out of total number of released particles over 7 years).

4.2.2 Seabed release – low discharge rate

The probability of coastline oiling for the seabed release – low discharge rate case simulation is given in APP6.5, Fig. D.5; see Fig. B for island names.

There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. Some islands coastlines (from Crooked Island to Ragged Island) in Eastern Bahamas have small probability of less than 0.1%. High probability is shown along the northern Cuban coast, especially southeast of the spill site between 79.0^{o}W and 78.2^{o}W with 21.65% of the total released particles, and southwest of the spill site between 79.8.0^{o}W and 79.0^{o}W with 8.06% while no particles landed in the far western region (west of 83.5^{o}W) of the northern Cuban coast (Fig. D.5).

Table 2 summarizes the shoreline oil statistics for the long term seabed / low discharge rate simulation over 7 years from 2004 to 2010 grouped by the seven regions of interest. The Northern Cuba shoreline has a maximum probability of 34.98%. Eastern U.S., Southeast Florida, and Florida Key have small probability of less than 0.1%. Western Bahamas has 0.14% and Eastern Bahamas has 0.12%. Especially, shorelines around Andros in Western Bahamas have 0% probability (5 particles landed) and Bahamian MPAs has 0.00% probability (15 particles landed out of total number of released particles over 7 years).

4.2.3 Seabed release – high discharge rate

The probability of coastline oiling for the seabed release – high discharge rate case simulation is given in APP6.6, Fig. D.6; see Fig. B for island names.

There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. Some islands coastlines (from Crooked Island to Ragged Island and around Acklins Island) in Eastern Bahamas have small probability of less than 0.1%. High probability is shown along the northern Cuban coast, especially southeast of the spill site between 79.0^{o}W and 78.2^{o}W with 16.83% of the total released particles, and southwest of the spill site between 79.8^{o}W and 79.0^{o}W with 5.82% while no particles landed in the far western region (west of 83.0^{o}W) of the northern Cuban coast (Fig. D.6).

Table 2 summarizes the shoreline oil statistics for the long term seabed release / high discharge rate simulation over 7 years from 2004 to 2010 grouped by the seven regions of interest. The Northern Cuba shoreline has a maximum probability of 27.26%. Eastern U.S., Southeast Florida, and Florida Keys have small probability of less than 0.1%. Western Bahamas has 0.29% with most of them landed in North Great Bahama Bank while Andros has 0.00% probability (22 particles landed). Eastern Bahamas has 0.11% and Bahamian MPAs has 0% probability (41 particles landed, representing out of total number of released particles over 7 years).

4.3 SHORELINE EXPOSURE TO OIL

Maps displaying which shorelines would be oiled in minimum time and average time are presented in the following sections for each of three discharge rates: medium rate (surface release, section 4.3.1), low rate (seabed release, section 4.3.2) and high rate (seabed release, section 4.3.3). Island names used in these maps are depicted in Fig. B. Small land masses surrounding the Cay Sal Bank are below the minimum polygon size; therefore, oil landing on them is not part of this calculation. The minimum time to shoreline is determined by calculating the 95th percentile of the time sequence from longest time to shortest time. Time ranges below refer to sub-regions within each of the polygon groups given in Table 2.1.

4.3.1 SHORELINE EXPOSURE TO OIL (surface release – medium discharge rate)

APP6.7 contains the maps of shoreline exposure to oil for the surface release simulation (Figs. D.7.1-D.7.2).

The northern Cuban coast shoreline, especially between 79.8.0^{o}W and 77.5^{o}W has the potential of becoming oiled in the shortest time with a minimum time of under 2 days with high probability of 24.23% (1 day) in southeast of the spill site and 17.77% (1 day) in southwest of the spill site, out of the total number of released particles (Fig. D4 and D7.1). Potential areas with a minimum time of 2-5 days are the western side of the high probability area to 81.5^{o}W (2.8 to 4.1 days) and the eastern side of the high probability area to 76.8^{o}W (4 days). Regions with a minimum time of 5-15 days are: east of 76.8^{o}W (7.7 to 13.2 days), the region between 82.3^{o}W and 81.5^{o}W along the northern Cuban coast (6.7 days), Southeast Florida (6.9 days), Florida Keys (10.6 days) and the region around Bimini Island in Western Bahamas (7.1 -13.3 days). Regions with a minimum time of 15-30 days are: Bahamian shorelines around Abaco Island in the Western Bahamas region (15.7 to 16.9 days) and shorelines from Long Island, Crooked Island (26.1 days), and to Ragged Island (20.3 days) in the Eastern Bahamas region. Shorelines around Acklins Island in the Eastern Bahamas region have a minimum time of 30.7 days with a low probability of less than 0.1%.

In terms of average time to reach the shoreline, the region between 79.8^{o}W and 77.5^{o}W along the northern Cuban coast has an average time of 1.9 to 4.2 days (Fig. D7.2). Starting from this region closest to the spill site, regions to both directions (westward and eastward) along the northern Cuban coast have longer average time to reach the shoreline: 6.7 days in west and 9.3 days in east (within the 5-10 day range, green color), 11.3 to 15.1 days in west and 11.1 days in east (within the 10-20 day range, yellow color) and 20.6 days for the Southeast Cuban corner (within the 20-30 day range, orange color). Eastern U.S. far away from the spill site has an average time of more than 30 days (34.4 days, red color) north of 32.5^{o}N, decreasing to 24.4 days (20-30 day range, orange color) between 28^{o}N and 32.5^{o}N. Southeast Florida (16 days) and Florida Keys (16.1 days) fall in the 10-20 day range (in yellow). The region around Bimini Island in the Western Bahamas region has an average time of 11.6-19 days (10-20 day range, yellow color). Shorelines around Abaco Island in the Western Bahamas region have an average time of 21.4-27.7 days (20-30 day range, orange color). Shorelines from Long Island, Crooked Island (28.8 days), and to Ragged Island (28.7 days) in the Eastern Bahamas region have an average time of more than 20-30 days (orange color).

4.3.2 SHORELINE EXPOSURE TO OIL (seabed release - low discharge rate)

APP6.8 contains the maps of shoreline exposure to oil for the surface release simulation (Figs. D.8.1-D.8.2).

The northern Cuban coast shoreline, especially between 79.8^{o}W and 78.2^{o}W has the potential of becoming oiled in the shortest time with a minimum time of under 2 days with high probability of 21.65% in southeast of the spill site (1.1 days) and 8.06% in southwest of the spill site (1.1 days) out of the total number of released particles (Fig. D5 and D8.1). Potential areas with a minimum time of 2-5 days are the western side of the high probability area to 80.5^{o}W (2.6 days) and the eastern side of the high probability area to 77.5^{o}W (2.8 days). Regions with a minimum time of 5-15 days are: east of 77.5^{o}W to 75.5^{o}W (6.2 days to 9.1 days), the region between 82.3^{o}W and 80.5^{o}W along the northern Cuban coast (6.4 to 14.1 days), south of 33^{o}N along the Eastern U.S. shoreline (10.4 days), Southeast Florida (6.4 days), Florida Keys (6.1 days), the region around Bimini Island along the western Great Bahama Bank (9.2 to 12.5 days) and south of Grand Bahama Island (14.4 days) in the Western Bahamas region. Some Bahamian shorelines around Andros Island (18 days) and Abaco Island (18.9 days and 19 days) in the Western Bahamas region fall in the 15-30 days range with a probability of less than 0.1%.

In terms of average time to reach the shoreline, the region between 79.8^{o}W and 78.2^{o}W along the northern Cuban coast has an average time of 3.3 to 3.7 days (Fig. D8.2). Starting from this region closest to the spill site, regions to both directions (westward and eastward) along the northern Cuban coast have longer average time to reach the shoreline: 7.4 days in west and 7.3 days in east (within the 5-10 day range, green color), 14.7 days in west and 16.3 to 19.9 days in east (within the 10-20 day range, yellow color), and 22.2 to 27.5 days in west and 24.7 days in east (within the 20-30 day range, orange color). Eastern U.S. far away from the spill site has an average time of more than 30 days (31 days, red color) north of 33°N, decreasing to 22.7 days (20-30 day range, orange color) further south (28°N-33°N). Southeast Florida (18.5 days) and Florida Keys (17.9 days) fall in the 10-20 day range (in yellow). Most shorelines in the Western Bahamas have an average time of 20.7 to 27.6 days (within the 20-30 day range, orange color).

4.3.3 SHORELINE EXPOSURE TO OIL (seabed release - high discharge rate)

APP6.9 contains the maps of shoreline exposure to oil for the surface release simulation (Figs. D.9.1-D.9.2).

The northern Cuban coast shoreline, especially between 79.8°W and 78.2°W has the potential of becoming oiled in the shortest time, with a minimum time of under 2 days with high probability of 16.83% in the southeast of the spill site (1.1 days) and 5.82% in the southwest of the spill site (1.1 days) out of the total number of released particles (Fig. D6 and D9.1). Potential areas with a minimum time of 2-5 days are the western side of the high probability area to 80.5°W (20.6 days) and the eastern side of the high probability area to 77.5°W (2.8 days). Regions with a minimum time of 5-15 days are: east of 77.5°W to 75.5°W (6.4 to 9.5 days), the region between 81.5°W and 80.5°W along the northern Cuban coast (6.2 days), south of 33°N along the Eastern U.S. shoreline (10.2 days), Southeast Florida (6.3 days), Florida Keys (6.3 days), the region around Bimini Island along the western Great Bahama Bank (12.3 to 14.1 days) and south of Grand Bahama Island in the Western Bahamas region (11.9 days). Some Bahamian shorelines around Andros Island (17.1 days) and Abaco Island (16.4 to 20.8 days) in the Western Bahamas region have a minimum time in the 15-30 day range with a probability of less than 0.1%.

In terms of average time to reach the shoreline, the region between 79.8°W and 78.2°W along the northern Cuban coast has an average time of 3.2 to 3.7 days (Fig. D9.2). Starting from this region closest to the spill site, regions to both directions (westward and eastward) along the northern Cuban coast have longer average time to reach the shoreline: 7.9 days in west and 7.6 days in east (within the 5-10 day range, green color), 15.7 days in west and 17.7 days in east (within the 10-20 day range, yellow color), and 24.4 to 24.8 days in west and 21.5 to 26.7 days in east (within the 20-30 day range, orange color). Eastern U.S. far away from the spill site has an average time of more than 30 days (31.9 days, red color) north of 33^{o}N, decreasing to 23.9 days (20-30 day range, orange color) further south (28^{o}N-33^{o}N). Shorelines around Bimini Island (20.8 to 24.7 days) and Little Bahama Bank (25.3 to 26.4 days) in the Western Bahamas region have an average time of 20-30 days (in orange). Shorelines around Abaco Island have an average time of 30.1 days (in red).

4.4 OIL ON SEA SURFACE

The 7-year simulation is split into individual oil spills of 90 days duration, with a period of 60 days of oil release and a period of 30 days of follow-up. For each of these 90-day oil spills, a map is derived showing the maximum extent of the sheen during the individual event. The statistics derived from all of these oil spills show the probability of presence of sheen of oil during an oil spill of 90-day duration.

4.4.1 Surface release case

Figure D.10 (APP6.10) shows the resulting map of probability of oil presence at the surface for the surface release simulation; a 10% threshold is employed. The area with the highest probability of oil presence extends south of the release point, in the deep part of the channel between Cuba and the Great Bahama Bank. This area extends with an East-West orientation along the Cuban coast; the extension is comparable in both directions. The part of the Cuban coast directly facing the release point is very exposed to oil presence. The oil spill has 3 directions for extension: to the east in the channel formed between Cuba and the Great Bahama Bank, to the west between Cuba and Cay Sal Bank, and to the North within the Gulf Stream flow. This latter branch is the one entraining the oil the furthest away, the area of lowest probability (10-25%) reaching Southeast Florida, but then staying offshore from the shelf break till ~32°N. The largest probabilities of oil presence (50% or higher) remain confined around the release point and extending between 80.50°W and 77°W along the Cuban coast. In particular, no island of the Bahamian archipelago outside the Cay Sal Bank area has a probability of being affected by oil landfall reaching the 10% threshold.

4.4.2 Seabed release – low discharge rate case

Figure D.11 (APP6.11) shows the resulting map of probability of oil presence at the surface for the seabed release / low discharge rate simulation; a 10% threshold is employed. The area with the highest probability of oil presence extends south of the release point, in the deep part of the channel between Cuba and the Great Bahama Bank. This area extends with an East-West orientation along the Cuban coast, with a preferred direction toward the East. The part of the Cuban coast facing the release point and extending eastward to 77.50°W is very exposed to oil presence. The oil spill has 2 main directions for extension: to the east in the channel formed between Cuba and the Great Bahama Bank, and to the west between Cuba and Cay Sal Bank. A 3rd direction is also noticed between Cay Sal and the Great Bahama Bank, but it shows smaller probability of presence. The largest probabilities of oil presence (50% or higher) remain confined in the channel between Cuba and the Great Bahama Bank and extending between 80.50°W and 76.50°W along the Cuban coast. In particular, no U.S. coastline and no island of the Bahamian archipelago outside the Cay Sal Bank area have a probability of being affected by oil landfall reaching the 10% threshold.

4.4.3 Seabed release – high discharge rate case

Figure D.12 (APP6.12) shows the resulting map of probability of oil presence at the surface for the seabed release / high discharge rate simulation; a 10% threshold is employed. The area with the highest probability of oil presence extends south of the release point, in the deep part of the channel between Cuba and the Great Bahama Bank. This area extends with an East-West orientation along the Cuban coast, with a clear preferred direction toward the East. The part of the Cuban coast facing the release point and extending eastward to 76.50°W is very exposed to oil presence. The oil spill has 3 directions for extension: to the east in the channel formed between Cuba and the Great Bahama Bank, to the west between Cuba and Cay Sal Bank, and between Cay Sal and the Great Bahama Bank. This latter direction shows the smallest probability of oil presence and reaches a small part of the Florida coastline. The largest probabilities of oil presence (50% or higher) remain close to the release point in the westward and northward branches, reaching 80.50°W and 24.50°N; in the eastward direction high probability reaches 76°W along the Cuban coast. Despite this preferred eastward extension, no island of the Bahamian archipelago outside the Cay Sal Bank area has a probability of being affected by oil landfall reaching the 10% threshold.

4.5 DISCUSSION OF LONG TERM SIMULATION (Part1)

The evolution of the spreading of oil particles from the surface and seabed release cases shows a large influence of the bathymetry of the area surrounding the Bahamas Petroleum Company release point. The oil initially extends in the channel between Cuba and the Great Bahama Bank. Since the latter is wider compared to the narrow Cuban shelf, it prevents most of the oil from reaching the majority of the Bahama islands, whereas on the other hand, Cuba is really vulnerable to an oil spill from the simulated release location.

West of the release point, oil at the surface favors extension along the Cuban coast, but a significant part also tends to extend northward. This wider meridional extension is made possible by the presence of deeper topography. The most northward extension is associated with the entrainment of the oil by the Florida Current – Gulf Stream system. This entrainment is stressed by the northwestward winds usually prevalent in the wet season. Through the wind-induced drift, this wind pattern pushes oil away from Cuba toward the oceanic current system. This explains how the Eastern U.S. and Florida coastlines tend to be more impacted during the wet season (see Figures D.1.4, D.1.5, D.2.4, D.2.5, D.2.11, and D.2.12).

East of the release point, oil at the surface is mainly entrained by episodes of eastward surface currents, and is not supported by the dominant westward winds. Hurricanes seem to have a noticeable effect only when they are directly over the zone around the release location, as was the case for Wilma in September 2005, which resulted in pushing oil toward the Western Bahamas (Figure D.1.3). Other hurricanes have a more marginal effect, mainly because the oil spill usually has a short spatial extension between the Great Bahama Bank and Cuba, with large quantities of oil reaching Cuba in a short time, so that there is little oil to be affected by the passage of a hurricane. The impact of a hurricane on an oil spill is very sensitive to the location of the source of the spill. For example, simulations with a spill originating in the Cay Sal region (not shown), which leads to the entrainment of large quantities of oil by the Gulf Stream, reveal that during the passage of Wilma in October 2005 the oil was dispersed on larger scale, affecting the northern Bahamas.

The surface and the two seabed release cases also allow for analyzing the effects of the discharge rate and the depth of release. In the case of the surface release (Fig. D.10), the extension of the spill toward the north is favored, due to the direct entrainment by the surface currents and the wind-induced drift. The area of highest probability of oil presence is less extended in the East-West direction, because of the dispersion effect of the surface currents and the wind-induced drift. On the other hand, both seabed release cases (Figs. D.11- D.12) show a more limited northward extension of the oil spill, but a more pronounced one in the East-West direction, especially toward the East. This can be attributed to the displacement of medium size particles at depth, in the East-West direction, before they emerge at the surface. Deep currents seem to enhance eastward entrainment of the oil droplets, as seen by the further eastward extension of the area of high probability of oil presence in the seabed release cases compared to the surface case (See Figures D.10, D.11 and D.12). The impact of topography on the displacement of oil droplets before they emerge is stronger than when they are at the surface: in the seabed release / high rate case, the probability of oil presence is more intense in the channel between Cay Sal Bank and the Great Bahama Bank than on Cay Sal Bank itself (Figure D.12), whereas it was not the case for the surface release (Figure D.10). Continental shelf breaks are a natural guideline for deep currents and deep entrainment of oil, while they shield the shelf areas from oil reaching the coastlines, as seen by the signature of higher probability of oil presence along the Great Bahama Bank shelf break near Cay Sal (Figure D.11). The difference in the discharge rate between the two seabed release cases shows that, unsurprisingly, the high rate case has larger areas of high probability of oil presence at the surface.

The total duration of an oil spill event is dependent on various parameters, the primary one being the duration of the oil leak from the wellhead. In addition, the localization of the source of oil, at the surface or at depth, plays an important role: oil at depth lives longer, since evaporation is more efficient in degrading the oil compared to biodegradation. Both processes, evaporation and biodegradation, are slower for heavy oil compounds, which is another determinant aspect to take into account when estimating the duration of an oil spill. In particular, there is currently still a large uncertainty about the rate of degradation of oil at depth, which has been represented to the best of today's knowledge in our state-of-the-art oil spill model.

The longer lifetime of oil at depth explains how it is be advected further away from the source, although deep currents are not as intense as at the surface. This is stressed by the fact that the winds tend to push oil at the surface along the neighboring coastlines, especially Cuba, which does not happen at depth.

At depth, the physical transport of oil is only due to currents, while at the surface this transport is sensible to both ocean currents and wind-induced surface drift, the latter being dominant in the case of intense winds (e.g. during hurricane Wilma). The biological activity plays a role in the biodegradation of oil at depth, while at the surface the weathering of oil is dominated by evaporation. The distribution of oil droplets size is also crucial for estimating the presence of oil between surface and deep oil presence: small droplets (<50 to 60 μm) are too small to reach the surface by buoyancy and will stay at depth for extended periods of time. Larger particles will eventually reach the surface, where their lifetime is shorter. The oil droplets size distribution is difficult to estimate, since it depends on the specific configuration of the oil source. This explains that we represented the impact of the high discharge rate and the expected associated higher shear rate and emulsification by a distribution of oil droplets size with larger proportions of oil toward small droplets. Hence, the presence of oil at depth is enhanced compared to the low discharge rate case.

All these aspects illustrate the challenges of modeling the oil behavior, since it is influenced by many physical and biological processes for which the key parameters are not always well known. However, we are confident that the main results presented here, which are dominated by details in ocean currents, prevailing wind directions and intensity, and topographic controls, are the best possible realizations of regional oil transport and fate.

5. RESULTS AND DISCUSSION, INDIVIDUAL SCENARIO SIMULATIONS (PART2)

5.0 TEST CASE STUDIES

Test Case studies have been selected for targeted scenario simulations, one group for the surface release, and one group for the seabed / high flow rate deep release. The choices and their criteria are outlined below.

For the surface release Case studies:

- Case B1: Situation with shortest time of oil to shore: February 2009, associated with an episode of several days of fast entrainment of oil toward Cuba.
- Case B2: Situation with maximum shoreline oiled area: September 2008, associated with entrainment of oil on the Eastern U.S. and Florida coastlines.
- Case B3: Hurricane Wilma case: October 2005.

For the seabed release Case studies:

- Case B4: Situation with shortest time of oil to shore: January 2010, associated with an episode of several days of fast entrainment of oil toward Cuba and the largest quantities reaching that coast.
- Case B5: Situation with maximum shoreline oiled area: October 2007, associated with entrainment of oil on the Eastern and Western Bahamas coastlines.
- Case B6: Situation with maximum volume of oil entrained in the water column: August 2006, when the quantity of oil below the surface is at its peak.

The number of particles released for the Task 4 simulations is proportional to the flow rate. For the surface release simulations, 1500 particles are released every 2 hours (flow rate of 2,400 m^3/day) for 30 days and the resulting spill is followed for another 30 days. For the seabed release simulations 2000 particles are released every 2 hours (flow rate of 3,200 m^3/day) for 60 days and the resulting spill is followed for another 30 days. This high frequency release allows for taking into account the sudden changes in current and atmospheric conditions.

5.1 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)

The time integrated probability density distribution of the oil at the surface is computed using a Probability Density Function (PDF), which provides a metric to evaluate the overall dispersal pattern of surface oil during the entire simulation period and the frequency of occurrence of oil in a given location over an advection time period (T). The PDF is thus defined as the cumulative number of oil particles found in a unit area (i) at each time interval (t), normalized by the total number of oil particles in the upper 20 meters at each time interval (t):

PDF = ∑(i,t)(number of particles in a unit area /total number of oil particles)*100.0,

where (i) is the index of each bin with more than 1 oil particle over the spill period. The sampled space is divided in bins of equal size (0.05^o by 0.05^o or a unit area of about 20 km^2) and the frequency of particles passing in each bin is computed for a given advection time (T), corresponding to the spill duration and follow up period. The total number of surface particles NSP(total) accrues oil particles in the upper 20 meters, rejecting those evaporating or making landfall. NSP(total) is computed at the end of each scenario calculation and thus includes particles for a total of 60 days for surface Cases B1-B3 and a total of 90 days for deep Cases B4-B6.

5.1.1 Surface release /CASE B1

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.13, APP7.1; NSP(total) in this Case is $3.3 * 10^6$.

The highest probability is shown toward the Cuban coast, south of the spill site. From the high probability area the surface oil spreads both eastward and westward along the Cuban coast. It has wide spread of small probability westward over the Cay Sal Bank, with a narrow northward pathway along the Great Bahama Bank. The area of oil spreading is limited by the dominant southwestward winds that push most of the surface oil directly onto the Cuban coasts.

5.1.2 Surface release /CASE B2

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.14, APP7.2; NSP(total) in this Case is 5.3 $*10^6$.

The highest probability is shown toward the Cuban coast, south of the spill site. From the high probability area more surface oil spreads eastward along the Cuban coast, with a small probability area extending further eastward, toward the Eastern Bahamas. To the west, the oil has a small probability of wide spreading over the Cay Sal Bank, with an extended northward pathway in the Florida Strait, reaching to the Southeast Florida and further north the Atlantic Interior.

5.1.3 Surface release /CASE B3

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.15, APP7.3; NSP(total) in this Case is 5.5 $*10^6$.

The highest probability is shown toward the Cuban coast, south of the spill site. From the high probability area, surface oil spreads eastward along the Cuban coast. Another part flows northward over the Great Bahama Bank and a third branch flows toward the Cay Sal Bank. Smaller probability areas have a wide spread over Cay Sal Bank, with a northward pathway to the north with a slight overflow onto the Great Bahama Bank and to the west of Cay Sal Bank, along the Cuban coast. An eastward branch of small probability also extends eastward along the Cuban coast.

5.1.4 Seabed release /CASE B4

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.16, APP7.4; NSP(total) in this Case is 4.4 $*10^6$.

The highest probability is shown toward the Cuban coast, south and southeast of the spill site. Within the high probability area, surface oil tends to spread eastward along the Cuban coast, with a secondary high probability branch also extending along the Cuban coast, but westward. A small probability exists for westward and northward extension, toward the Atlantic Interior. The area of small probability is notably larger than for the surface release cases. This is due to the larger amplitude of the spill, which has a higher flow rate, and to the duration of the spill, which lasts 60 days in the seabed release cases, compared to 30 days for the surface release cases. These differences compensate the fact that some oil remains at depth in the sea bed release case for seabed release simulations, and more oil has a chance of being advected away from the release site. Several interesting patterns exist with small probability, shown as a broad intrusion through the North Province Channel reaching Eleuthera Island in Eastern Bahamas (76^{o}W and 26^{o}N), a broad overflow of the northward branch eastward over the Great Bahama Bank and Little Bahama Bank, and an eastward broad spread along the Cuban coast. Coastal areas along the Eastern U.S., Southeast Florida, and Florida Keys are not affected from the surface oil spread.

5.1.5 Seabed release /CASE B5

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.17, APP7.5; NSP(total) in this Case is 5.2 *10^{6}.

The highest probability is shown toward the Cuban coast, south and southeast of the spill site. Within the high probability area more surface oil spreads eastward along the Cuban coast, with secondary branches westward along the Cuban coast and a northeastward overflow over the Great Bahama Bank. To the west, a small probability exists to reach the Atlantic Interior. Additional interesting patterns of small probability are shown as a broad intrusion through the North Province Channel reaching the south of Abaco Island, a narrow overflow eastward onto the eastern Great Bahama Bank (by the northward branch), broad coverage over Little Bahama Bank, and eastward broad spreading along the Cuban coast. The Florida Keys and Coastal areas north of 30^{o}N (along the Eastern U.S.) are not affected from the surface oil spread, while coastal areas south of 30^{o}N (Southeast Florida) exhibit small probability to be exposed to the surface oil spread. The area of small probability is notably larger than for the surface release cases (see comments in section 5.2.2).

5.1.6 Seabed release /CASE B6

The map of probability density distribution of the oil at the surface (upper 20m) is shown in Fig. D.18, APP7.6; NSP(total) in this Case is 4.6 $*10^6$.

The highest probability is shown toward the Cuban coast, south and southeast of the spill site. Within the high probability area, surface oil spreads both eastward and westward along the Cuban coast. An area of small probability reaches the Atlantic Interior. Additional interesting patterns with small probability are shown as narrow overflow eastward over the eastern Great Bahama Bank (by the northward branch), broad coverage over Little Bahama Bank, and a wide eastward tail along the Cuban coast. As opposed to previous seabed release cases, there is no continuous intrusion through the North Province Channel with sporadic surface oil presence. Coastal areas north of 29^{o}N along the Eastern U.S., south of 27^{o}N along the Southeast Florida and the Florida Keys are not affected from the surface oil spread, while coastal areas south of 29^{o}N along the Eastern U.S. and Southeast Florida to 27^{o}N are exposed to the surface oil spread. The area of small probability is notably larger than for the surface release cases (see comments in section 5.2.2).

5.2 CALCULATION OF INTERACTION OF OIL SLICKS WITH LAND WITH TIME

6-hourly outputs of the 60-day simulation are used to derive instantaneous concentrations of oil at the surface (g/m^2), based on the flow rate and the number of particles released. This concentration is used to derive oil thickness at the surface (µm, based on NRC, 1985, see Table 3) in 0.05° squares. Thickness smaller than 0.05 µm is not shown.

Table 3: Oil thickness (microns in g/m^2), based on NRC (1985).

MINIMUM µm = (g/m^2)	MAXIMUM µm = (g/m^2)	APPEARANCE ON WATER SURFACE
0.05	0.2	Colorless and silver sheen
0.2	0.8	Rainbow sheen1
1	4	Dull brown sheen
10	100	Dark brown sheen
1000	10,000	Black oil

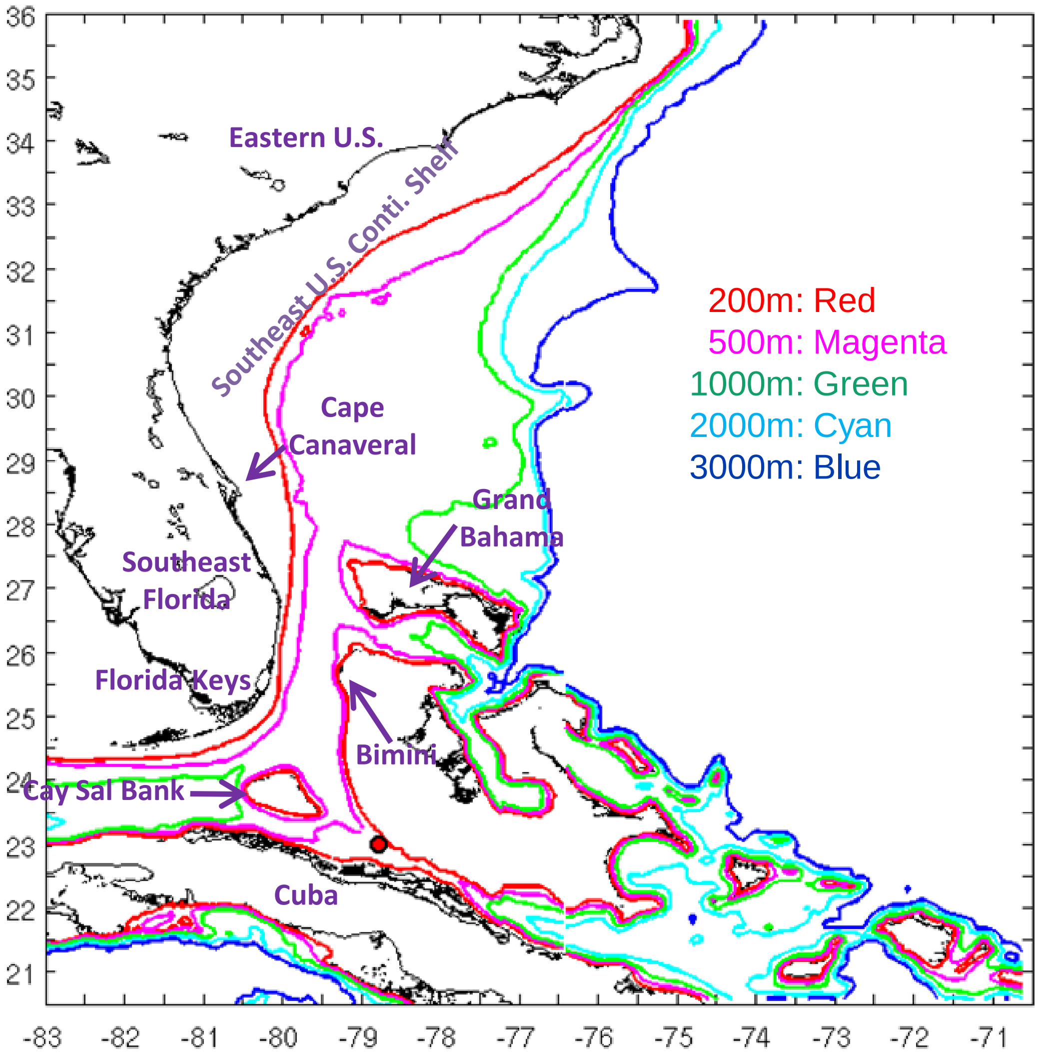

Fig. C: Study domain and bathymetry contours used in the plots and animations of APP7.7-APP7.12.

5.2.1 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (surface release/CASE B1)

The animation presenting the time evolution of the surface slick and its thickness, between February 1st and April 2, 2009, during an episode of short time of oil to shore, is included as File D19 (APP7.7). Figure D19 (APP7.7) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

In the first week after the beginning of the spill, the oil is directly advected toward the Cuban coast, with typical time of less than a day. Mid-February, a tongue of oil is advected westward along the Cuban coasts. Part of it then migrates to the north between Cay Sal Bank and the Great Bahama Bank, where it dissipates through evaporation. In March, after the end of the oil release on March 2, the final slick extends to the east, but it quickly disappears from the surface of the sea, after being pushed onto the Cuban coastline or evaporated.

5.2.2 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (surface release/CASE B2)

The animation presenting the time evolution of the surface slick and its thickness, between September 1st and October 31, 2008, during an episode of large shoreline affected, is included as File D20 (APP7.8). Figure D20 (APP7.8) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

In the first week after the beginning of the spill, the initial slick extends toward the east and strongly affects the Cuban coastline. It then reverses to the northwest and follows the shelf edge along the Great Bahama Bank. Between mid and late September, this large slick is split into many smaller ones, some of them being entrained by the Florida Current and affecting the Southeast Florida and Eastern U.S. coasts at Cape Canaveral (~27°N), while some oil stays closer to the release point and affects Cay Sal Bank. By the end of September, the spread from the release point is directed toward the east, and the oil quickly disappears from the surface after the end of the oil release on October 1st, after having evaporated or made landfall on Cuba.

5.2.3 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (surface release/CASE B3)

The animation presenting the time evolution of the surface slick and its thickness, between October 1st and November 30, 2005, during Hurricane Wilma, is included as File D21 (APP7.9). Figure D21 (APP7.9) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

During the first days following the beginning of the spill, the main slick extends to the east. A burst of northward winds pushes it onto the Great Bahama Bank, but the oil slick does not make landfall on Andros Island, and retracts back to the channel between Cuba and the Great Bahama Bank. Later in October, the main slick extends westward, under the influence of dominant winds, and overflows over Cay Sal Bank. Then, on October 25, Hurricane Wilma passes over Florida, coming from the Gulf of Mexico and going northeastward. Its cyclonic winds strongly push this slick away to the east, by more than 100 km in one day. On October 26, part of the slick overflows onto the Great Bahama Bank, but no oil makes landfall on Western Bahamas, except for Bimini Islands that are hit by the incoming oil. After the passage of Wilma, the main slick quickly disappears at the surface, as does the slick close to the release point after the end of the oil release on October 31. Despite the presence of Hurricane Wilma and its impact on the surface oil slick, Cuba is still the main coastline affected by the spill.

5.2.4 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (seabed release/CASE B4)

The animation presenting the time evolution of the surface slick and its thickness, between January 1st and April 1st, 2010, during an episode of short time of oil to shore, is included as File D22 (APP7.10). Figure D22 (APP7.10) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

During the first two weeks, the surface slick extends to the east, and strongly affects the Cuban coastlines. Early February, the main slick starts to reverse, while a rather large slick stays between Cuba and the Great Bahama Bank between 76 and 77°W. Mid-February, isolated surface slicks are seen to form west of the release point and along Cay Sal Bank, many of which stay between Cay Sal Bank and the Great Bahama Bank. At the end of the oil release, on March 2nd, the main slick is again to the east, but small slicks are also seen to be advected westward along the Cuban coasts. Two weeks later, the last surface slicks are isolated around 76°W between Cuba and the Great Bahama Bank.

5.2.5 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (seabed release/CASE B5)

The animation presenting the time evolution of the surface slick and its thickness, between October 1st and December 30, 2007, during an episode of export of oil far from the release point, is included as File D23 (APP7.11). Figure D23 (APP7.11) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

During the first week, the main slick is directed toward the east. Mid-October, a burst of northward winds pushes the main slick onto the Great Bahama Bank. That slick reaches small reef islands that are part of the Eastern Bahamas, but does not make landfall on main islands. It then retracts slowly into the channel between Cuba and the Great Bahama Bank. The main slick is dominantly extending eastward, with short episodes of reversal to the west. At several episodes during the event, but especially in late November, isolated slicks are seen to form between Cay Sal Bank and the Great Bahama Bank. These slicks affect the Bimini Islands in the Western Bahamas, and some of them are advected to the north by the Gulf Stream. After the end of the oil release, on November 30, the oil quickly disappears from the surface after evaporating or making landfall, essentially on Cuban coasts. The last significant slicks at the surface are seen along Cuba east of the release point.

5.2.6 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (seabed release/CASE B6)

The animation presenting the time evolution of the surface slick and its thickness, between August 1st and October 30, 2006, during an episode of large volume of oil in the water column, is included as File D24 (APP7.12). Figure D24 (APP7.12) shows snapshots extracted from the animation and illustrating the evolution of the slick for the considered scenario. The bathymetry contours used in Figures D.19-D.24 are shown in Fig. C.

During the first week of the spill, the main slick is directed to the west, but it then reverses to the east on mid-August. Early September, a sudden burst of northward winds starts to push oil over the Great Bahama Bank, but the slick quickly goes back toward the channel between Cuba and the Great Bahama Bank. The main slick remains toward the east throughout the event, with short episodes of reversal to the west, as seen in late September. Late September also, isolated slicks are seen to briefly form between Cay Sal Bank and the Great Bahama Bank. After the end of the oil release, on September 30, the main slick is directed to the east and the oil quickly disappears from the surface, being advected toward Cuba or evaporated.

5.3 CALCULATION OF OIL BUDGET AND PARTITIONS OVER TIME

The model includes the processes of biodegradation, evaporation, and landfall, which are combined to describe the fate of the oil that is transported by oceanic currents. The loss due to biodegradation and dissolution of hydrocarbons is simulated using temperature and fraction-dependent formulas; the evaporation rate is applied to particles in the upper 20m of the water column and is a function of the hydrocarbon fractions; and oil particles that reach a minimum depth of 3 m thickness of the ocean model are considered having made landfall along the coast and captured in the coastal polygons. We represent the fate of the oil spilled over time by computing the percentage of oil in each of the following fresh and weathered stages: 1) in suspension in the water column, 2) at the sea surface in the form of oil slicks or mats, 3) biodegraded, dissolved or deposited on the seafloor, 4) evaporated in the form of volatile hydrocarbons, and 5) beached or making landfall. The percent of oil in each of these stages is scored against the total mass of oil spilled.

5.4 OIL BUDGET AND PARTITIONS OVER TIME

5.4.1 OIL BUDGET AND PARTITIONS OVER TIME (surface release/CASE B1)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE B1) are given in Fig. D.25, APP7.13.

In this case, the shortest time of oil to shore is associated with an episode of several days of fast entrainment of oil toward Cuba. Here most of the oil comes to shore and we see a rapid increase of large amount of oil beached reaching a maximum of approximately 55% of the total oil discharged. About 5% remains at the surface throughout the spill duration and is quickly evaporated afterward. Evaporation reaches about 42% but is lower than landfall. Biodegradation is negligible, as the weathering of oil at the surface is dominated by evaporation.

5.4.2 OIL BUDGET AND PARTITIONS OVER TIME (surface release/CASE B2)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE C1) are given in Fig. D.26, APP7.14.

In this case, the maximum of shoreline oiled is associated with entrainment of oil toward the Eastern U.S. and Florida coastlines, on top of the Cuban coast, which remains the most impacted coastline. Coastlines are impacted immediately during the first week, then after two weeks, indicating that there is some lag in the impact on a different region. The total landfall is approximately 30-32% of the total oil discharge, about 10% is at the sea surface for 5 weeks, and the rest the oil forms aerosols (about 70%). Biodegradation is negligible, as the weathering of oil at the surface is dominated by evaporation.

5.4.3 OIL BUDGET AND PARTITIONS OVER TIME (surface release/CASE B3)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE C1) are given in Fig. D.27, APP7.15.

In this case, the passage of hurricane Wilma is associated with oil reaching Cuba and the Western Bahamas. There is a lag of about 10 days before landfall, which tends to decrease the percent of oil at the surface. Maximum landfall at the end if the 30-days spill is approximately 30% of the total discharge. Evaporation is very high, reaching nearly 70% of the total amount of oil spilled. Biodegradation is negligible, as the weathering of oil at the surface is dominated by evaporation.

5.4.4 OIL BUDGET AND PARTITIONS OVER TIME (seabed release/CASE B4)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE C1) are given in Fig. D.28, APP7.16.

In this case, the shortest time of oil to shore is associated with an episode of several days of fast entrainment of oil toward Cuba and the largest quantities reaching that coast. Landfall occurs quickly in the first few days following the deep blowout and increases steadily, yet not as fast as when the spill occurs at the surface. Indeed, maximum landfall is of 30% of the total discharge after 60 days. Most of the oil is being biodegraded (about 50% after 60 days). About 4% and 2% of the discharge is in the form of suspended oil and surface oil slicks, respectively, throughout the 60-days spill duration and is biodegraded and evaporated in the following 30 days.

5.4.5 OIL BUDGET AND PARTITIONS OVER TIME (seabed release/CASE B5)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE C1) are given in Fig. D.29, APP7.17.

In this case, the maximum shoreline oiled is associated with entrainment of oil on the Eastern and Western Bahamas coastlines, on top of the Cuban coastline, which is the most impacted. While the final budget is similar to the previous case of shorter time to coastline, significant landfall is delayed by two weeks, then increases steadily reaching a maximum of approximately 25% of the total discharge. Evaporation is lower than biodegradation, with maximum values of 21% and 50%, respectively, after the well is capped.

5.4.6 OIL BUDGET AND PARTITIONS OVER TIME (seabed release/CASE B6)

Oil budget and partitions (e.g., in suspension, at the sea surface, evaporated, biodegraded/deposited and landed) over time (CASE C1) are given in Fig. D.30, APP7.18.

In this case of maximum volume of submerged oil in suspension in the water column, the landfall and oil at the surface are lower than in the previous cases by 5% to less than 1% at all times. Yet, suspended oil does not exceed 5% of the total oil discharge at any time.

5.5 DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION

5.5.1 DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) (seabed release/CASE B4)

6-hourly outputs of the 90-day simulation are used to follow the instantaneous depth of individual submerged oil particles.

Figure D31 (APP7.19) shows instantaneous maps of the submerged oil droplets (below 20 m), between January 1st and April 1st, 2010, during an episode of short time of oil to shore. The selected dates are the same as for Figure D22 (APP7.10). These maps are only indicative of the pathways of oil particles in the simulation, and do not illustrate oil concentration.

During the first week following the beginning of the spill, two branches of deep plumes extend, one to the west and one to the east; the eastward branch is shallower than the westward one. This is still the case in mid-January. In early February, the eastward branch appears comparable to the previous dates, and oil droplets appear shallower further along the channel between Cuba and the Great Bahama Bank. At the same date, deep oil droplets west of the release point experience localized deepening to about 400 m depth, around 23°N and further north along the Great Bahama Bank. Isolated deep particles of various depths have already been advected toward the Atlantic interior by the Gulf Stream. In mid-February, oil particles in the eastward branch keep extending further, with comparable depth as previously. At the same date, a downwelling affect particles around 24-25°N along the shelf edge, and some particles go deeper than 500m. Some of the deep droplets enter the Providence Channel, between the Great and Little Bahama Bank, toward the east. These features are also noticeable in early March, with deep oil droplets being advected far north toward the Atlantic interior. Particles of various depths are noticed between the Great and Little Bahama Bank. A third branch forms to the west following the Cuban coast. Two weeks after the end of the oil release, on March 2nd, many deep oil droplets are still present. Another episode of downwelling of oil droplets is noticed at 24-25°N along the Great Bahama Bank.

5.5.2 DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) - (seabed release/CASE B5)

6-hourly outputs of the 90-day simulation are used to follow the instantaneous depth of individual submerged oil particles.

Figure D32 (APP7.20) shows instantaneous maps of the submerged oil droplets (below 20 m), between October 1st and December 30, 2007, during an episode of export of oil far from the release point. The selected dates are the same as for Figure D23 (APP7.11). These maps are only indicative of the pathways of oil particles in the simulation, and do not illustrate oil concentration.

In the first week after the beginning of the oil spill, deep oil droplets extend exclusively to the northwest along the edge of the Great Bahama Bank, at a maximum depth of about 250 m, which corresponds to the initial separation height between gas and oil droplets at the release location. In mid-October, this branch keeps extending to the north following the edge of the Great Bahama Bank, with particles just west of the release point being pushed deeper (~300 m). Some oil particles are now advected to the east, with a depth shallower than 100 m. In early November, deeper particles advected to the west of the release point reach depth of 400 to 500 m very close to the release point. Further north, particles of various depths start entering the Providence Channel, between the Great and Little Bahama Banks, while some others are advected to the north toward the Atlantic interior. The eastward branch keeps extending, at comparable shallower depth. In mid-November, some particles west of the release point experience downwelling at 24-25°N along the Great Bahama Bank edge, while in the same area some others are noticed with depth shallower than 100 m. This suggests the formation of several distinct layers. The deeper particles reach 500 to 600 m depth; some of them enter the Providence Channel, going far east toward the Abaco Islands, while some of them are advected by the Gulf Stream toward the north. Particles of various depths follow both paths. In late November, the situation is comparable, with the signature of both deep and shallow particles at 24-25°N, between Cay Sal Bank and the Great Bahama Bank. The eastward branch is less extended. Two weeks after the end of the oil release, on November 30, many submerged oil droplets are advected northward at various depths by the Gulf Stream. Some are seen to be entrained into a large eddy between 30 and 32°N. A spot of deep particles is seen again at 24-25°N along the Great Bahama Bank. The eastward branch of deep particles extends further east than in the preceding weeks.

5.5.3 DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) - (seabed release/CASE B6)

6-hourly outputs of the 90-day simulation are used to follow the instantaneous depth of individual submerged oil particles.

Figure D33 (APP7.21) shows instantaneous maps of the submerged oil droplets (below 20 m), between August 1st and October 30, 2006, during an episode of large volume of oil in the water column. The selected dates are the same as for Figure D24 (APP7.12). These maps are only indicative of the pathways of oil particles in the simulation, and do not illustrate oil concentration.

In the first week after the beginning of the oil spill, submerged oil droplets extend toward both to the east and to the west, with droplets in the westward branch being deeper than those in the eastward branch. In late August, the eastward branch keeps extending at relatively shallow depth (~100 m), while on the western side of the release point, particles tend either to stay along the Cuban coast, or exending along the edge of the Great Bahama Bank. Some particles among the latter group experience deepening at 24-25°N, whereas some other particles remain at shallower levels in the near-by area between Cay Sal Bank and Great Bahama Bank, suggesting the formation of several distinct layers of submerged oil there. In early September, we notice several patches of droplets at various depths along the western branch, extending northward along the topography of Great Bahama Bank and further north, while the eastward branch appears more uniform and shallow. This is still the case in mid-September, but with less particles exported northward. The location for downwelling along the Great Bahama Bank at 24-25°N is again noticeable. In late September, the northward extension resumes, with again the signature of several layers in the area between Cay Sal Bank and the Great Bahama Bank. This feature is also noticed after the end of the oil release on September 30, with an export of deep particles at various depths toward the north by the Gulf Stream. The eastward branch of submerged droplets is reduced, but remains in the same depth range.

5.6 CALCULATION OF RISE AND TRANSPORT OF OIL DROPLETS

6-hourly outputs of the 90-day seabed release simulations are used to follow oil particles at depth. Oil droplets are followed based on their depth. The depth of oil droplets is primarily dictated by their size: droplets larger than 200 μm quickly rise to the surface through buoyancy, while droplets smaller than 50 to 60 μm tend to stay at depth.

Animations presenting the 3D evolution of oil droplets at depth are produced. These animations are based on individual droplet transport and are not indicative of oil concentration or toxicity. Fig. D shows the 3D view used for all animations, with marked landmarks to aid orientation.

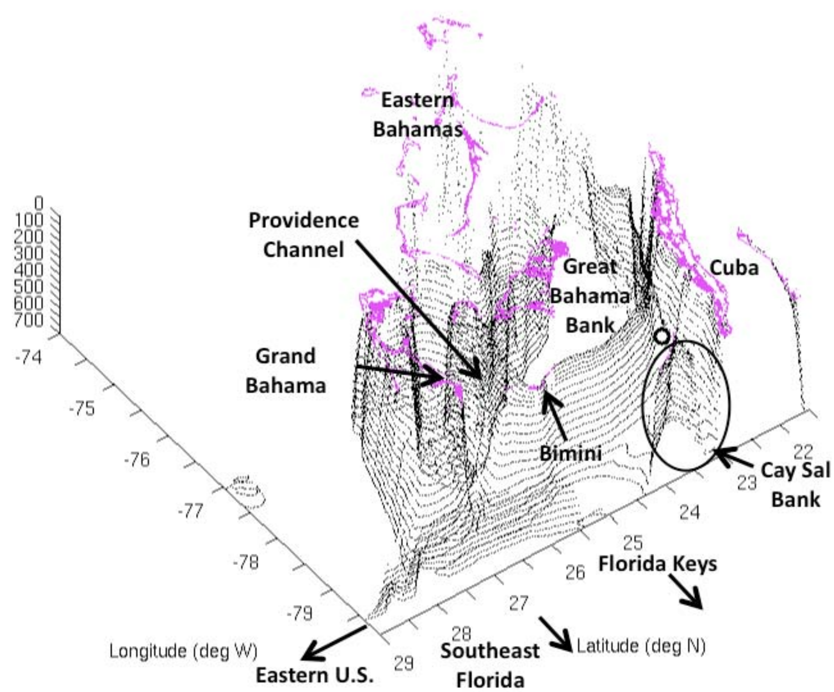

Fig. D: Three-dimensional view and landmarks used in the 3D animations of APP7.22-7.24, files 34-36.

5.6.1 RISE AND TRANSPORT OF OIL DROPLETS (seabed release/CASE B4)

The animation presenting the 3D evolution of oil droplets at depth, between January 1st and April 1st, 2010, during an episode of short time of oil to shore, is included in D34 (APP7.22).

Until January 15, we first notice the spread of submerged droplets between 100 and 300 m deep northwestward along the Great Bahama Bank, but also westward also along the Cuban coast. In the following days, the upper particles are entrained within eddies and upwelled to the surface in these two branches, while deeper particles keep being entrained. At the same period, the eastward export of submerged oil droplets, which was initially weak, seems to intensify, with submerged droplets mainly in the first 150 m. Particles along the Great Bahama Bank that reach 25-26°N start being accelerated northward as they join the Gulf Stream.

The northward export decreases in late January, until another episode of export takes place in the first week of February. Particles between 100 and 400 m are advected along the Great Bahama Bank, with upper particles being upwelled in the area east of Cay Sal Bank, whereas deeper particles are downwelled along the topography at about 25°N. This distinct vertical displacement leads to the formation, after February 10, of isolated layers containing oil in the water column. The oil droplets that keep being advected northward tend to accelerate when they reach 25-26°N as they reach the Gulf Stream. During the same period, upwelling of oil droplets takes place again between Cuba and Cay Sal Bank.

Starting around February 20, some particles are also noticed to enter the Providence Channel, between the Great and the Little Bahama Banks. After the end of the oil release, on March 2nd, the number of submerged droplets west of the release point decreases rapidly, while the eastward branch remains populated. A last episode of northward export of deep particles, with comparable downwelling along the topography as previously noticed, is noticed between March 20 and 25.

5.6.2 RISE AND TRANSPORT OF OIL DROPLETS (seabed release/CASE B5)

The animation presenting the 3D evolution of oil droplets at depth, between October 1st and December 30, 2007, during an episode of export of oil far from the release point, is included as File D35 (APP7.23).

In October, the export of submerged droplets is essentially to the west of the release point, with particles mainly between 100 and 300 m depth being advected along the Great Bahama Bank. After October 20, upper particles start being upwelled to the surface by mesoscale eddies around 24-25°N, close to Cay Sal Bank. In November, the deeper submerged droplets tend to be downwelled along Great Bahama Bank, while upper particles keep being upwelled in the same area between Cay Sal Bank and the Great Bahama Bank. Many submerged droplets at various depths enter the Providence Channel, while the rest of them are accelerated northward by the Gulf Stream north of 26°N.

In the late week of November, we notice a large export of particles to the east of the release point, in the upper 150 m. After the end of the oil release, on November 30, the number of submerged oil droplets decreases, but we can still notice some episodes of northward export, with both upwelling of the upper submerged particles through eddies in the area between Cay Sal Bank and the Great Bahama Bank, and downwelling of deeper particles along the topography at 25-26°N. This distinct vertical displacement leads to formation of various layers, whose dynamics and paths are different.

5.6.3 RISE AND TRANSPORT OF OIL DROPLETS (seabed release/CASE B6)

The animation presenting the 3D evolution of oil droplets at depth, between August 1st and October 30, 2006, during an episode of large volume of oil in the water column, is included as File D36 (APP7.24).

In October, the initial spread of oil is mainly to the west of the release point. Oil droplets at depth between 100 and 400 m are advected along the Great Bahama Bank, with a secondary branch forming along the Cuban coast. The upper droplets tend to be upwelled to the surface by mesoscale eddies, between Cay Sal Bank and the Great Bahama Bank, and between Cay Sal Bank and Cuba, while droplets deeper in the water column keep being advected northward. Submerged oil droplets reaching 26°N tend to accelerate once the reach the Gulf Stream.

Late August and early September, deeper droplets experience downwelling when advected along the Great Baham Bank, between 24 and 26°N. Many of the deeper droplets enter the Providence Channel. In mid September, the number of submerged oil droplets advected along the topography decreases, and many submerged oil droplets are advected this time to the east of the release point. This eastward branch is shallower than the westward one, with droplets mainly in the top 150 m.

The northwestward export resumes after September 20, again with upwelling of droplets between Cay Sal Bank and the Great Bahama Bank, and downwelling for deeper particles along the bathymetry. Such episodes lead to the formation of oil layers at distinct depths. Similar episodes take place in October, after the end of the oil release on September 30, although the number of submerged droplets decreases. There is almost no export to the east at that period.

5.7 SUBMERGED OIL PLUME

5.7.1 SUBMERGED OIL PLUME (seabed release/CASE B4)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D37 (APP7.25) shows maps of the maximum concentration encountered on the vertical in the water column below 20m, between January 1st and April 1st, 2010, during an episode of short time of oil to shore.

During the first weeks, the deep oil plume extends mainly to the west, whereas the surface slick extends to the east (Part 5.4.1). The deep plume follows the shelf edge along the Great Bahama Bank. Mid-January, the main deep plume reverses to the east, while a secondary westward branch flows along the Cuban coast. Early February, the deep plume extends in both directions along the shelf edge. In mid-February, it is stays west of the release point, while a smaller plume keeps drifting northward along the shelf edge. Early March, the deep plume once again reverses to the east, until the end of the oil release on March 2nd. Two weeks later, two deep plumes are still noticed, one northward along the shelf edge along the Great Bahama Bank, one to the east between Cuba and the Great Bahama Bank between 76°W and 77°W.

5.7.2 SUBMERGED OIL PLUME (seabed release/CASE B5)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D38 (APP7.26) shows maps of the maximum concentration encountered on the vertical in the water column below 20m, between October 1st and December 30, 2007, during an episode of export of oil far from the release point.

During the first month, the deep oil plume extends mainly to the west, whereas the surface slick extends to the east (Part 5.4.2). The deep plume follows the shelf edge along the Great Bahama Bank. It remains essentially westward, with episodes of eastward deep export in late November. Isolated plumes are advected as far as 26°N along the shelf edge. After the end of the oil release, on November 30, the main deep plume remains west of the release point.

5.7.3 SUBMERGED OIL PLUME (seabed release/CASE B6)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D39 (APP7.27) shows maps of the maximum concentration encountered on the vertical in the water column below 20m, between August 1st and October 30, 2006, during an episode of large volume of oil in the water column.

During the first week, the deep oil plume extends northwestward along the shelf edge of the Great Bahama Bank, whereas the surface main slick evolves westward along the Cuban coast. In late August and early September, the main deep plume stays in the vicinity of the release point. From mid-September and on, the deep plume extends again toward the northwest, with high deep concentration extending to 24°N late September. After the end of the oil release on September 30, the northern deep plume is still extended as far as 26°N.

5.8 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN

5.8.1 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (seabed release/CASE B4)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D.40 (APP7.28) shows time-depth diagram showing the maximum concentration encountered horizontally in the water column below 20m, east and west of the release point (at a distance exceeding 15 km), between January 1st and April 1st, 2010, during an episode of short time of oil to shore.

West of the release point, toward Cay Sal Bank and the Florida Straits, the higher concentrations are encountered between 200 and 350m, i.e. in the range close to the separation height above the wellhead (250 m deep). We can identify episodes of larger export, in early and mid February. Also, the formation of several layers is noticeable, like around February 20, or March 5. This layering is due to deep, small particles experiencing different vertical movement depending on their location. An episode of downwelling is noticed late January and early February, reaching 500 m. Episodes of upwelling are also noticed, around January 10, February 15, or March 10.

To the east, the plume sometimes shows comparable oil concentration, but it is shallower, extending in the first 200 m. This is due to the bathymetry constraint in the Old Bahama Channel, between Cuba and the Great Bahama Bank. As is the case west of the release point, we can identify several layers of oil presence, especially in early March. However, episodes of upwelling or downwelling are less clearly defined. The presence of an eastward deep plume is noticed until the end of the 90-day study period, whereas the signature of the westward plume dissipates after mid-March.

5.8.2 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (seabed release/CASE B5)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D.41 (APP7.29) shows time-depth diagram showing the maximum concentration encountered horizontally in the water column below 20m, east and west of the release point (at a distance exceeding 15 km), between October 1st and December 30, 2007, during an episode of export of oil far from the release point.

West of the release point, we notice several episodes of intense oil concentration between 200 and 350 m depth, i.e. in the range close to the separation height above the wellhead (250 m deep). The plume forms layers at different depths, like in mid-October. Episodes of downwelling lead to the formation of deep, secondary oil plumes, like in late October, or late November. Episodes of upwelling also take place, mid and late October and mid November.

To the east, the oil concentration is far less intense. Oil is limited to the first 200m. Episodes of downwelling are noticed late October and late November, but the intensity of the resulting deep plume quickly decreases. The signatures of both western and eastern deep plume decrease after mid December, before the end of the study period.

5.8.3 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (seabed release/CASE B6)

6-hourly outputs of the 90-day simulation are used to derive instantaneous concentrations of oil at depth (in ppb), based on the flow rate and the number of particles released. This concentration is calculated in 0.05° squares, over 10 m water layers. Oil concentration smaller than 10 ppb is not shown.

Figure D.42 (APP7.30) shows time-depth diagram showing the maximum concentration encountered horizontally in the water column below 20m, east and west of the release point (at a distance exceeding 15 km), between August 1st and October 30, 2006, during an episode of large volume of oil in the water column.

To the west of the release point, we notice several episodes of intense oil concentration between 200 and 400 m depth, i.e. in the range or deeper than the separation height above the wellhead (250 m deep). The plume forms layers at different depths, especially after episodes of intense downwelling, like in early and late September. Episodes of upwelling are also noticed late August, mid September and early October, although they are not associated with high concentration close to the surface. Deep plumes keep their signature long after the end of the oil release on September 30.

To the east, the deep plume is far less intense, except for an episode of deep export in early September, associated with a deepening of the plume below 200 m.

5.9 DISCUSSION OF INDIVIDUAL SCENARIO SIMULATIONS (Part 2)

The dynamics of an oil spill originating at the location chosen for this study is essentially driven by the local bathymetry. At the surface, this is especially the case when the spill extends to the east. There, the slick is constrained between Cuba and the Great Bahama Bank. Even after northward wind burst, the slick usually goes back to its initial path. To the west, the surface slick appears less constrained by the topography and is more sensitive to the changes in the winds, as illustrated by the case study during Wilma. When extending westward, the surface slick has a chance to reach the Florida Current, and some material can then be pushed to Florida or Eastern U.S. coast, or to the Western Bahama islands. A surface spill of a few weeks is likely to show episodes of both eastward and westward extension. However, the major part of the oil will affect the Cuban coasts, which are directly facing the source of the oil, and are not protected by a large continental shelf like the Bahama islands are with the Great Bahama Bank. Dominant southwestward winds during the wet season may only intensify this tendency, but it remains valid at any time of the year.

The dynamics of submerged plumes is also dominated by topography. The submerged plumes usually has a very different evolution and pathways from the surface slicks, as seen in the short-term seabed release simulations, for which the dominant surface export is eastward while it is westward at depth. Oil at the depth indeed encounters different currents, and is not influenced by the surface wind induced drift. The westward submerged oil particles tend to follow the edge of the Great Bahama Bank. It is a natural waveguide for exporting submerged oil. When submerged particles are advected to the east, they are also constrained by local topography between the Great Bahama Bank and the Cuban shelf.

Since submerged oil droplets tend to degrade slower than surface evaporation and are not pushed to the Cuban coast, as is the case at the surface, they are associated, in this study case, with a wide extension of the spill. For the eastward branch, submerged oil can probably be advected as far or further compared to the surface, and since submerged oil there is in the first 150 or 200 m, it can eventually be upwelled to the surface and be potentially harmful. For the westward branch, the area between Cay Sal bank and the Great Bahama Bank seems to favor upwelling of submerged oil, and thus favors surfacing of oil at a location where it can then be advected toward the Gulf Stream. The rather intense northward current at depth along the Great Bahama Bank favors quick export of droplets of various sizes, some of which may eventually surface (due to their buoyancy) far from the initial release point. The particular configuration of the seabed release in this study seems favorable for a wide extension of the spill at depth.

As a general conclusion, an oil spill taking place at the location under study will certainly have a major impact on the Cuban coastlines in the vicinity of the release point. Particular wind conditions may allow for transport of small quantities of oil to the west, where it can eventually be advected by the Florida Current and potentially affect the Florida or Eastern U.S. coasts, or the Western Bahama Islands. In case of a seabed spill, it is expected that some oil will surface at a distance from the initial spill due to intense deep dynamics along the Great Bahama Bank. This would favor a wide spread of oil, with possible impact further on the Cuban coast, but also on the Florida or Eastern U.S. coasts, or the Western Bahama Islands.

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APPENDICES

APP1: MODEL DETAILS

APP1A. HYDRODYNAMIC MODELING DETAILS

A high resolution (1/100^{o} or ~900 m) model has been developed around the Florida Straits and South Florida, encompassing the Florida Keys, based on the Hybrid Coordinate Ocean Model (HYCOM) and, therefore, abbreviated as FKeyS-HYCOM. HYCOM is a comprehensive, three-dimensional hydrodynamic model with data assimilative capabilities, advanced mixing schemes and a hybrid vertical coordinate system that is flexible in isopycnal, z-level and sigma discretizations. The community available code and details on model attributes are given at http://hycom.org. The large range of depth values in the study region (Fig. A and Figs. 2.2, 2.3) is particularly conducive to the choice of the HYCOM code, so that isopycnic coordinates are maintained in the "open sea" domain (Florida Straits), with a smooth transition to bottom following (sigma) and/or Cartesian (fixed z-level) coordinates in the coastal and shelf areas (Great Bahama Bank, Little Bahama Bank, Cay Sal Bank, Southwest Florida Shelf, Atlantic Florida Keys Shelf). The HYCOM open-ocean vertical grid includes fixed level (z) coordinates near the ocean surface that transit smoothly to isopycnic coordinates in the stratified ocean interior. This provides vertical resolution in the surface boundary layer while preserving the advantage of isopycnic coordinates throughout most of the water column.

The FKeyS-HYCOM has been embedded within a coarser scale model (1/25^{o}, ~3.5 to 4 km) application of HYCOM for the Gulf of Mexico (GoM-HYCOM, run at the Naval Research Lab, NRL, at the Stennis Space Center). The topography is derived from the 2-minute NRL DBDB2 global dataset with a minimum depth of 2m. The atmospheric forcing (three-hourly wind stress, air temperature, atmospheric humidity, heat fluxes and precipitation) is provided by the U.S. Navy's Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS, Hodur 1997; Hodur et al., 2002) at 27 km resolution. The global HYCOM model (resolution of 1/12 ^{o}, ~7-8 km) is used for particles entering the Atlantic interior (north of ~30 ^{0}N).

APP1B. OIL SPILL MODELING DETAILS

We use an integrated oil spill application recently developed from a three-dimensional (3D) transport code, the Connectivity Modeling System (CMS, Paris et al. 2007). The model represents discharged oil as droplets with chemical fractions and predicts their dispersion and fate based on 3D currents and mixing parameters obtained from high vertical and horizontal resolution, data assimilated ocean circulation nested models (HYCOM).

The oil spill model takes into account flow rates, oil density, viscosity, a wide range of particle sizes creating rising velocity differences (Chen and Yapa 2002; Zheng et al., 2003; Johansen et al., 2003), and adds processes of weathering in the water column and evaporation at the sea surface. In addition, the CMS has several critical features for management as 1) it integrates a Coastal Polygon module to capture oil beached on the coastline at each time step, and 2) has high throughput computing capabilities allowing to run a large number of oil fate prediction forecasts to obtain a statistical picture of the possible impact of the spill on environmentally sensitive areas.

Oil Fractions: The crude oil chemical properties are simulated with input parameters of hydrocarbon fractions. The phase behavior of petroleum is complex because of the large mixture of specific concentrations of diverse molecules with different properties of solubility. The million or so different molecules are simplified to individual particles belonging to three uneven fractions of light, medium, and heavy oil with infinitesimal combinations of density and size within a constrained range.

Oil Weathering and Landfall: An evaporative decay is applied for particles less than 20 m deep. The evaporation rate depends on the hydrocarbon fractions where the light fraction has a shorter half-life and the heavy fraction has a longer half-life (Korotenko et al. 2010). We used a composition of 18% of light oil, 42% of medium oil, and 40% of heavy oil, with densities consistent with reported values for High Sulfur crude oil (Yang and Wang, 1977). Oil particles that reach a minimum depth of 3 m thickness of the ocean model are considered having made landfall along the coast and captured in the Coastal Polygon matrix of the CMS. The loss due to biodegradation and dissipation of hydrocarbons is simulated using temperature and fraction-dependent formulas (Adcroft et al. 2010).

Oil Spill Simulations: The number of released particles is proportional to the flow rate. For the SEABED RELEASE high-rate case (3,200 m^3/day), 2000 particles are released once a day for the long-term simulation (Task 3), 1000 for the SEABED RELEASE low-flow rate (1,600 m^3/day), and

1,500 for the SURFACE RELEASE case (medium flow rate, 2,400 m^3/day). For the short-term simulations (Task 4), 2000 particles are released every 2 hours for 60 days for the SEABED RELEASE cases, while 1500 particles are released every 2 hours for 30 days for the SURFACE RELEASE cases; in both cases the spill is then followed for 30 more days. The spill location of the Bahamas Petroleum Company Southern Licences represents the initial conditions for particle locations in the model, at the surface for SURFACE RELEASE experiments and according to the evaluated separation height for SEABED RELEASE experiments (see APP1D).

APP1C. COUPLED MODELING

The Connectivity Modeling System (CMS) is an offline coupled modeling system and uses daily archives of the HYCOM-Global and the GOM-HYCOM, and 6-hourly archives from the very high resolution FKeyS-HYCOM (see section 2.1a). The CMS downloads the ocean circulation data online via OPeNDAP access, and its Lagrangian algorithm operates offline and has the unique multi-scale capability of seamlessly tracking particles over all three circulation models. The oil-spill application of the CMS moves individual oil droplets by getting the 3D current speed information (u,v,w) from the circulation models and recalculates their position every time step (Δt = 1800 sec) in a regular 3D longitude-latitude-depth (x,y,z) framework describing the study region. Independently from oceanic transport, oil droplets have a vertical terminal velocity computed with an integrated formulation described by Zheng and Yapa (2002) and Zheng et al. (2003). This fluid particle algorithm solves for a broad range of gas bubble and oil droplet sizes. Critical values are the density differences between water and oil, viscosity of the water, and particle diameter. Thus, density of seawater is computed at each time step from the temperature and salinity of the hydrodynamic modeling system.

APP1D. SEABED RELEASE (DEEP RELEASE) SIMULATION MODEL ATTRIBUTES

The release point location is given in Table 1 (also marked in Fig. A and all horizontal maps) and is within the regional GoM-HYCOM model grid, in close vicinity to the local FKeyS-HYCOM model grid. Therefore, upon their release, particles quickly take advantage of the highest resolution currents possible.

The oil is emitted at depth in the form of a high-pressure jet mixing oil and gas. The dynamics of this jet is determined by the initial flow of gas and oil, but also by the ambient current and stratification (Socolofsky et al., 2011).

As an example, the Deepwater Horizon oil spill initial jet was dominated by stratification, whereas the DeepSpill experiment in the North Sea, one of the first experiments focusing on deep plume dynamics (Johansen et al., 2003), was current dominated.

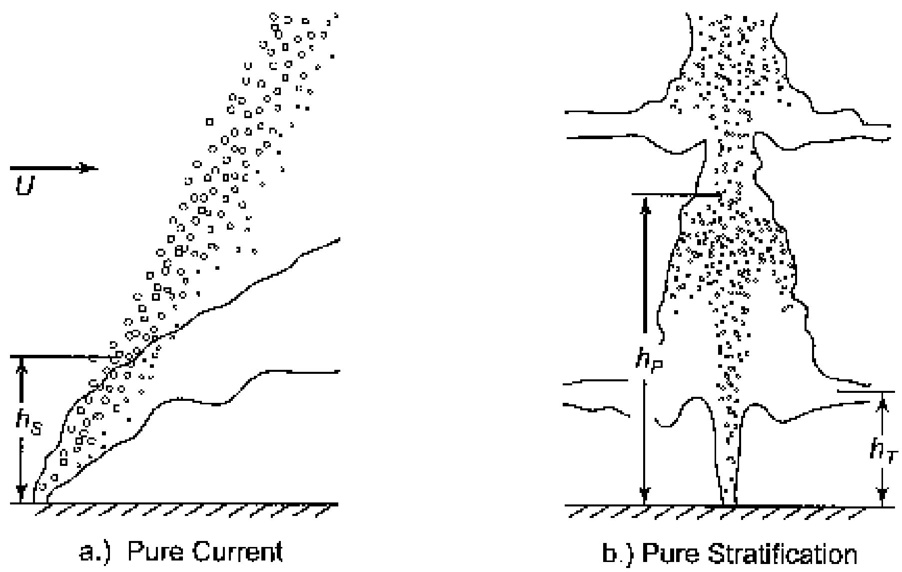


Fig. 1.1: Current (left) and stratification (right) dominated jet dynamics.

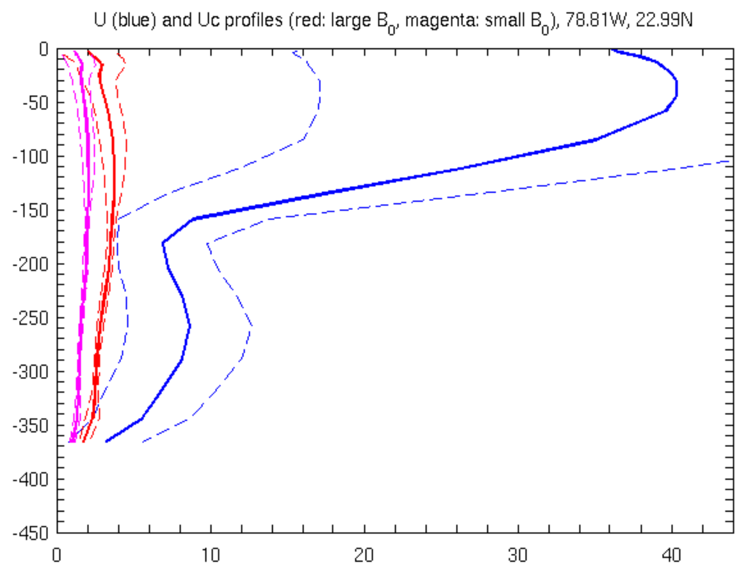


Fig. 1.2: Local current vertical profile (blue), U_c profile for the large (red) and small (magenta) discharge rates. The horizontal axis is current velocity in cm/s. The dashed lines denote variability.

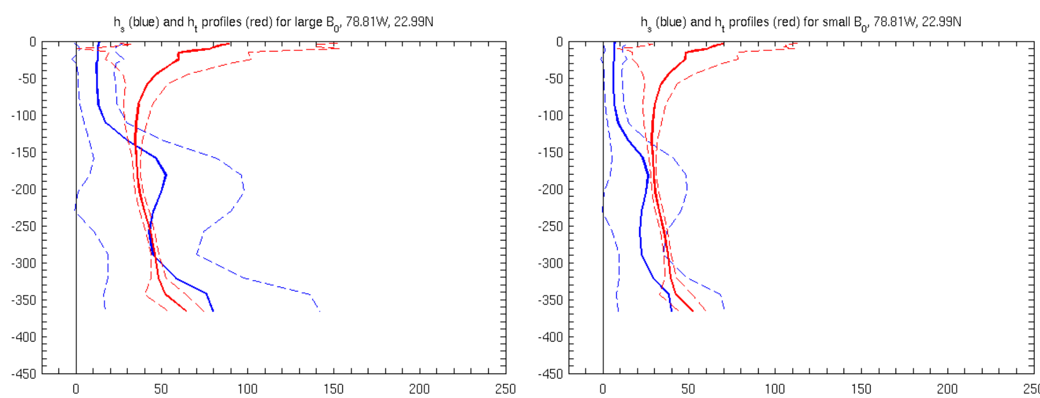


Fig. 1.3: Comparison between the vertical distribution of the trap height h_t (red line, in m), for a stratification dominated jet, and of the separation height h_s (blue line, in m), for a current dominated jet. (Left panel): values for the large discharge rate (3,200 m^3/day; (Right panel): values for the small discharge rate (1,600 m^3/day). The horizontal axes give height values in m. The dashed lines denote variability.

To determine whether the plume is current or stratification dominated, one has to determine a critical value U_c. If the local current intensity is over this value, the plume is current dominated, if not it is dominated by stratification. The critical current U_c is the one for which the estimated peel height (h_p) corresponding to a stratification dominated plume (Figure 1.1) equals the separation height (h_s) characterizing current dominated plumes. The separation height is the height above the sea bottom at which the gas and oil separates from the initial jet, forming bubbles and droplets. The details of the estimation of h_s, h_p and U_c can be found in Socolofsky et al. (2011).

We use model outputs for 90 days in 2010 to estimate the local currents and stratification close to the location considered for the Bahamas Petroleum Company experiment and test whether the oil and gas jet is rather current or stratification dominated.

From Figure 1.2, one sees that for both discharge rates the local current at depth is larger than the U_c value, meaning that the jet is dominated by currents. This means that the height above the sea floor at which oil droplets can be considered independent from the initial jet is the separation height (h_s, Figure 1.1).

From Figure 1.3, we see that the separation height is about 80 m for the large discharge rate close to the bottom, and 40 m for the small discharge rate.

APP2: COASTAL POLYGONS

Coastal polygons at the land-sea boundary are used to identify the timing and quantify the magnitude of oil landfall. Then, they are used to compute all study deliverables (APP6 and APP7). The polygons extend offshore to cover the sensitive marshes, coral reefs, and shallow banks areas, and are grouped in seven regions representing the U.S., Bahamian, and Cuban coastlines. An additional region has been defined as the "Atlantic interior", which is an open sea area (no coastal polygons), used for certain calculations of particle fate (section 5). A coastline bounded by the study domain (20.5^0N to 36^0N / 73^0W to 84^0W) was downloaded from the National Oceanographic Atmospheric Administration's Electronic Navigation Chart server (http://www.nauticalcharts.noaa.gov/csdl/encdirect_download.html). This coastline was then buffered by 2.5 kilometers in ArcMAP (©2010 ESRI) to accommodate the oceanographic model's largest grid size. The buffered coastline was further divided into smaller polygons.

In the Bahamas this division was by island and by marine reserves, or Marine Protected Areas (MPAs). Five MPAs were included (Fig. 2.1): North Bimini, South Berry Islands, Jewfish Cays (Great Exuma), Crab Cay, and No Name Cay. The north coast of Cuba was split into 50km lengths. In the United States, regions were divided using Miami and the 28^{th} degree of latitude as cuts.

The list of the regional polygons is given in Table 2.1 and the map in Fig. 2.2. For the scenario simulations, the Western Bahamas domain included 3 sub-domains (Andros island, Little Bahama bank and the North part of the Great Bahama Bank) to allow more detail in polygons. The extended list of polygons is given in table 2.2 and the map in Fig. 2.3.

Table 2.1: Grouping of coastal polygons used in the analysis of oil landfall for the long term simulation (section 4, App. 6).

Group number	Group name	Polygon number
1	Eastern US	1-2
2	Southeast Florida	3
3	Florida Keys	4, 42
4	Western Bahamas	5-16, 24-25,44-50,63
5	Eastern Bahamas	17-23,26-41,43
6	Northern Cuba	51-62
7	Bahamian MPAs	64-68

Table 2.2: Grouping of coastal polygons used in the analysis of oil landfall for the scenario simulations (section 5, App. 7).

Group Number	Group name	Polygon number
1	Eastern US	1-2
2	Southeast Florida	3
3	Florida Keys	4, 42
4	Western Bahamas	5-16, 24-25,44-50,63
4a	Little Bahama Bank	5-8
4b	Andros	24-25
4c	North Great Bahama Bank	9-16
4d	CaySal Bank	44-50, 63
5	Eastern Bahamas	17-23,26-41,43
6	Northern Cuba	51-62
7	Bahamian MPAs	64-68

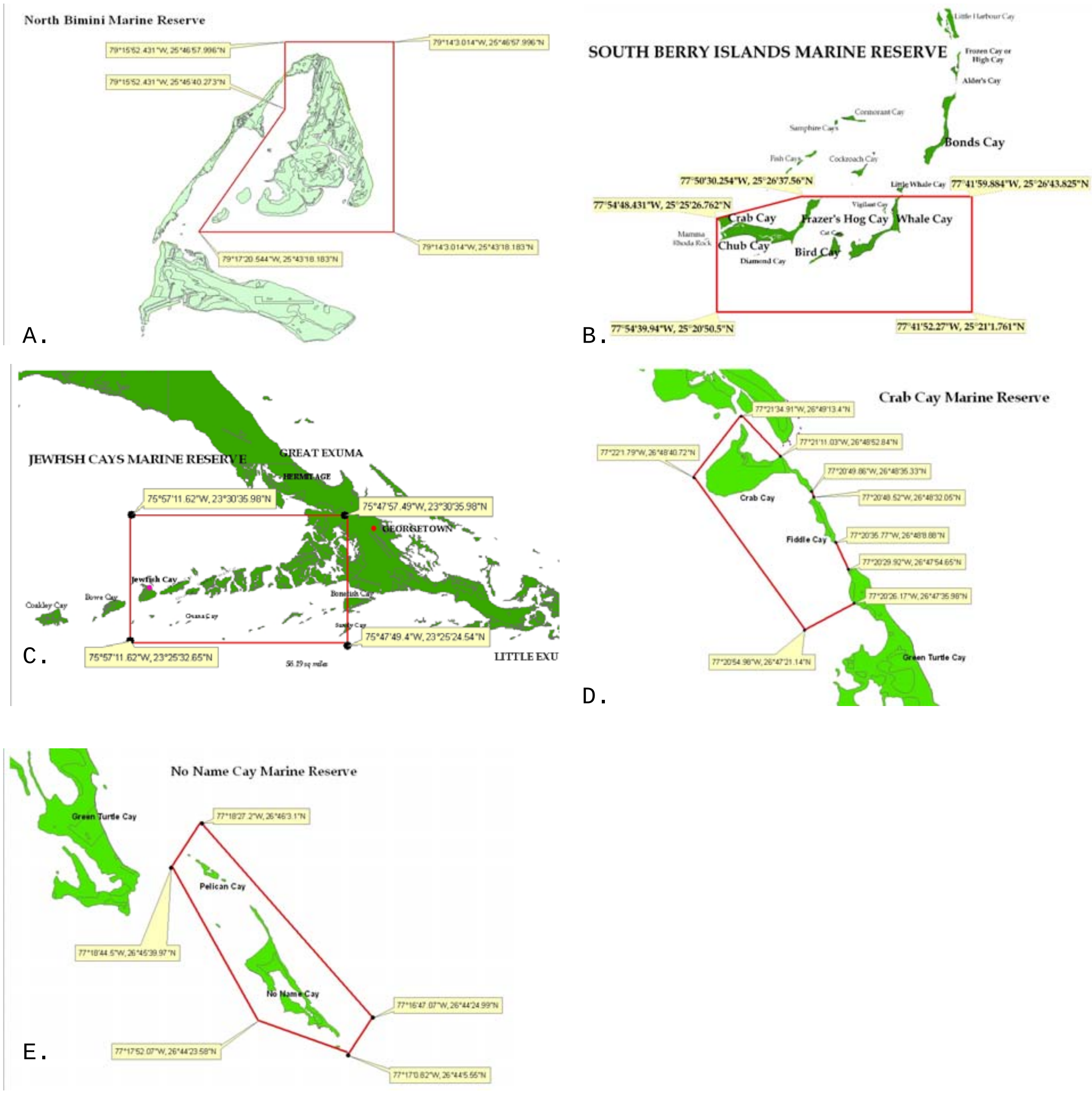


Fig. 2.1. The marine reserves of A) North Bimini, B) South Berry Islands, C) Jewfish Cays (Great Exuma), D) Crab Cay, and E) No Name Cay are represented in the coastal polygons (Fig. 2.2 and 2.3) and grouped to analyze the oil spill impacts on Marine Protected Areas (MPAs group 7, Tables 2.1 and 2.2).

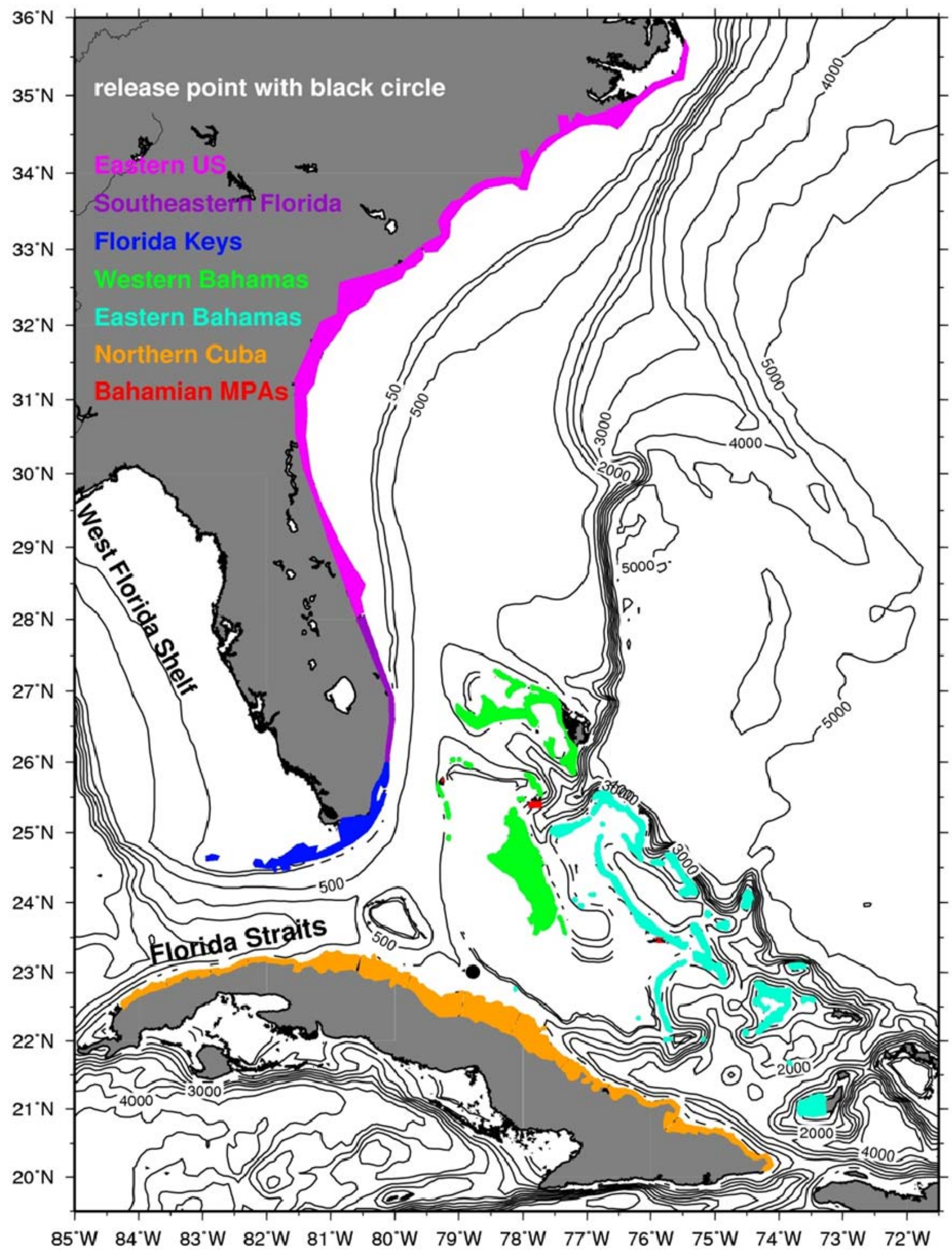


Fig. 2.2: Extended study domain and coastal polygons groups (Table 2.1) used in the analysis of the long term simulation (section 4, App. 6); the black circle indicates the release point; the MPAs represented by the red polygons are shown in Fig. 2.1. The coastal polygons are color-coded by regions: pink = Eastern U.S. coast; purple = Southeastern Florida; royal blue = Florida Keys; green = Western Bahamas; cyan = Eastern Bahamas; orange = Cuba; red = Bahamian MPAs.

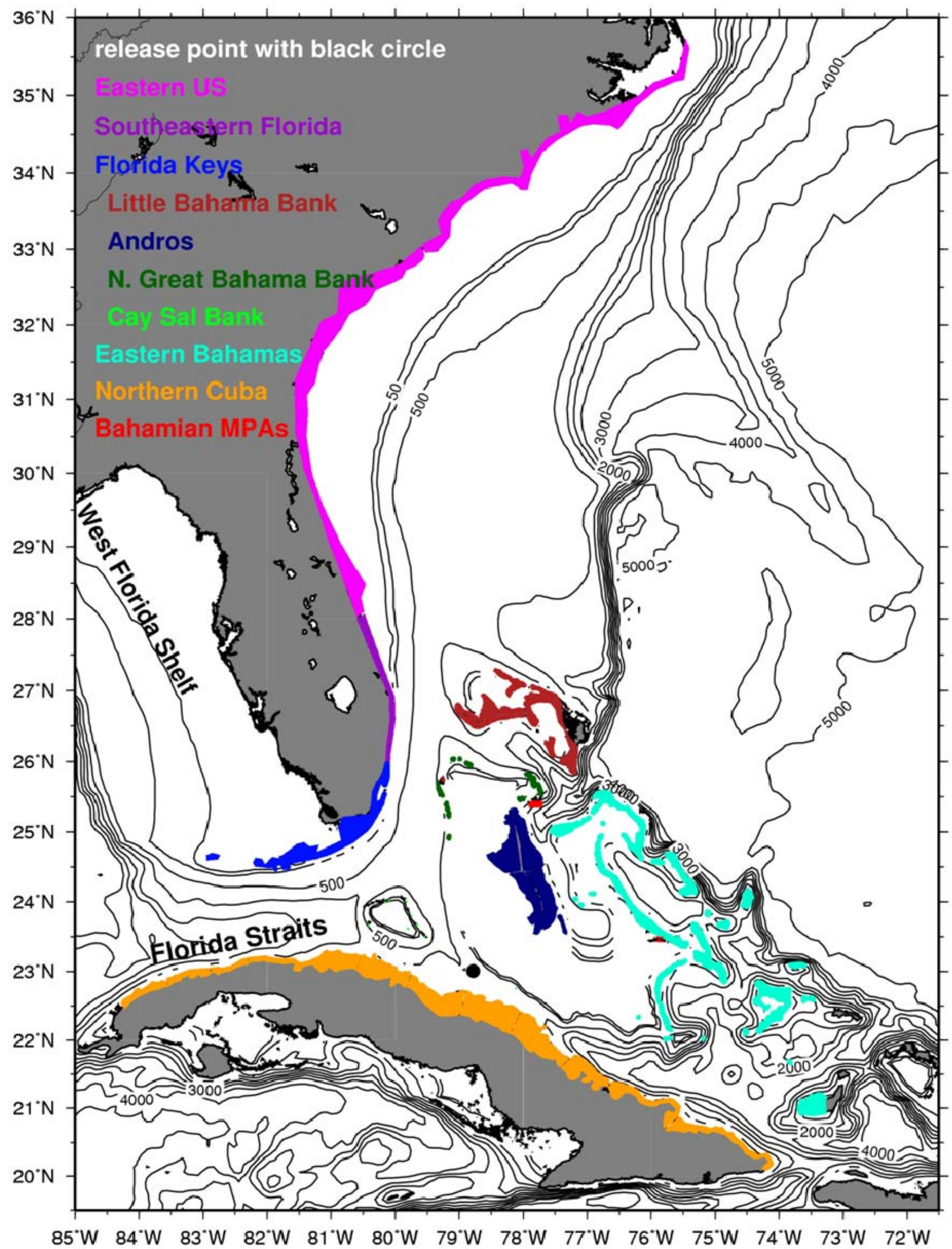


Fig. 2.3: Extended study domain and coastal polygons groups (Table 2.2) used in the analysis of scenarios (section 5, App. 7); the black circle indicates the release point; the MPAs represented by the red polygons are shown in Fig. 2.1. The coastal polygons are color-coded by regions: pink = Eastern U.S. coast; purple = Southeastern Florida; royal blue = Florida Keys; brown = Little Bahama Bank; dark blue = Andros; dark green = N. Great Bahama Bank; light green = Cay Sal Bank; cyan = Eastern Bahamas; orange = Cuba; red = Bahamian MPAs.

APP3: ATMOSPHERIC FORCING CHARACTERISTICS

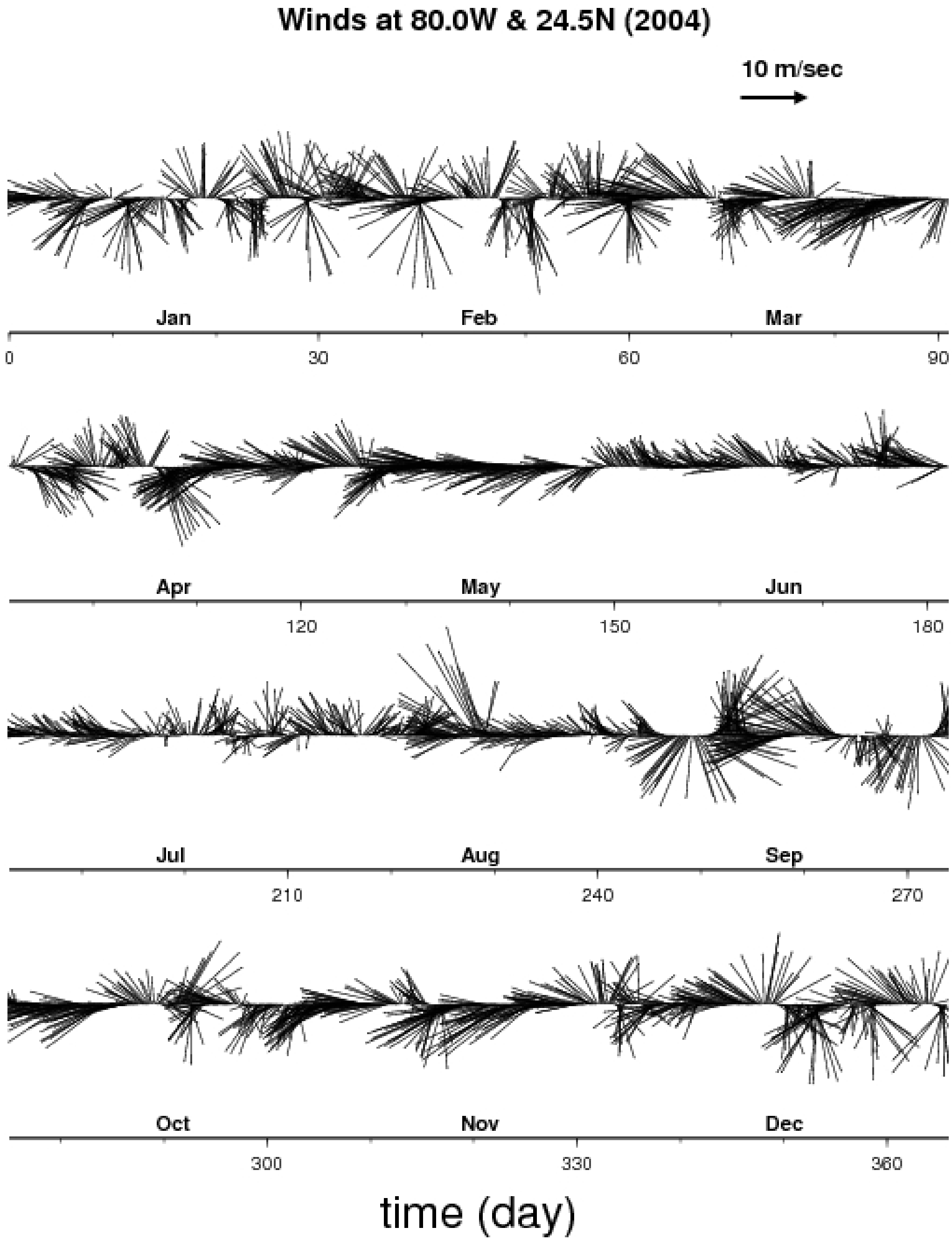


Fig. 3.1: Wind vectors for year 2004.

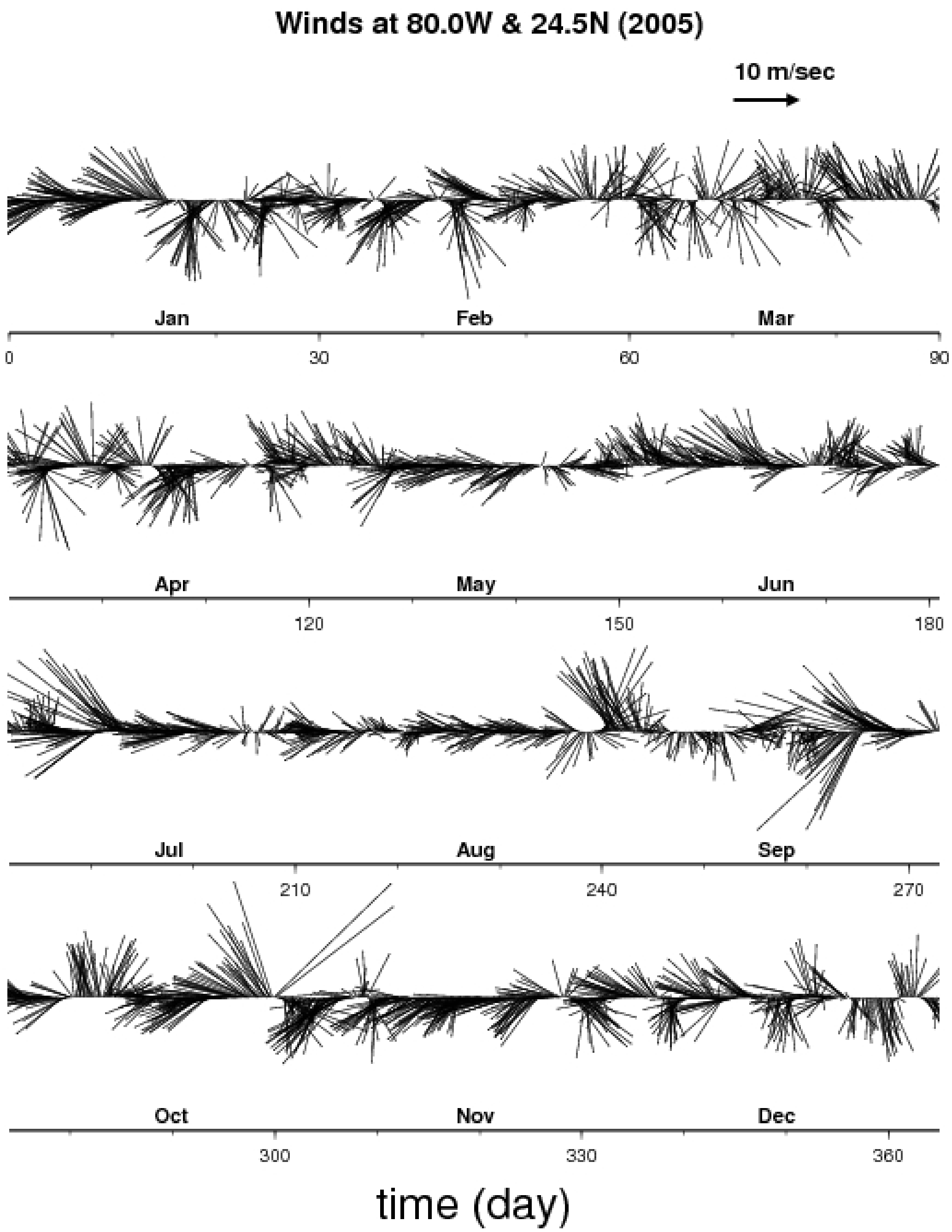


Fig. 3.2: Wind vectors for year 2005.

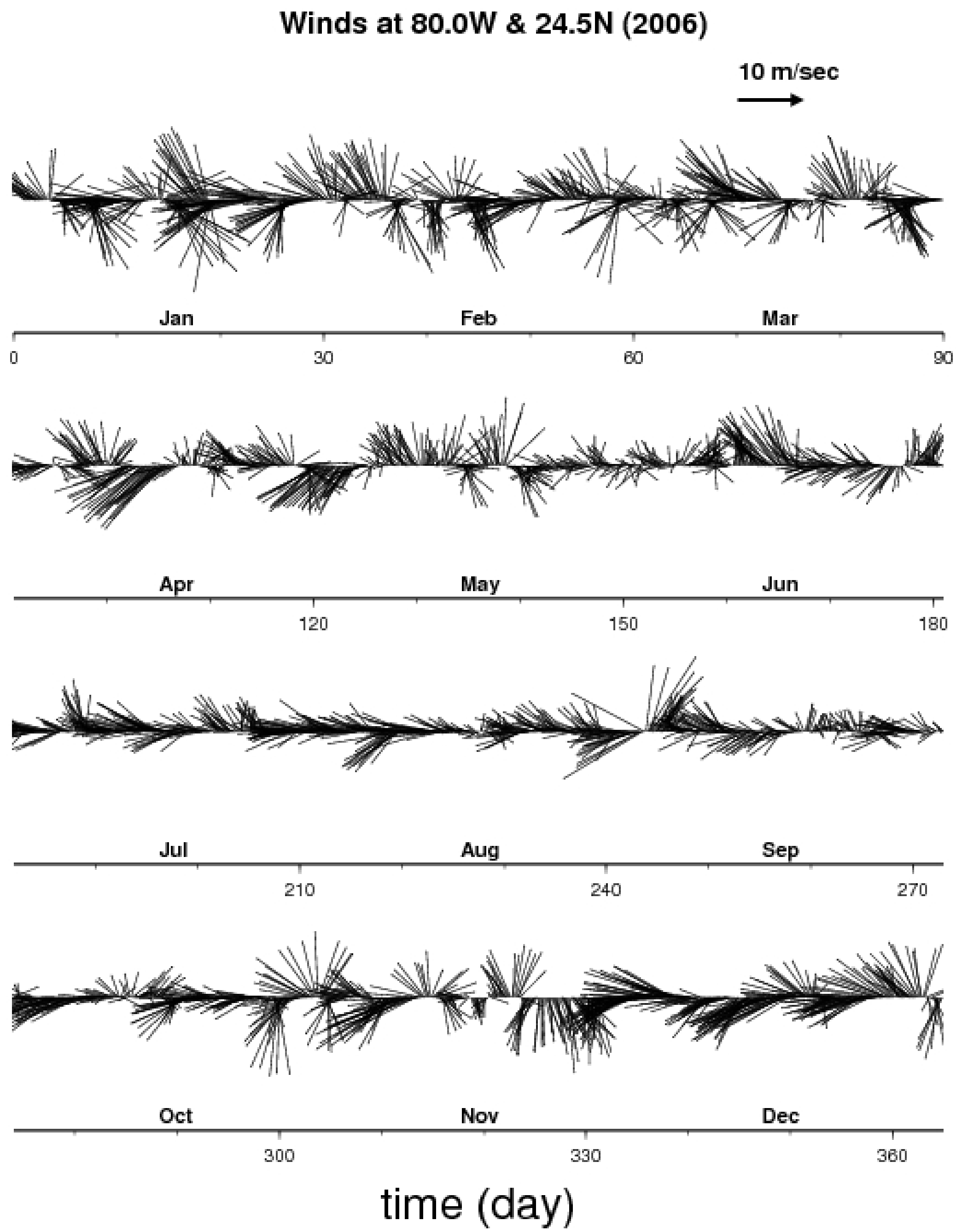


Fig. 3.3: Wind vectors for year 2006.

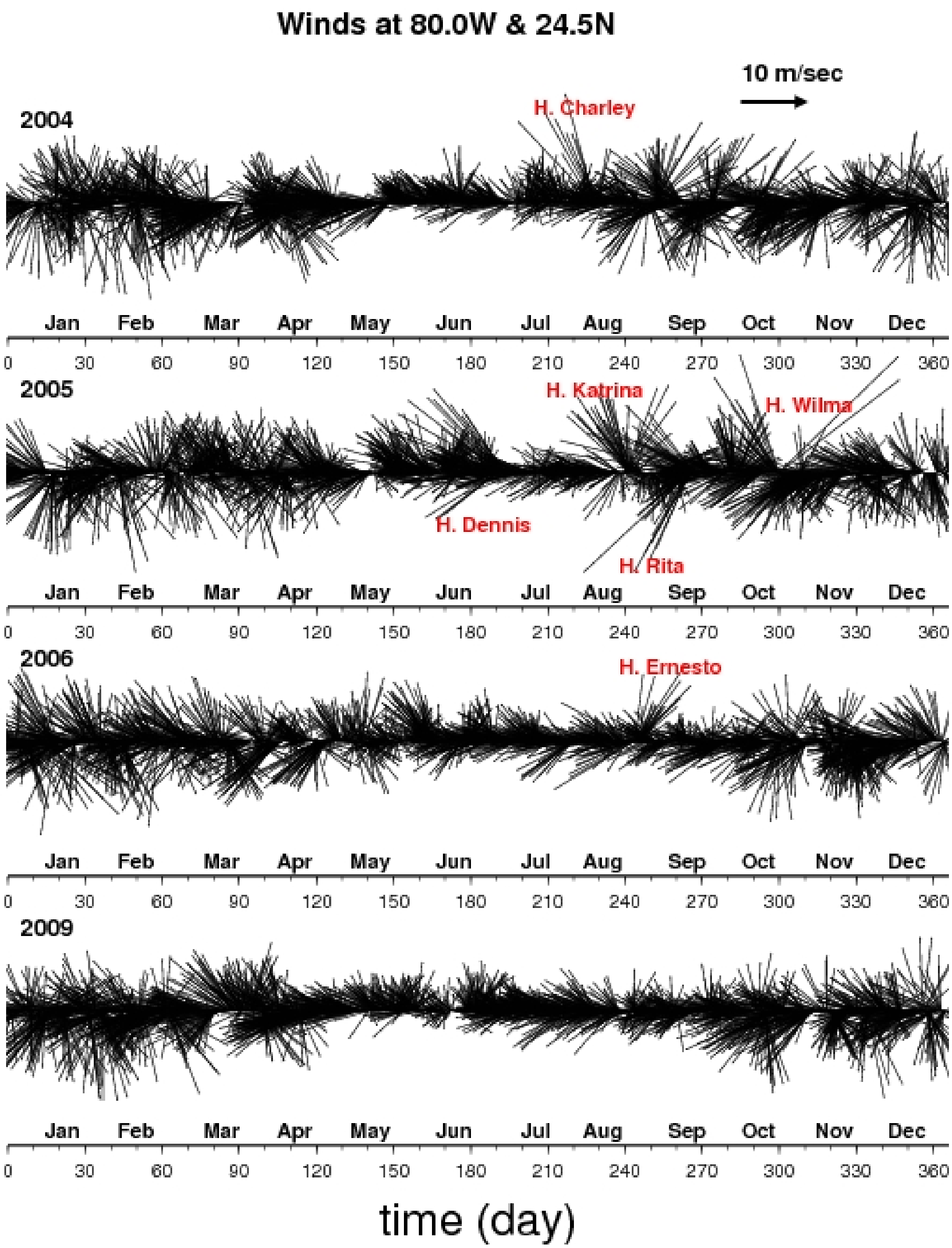


Fig. 3.4: Wind vectors for years 2004, 2005, 2006 and 2009. Red letters mark hurricanes.

APP4: VARIABILITY OF CURRENTS (WET and DRY SEASONAL MEANS)

Figs 4.1 to 4.13 exhibit the seasonal mean currents (surface, 300m and 500m) in the Florida Straits for each of the wet and dry seasons (starting with wet season in 2004 and ending with wet season in 2010); the full study domain is shown.

The seasonally averaged currents highlight the prevailing circulation patterns, excluding high frequency variability as is shown in the example of Fig. 5.1 (also see section 3). In agreement with the limited observational studies cited in section 1, the deep currents are much less variable than the surface currents. The deep currents are also generally much weaker and often in the reverse direction than the surface currents, especially within the channels marked in Fig. 1. An exception is currents around the Cay Sal Bank at 300m, which exhibit stronger than surface flows, encompassing the bank in a counter-clockwise pattern. In the Old Bahama Channel, there is a strong tendency for surface inflow along Cuba and outflow along the Bahamas.

Inter-annual and seasonal variability exists. For instance, the wet season of 2010 differs from other seasons and years, as the surface flow pattern around the Cay Sal Bank is in the same direction as at depth. Off the east side of the Cay Sal Bank, the wet seasons are characterized by a southward flow (coming from north of 25.0^0N along the 79.2^0W meridional direction), while this flow is not evident in the dry seasons. Along the northern Cuban coast, two northwestward coastal currents can be seen: (a) west of 80.5^0W and (b) east of 79.8^0W. In the wet season of 2004, these two coastal currents are connected along the coast and join the Florida Current. However, in the wet season of 2010, there is no Cuban coastal current west of 80.5^0W.

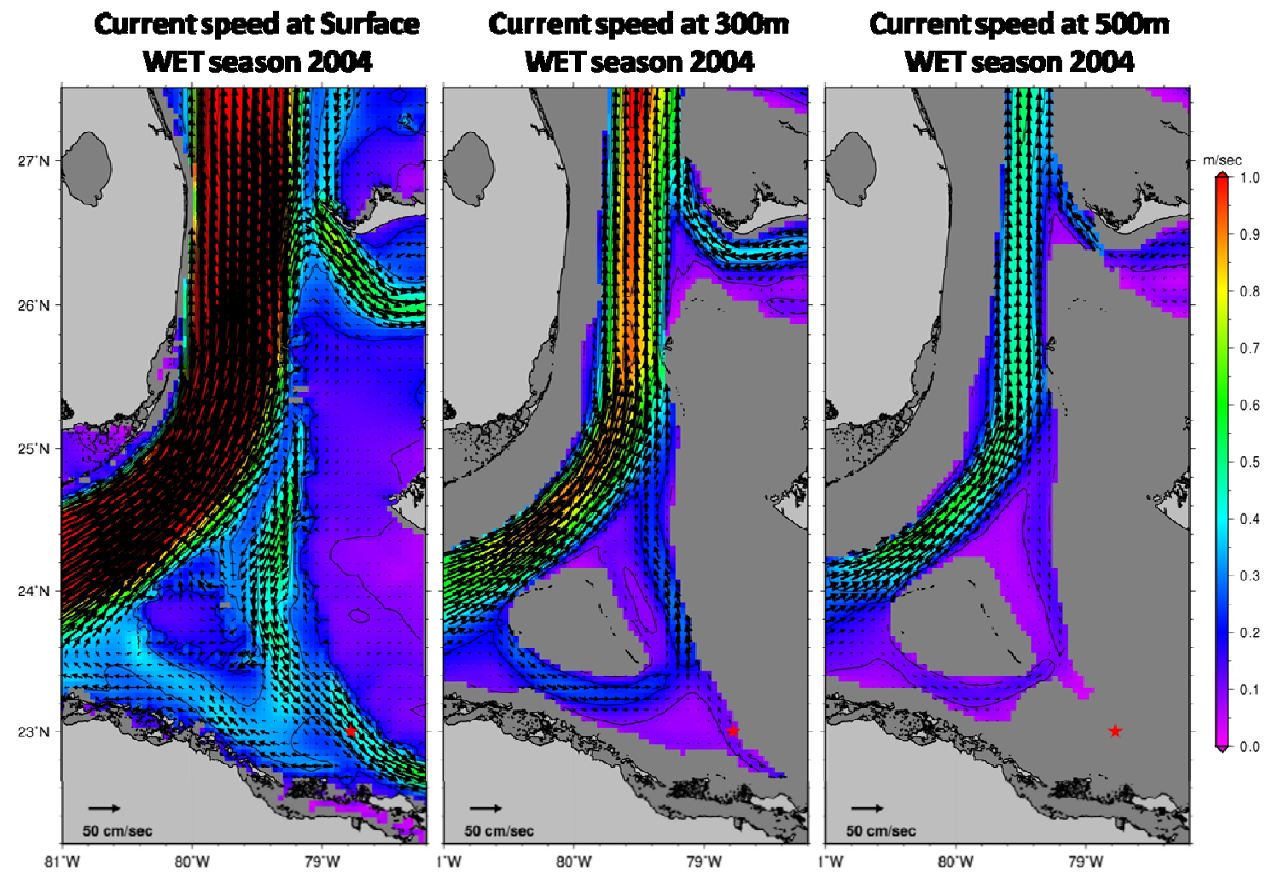


Fig. 4.1: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2004. Full study domain. Red star marks the release location.

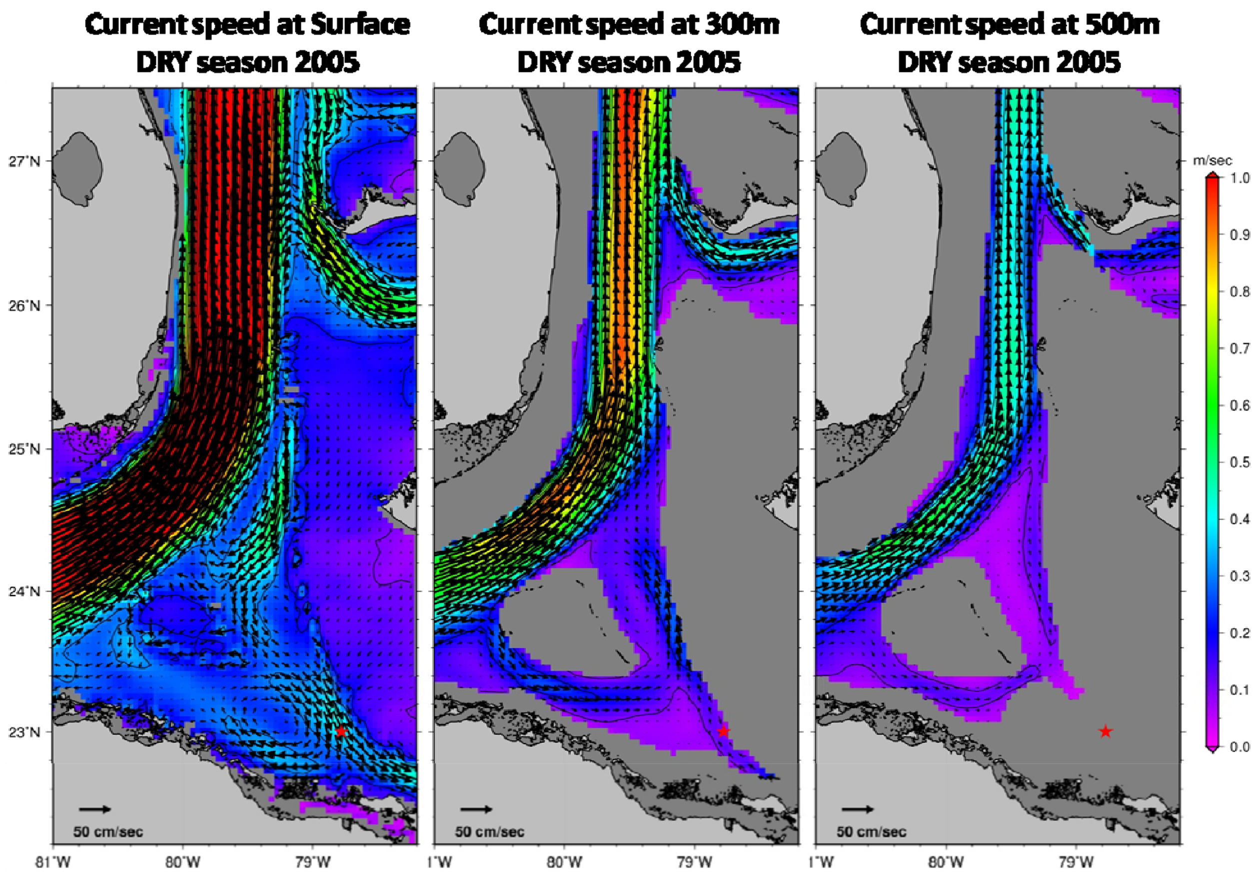


Fig. 4.2: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2005. Full study domain. Red star marks the release location.

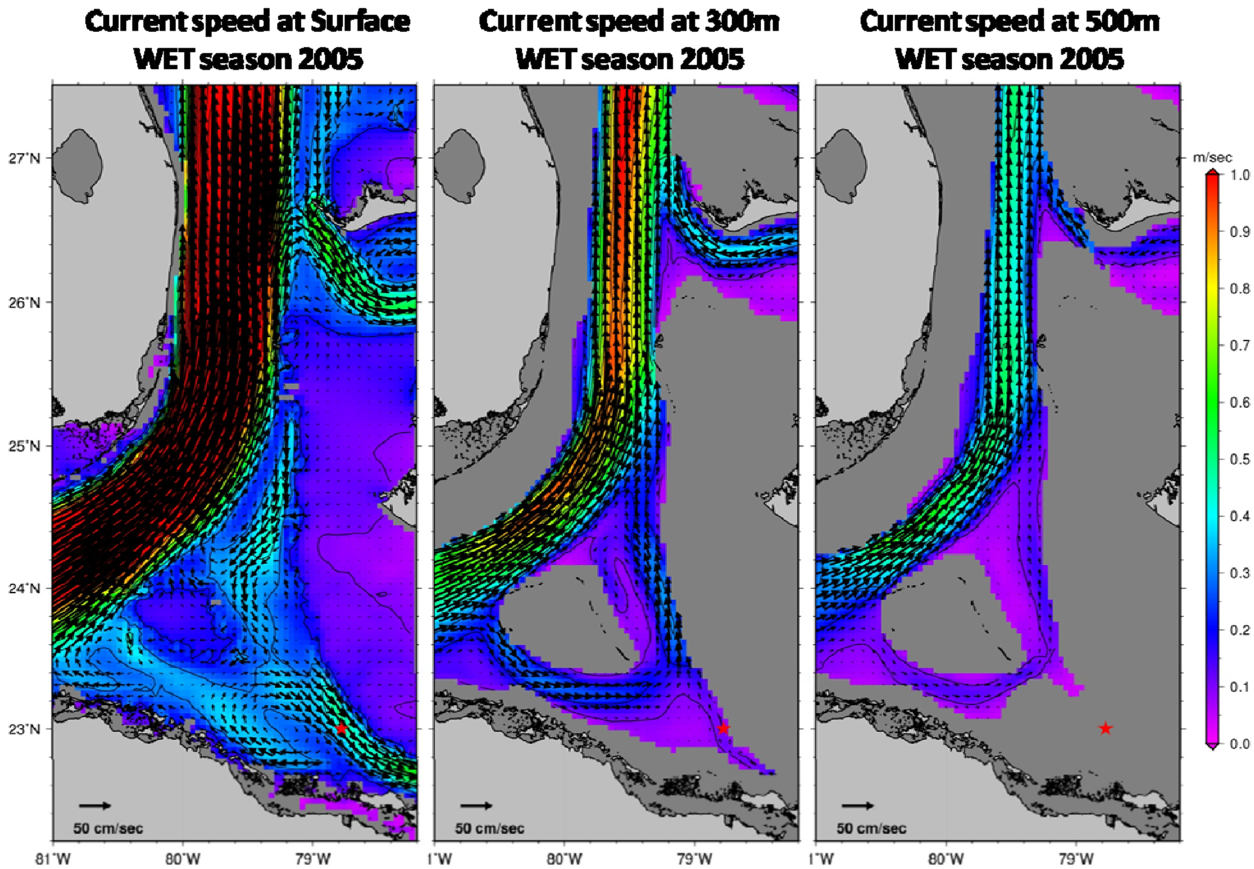


Fig. 4.3: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2005. Full study domain. Red star marks the release location.

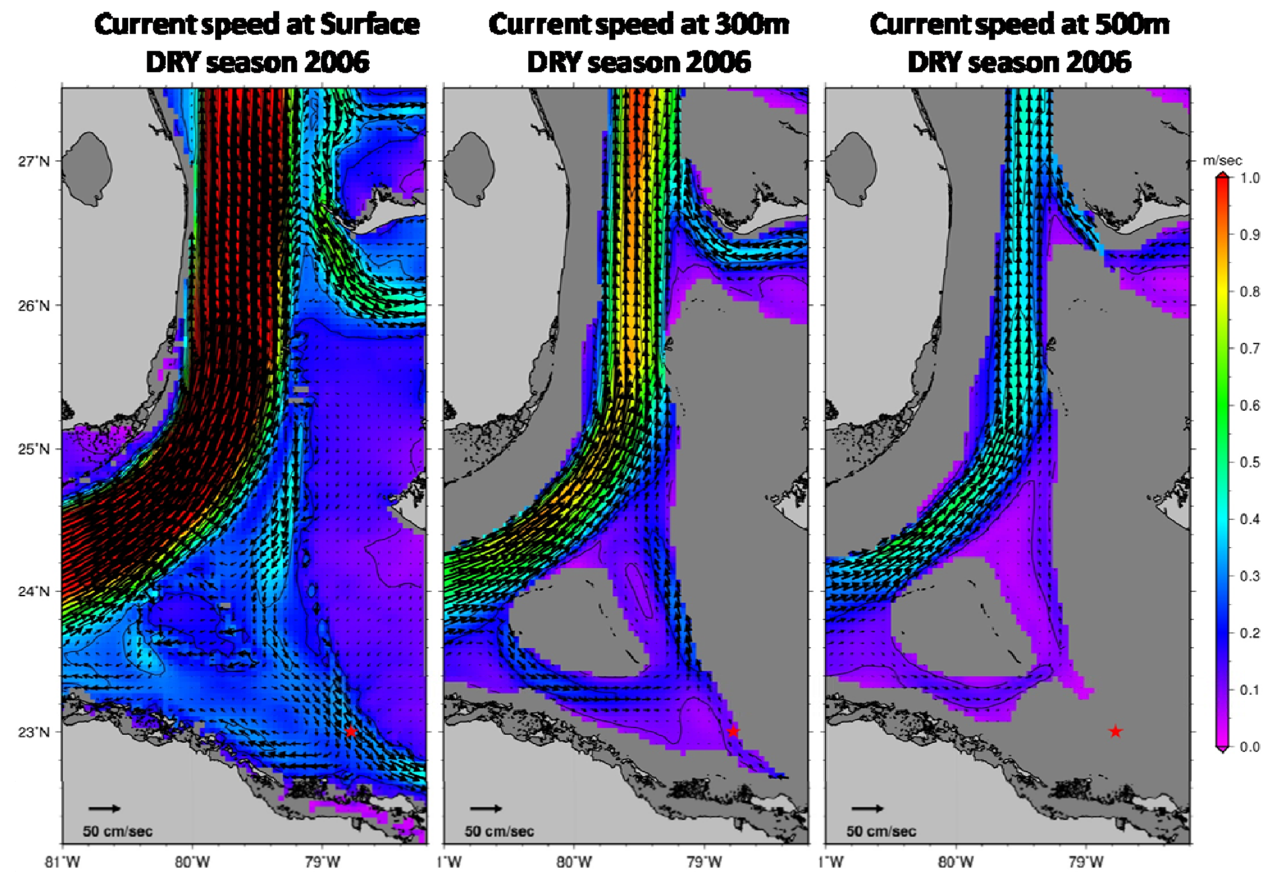


Fig. 4.4: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2006. Full study domain. Red star marks the release location.

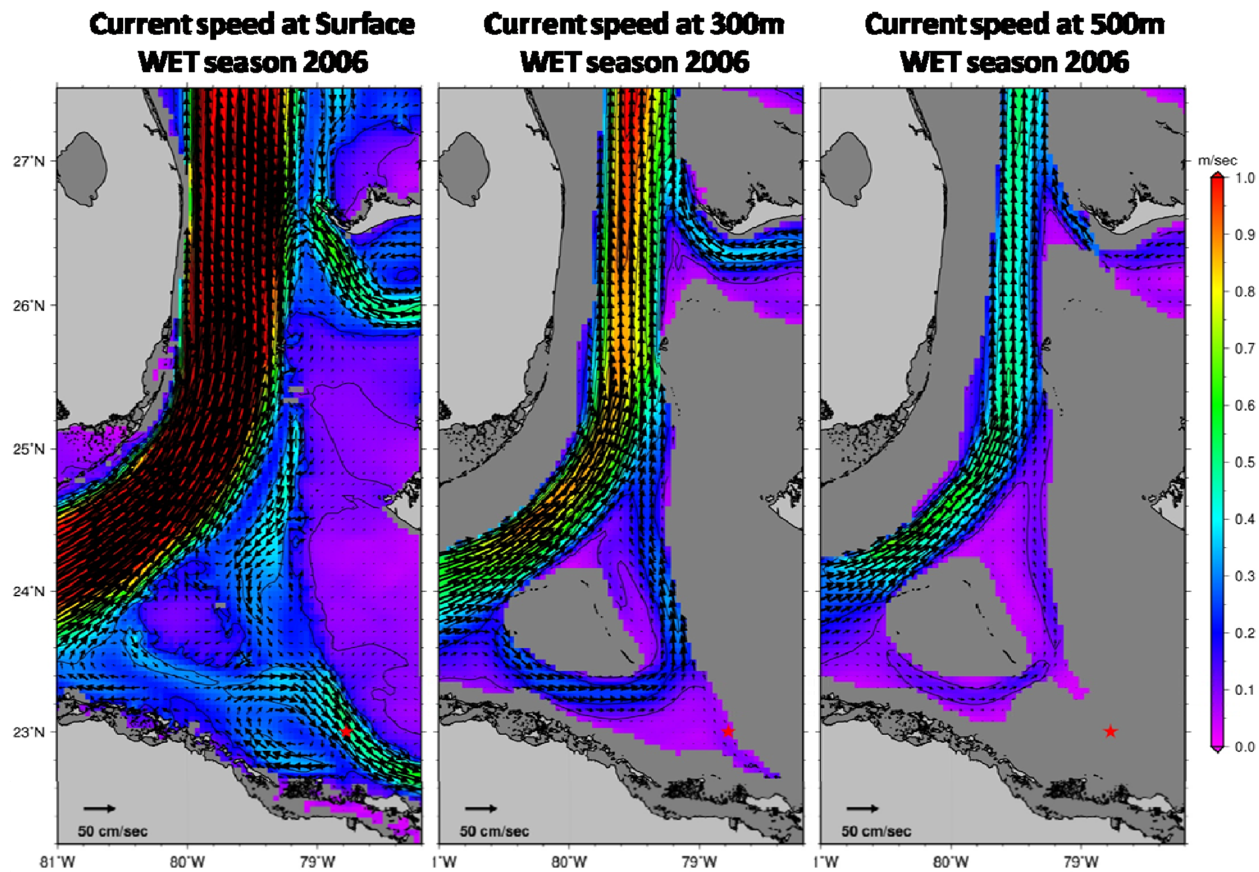


Fig. 4.5: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2006. Full study domain. Red star marks the release location.

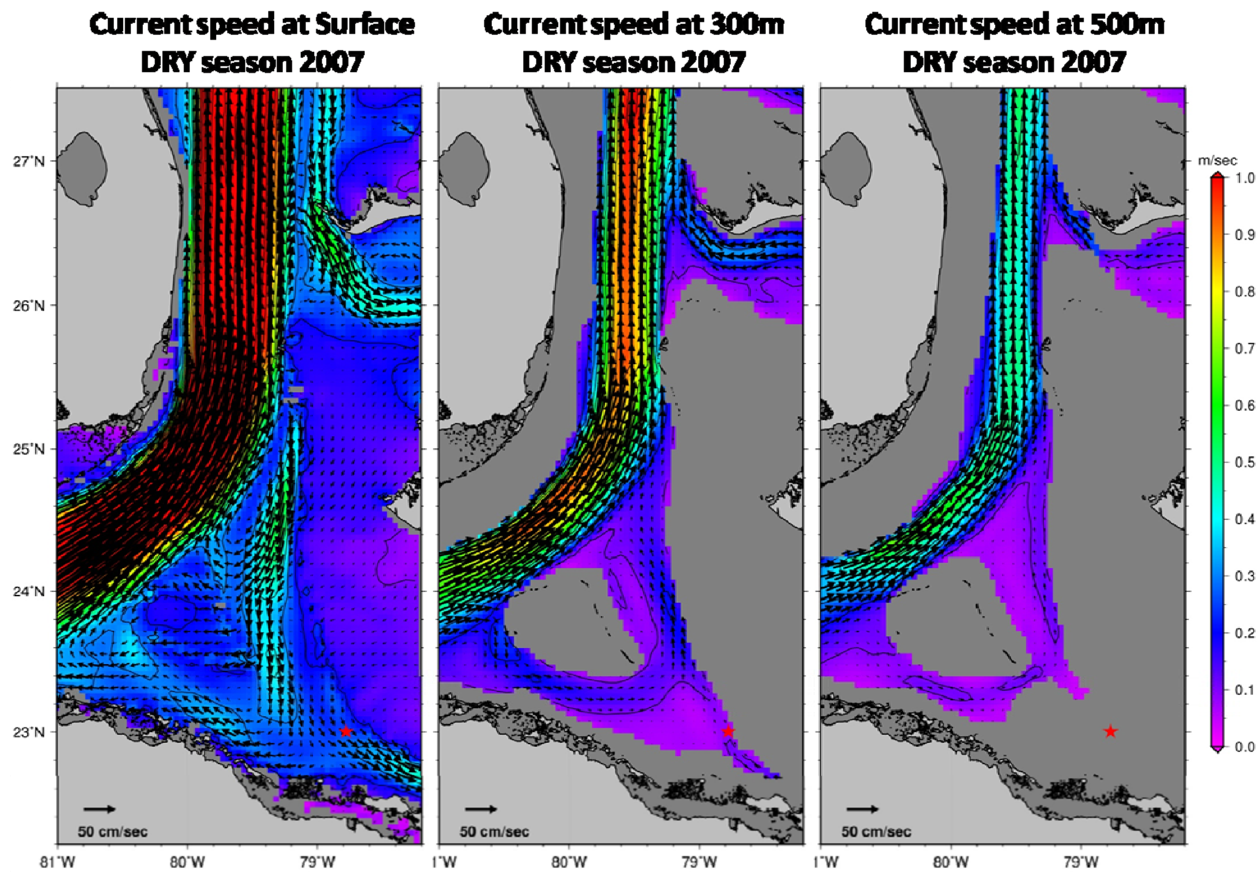


Fig. 4.6: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2007. Full study domain. Red star marks the release location.

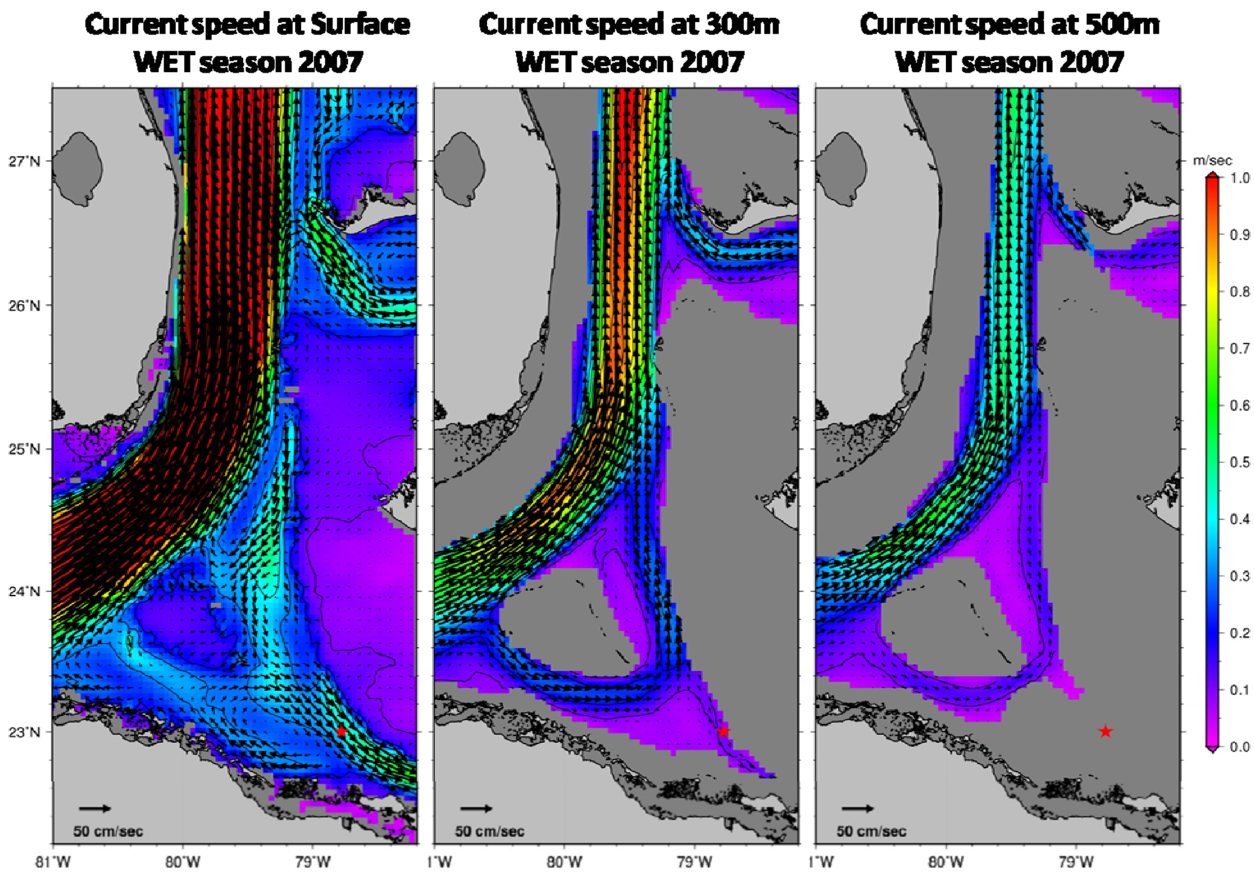


Fig. 4.7: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2007. Full study domain. Red star marks the release location.

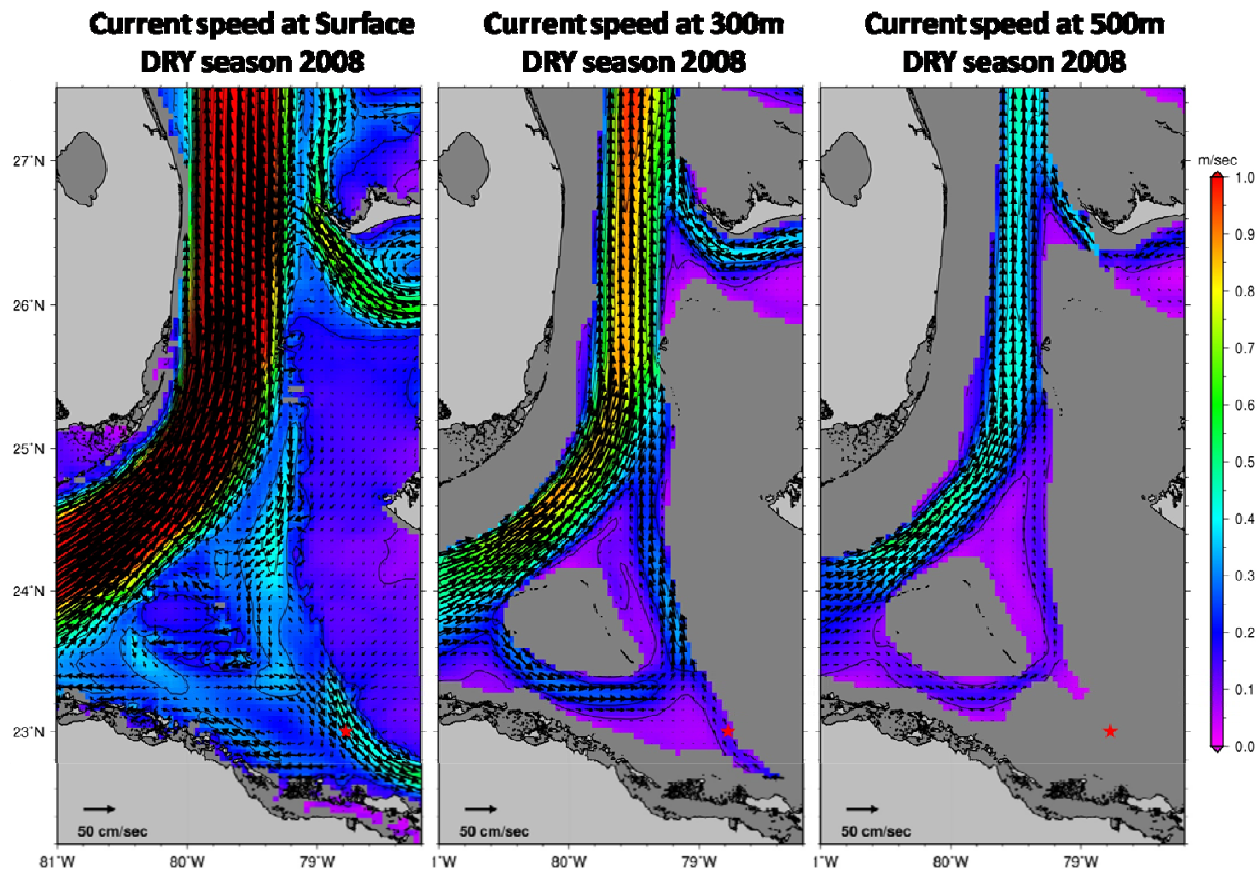


Fig. 4.8: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2008. Full study domain. Red star marks the release location.

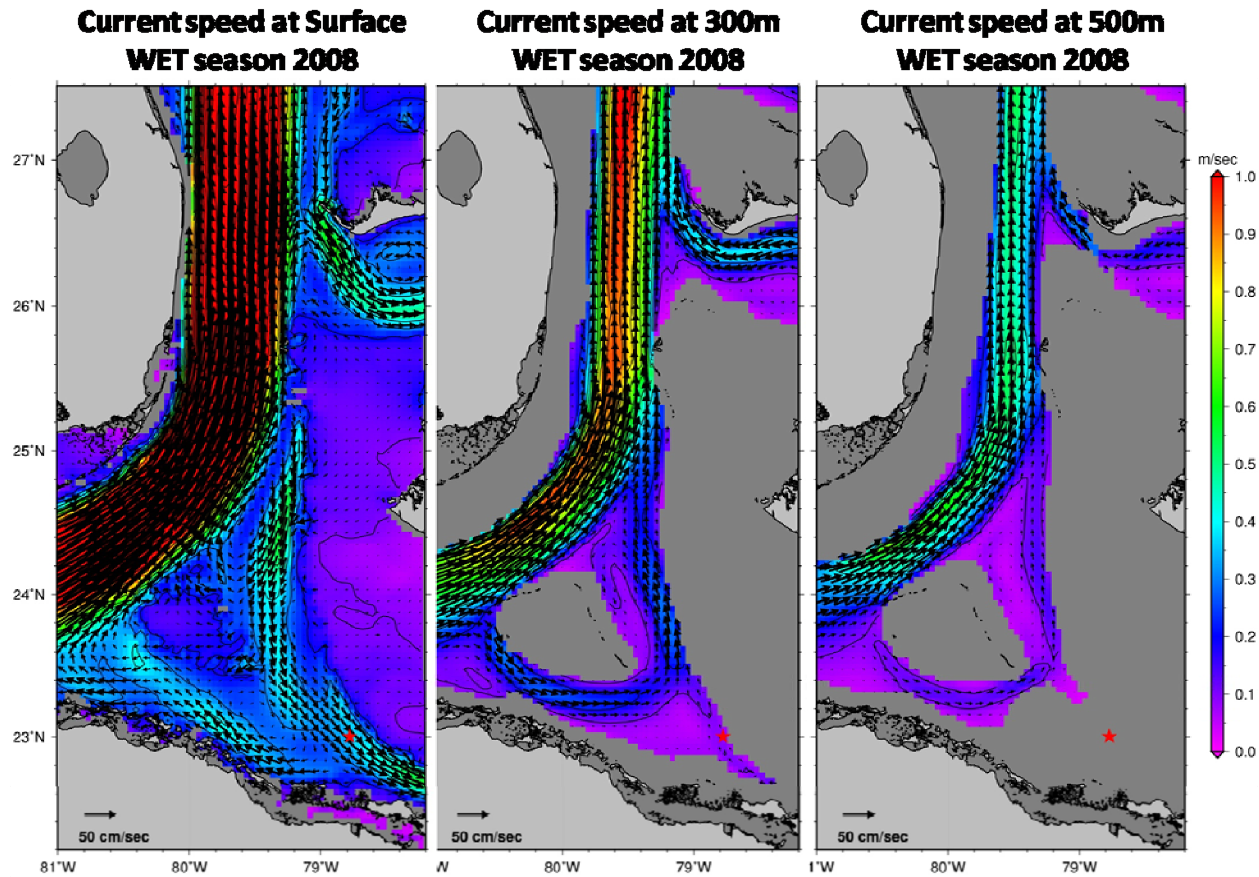


Fig. 4.9: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2008. Full study domain. Red star marks the release location.

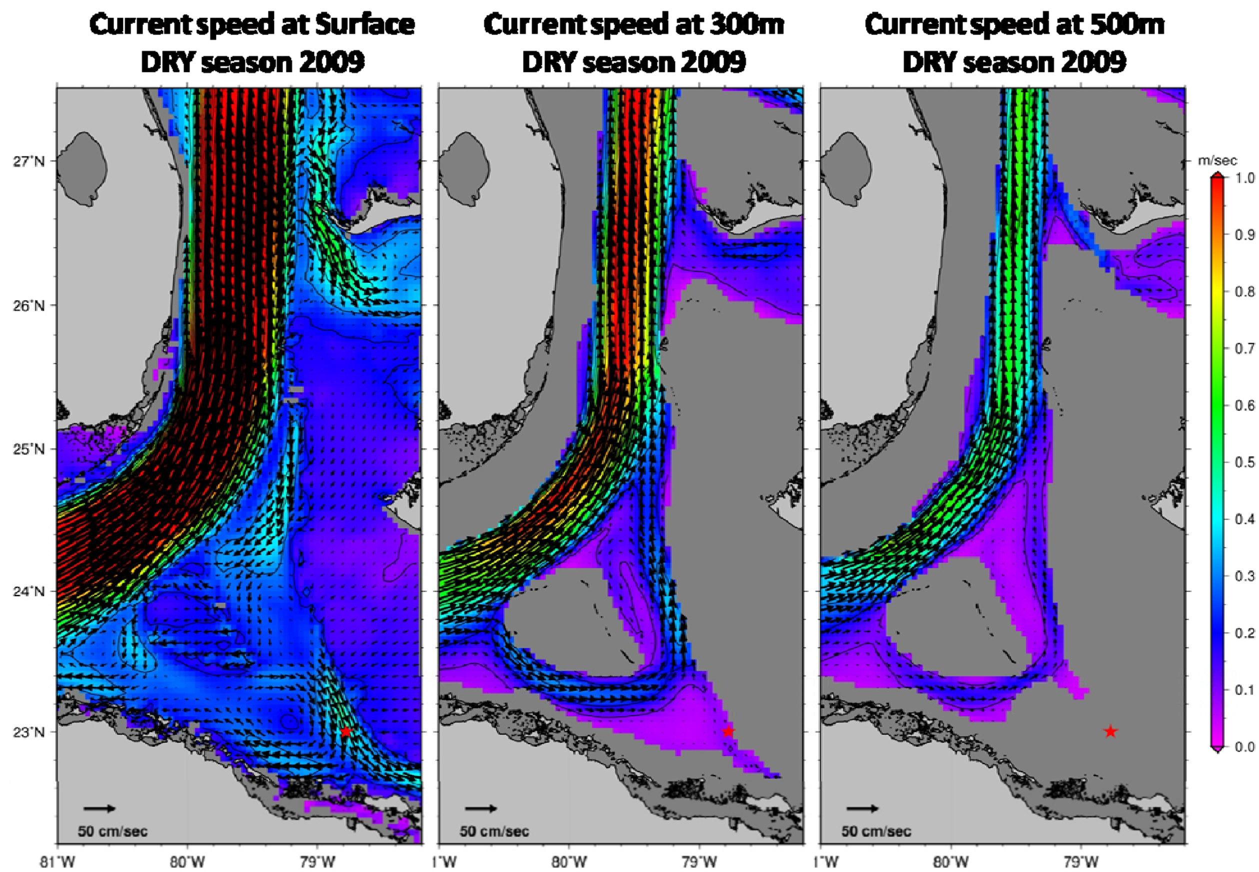


Fig. 4.10: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2009. Full study domain. Red star marks the release location.

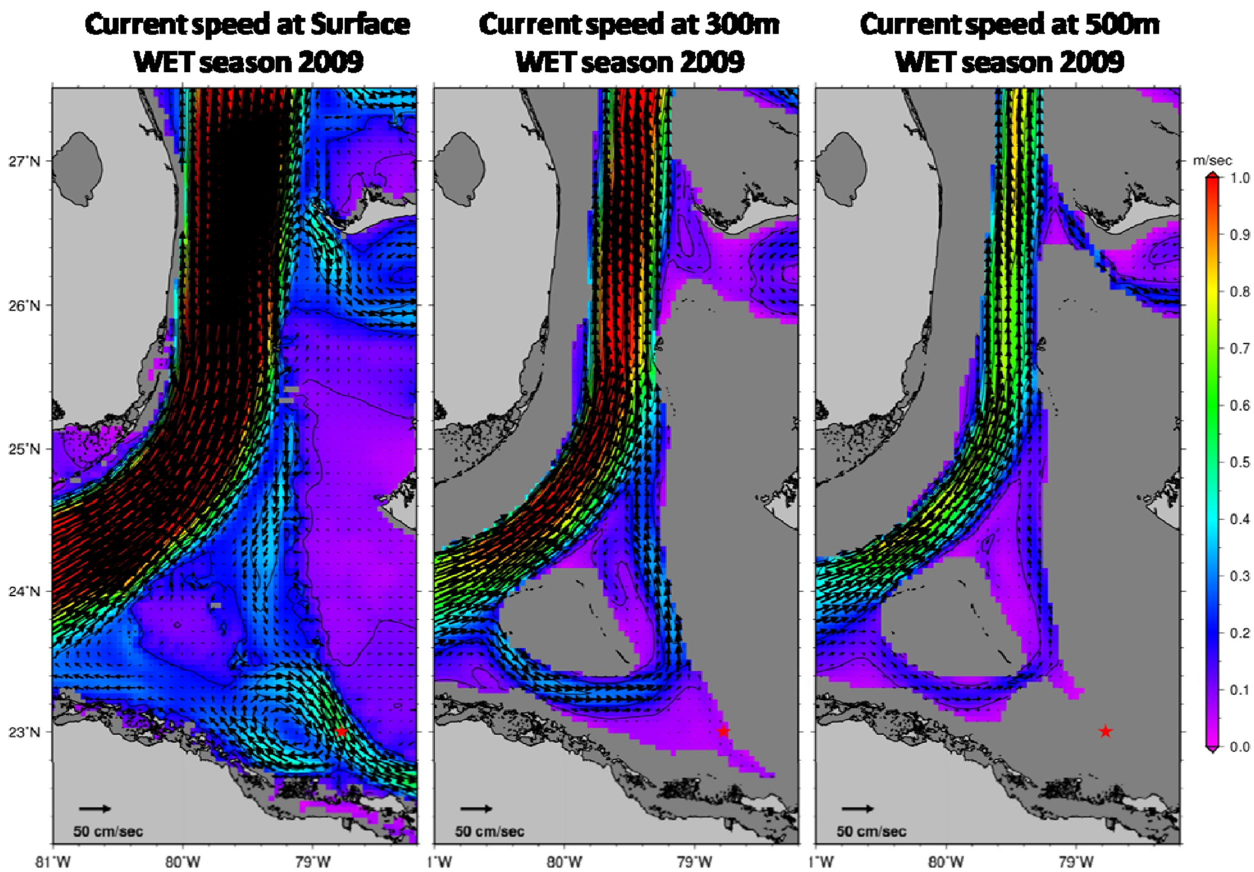


Fig. 4.11: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2009. Full study domain. Red star marks the release location.

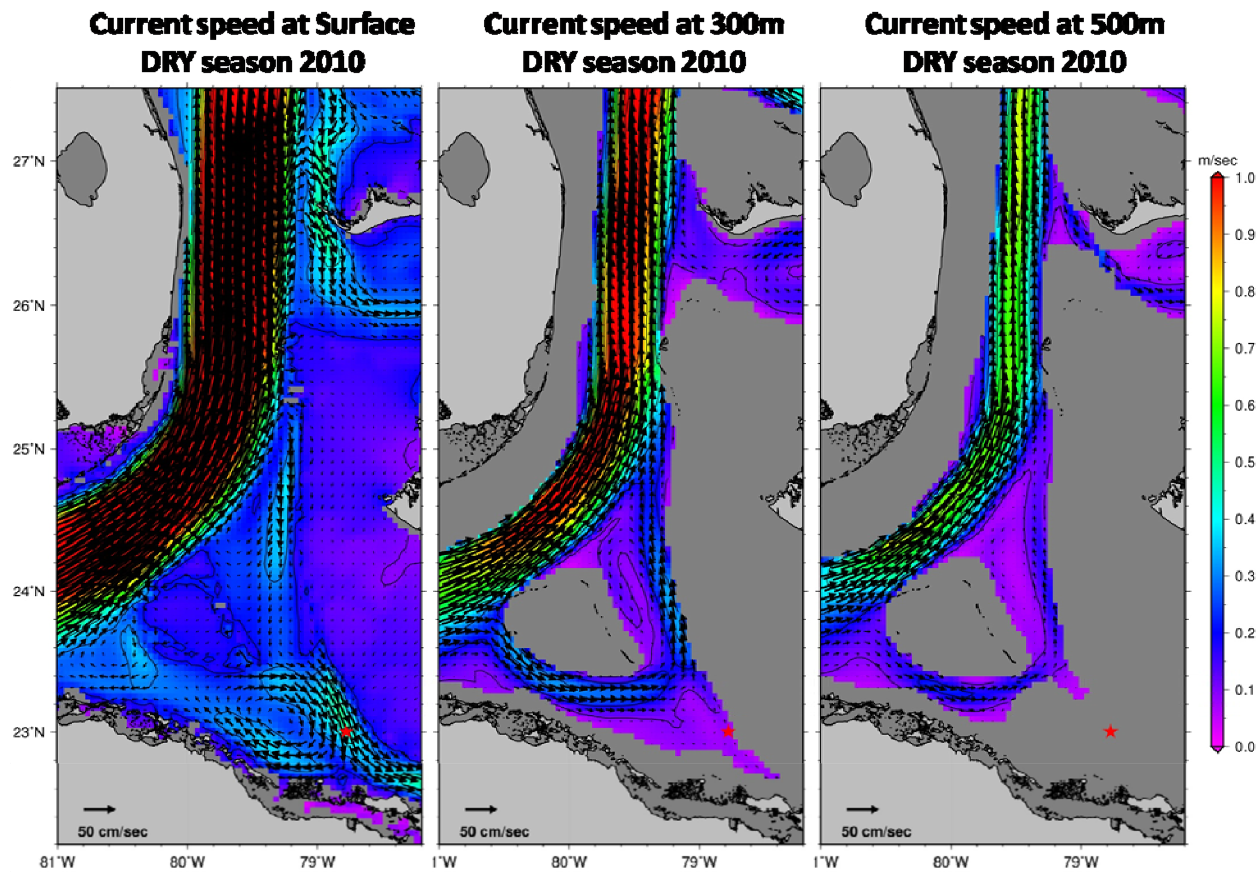


Fig. 4.12: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for dry season in 2010. Full study domain. Red star marks the release location.

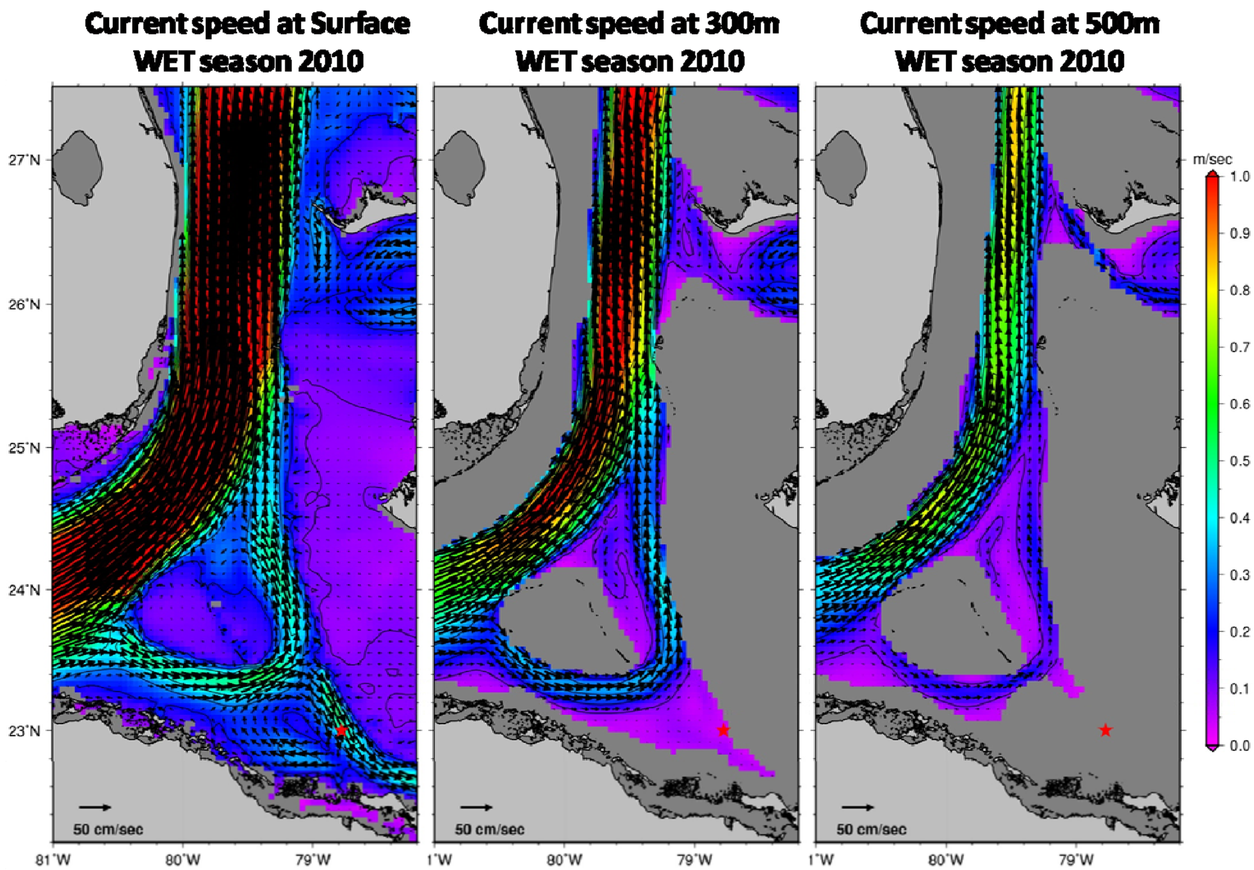


Fig. 4.13: Seasonal mean currents (surface, 300m and 500m) in the Florida Straits for wet season in 2010. Full study domain. Red star marks the release location.

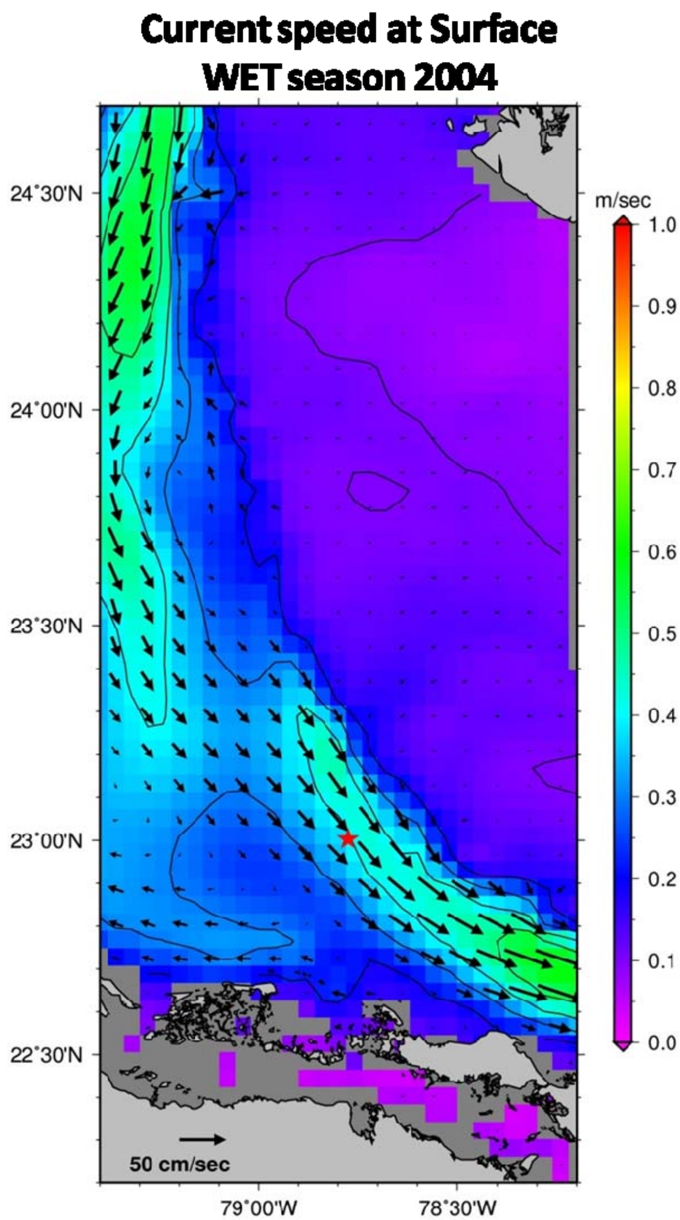


Fig. 4.14: Seasonal mean currents at surface for wet season in 2004. Detail of study domain around the release location (marked by red star).

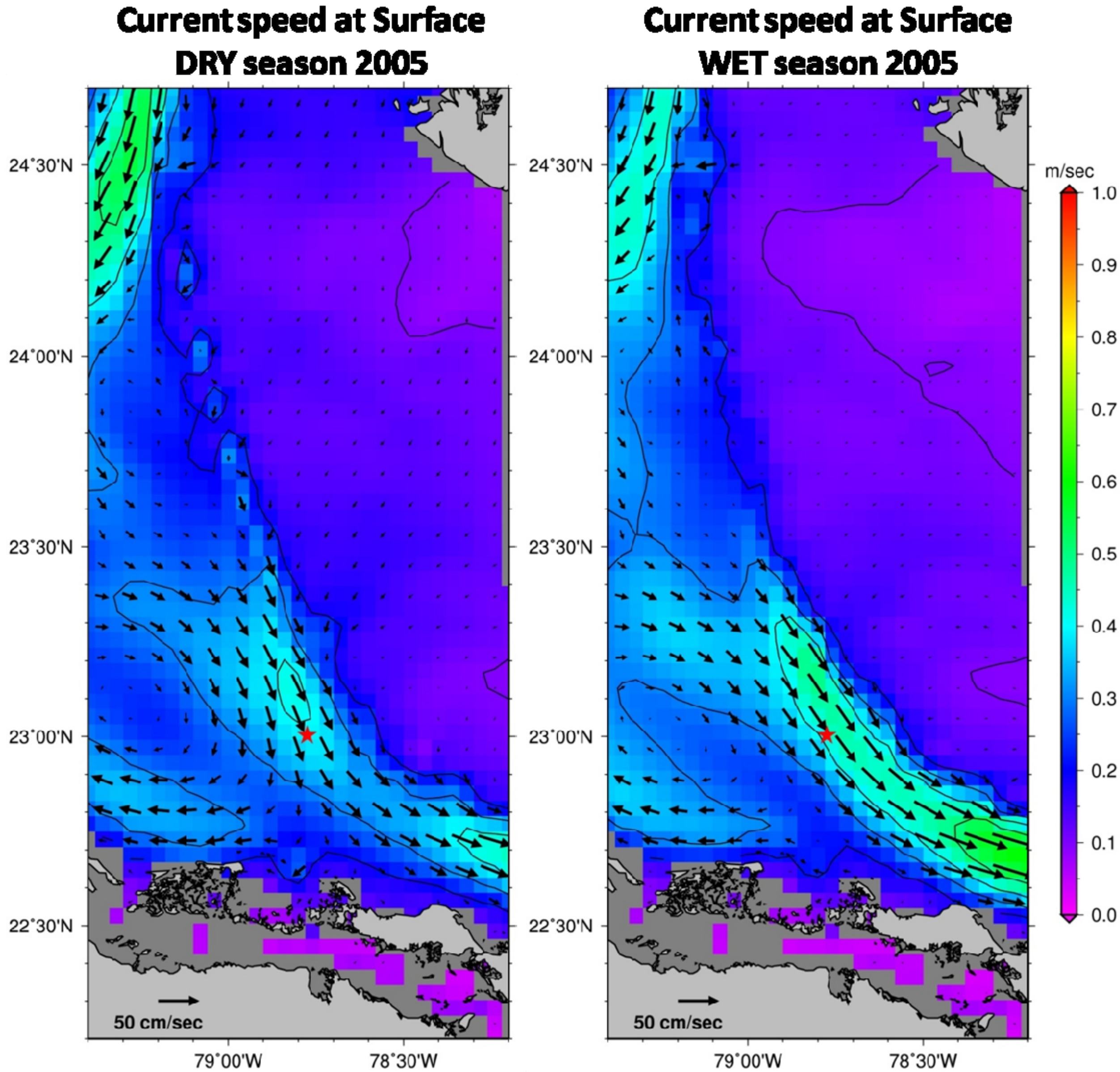


Fig. 4.15: Seasonal mean currents at surface for dry (left) and wet (right) season in 2005. Detail of study domain around the release location (marked by red star).

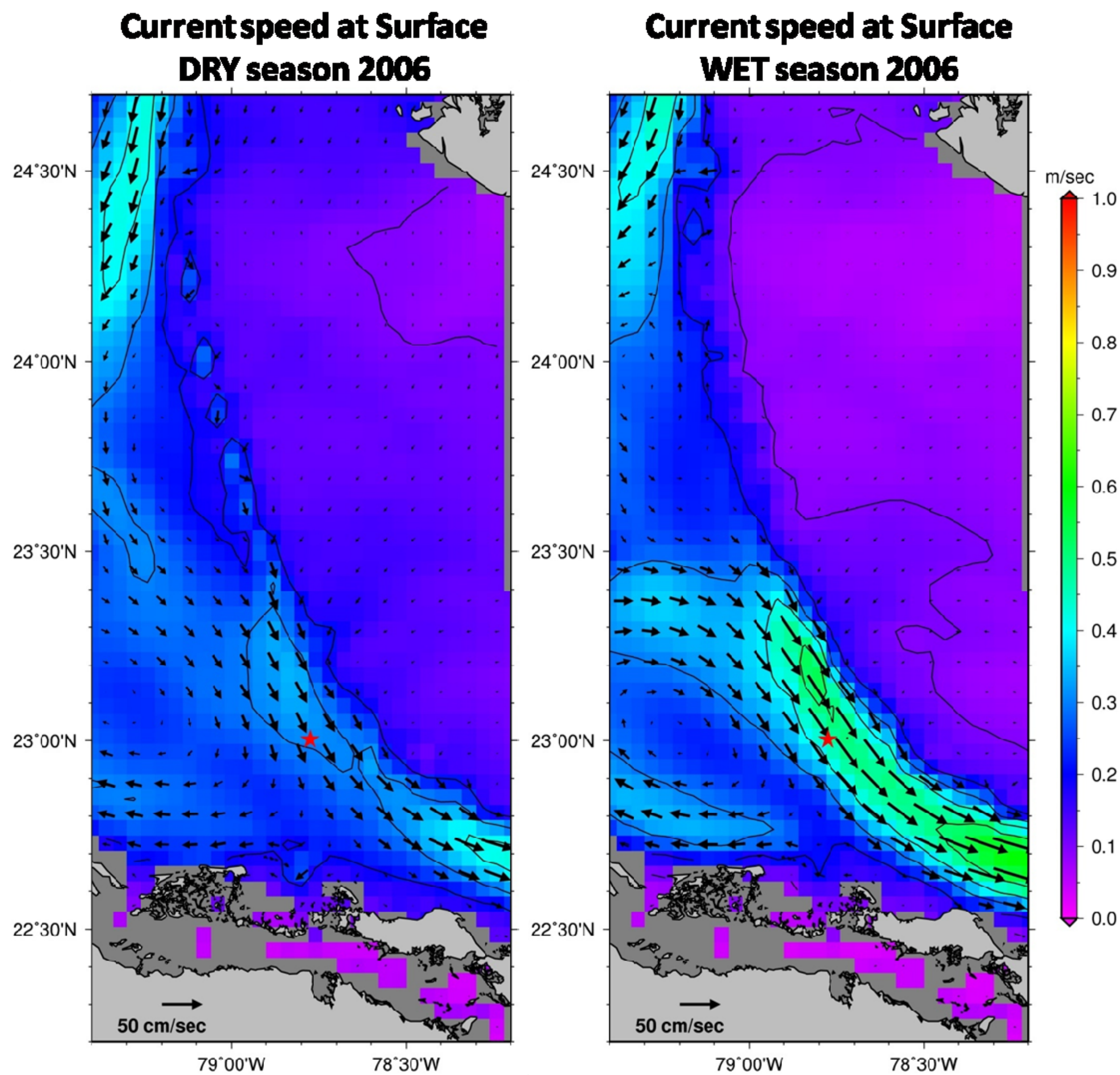


Fig. 4.16: Seasonal mean currents at surface for dry (left) and wet (right) season in 2006. Detail of study domain around the release location (marked by red star).

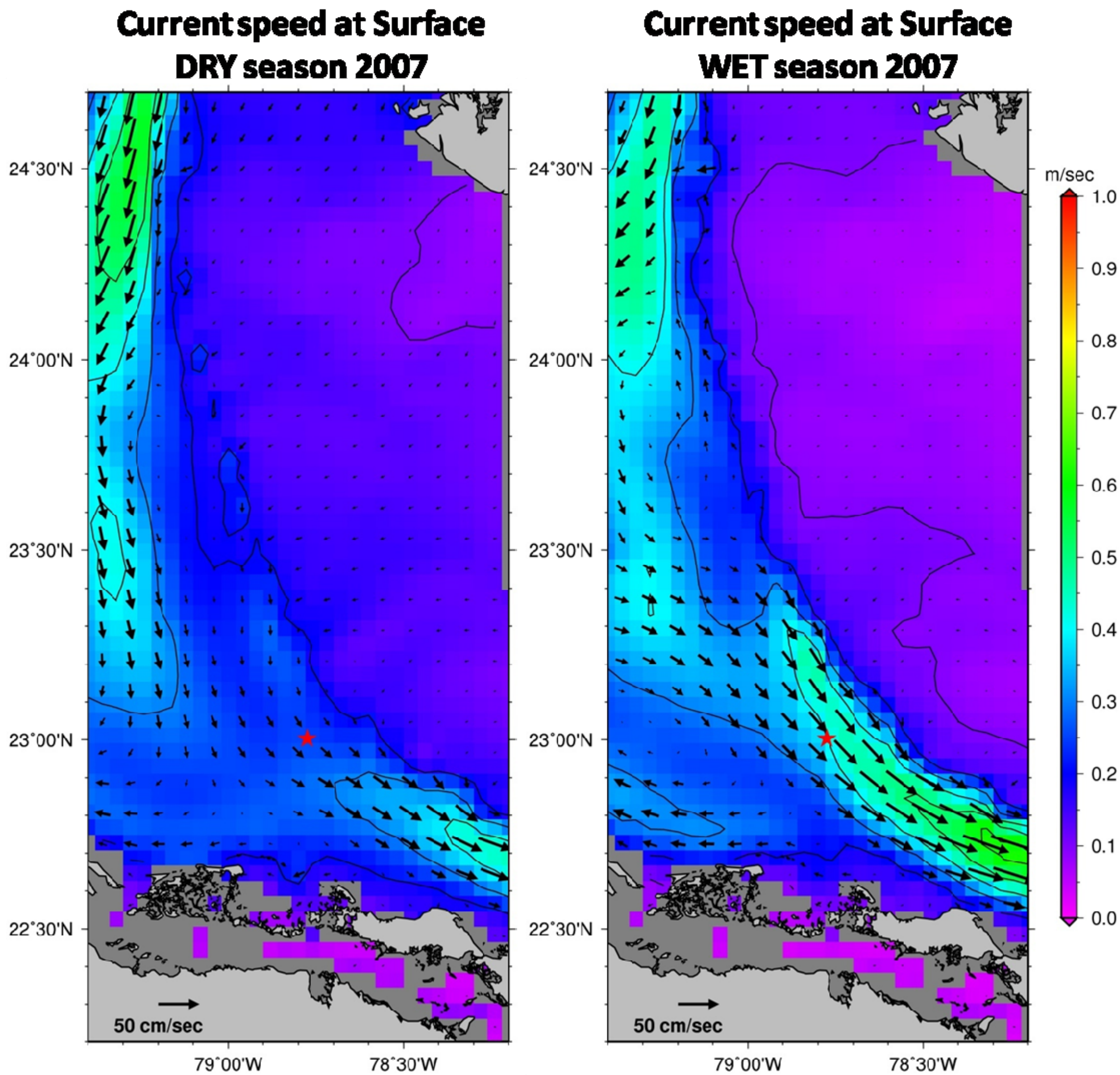


Fig. 4.17: Seasonal mean currents at surface for dry (left) and wet (right) season in 2007. Detail of study domain around the release location (marked by red star).

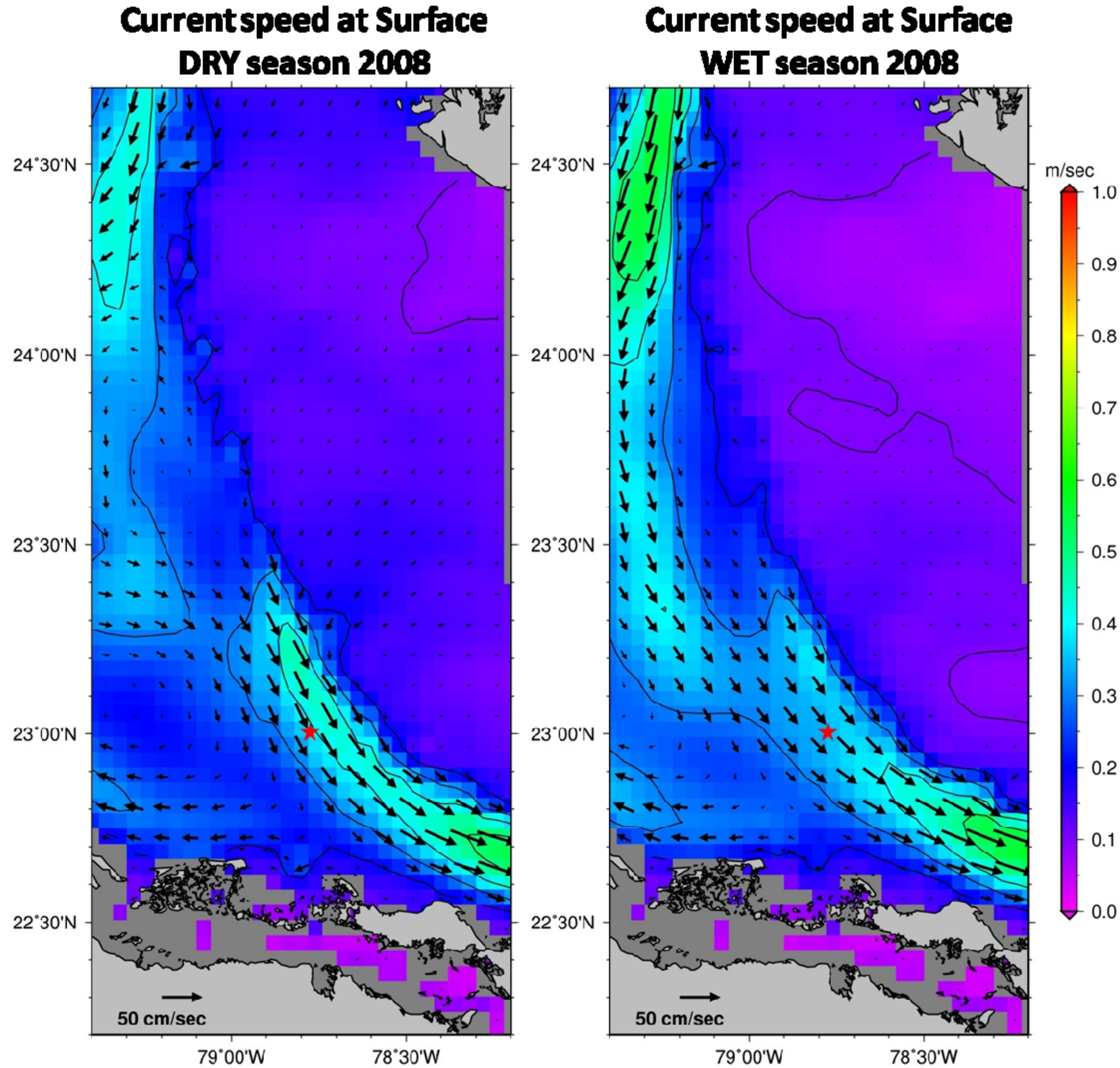


Fig. 4.18: Seasonal mean currents at surface for dry (left) and wet (right) season in 2008. Detail of study domain around the release location (marked by red star).

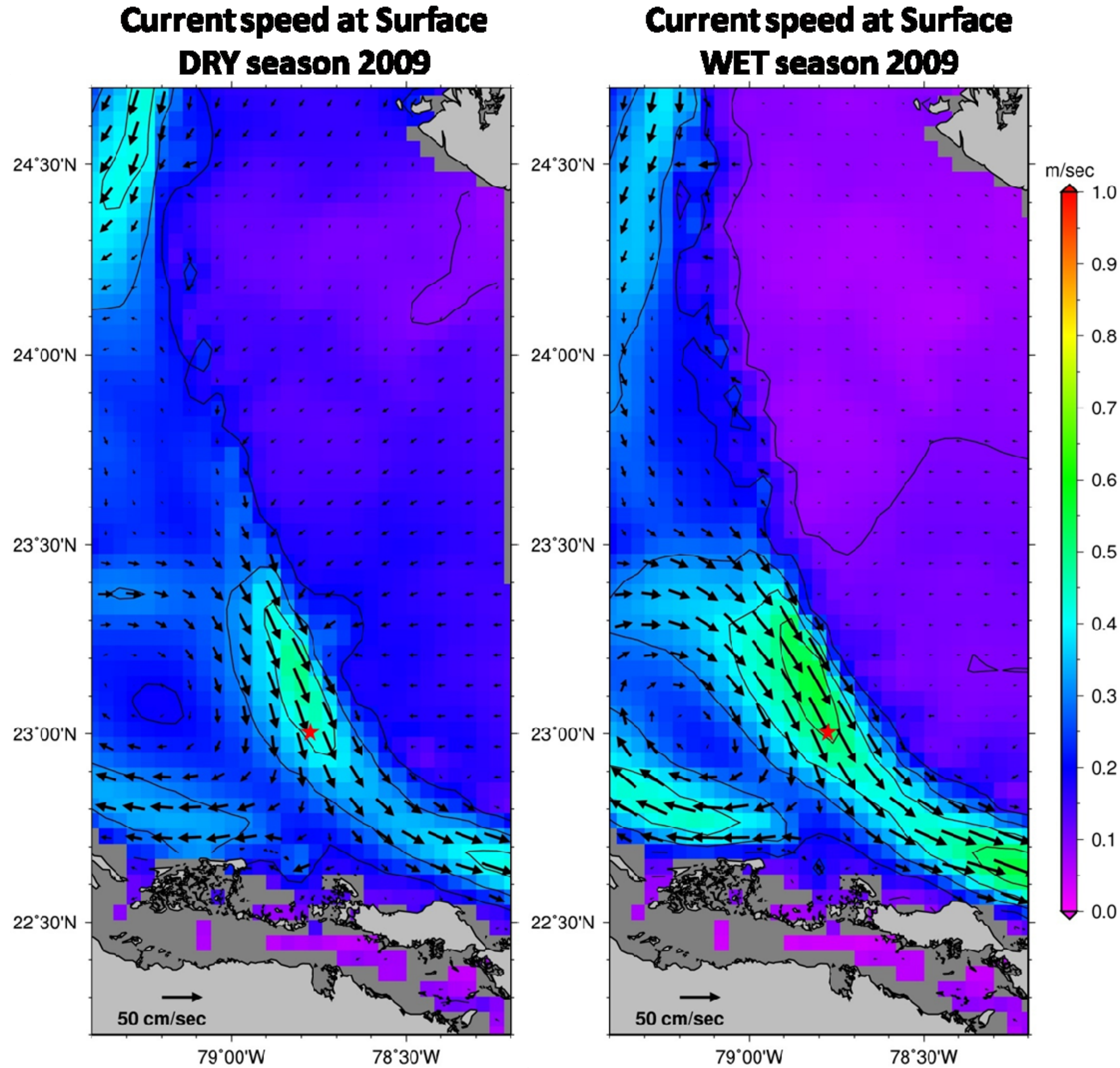


Fig. 4.19: Seasonal mean currents at surface for dry (left) and wet (right) season in 2009. Detail of study domain around the release location (marked by red star).

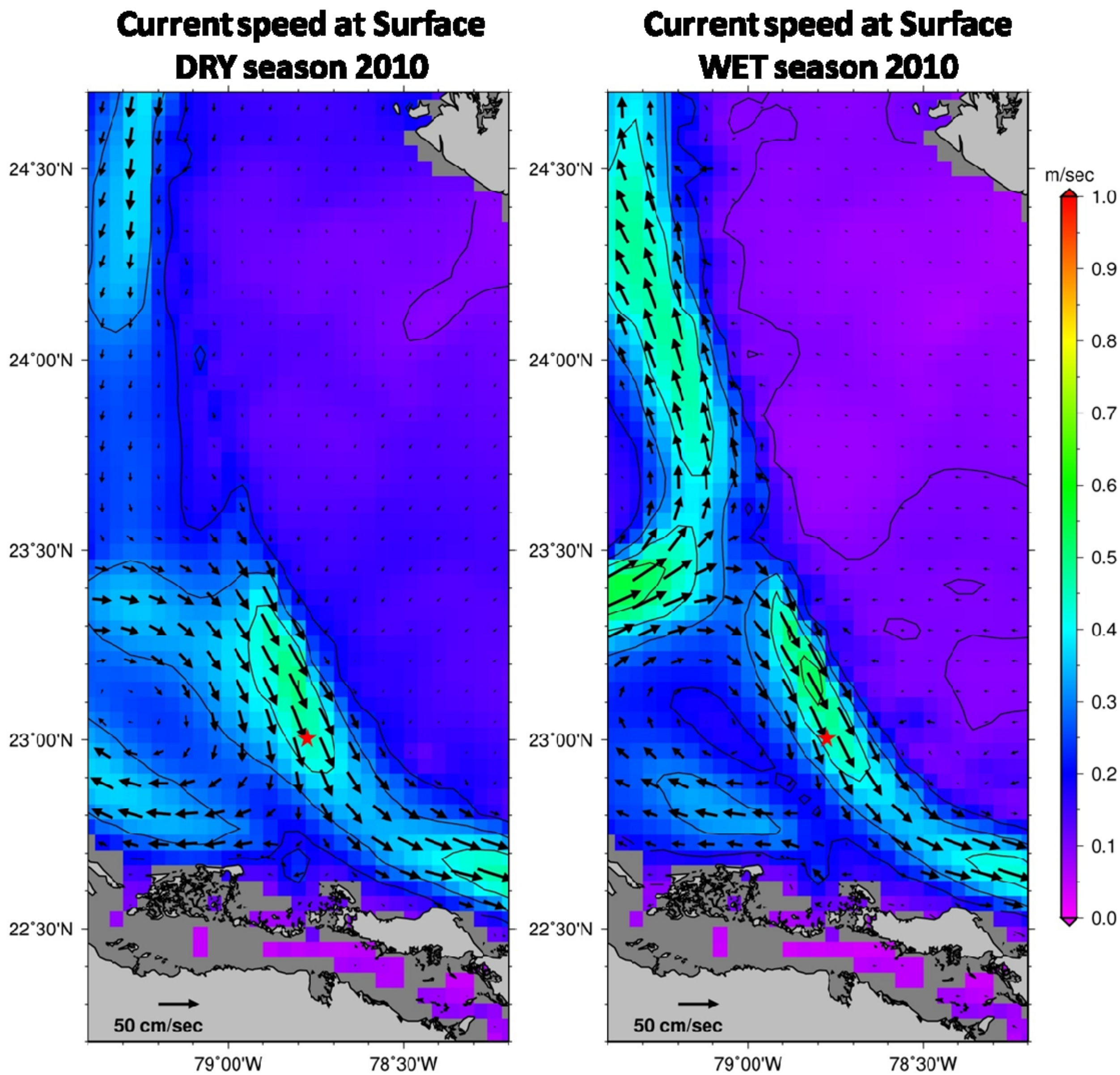


Fig. 4.20: Seasonal mean currents at surface for dry (left) and wet (right) season in 2010. Detail of study domain around the release location (marked by red star).

APP5: VARIABILITY OF THE FLORIDA CURRENT

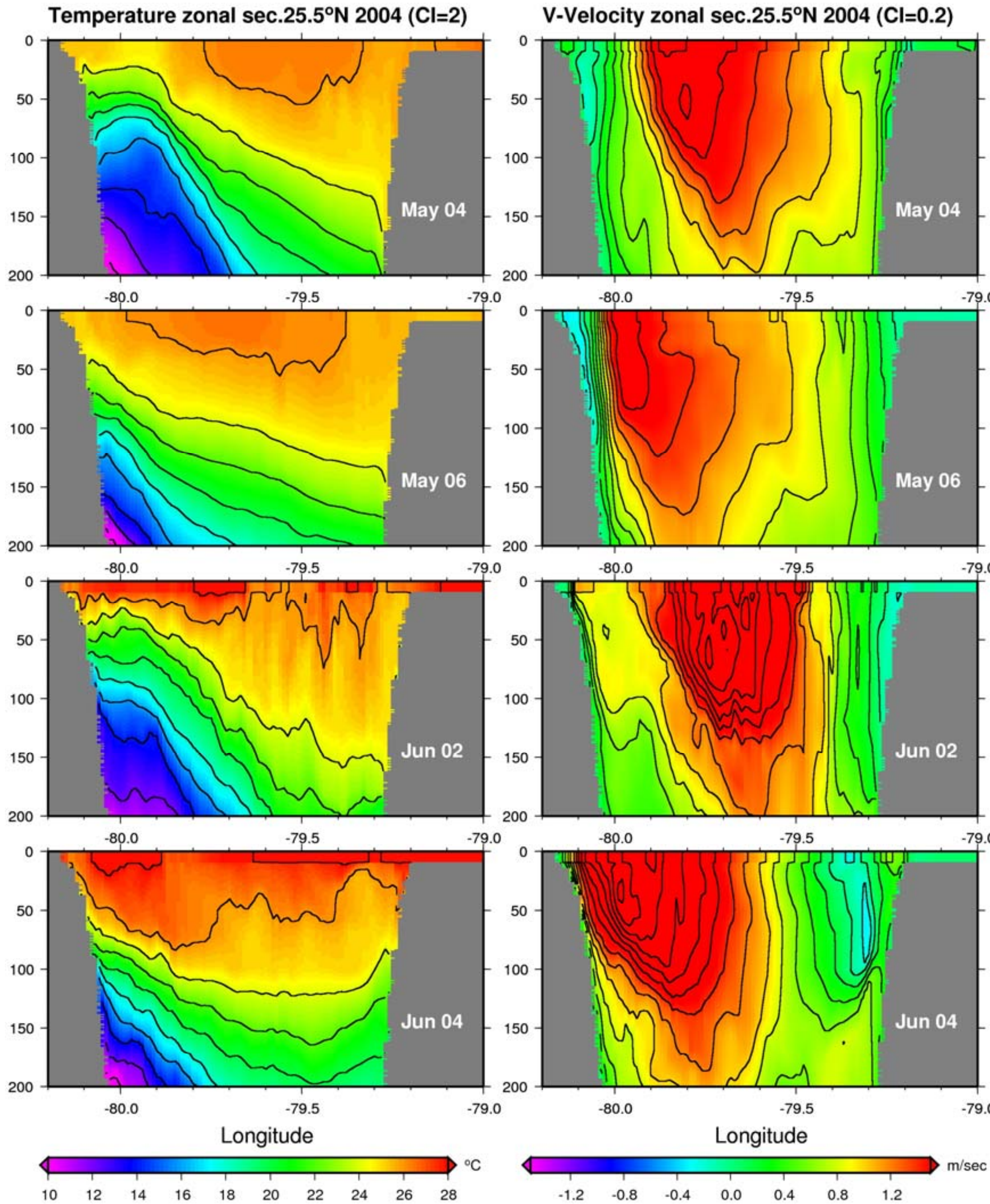


Fig. 5.1: Cross-sectional distributions of model computed Temperature (left) and normal velocity (right) at 25.5°N (Florida coast is at the left/west and the Bahamas coast is at the right/east) on (top to bottom) May 4, May 6, June 2 and June 4, 2004, showing the vertical structure and short-term variability of the Florida Current. Contour intervals are 2 units. *From Kourafalou and Kang (2011).*

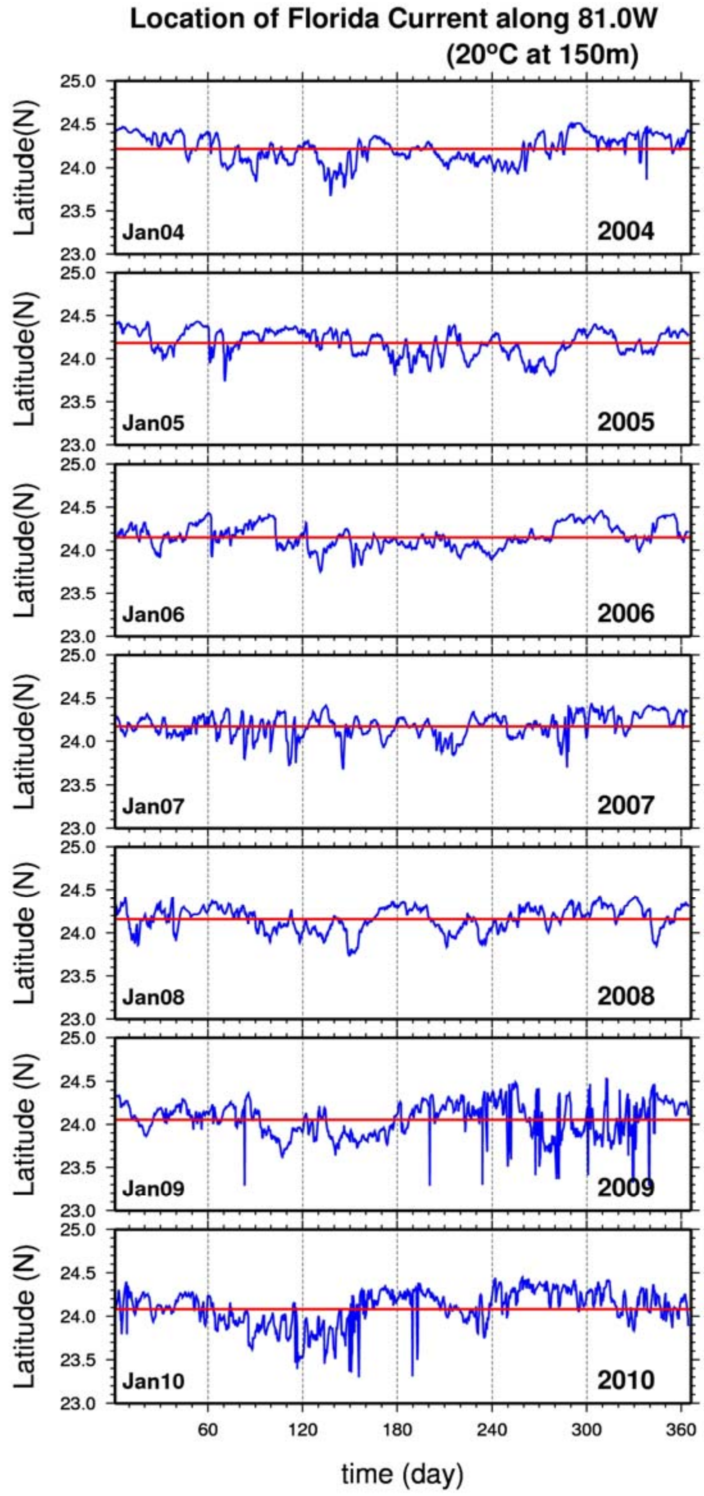


Fig. 5.2: Time series of the Florida Current position along 81^0W (with respect to latitude), defined by the 20^0C isotherm at 150m) – years 2004-2010. The red line marks the mean latitude (for each year) around which the Florida Current meanders. Time in Julian days.

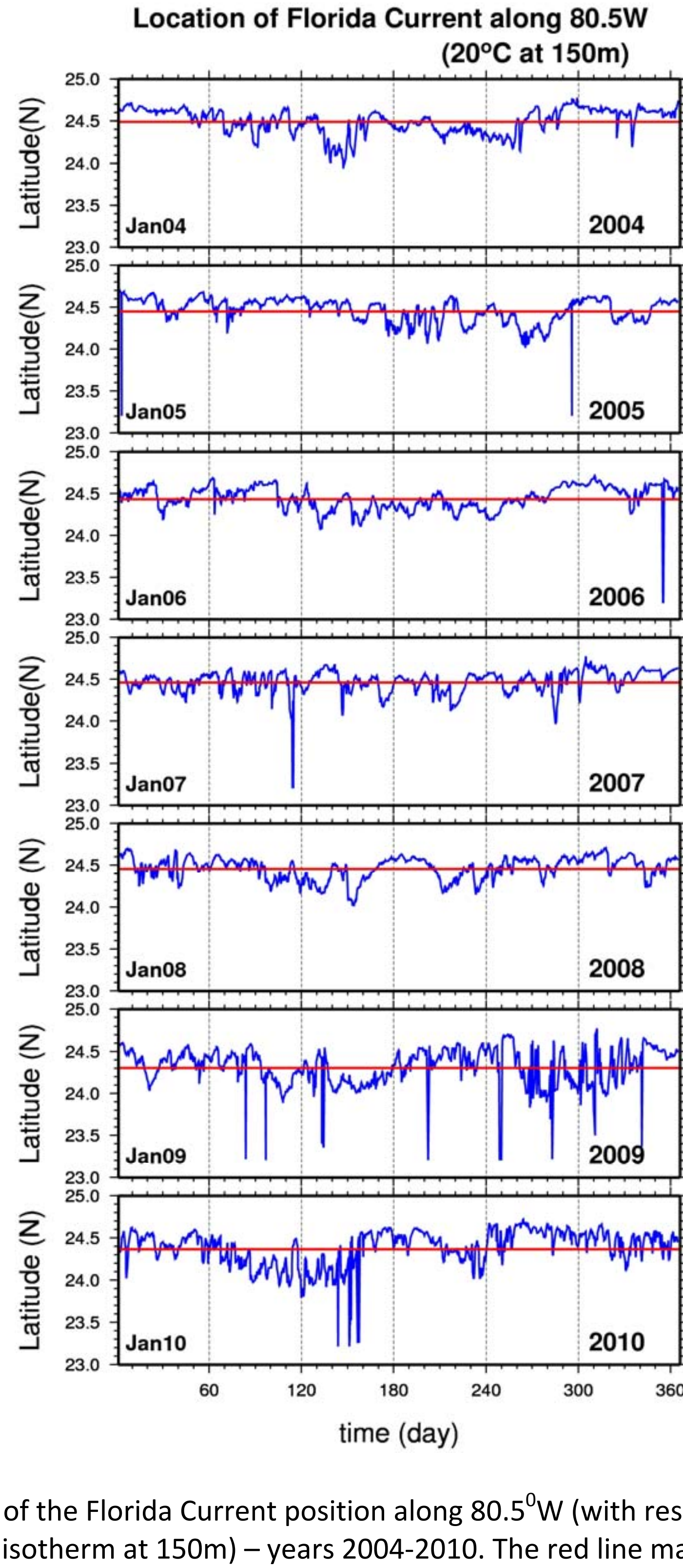


Fig. 5.3: Time series of the Florida Current position along 80.5^{0}W (with respect to latitude), defined by the 20^{0}C isotherm at 150m) – years 2004-2010. The red line marks the mean latitude (for each year) around which the Florida Current meanders. Time in Julian days.

APP6: LONG TERM SIMULATION RESULTS (Part 1)

APP6.1 OIL LANDFALL (SURFACE RELEASE)

Oil landfall frequency is expressed as the daily proportion of oil reaching coastal polygons from the total daily oil discharge (medium rate: 2,400 m^3/day). The time series are used to select periods of high magnitude of coastal oiling. To take into account the overlap of daily spills (i.e., 40-day life time), we ran a 20-day moving average on the daily frequencies, which smoothed out variations without changing the timing of the peaks. Note that: 1) the graphs presented for each regional group of polygons have different y-axis scales for better visualization; 2) the colors of the time series match the group of polygons from Figure 2.2.

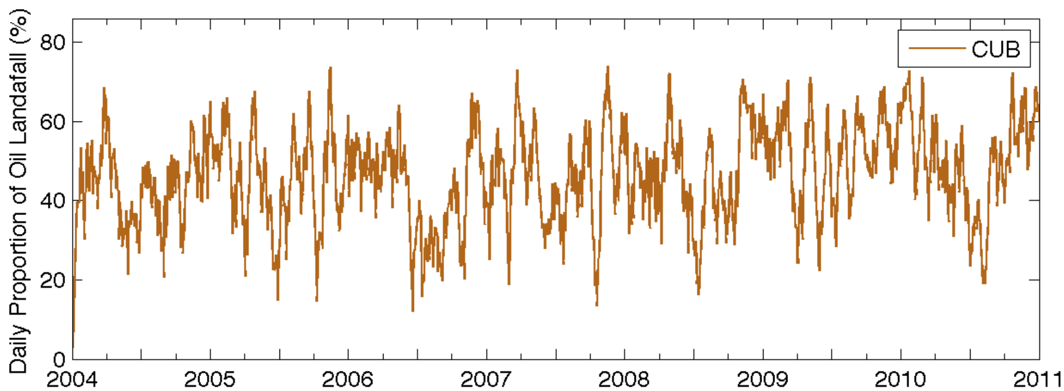


Figure D.1.1: Time series of oil landfall from surface daily spills from January 2004 to December 2010 in North Central and Northwest Cuba.

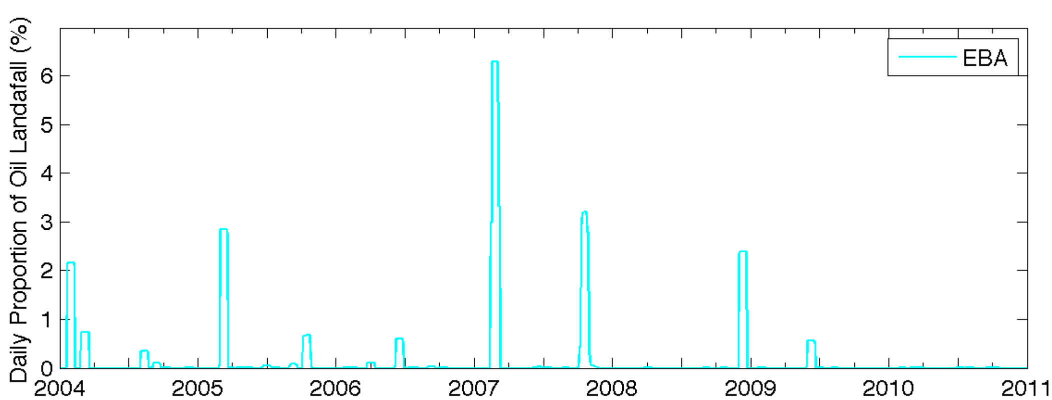


Figure D.1.2: Time series of oil landfall from surface daily spills January 2004 to December 2010 in the Eastern Bahamas (EBA)

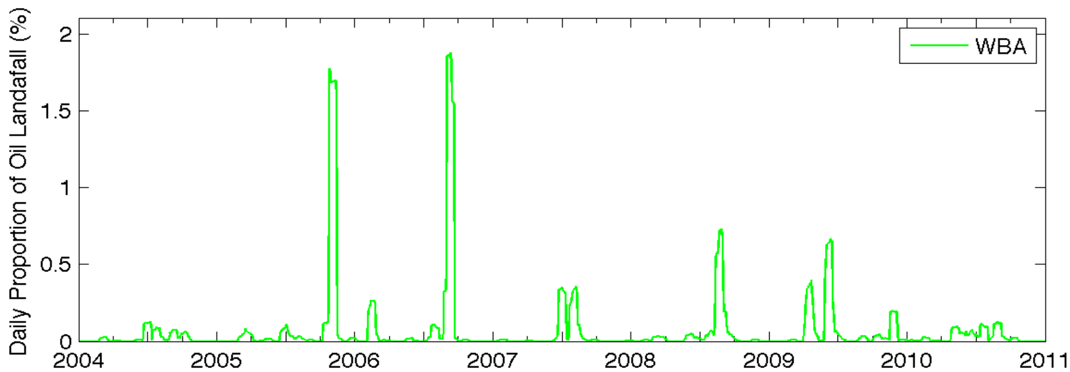


Figure D.1.3: Time series of oil landfall from surface daily spills January 2004 to December 2010 in the Western Bahamas (WBA).

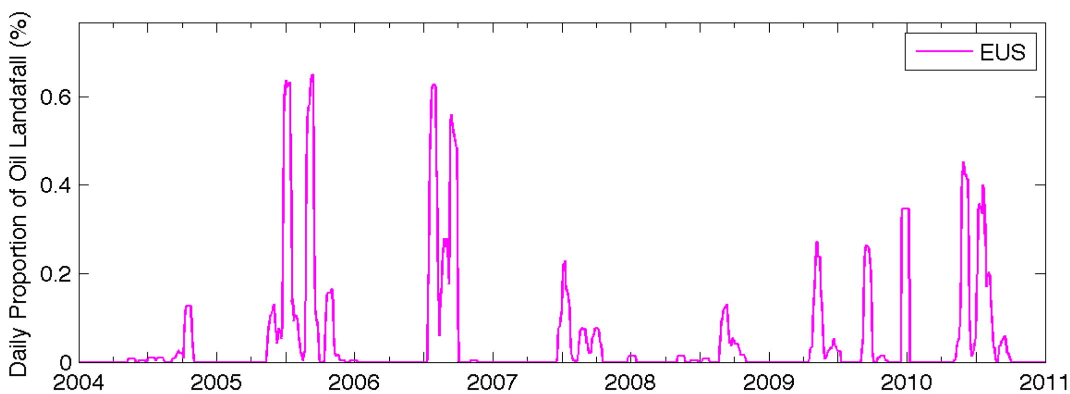


Figure D.1.4: Time series of oil landfall from surface daily spills January 2004 to December 2010 in the Eastern U.S. coast (EUS).

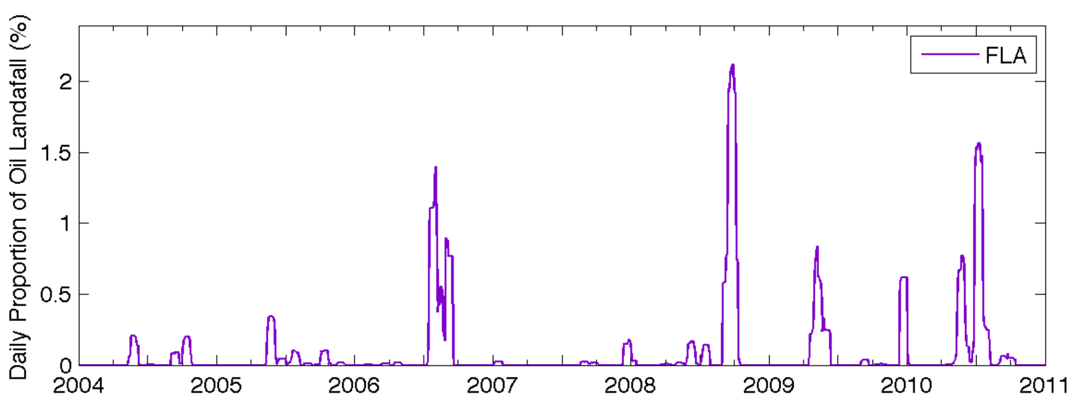


Figure D.1.5: Time series of oil landfall from surface daily spills January 2004 to December 2010 in the Southeastern coast of Florida (FLA).

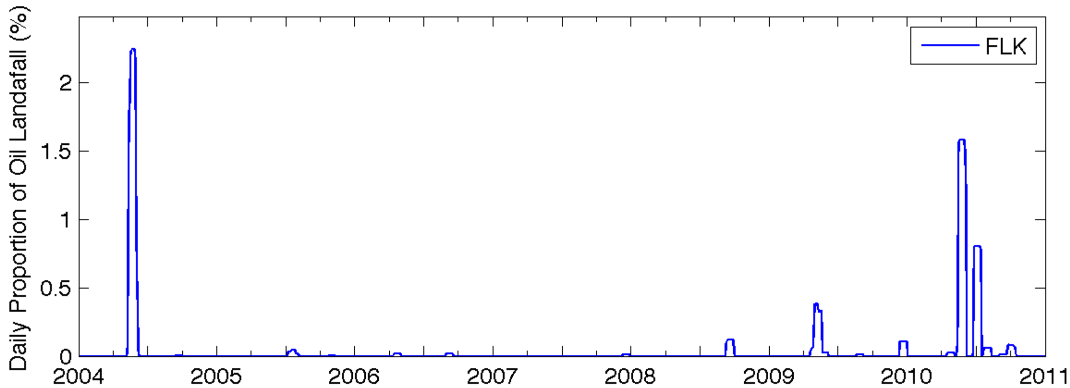


Figure D.1.6: Time series of oil landfall from surface daily spills January 2004 to December 2010 in the Florida Keys (FLK).

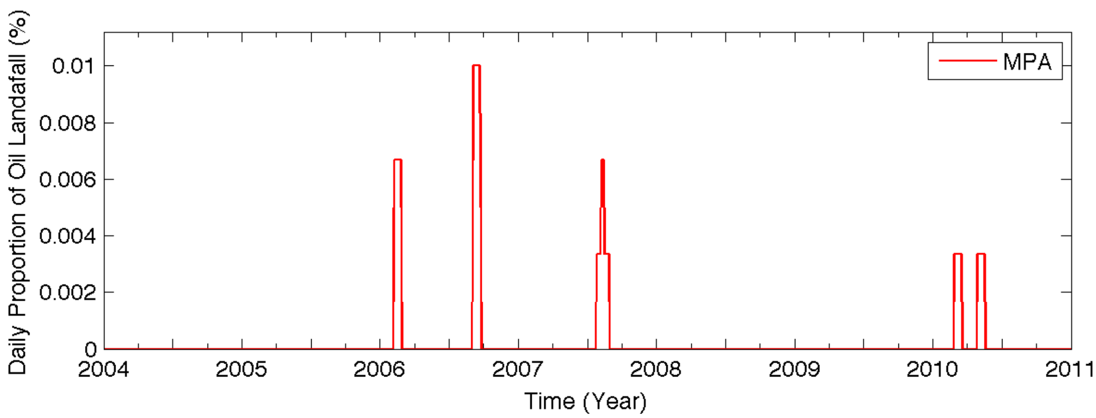


Figure D.1.7: Time series of oil landfall from surface daily spills January 2004 to December 2010 in five Bahamian Marine Reserves or Marine Protected Areas (MPA).

APP6.2 OIL LANDFALL (SEABED RELEASE-low discharge rate)

Oil landfall frequency is expressed as the daily proportion of oil reaching coastal polygons from the total daily oil discharge (low rate: 1,600 m^3/day). The time series are used to select periods of high magnitude of coastal oiling. To take into account the overlap of daily spills (i.e., 40-day life time), we ran a 20-day moving average on the daily frequencies, which smoothed out variations without changing the timing of the peaks. Note that: 1) the graphs presented for each regional group of polygons have different y-axis scales for better visualization; 2) the colors of the time series match the group of polygons from Figure 2.2.

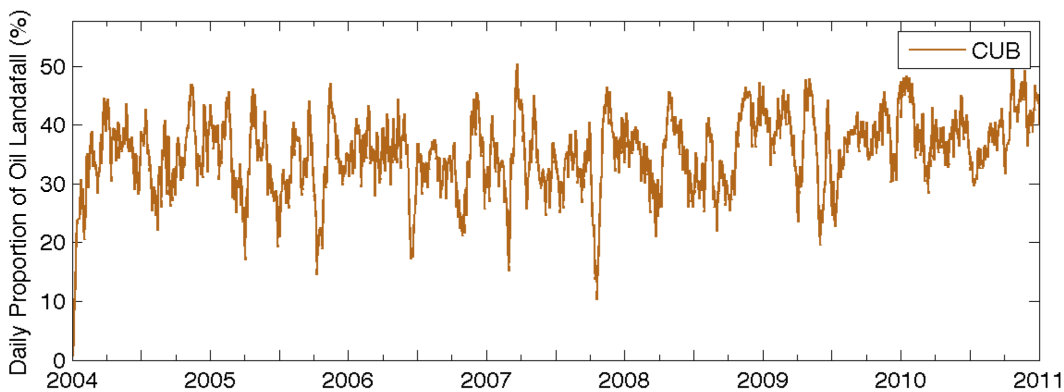


Figure D.2.1: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in North Central and Northwest Cuba.

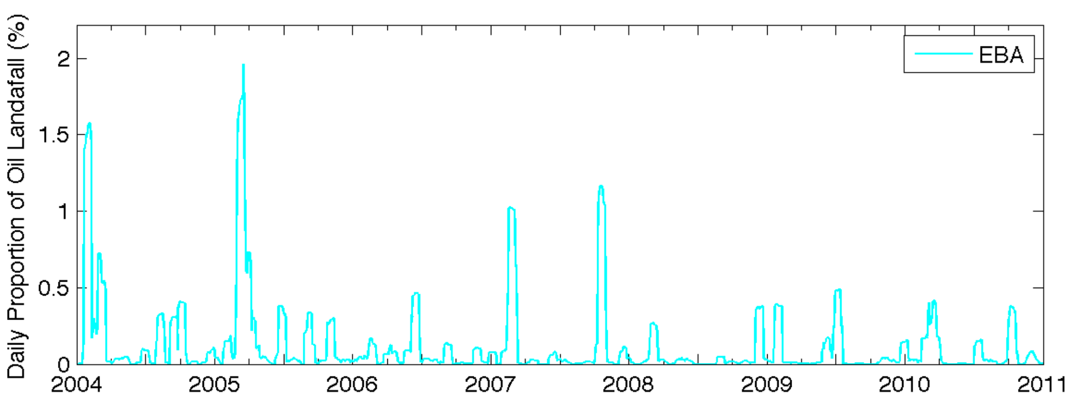


Figure D.2.2: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in the Eastern Bahamas (EBA).

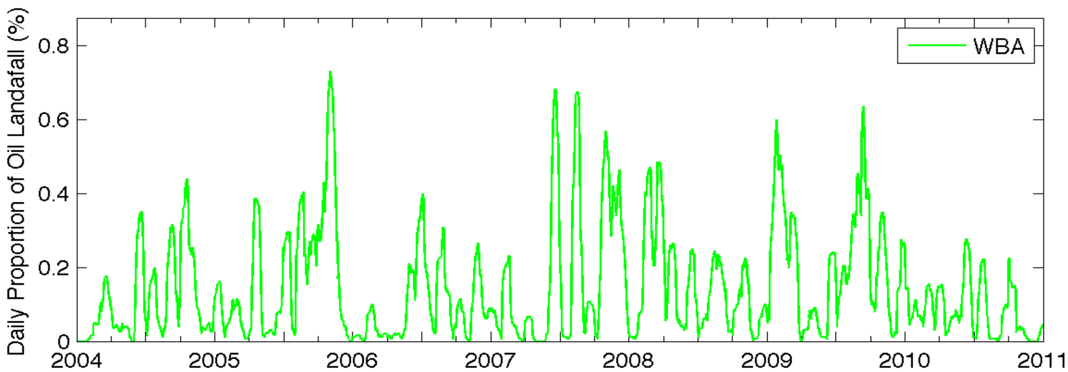


Figure D.2.3: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in the Western Bahamas (WBA).

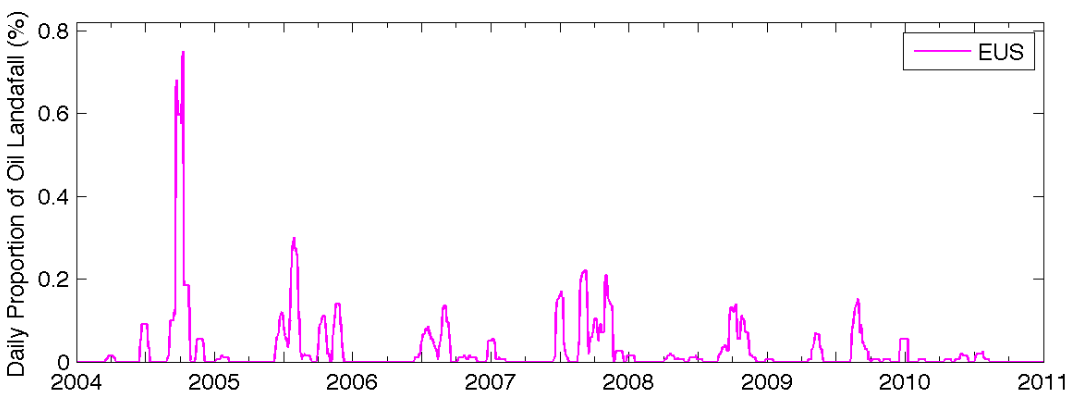


Figure D.2.4: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in the Eastern U.S. coast (EUS).

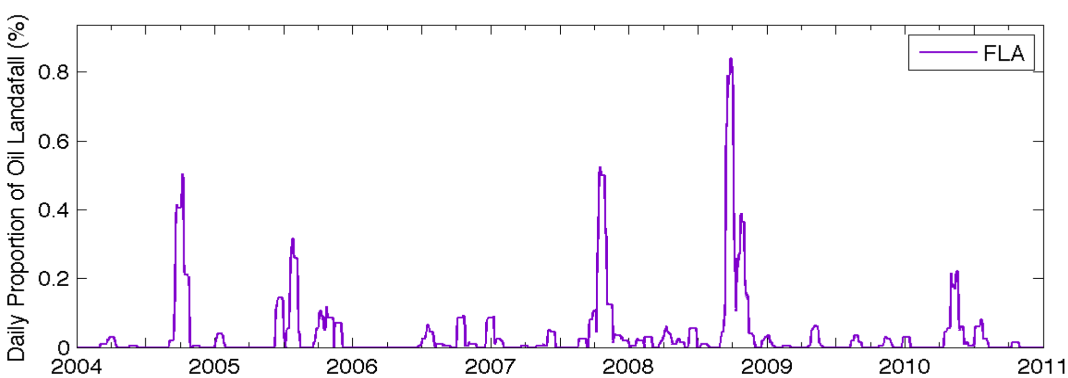


Figure D.2.5: Time series of oil landfall deep daily spills at low flow rate from January 2004 to December 2010 in the Southeastern coast of Florida (FLA).

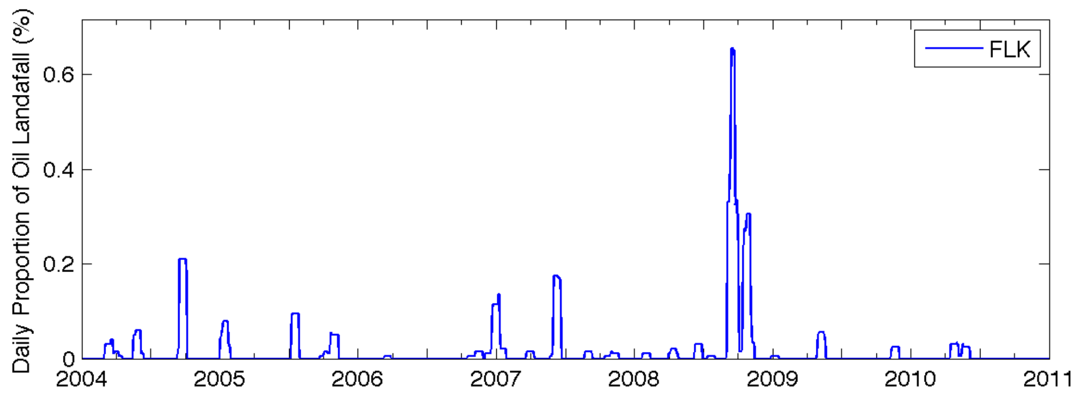


Figure D.2.6: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in the Florida Keys (FLK).

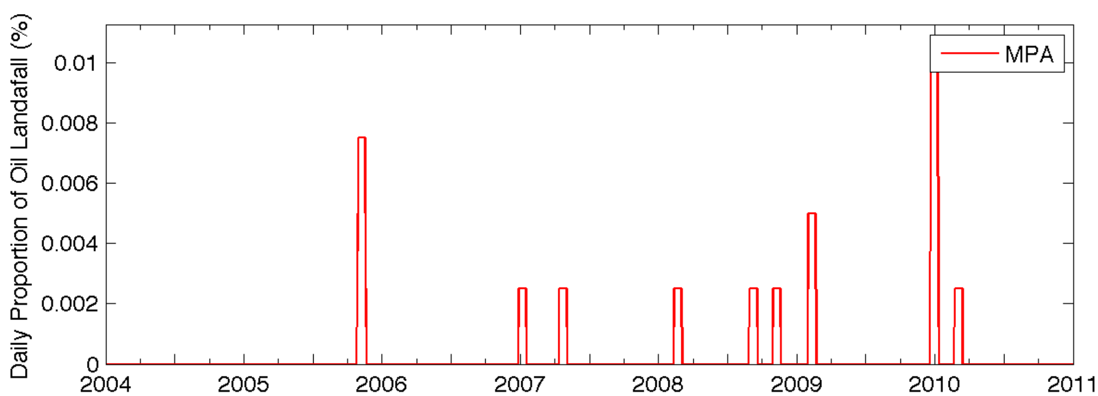


Figure D.2.7: Time series of oil landfall from deep daily spills at low flow rate from January 2004 to December 2010 in five Bahamian Marine Reserves or Marine Protected Areas (MPA).

APP6.3 OIL LANDFALL (SEABED RELEASE-high discharge rate)

Oil landfall frequency is expressed as the daily proportion of oil reaching coastal polygons from the total daily oil discharge (high rate: 3,200 m^3/day). The time series are used to select periods of high magnitude of coastal oiling. To take into account the overlap of daily spills (i.e., 40-day life time), we ran a 20-day moving average on the daily frequencies, which smoothed out variations without changing the timing of the peaks. Note that: 1) the graphs presented for each regional group of polygons have different y-axis scales for better visualization; 2) the colors of the time series match the group of polygons from Figure 2.2.

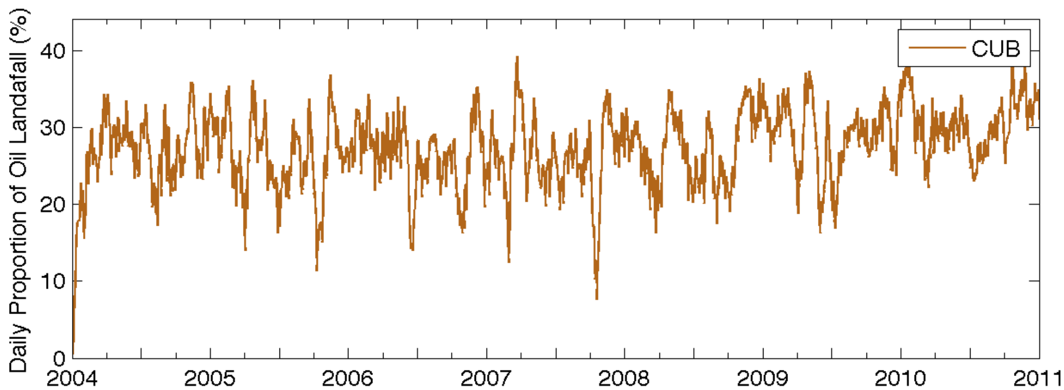


Figure D.2.8: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 in North Central and Northwest Cuba.

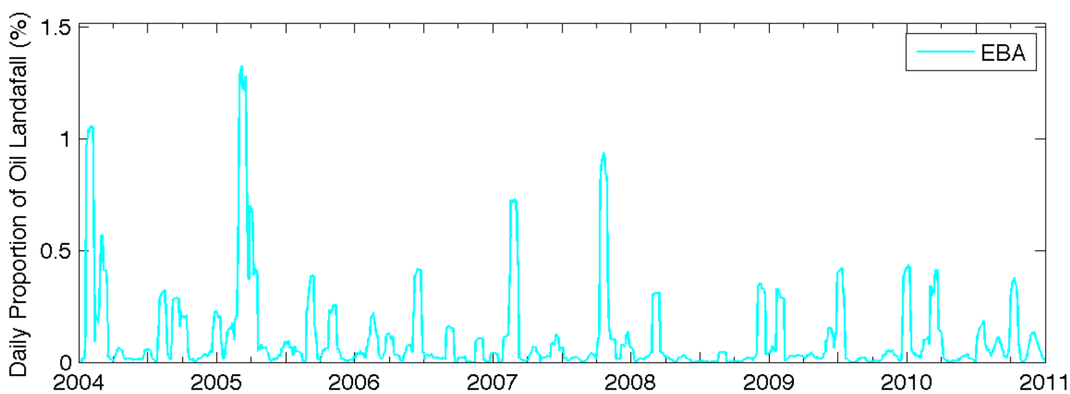


Figure D.2.9: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 in the Eastern Bahamas (EBA).

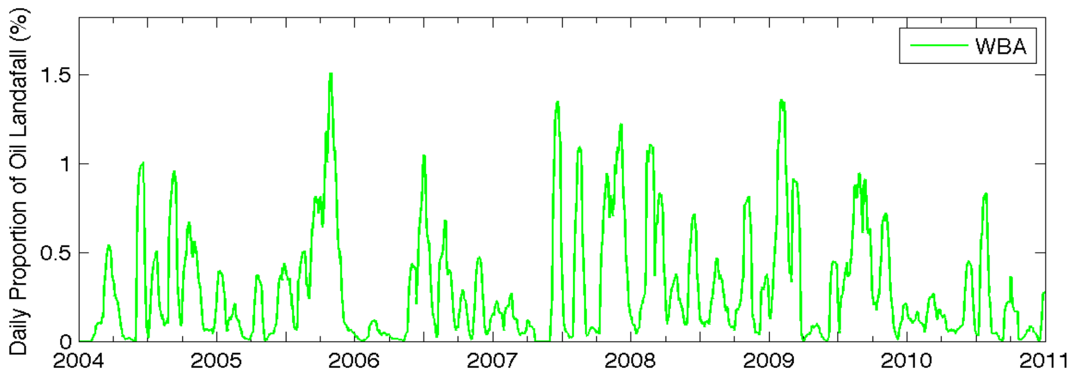


Figure D.2.10: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 in the Western Bahamas (WBA).

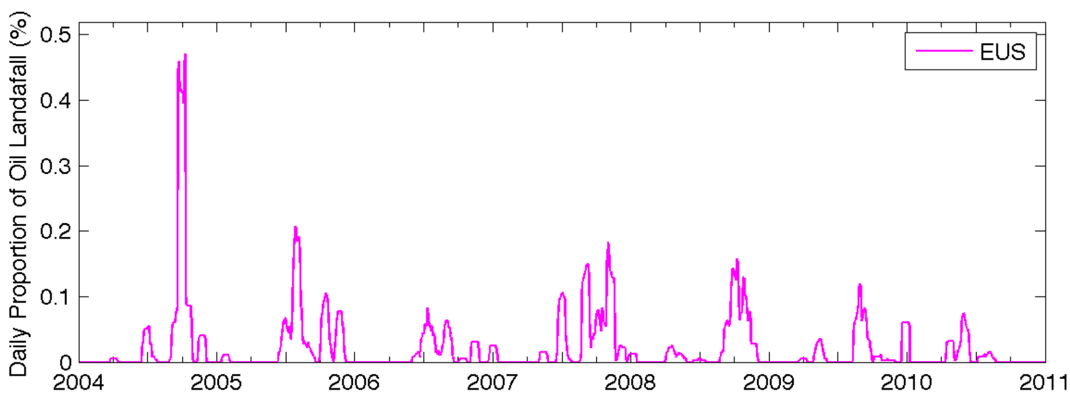


Figure D.2.11: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 in the Eastern U.S. coast (EUS).

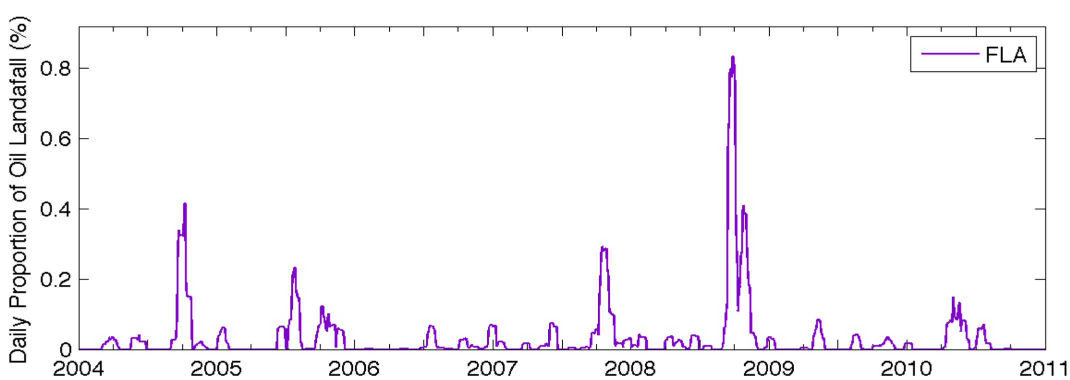


Figure D.2.12: Time series of oil landfall deep daily spills at high flow rate from January 2004 to December 2010 in the Southeastern coast of Florida (FLA).

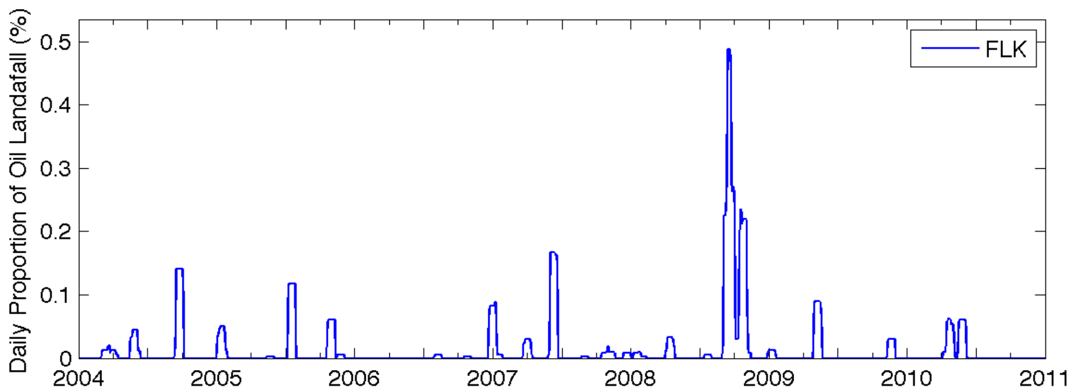


Figure D.2.13: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 in the Florida Keys (FLK).

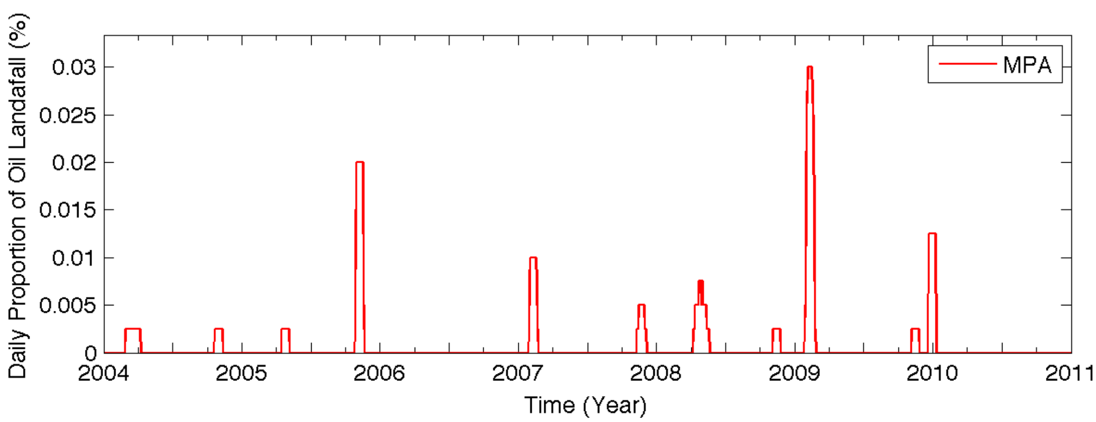


Figure D.2.14: Time series of oil landfall from deep daily spills at high flow rate from January 2004 to December 2010 five Bahamian Marine Reserves or Marine Protected Areas (MPA).

APP6.4 PROBABILITY OF COASTLINE OILING (SURFACE RELEASE)

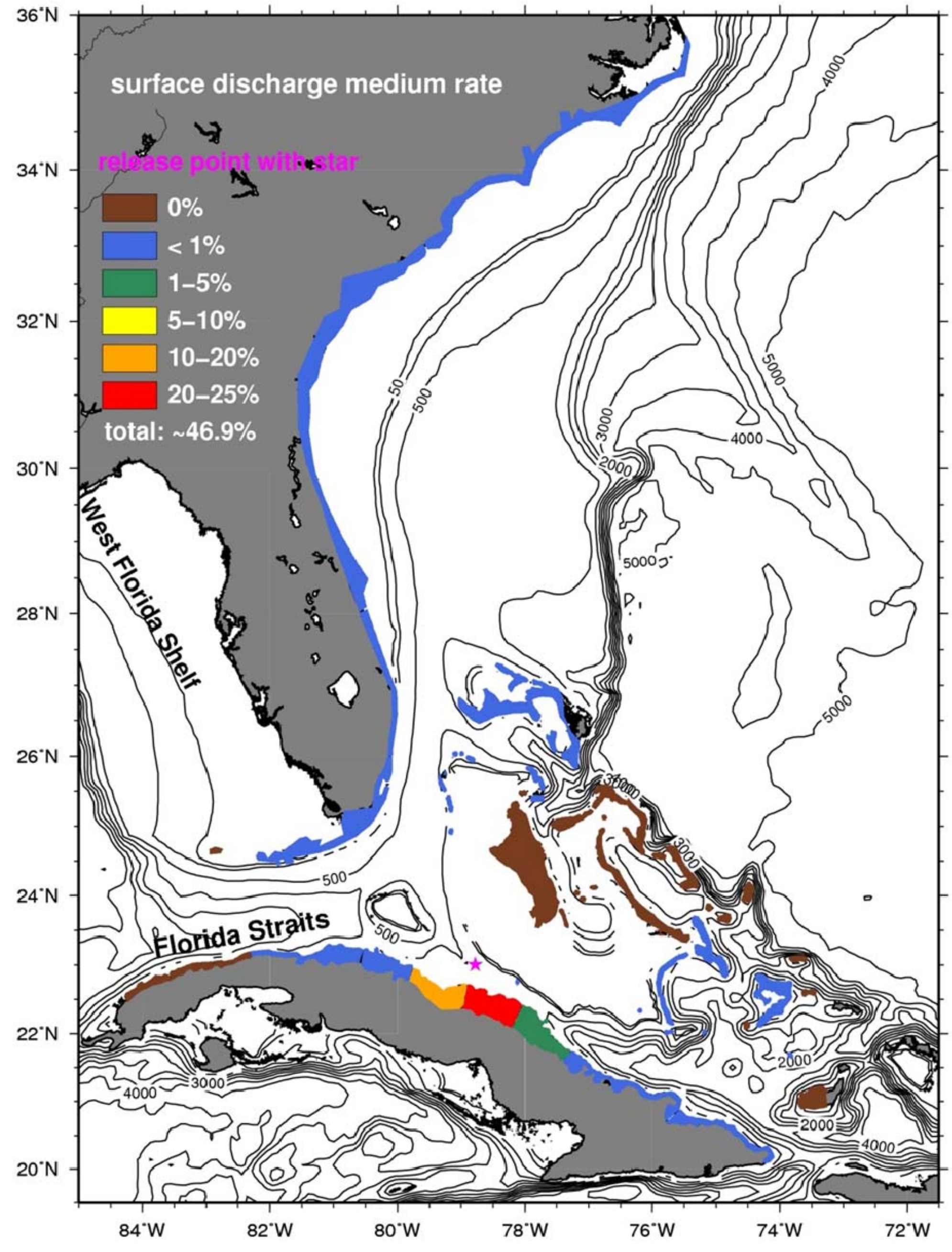


Figure D.4: Map displaying probability distribution of oiling on the coastline from the long term simulation over the 2004-2010 7 year periods. About 46.9 % of total released particles landed on the coastline with a maximum landing on the northern Cuban coast (in red). NOTE: release location is marked with a magenta star. There are some coastlines with no particles landed (in dark brown) mostly in eastern Bahamas and Dry Tortugas.

APP6.5 PROBABILITY OF COASTLINE OILING (SEABED RELEASE-low discharge rate)

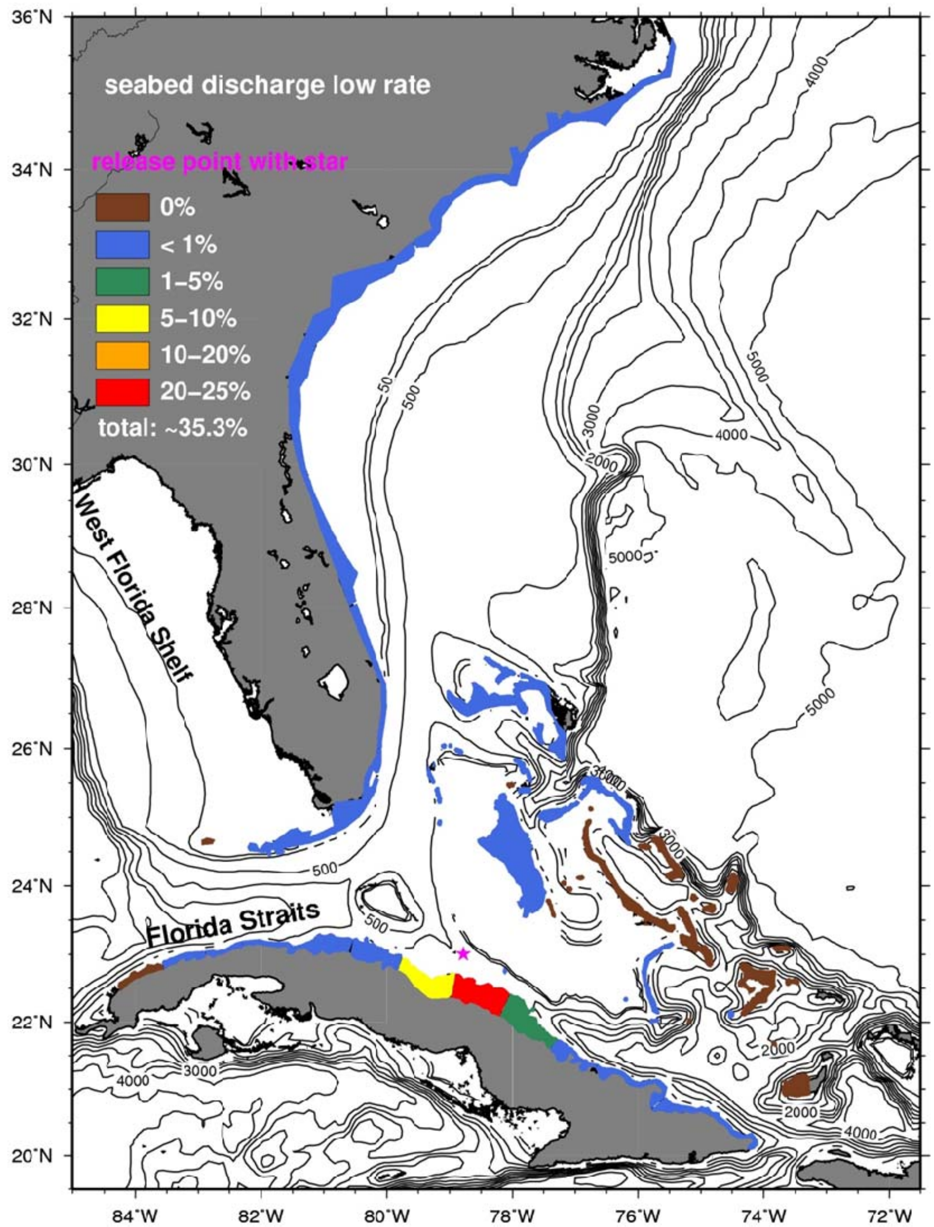


Figure D.5: Map displaying probability distribution of oiling on the coastline from the long term simulation over the 2004-2010 7 year periods. About 35.3 % of total released particles landed on the coastline with a maximum landing on the northern Cuban coast (in red). NOTE: release location is marked with a magenta star. There are some coastlines with no particles landed (in dark brown) mostly in eastern Bahamas and Dry Tortugas.

APP6.6 PROBABILITY OF COASTLINE OILING (SEABED RELEASE-high discharge rate)

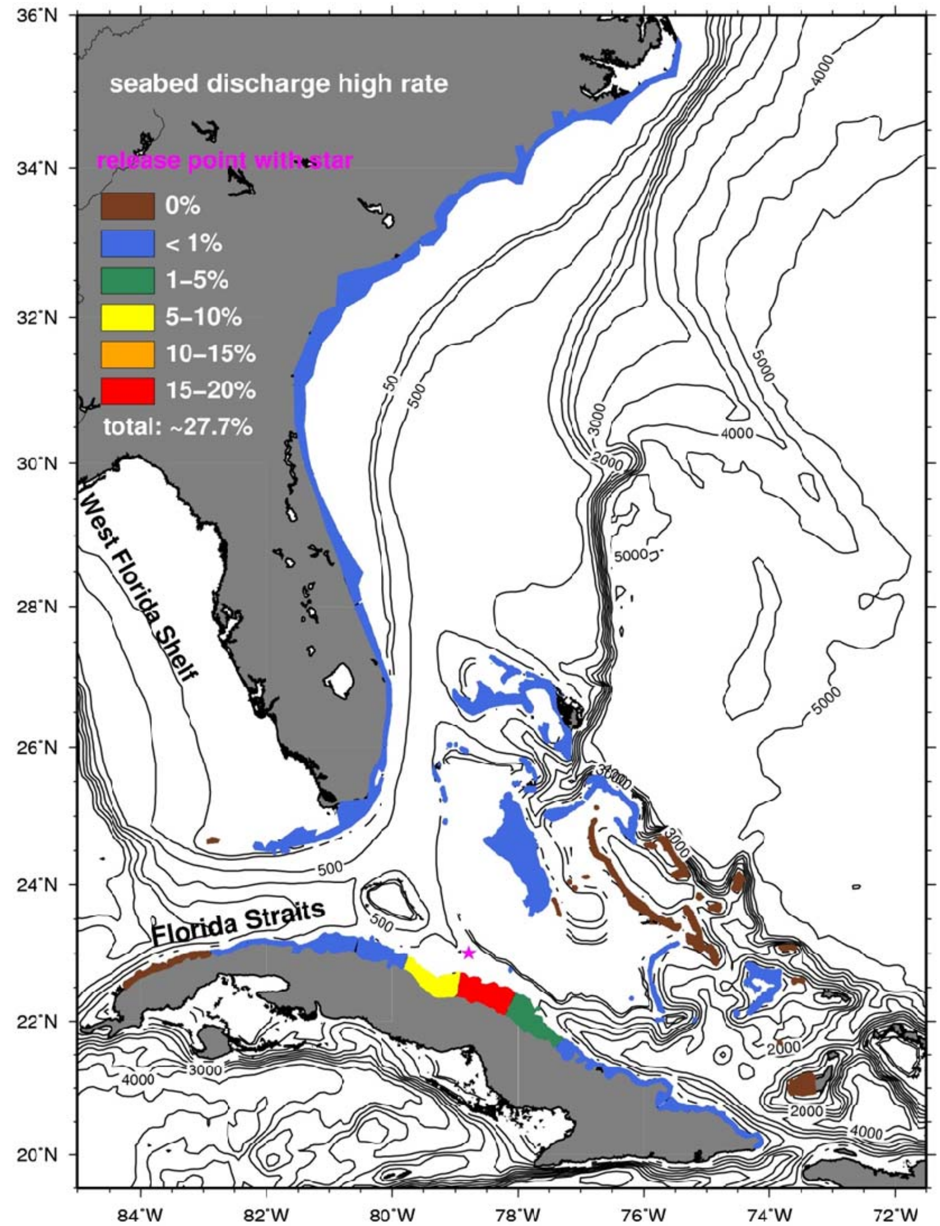


Figure D.6: Map displaying probability distribution of oiling on the coastline from the long term simulation over the 2004-2010 7 year periods. About 27.7 % of total released particles landed on the coastline with a maximum landing on the northern Cuban coast (in red). NOTE: release location is marked with a magenta star. There are some coastlines with no particles landed (in dark brown) mostly in eastern Bahamas and Dry Tortugas.

APP6.7 SHORELINE EXPOSURE TO OIL (SURFACE RELEASE)

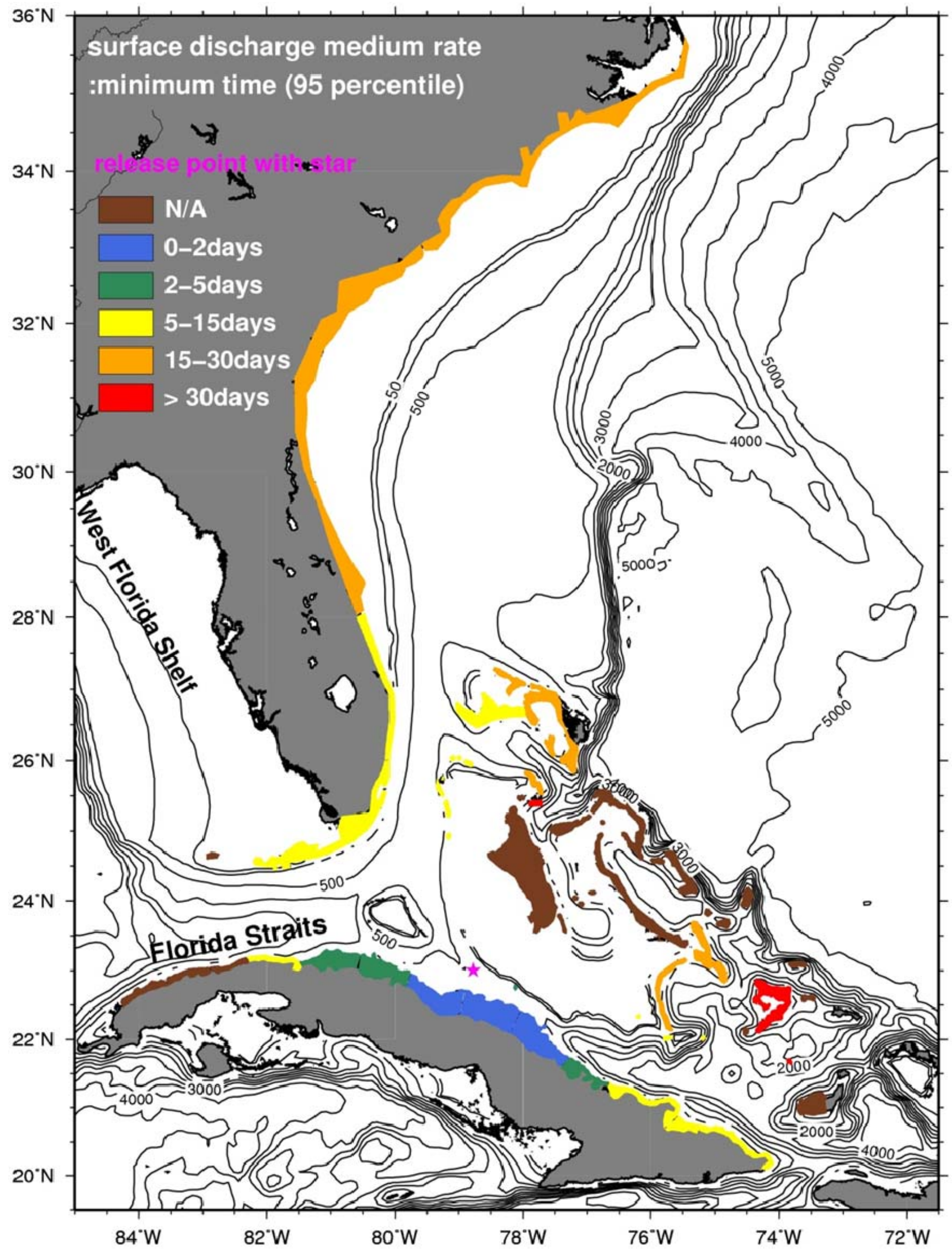


Figure D.7.1: Map displaying minimum time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

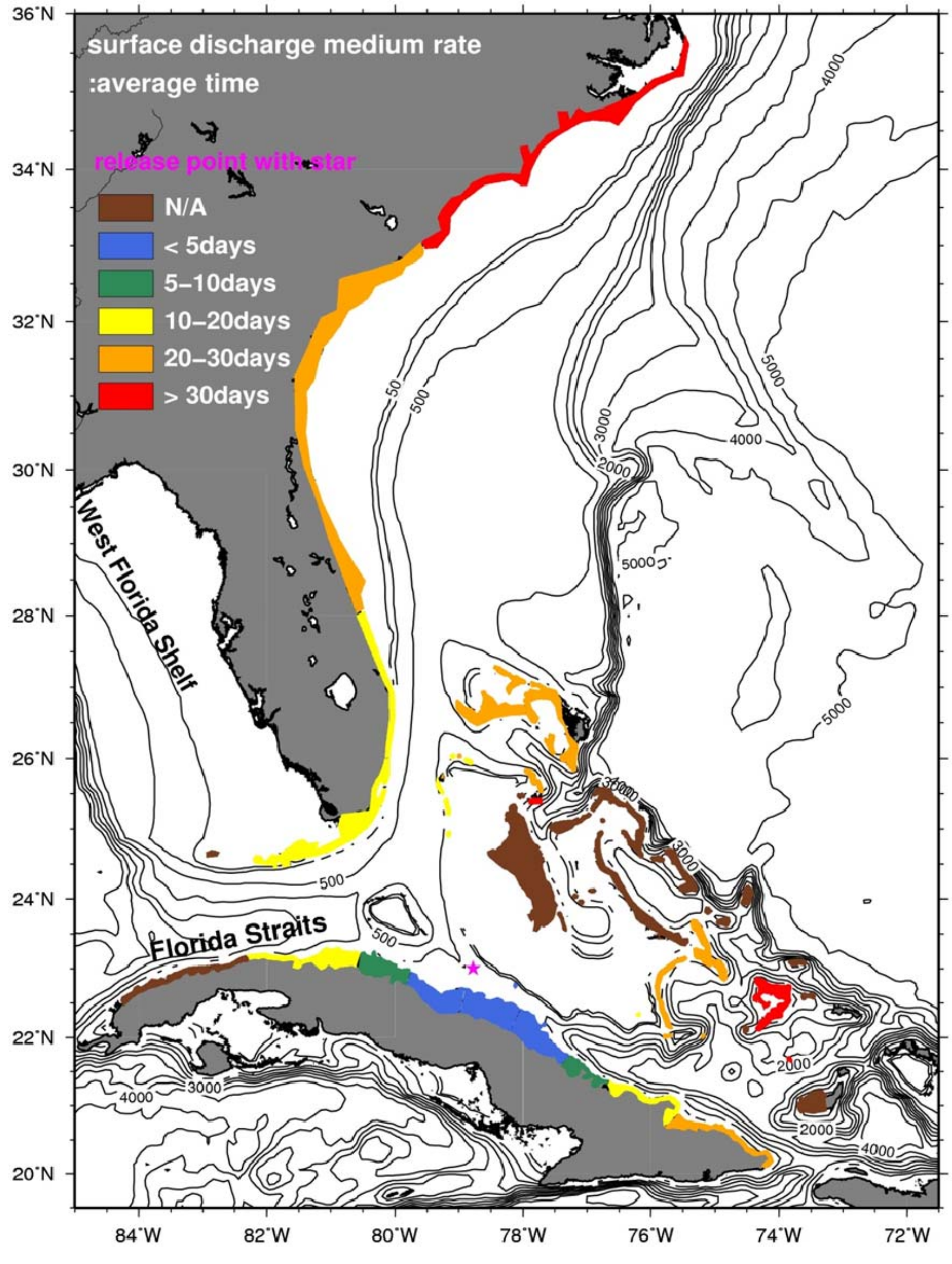


Figure D.7.2: Map displaying average time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

APP6.8 SHORELINE EXPOSURE TO OIL (SEABED RELEASE-low discharge rate)

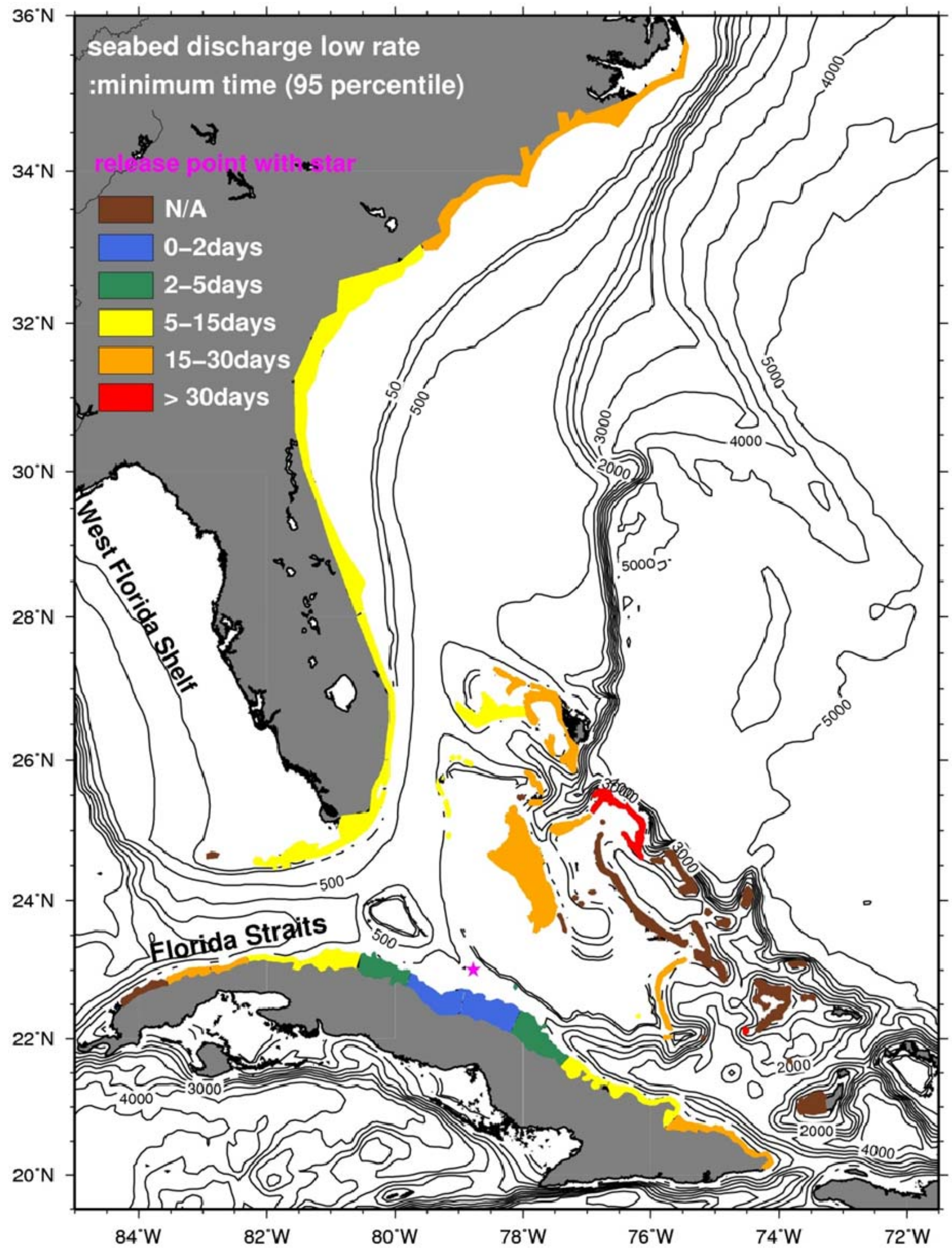


Figure D.8.1: Map displaying minimum time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

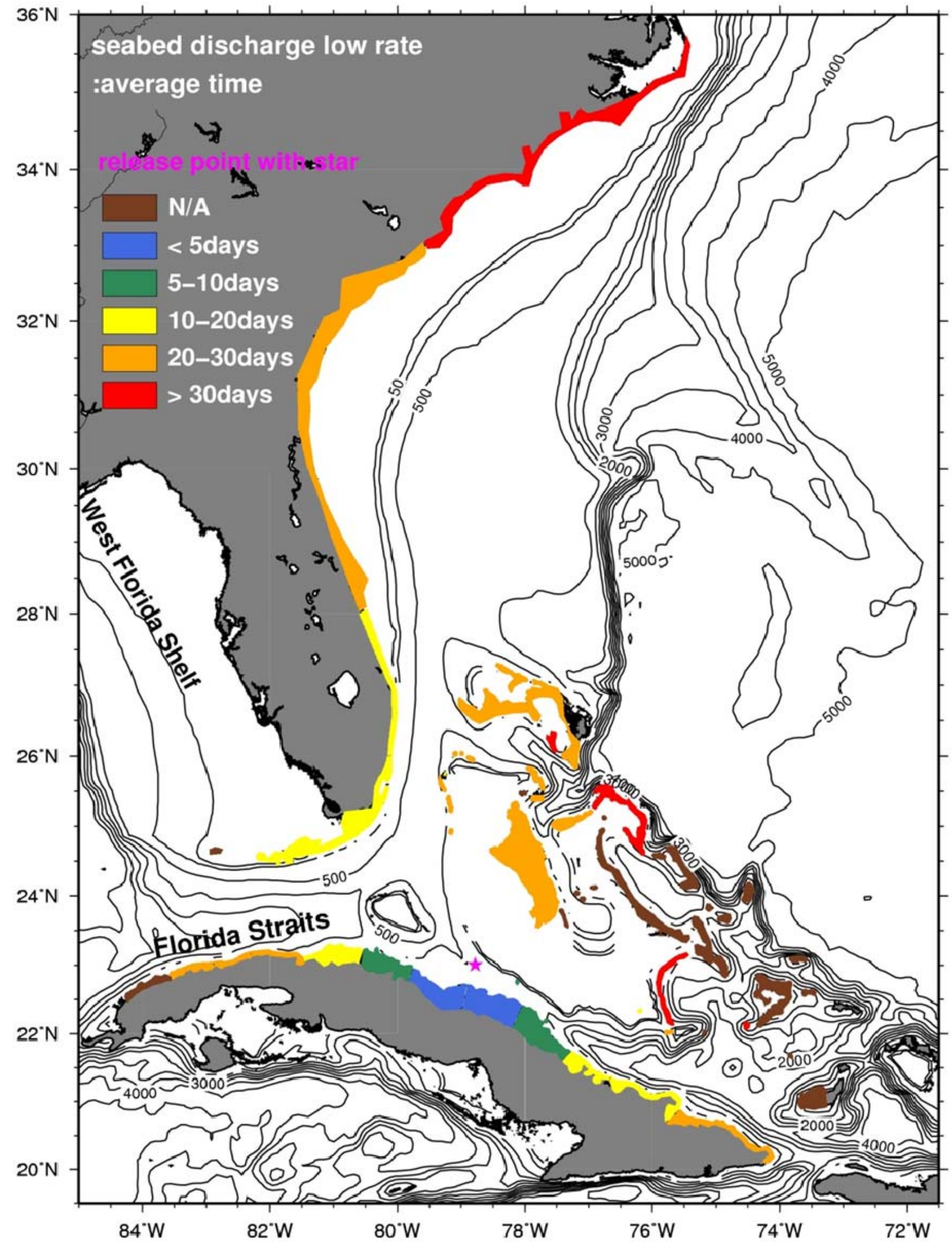


Figure D.8.2: Map displaying average time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

APP6.9 SHORELINE EXPOSURE TO OIL (SEABED RELEASE-high discharge rate)

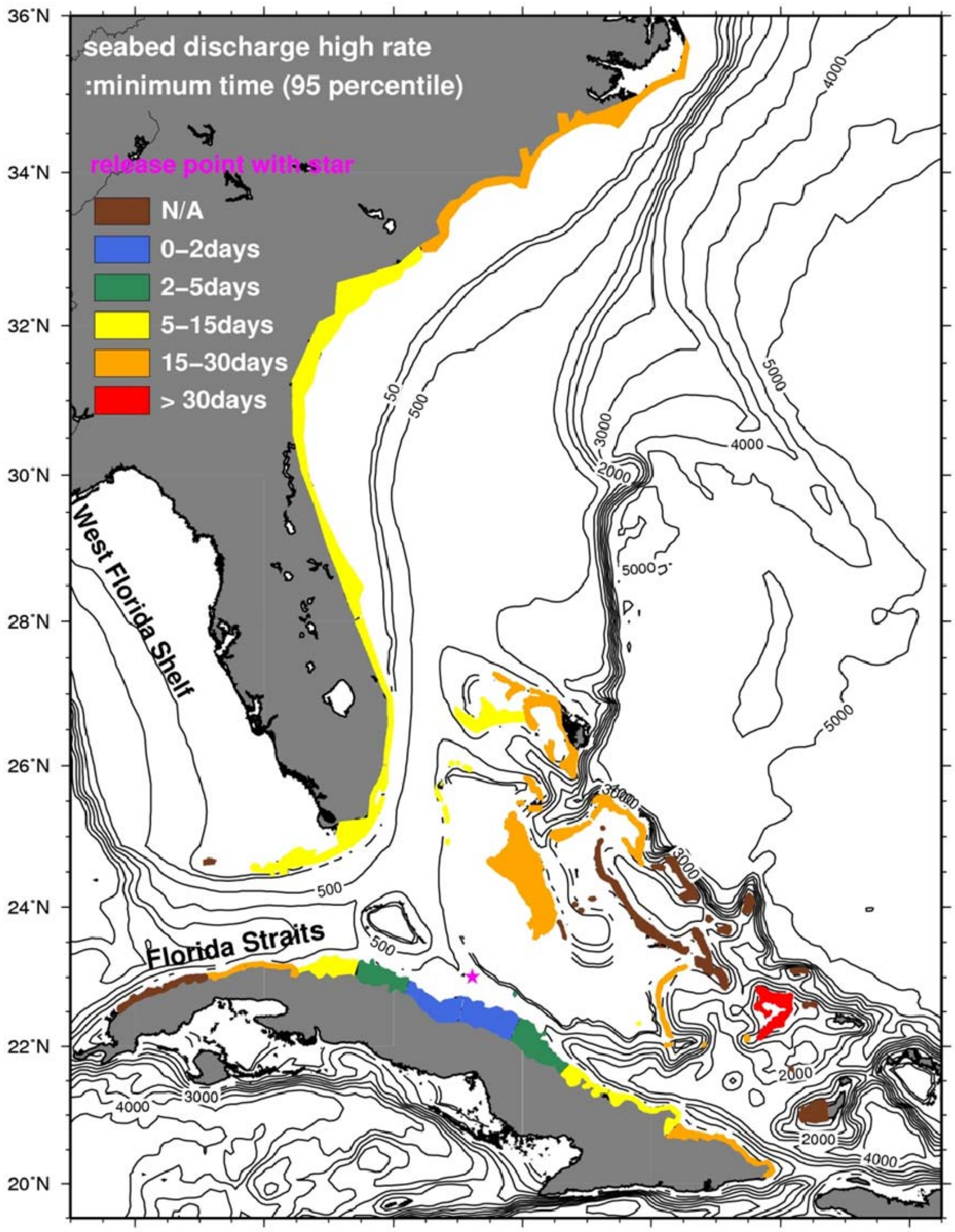


Figure D.9.1: Map displaying minimum time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in Eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

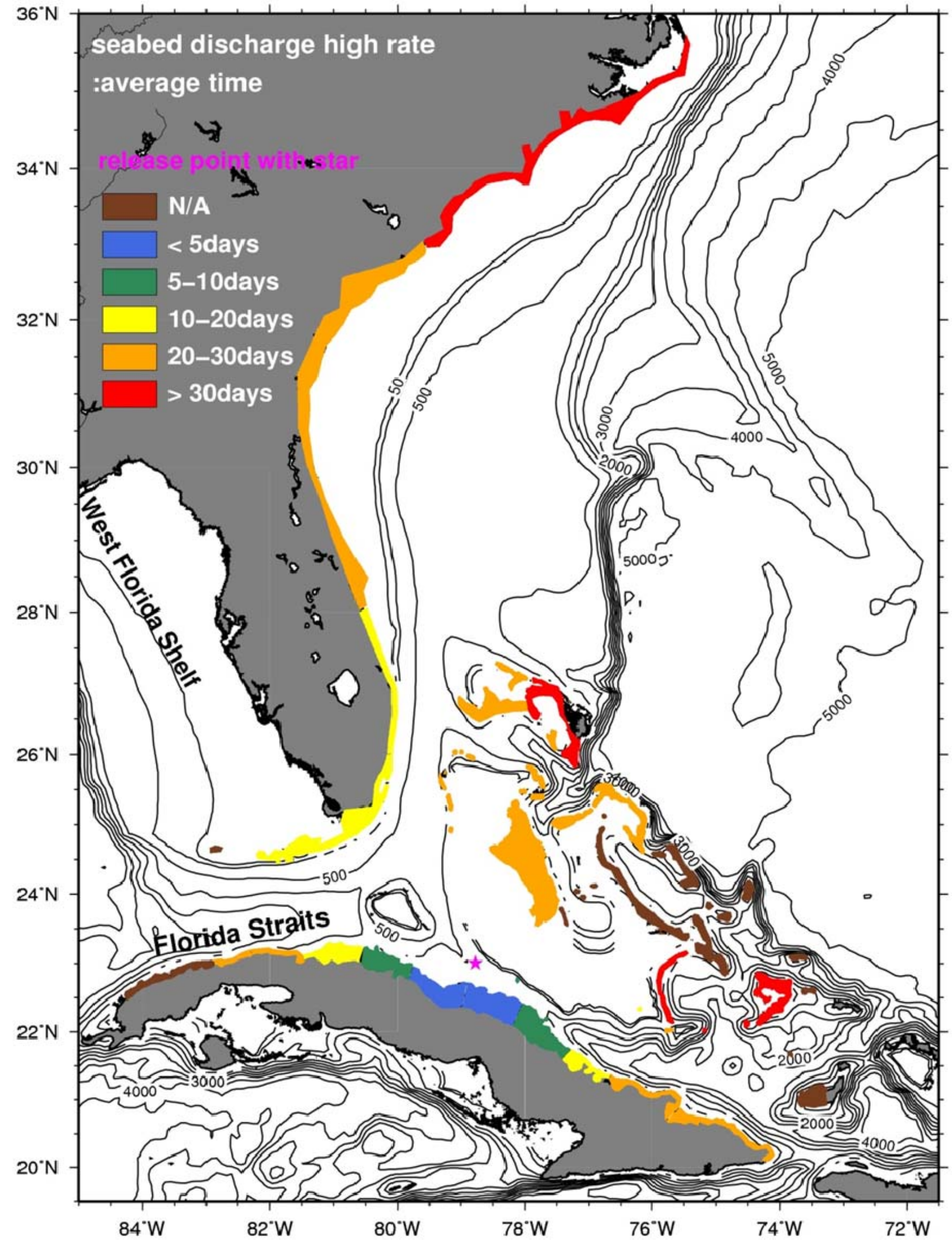


Figure D.9.2: Map displaying average time to shoreline exposure to oil. There are some coastlines with no particles landed (in dark brown) mostly in eastern Bahamas and Dry Tortugas. The release location is marked with a magenta star.

APP6.10 OIL ON SEA SURFACE (SURFACE RELEASE)

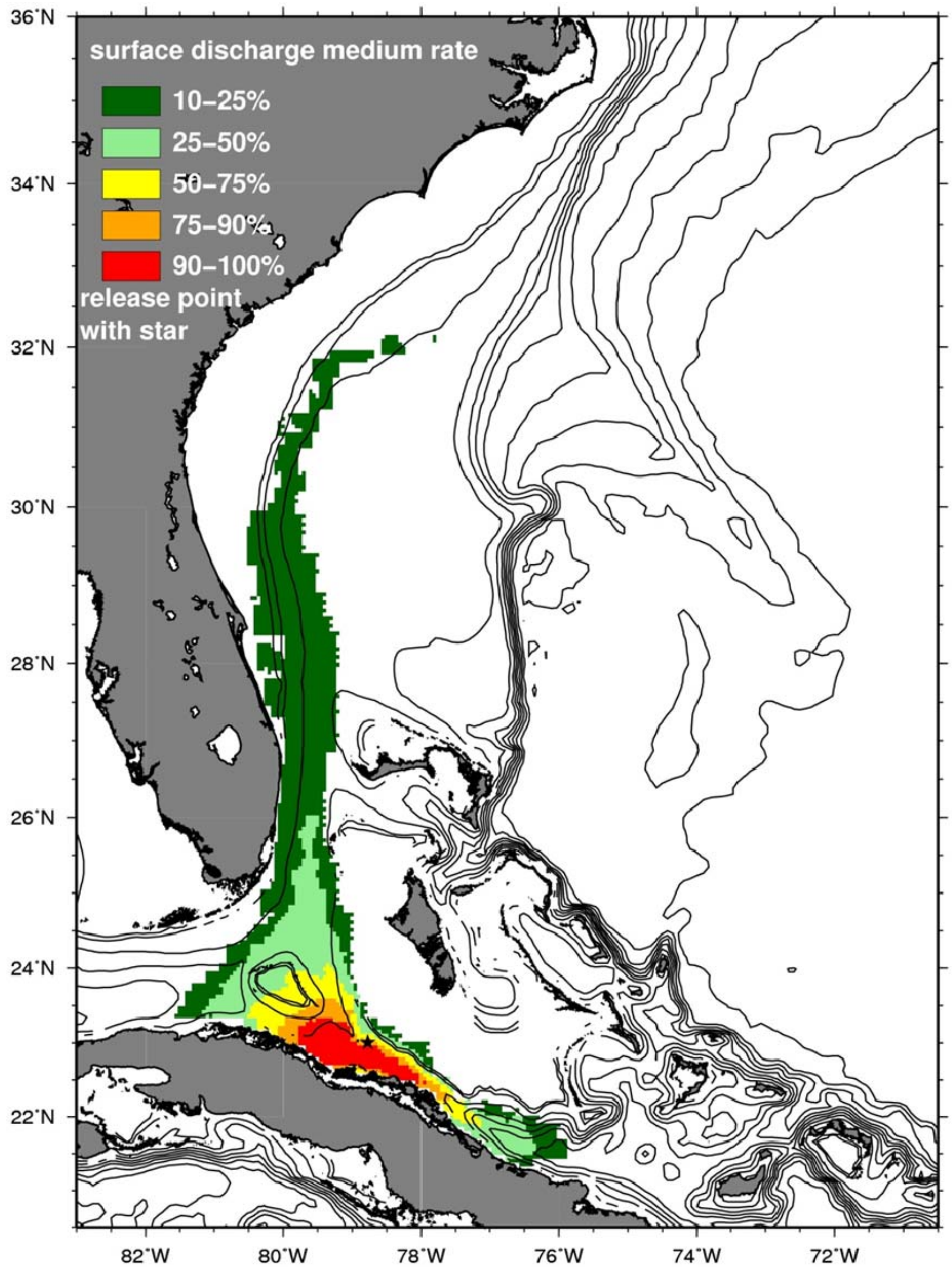


Figure D.10: Map of probability of oil presence (%) at the surface, in case of a surface release for 60 days with a medium discharge rate of 2,400 m^3/day. This quantity is defined as the probability to observe oil sheen (surface concentration > 0.05 μm) at the surface during a 90-day duration spill (see section 4.4). The release location is marked with a black star.

APP6.11 OIL ON SEA SURFACE (SEABED RELEASE-low discharge rate)

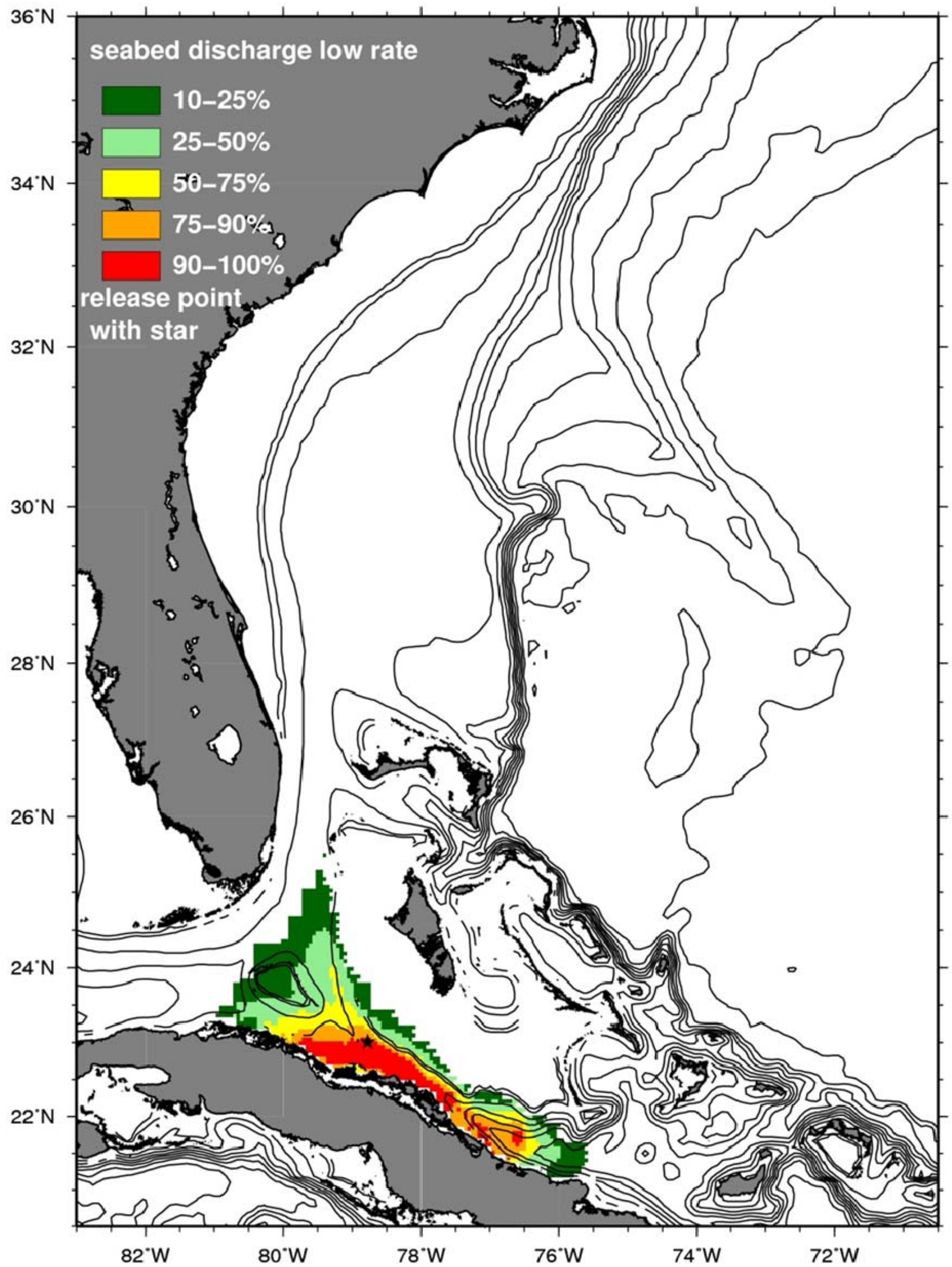


Figure D.11: Map of probability of oil presence (%) at the surface, in case of a seabed release-low rate deep release for 60 days with a low discharge rate of 1,600 m^3/day. This quantity is defined as the probability to observe oil sheen (surface concentration > 0.05 µm) at the surface during a 90-day duration spill (see section 4.4). The release location is marked with a black star.

APP6.12 OIL ON SEA SURFACE (SEABED RELEASE-high discharge rate)

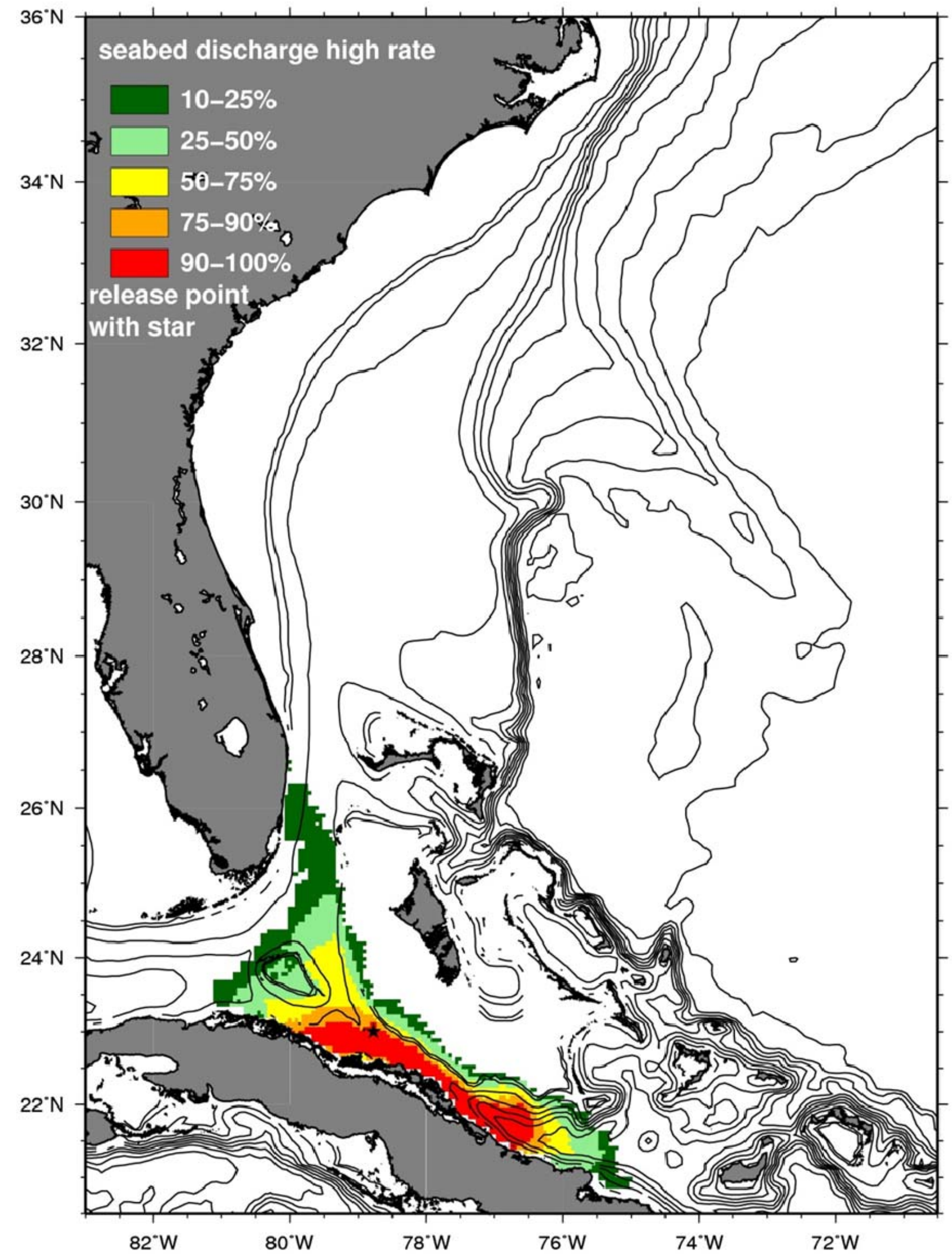


Figure D.12: Map of probability of oil presence (%) at the surface, in case of a seabed release-high rate deep release for 60 days with a high discharge rate of 3,200 m^3/day. This quantity is defined as the probability to observe oil sheen (surface concentration > 0.05 μm) at the surface during a 90-day duration spill (see section 4.4). The release location is marked with a black star.

APP7: INDIVIDUAL SCENARIO SIMULATION RESULTS (Part 2)

APP7.1 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SURFACE RELEASE/CASE B1)

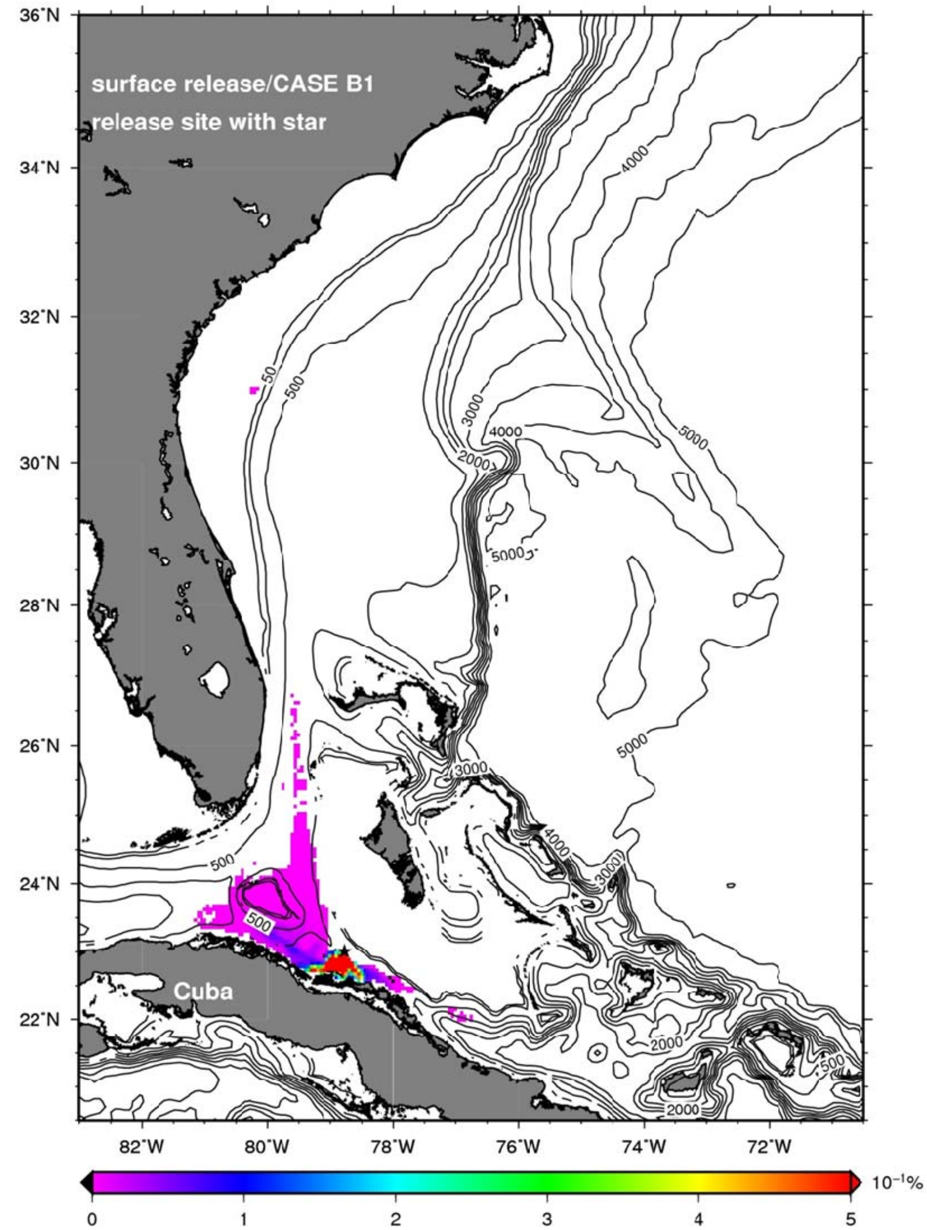


Fig. D.13: Probability density distribution of the oil at the surface (upper 20m) for the situation with shortest time of oil to shore (Case B1), February 2009. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.1. The spill site is marked with a black star. Magenta areas denote minimal probability (less than 0.02%).

APP7.2 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SURFACE RELEASE/CASE B2)

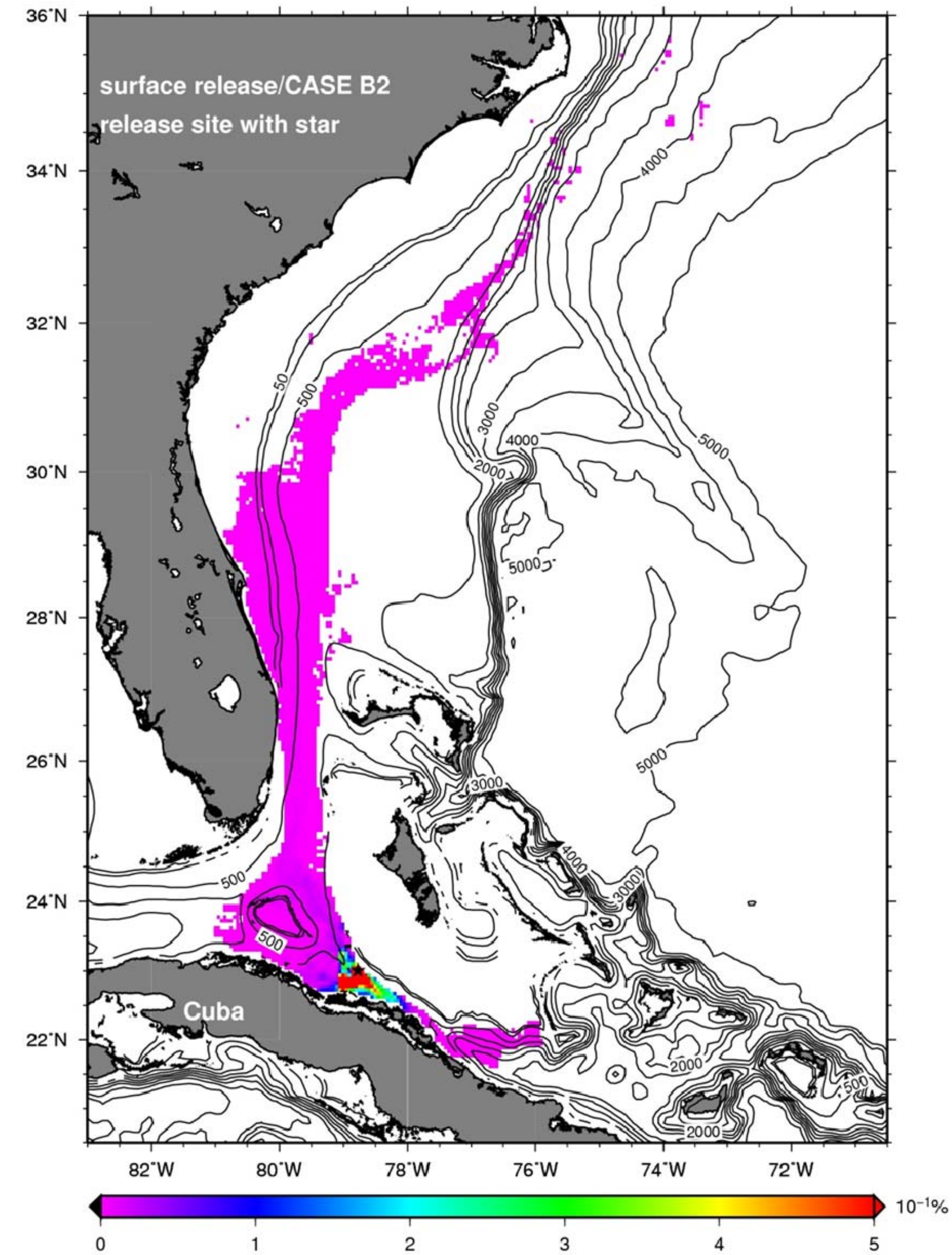


Fig. D.14: Probability density distribution of the oil at the surface (upper 20m) for the situation with maximum shoreline oiled area (Case B2), September 2008. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.2. The spill site is marked with a black star. Magenta areas denote minimal probability (less than 0.02%).

APP7.3 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SURFACE RELEASE/CASE B3)

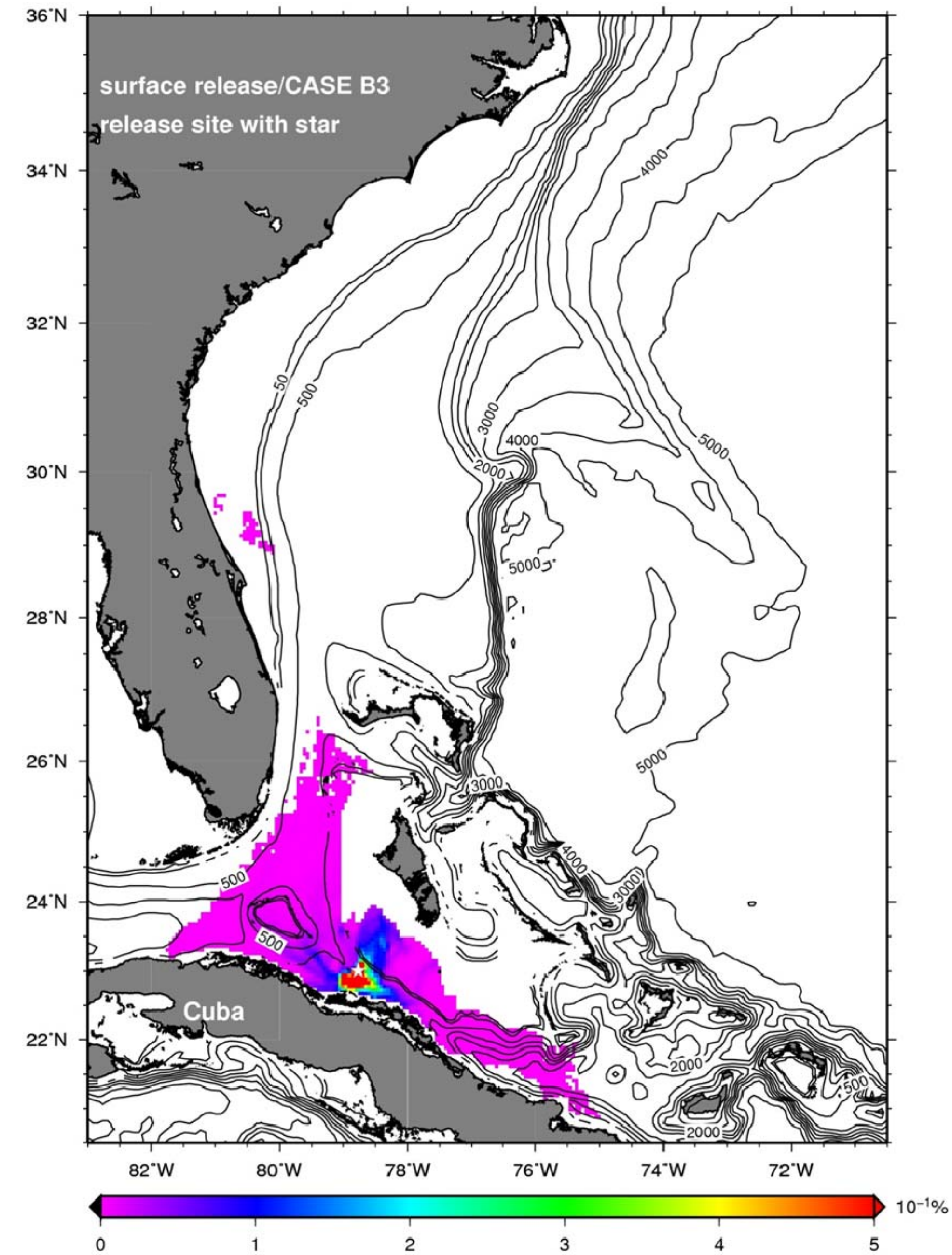


Fig. D.15: Probability density distribution of the oil at the surface (upper 20m) for the situation with hurricane Wilma (Case B3), October 2005. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.2. The spill site is marked with a white star. Magenta areas denote minimal probability (less than 0.02%).

APP7.4 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SEABED RELEASE/CASE B4)

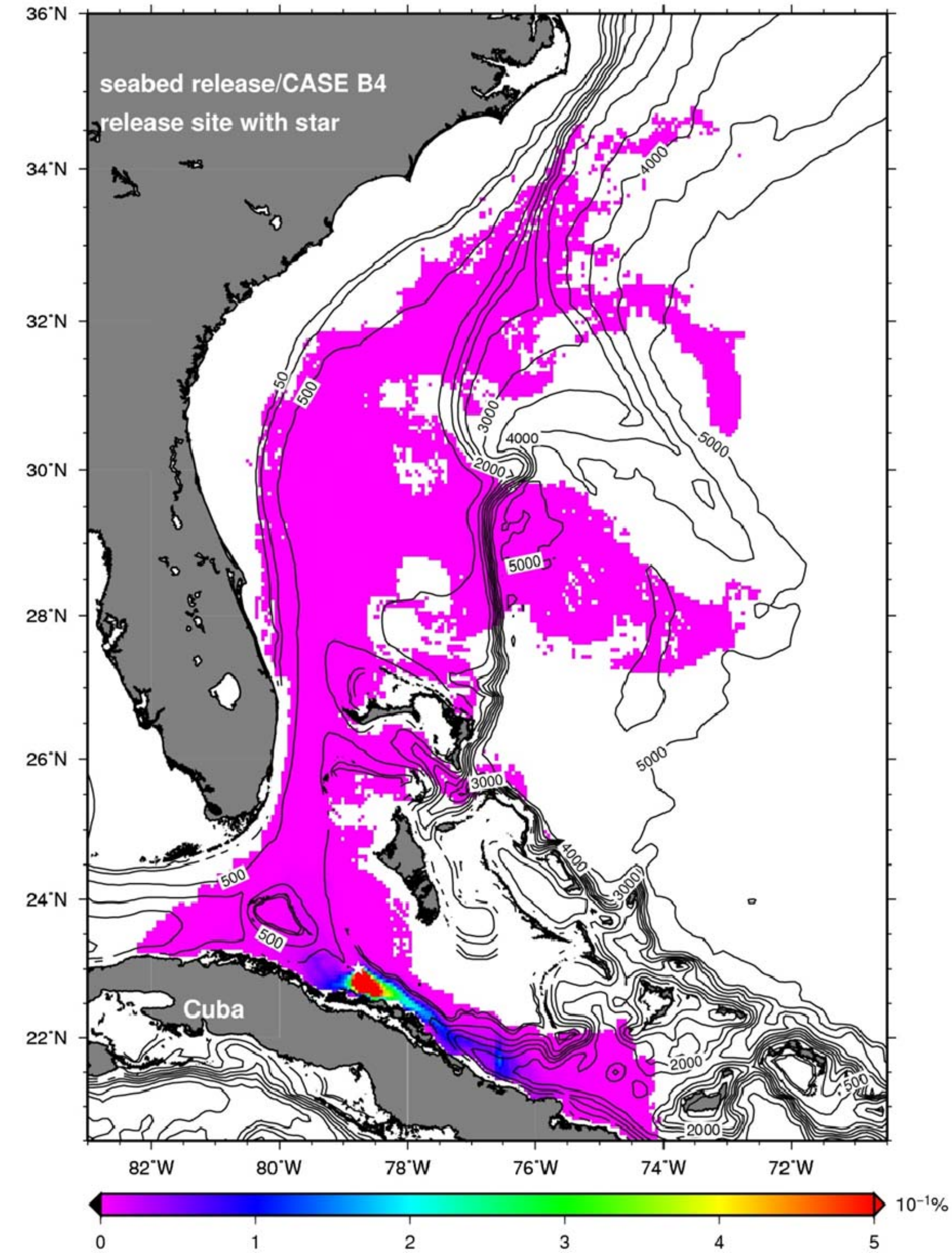


Fig. D.16: Probability density distribution of the oil at the surface (upper 20m) for the situation with shortest time of oil to shore (Case B4), January 2010. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.2. The spill site is marked with a white star. Magenta areas denote minimal probability (less than 0.02%).

APP7.5 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SEABED RELEASE/CASE B5)

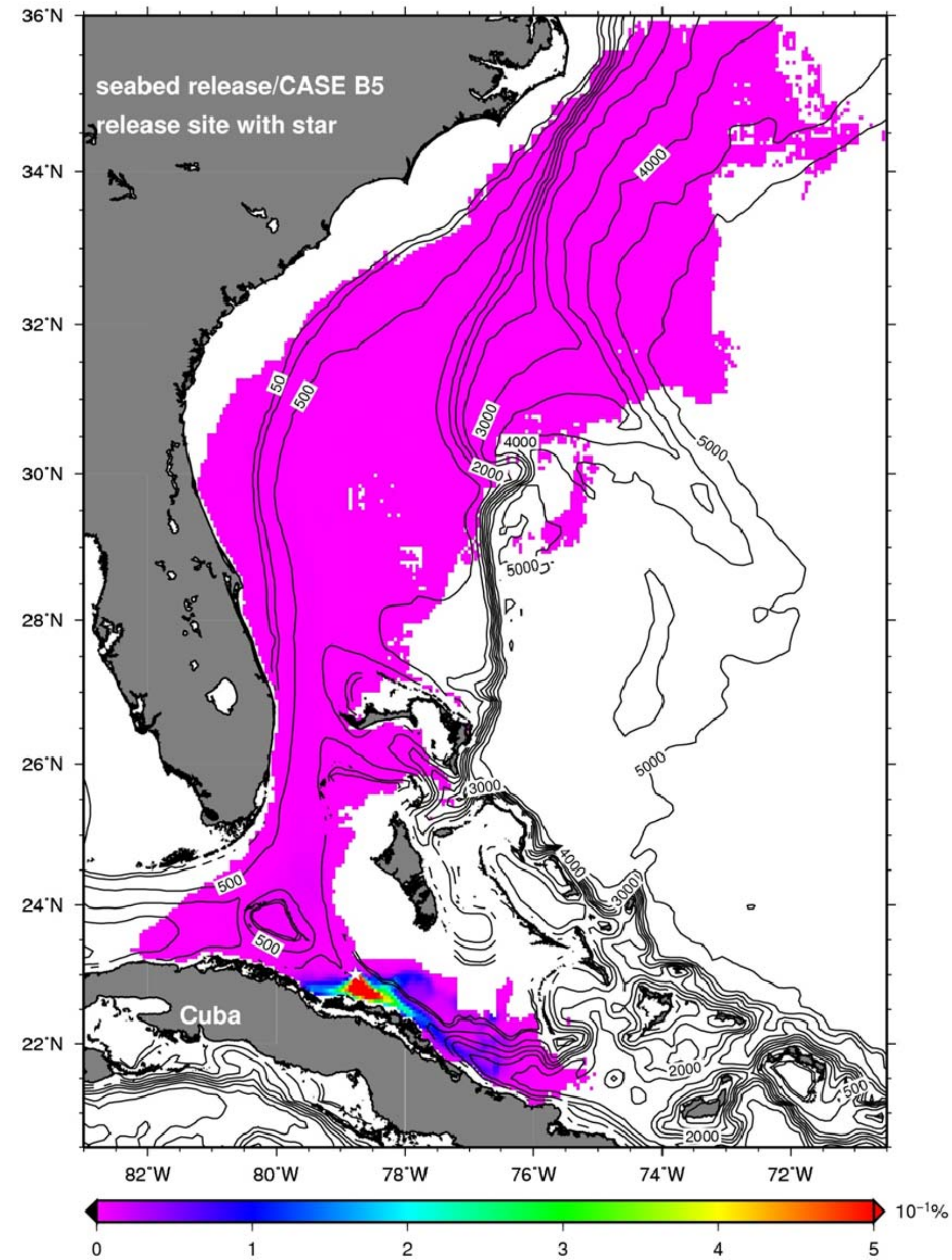


Fig. D.17: Probability density distribution of the oil at the surface (upper 20m) for the situation with maximum shoreline oiled area (Case B5), October 2007. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.2. The spill site is marked with a white star. Magenta areas denote minimal probability (less than 0.02%).

APP7.6 PROBABILITY DENSITY DISTRIBUTION OF THE OIL AT THE SURFACE (upper 20m)-(SEABED RELEASE/CASE B6)

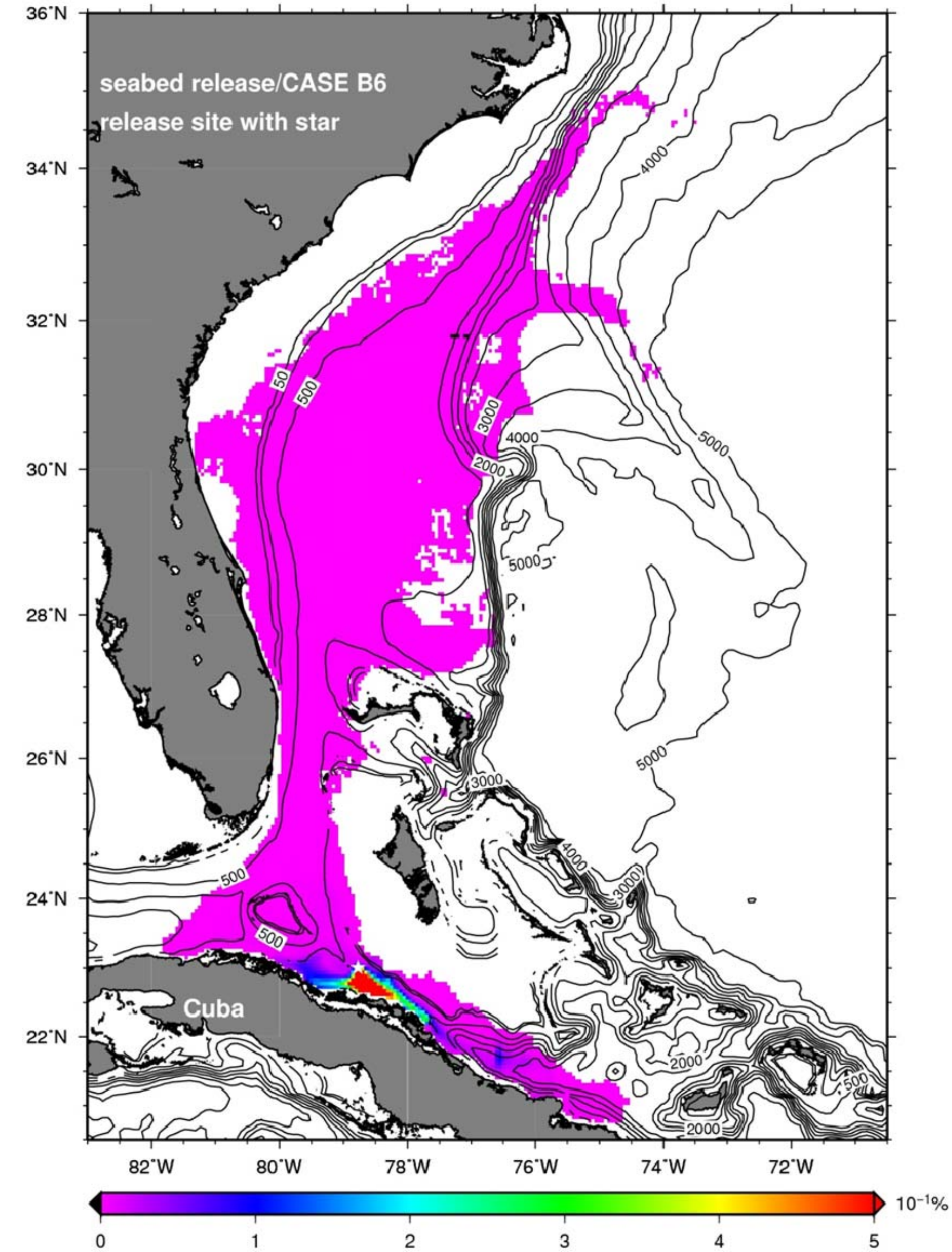


Fig. D.18: Probability density distribution of the oil at the surface (upper 20m) for the situation with maximum volume of oil entrained in the water column (Case B6), August 2006. The color scale is the % of oil particles over the total number of surface particles remaining in the domain at the end of the simulation (section 5.1); values should be divided by 10 (10^1) and they give the actual number of particles if multiplied by N(total), given in section 5.1.2. The spill site is marked with a white star. Magenta areas denote minimal probability (less than 0.02%).

APP7.7 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SURFACE RELEASE/CASE B1)

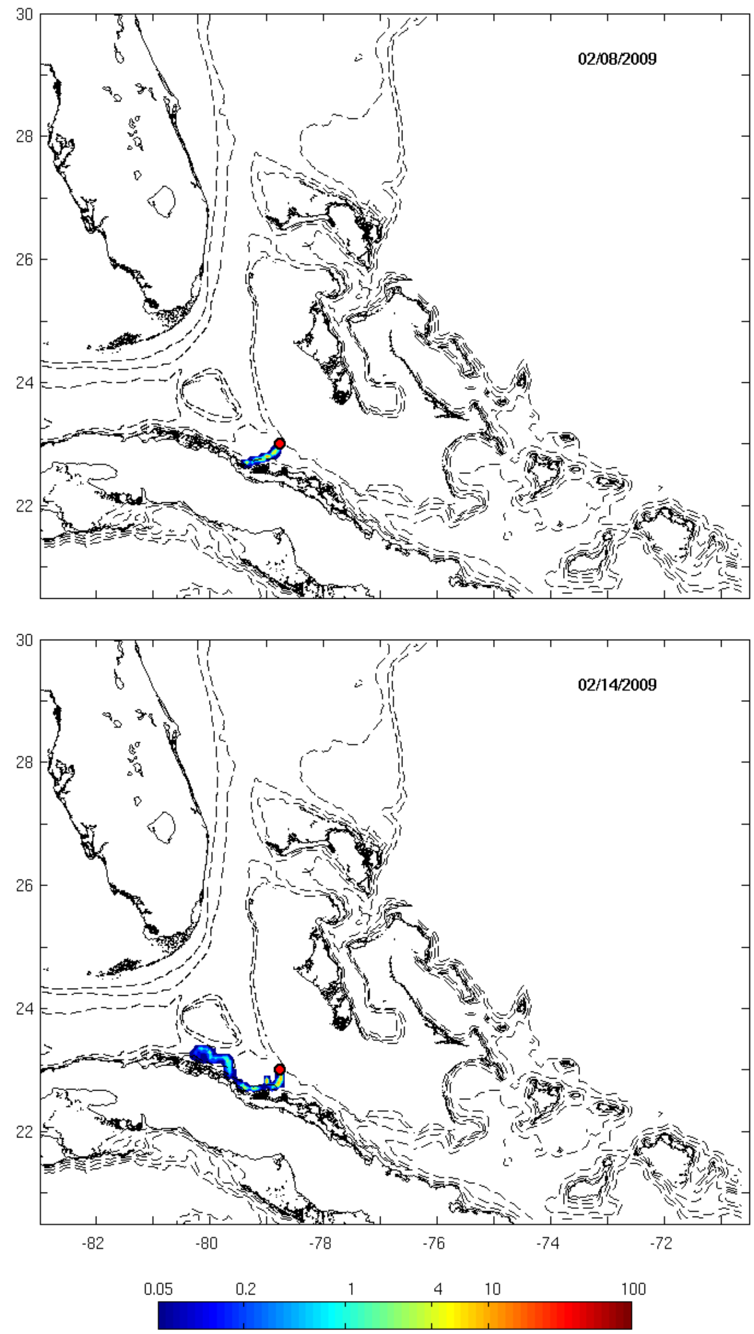


Fig. D.19a: Surface maps of oil slick thickness (CASE B1, in μm) on February 8 and February 14, 2009. The red circle indicates the origin of the spill. Animation provided separately, file D19.

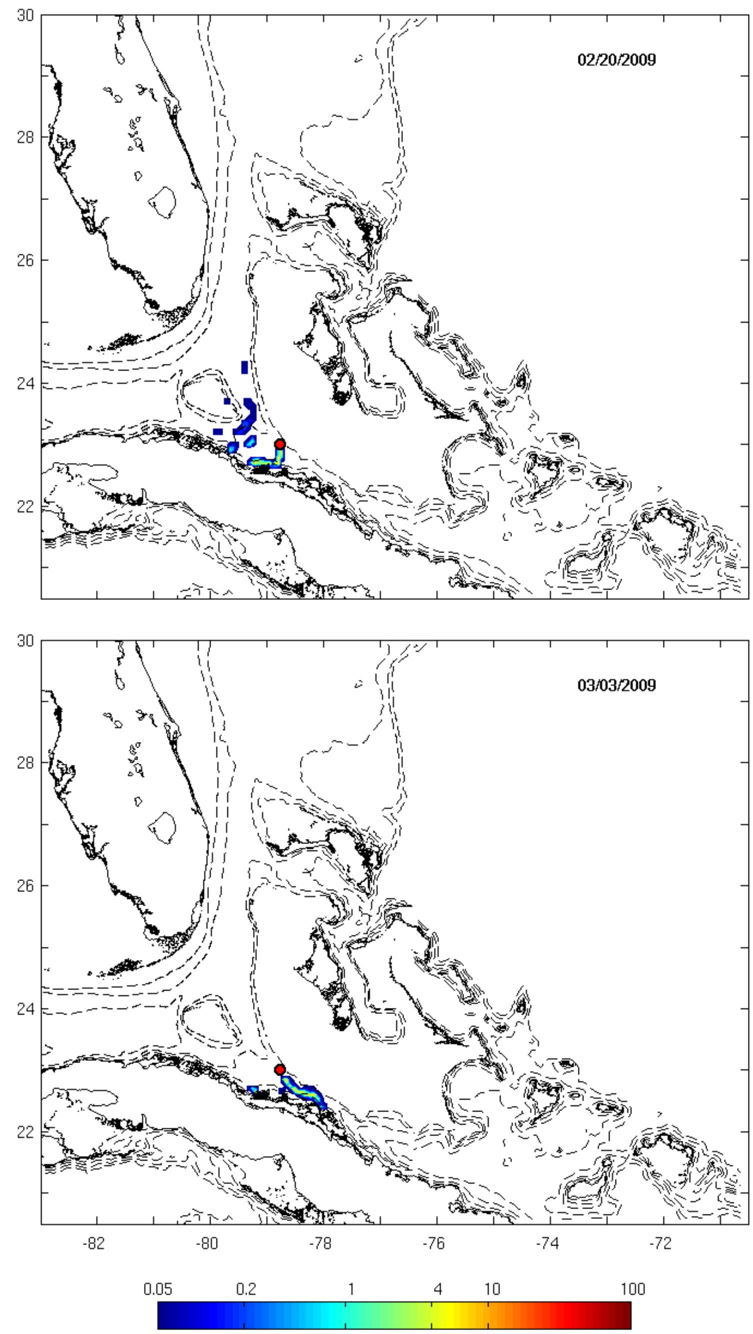


Fig. D.19b: Surface maps of oil slick thickness (CASE B1, in μm) on February 20, and March 3, 2009. The red circle indicates the origin of the spill. Animation provided separately, file D19.

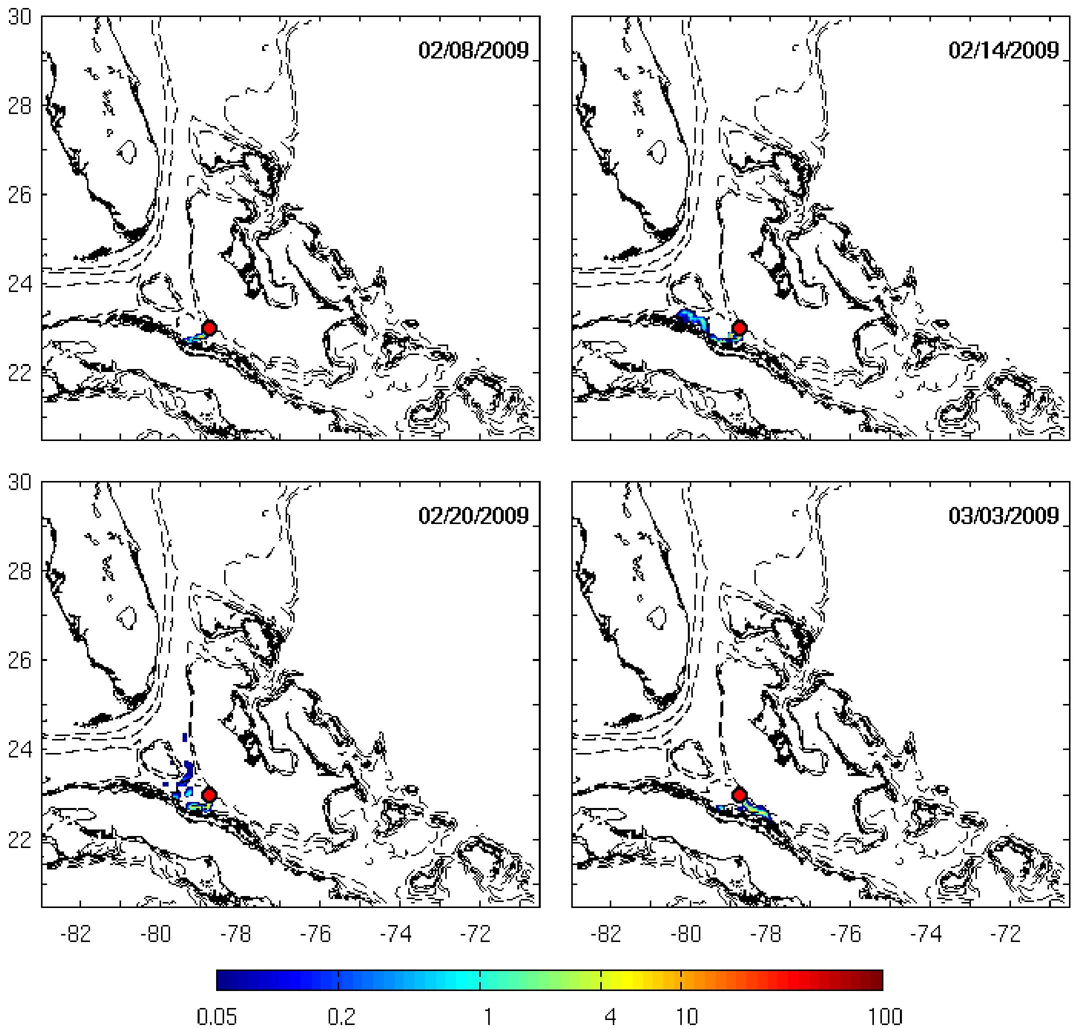


Fig. D.19c: Surface maps of oil slick thickness (CASE B1, in μm) on February 8, February 14, February 20, and March 3, 2009. The red circle indicates the origin of the spill. Animation provided separately, file D19.

APP7.8 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SURFACE RELEASE/CASE B2)

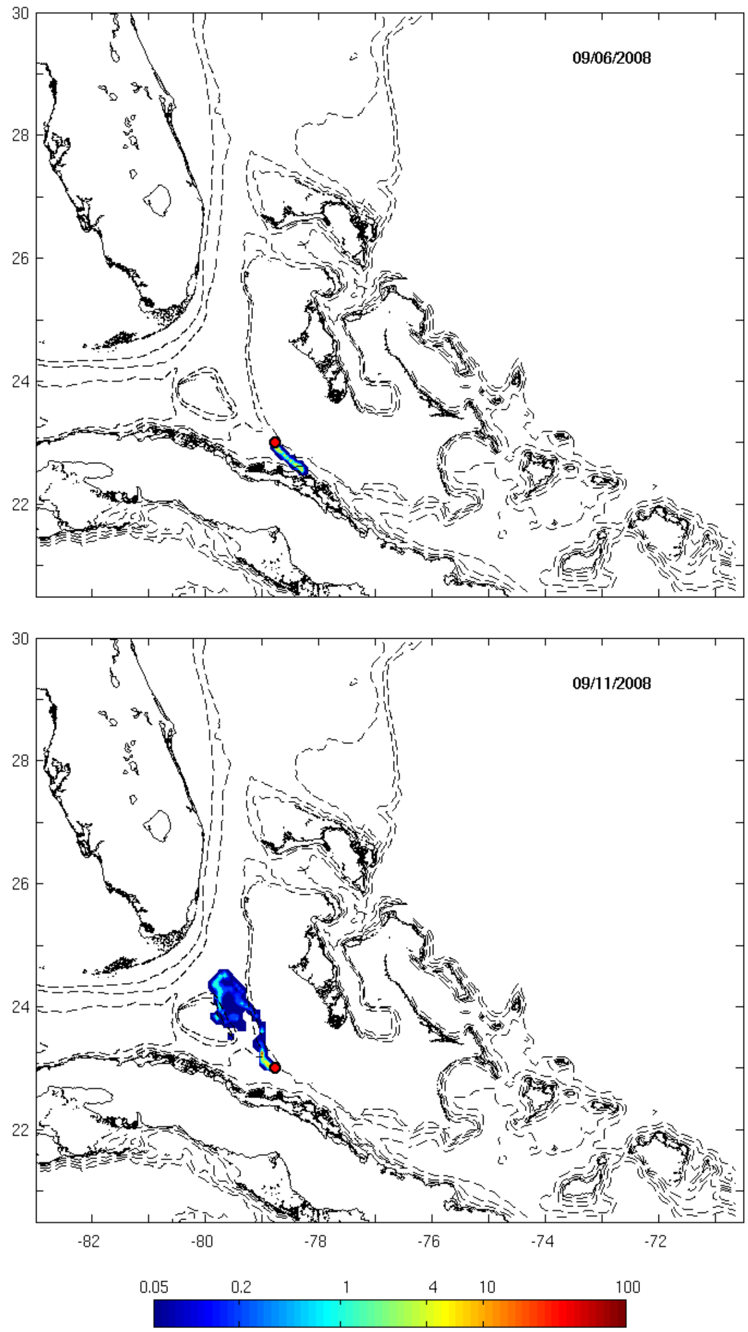


Fig. D.20a: Surface maps of oil slick thickness (CASE B2, in μm) on September 6 and September 11, 2008. The red circle indicates the origin of the spill. Animation provided separately, file D20.

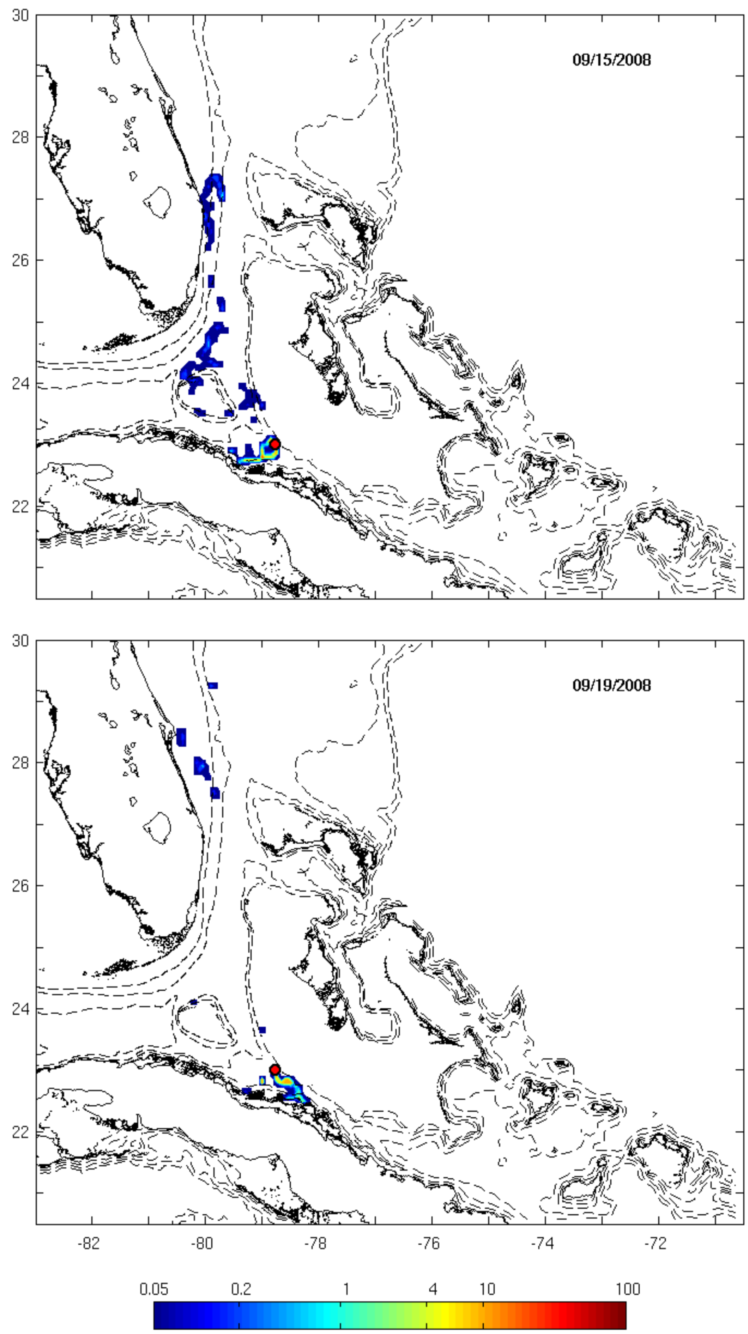


Fig. D.20b: Surface maps of oil slick thickness (CASE B2, in μm) on September 15 and September 19, 2008. The red circle indicates the origin of the spill. Animation provided separately, file D20.

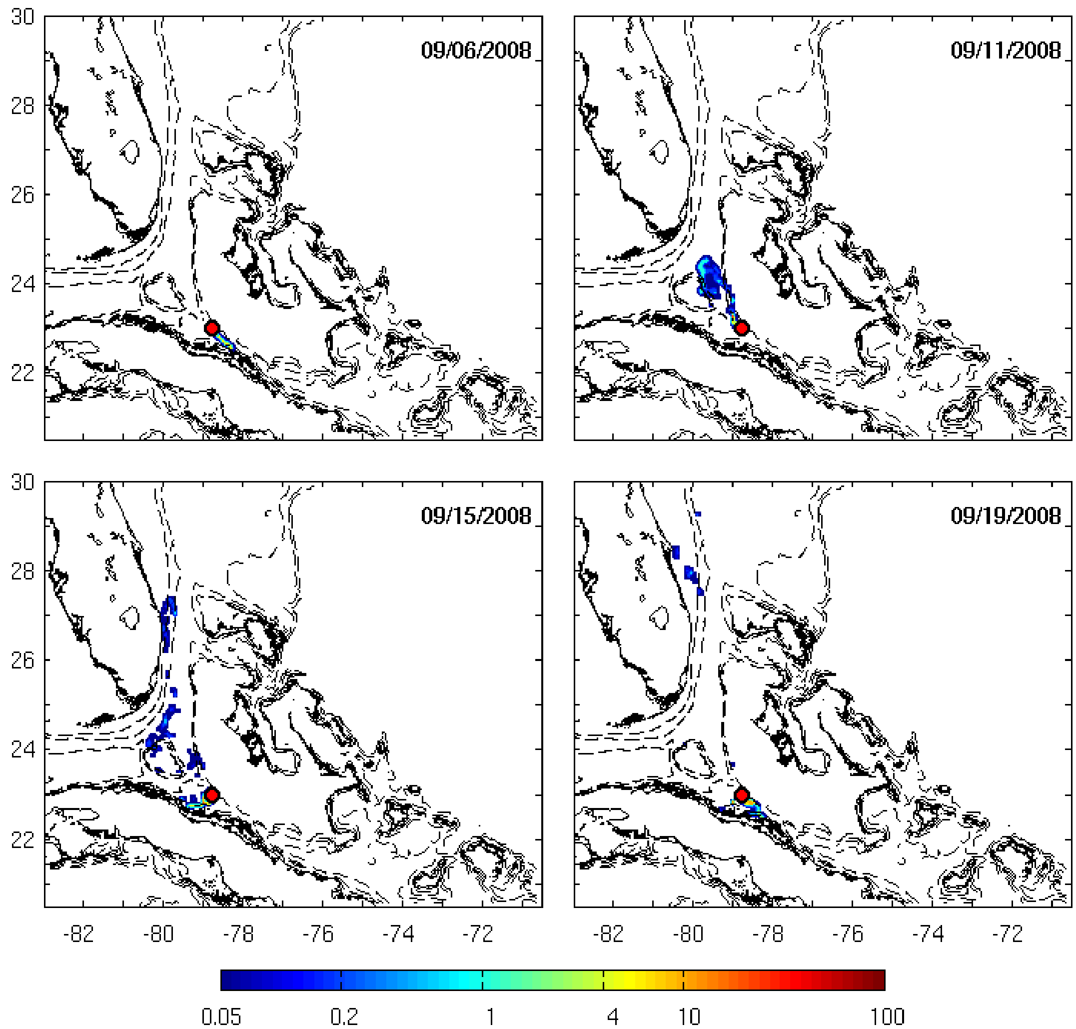


Fig. D.20c: Surface maps of oil slick thickness (CASE B2, in μm) on September 6, September 11, September 15, and September 19, 2008. The red circle indicates the origin of the spill. Animation provided separately, file D20.

APP7.9 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SURFACE RELEASE/CASE B3)

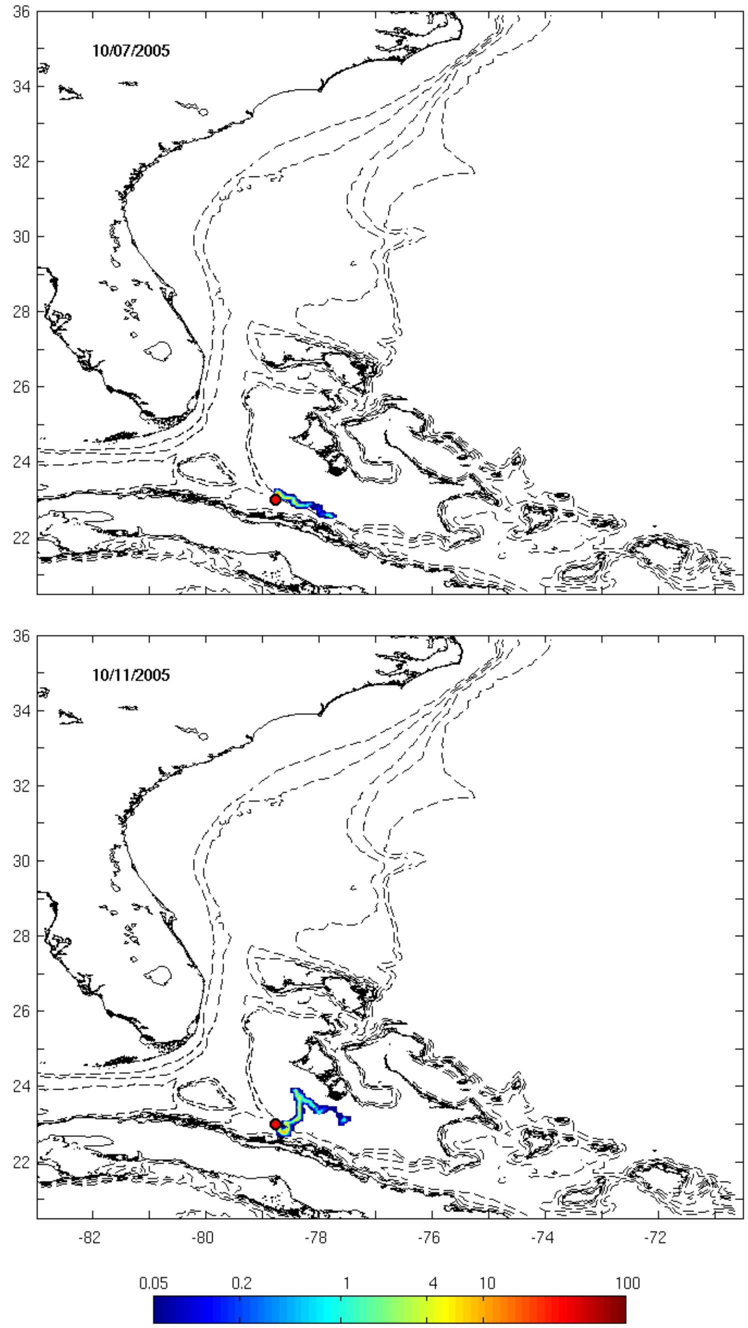


Fig. D.21a: Surface maps of oil slick thickness (CASE B3, in μm) on October 7 and October 11, 2005. The red circle indicates the origin of the spill. Animation provided separately, file D21.

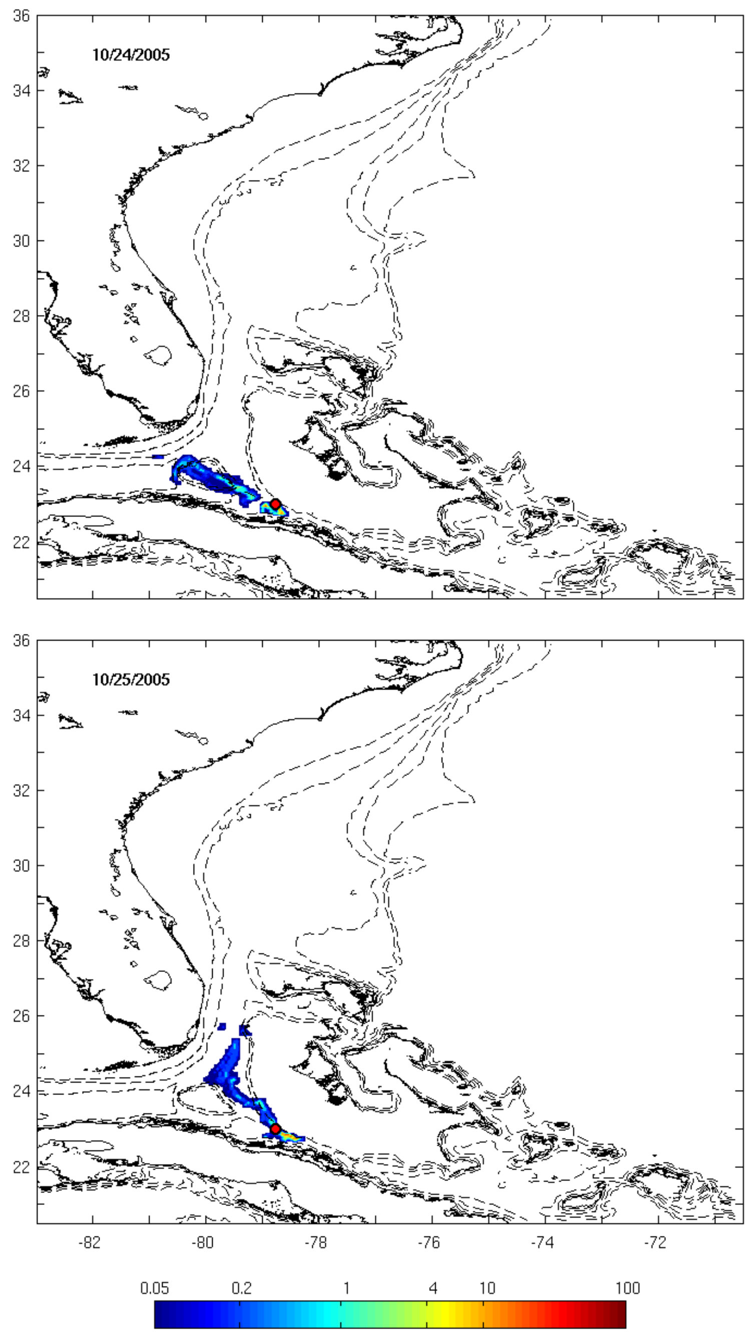


Fig. D.21b: Surface maps of oil slick thickness (CASE B3, in μm) on October 24 and October 25, 2005. The red circle indicates the origin of the spill. Animation provided separately, file D21.

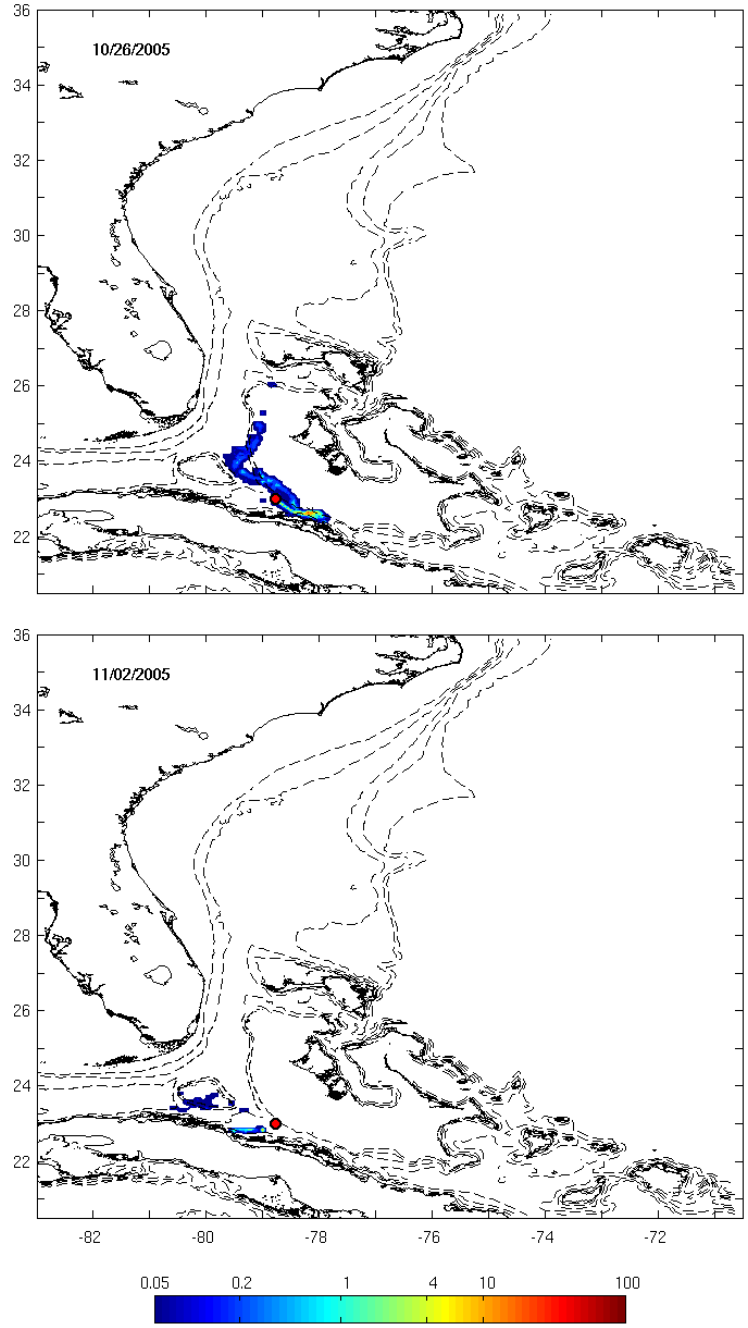


Fig. D.21c: Surface maps of oil slick thickness (CASE B3, in μm) on October 26, and November 2, 2005. The red circle indicates the origin of the spill. Animation provided separately, file D21.

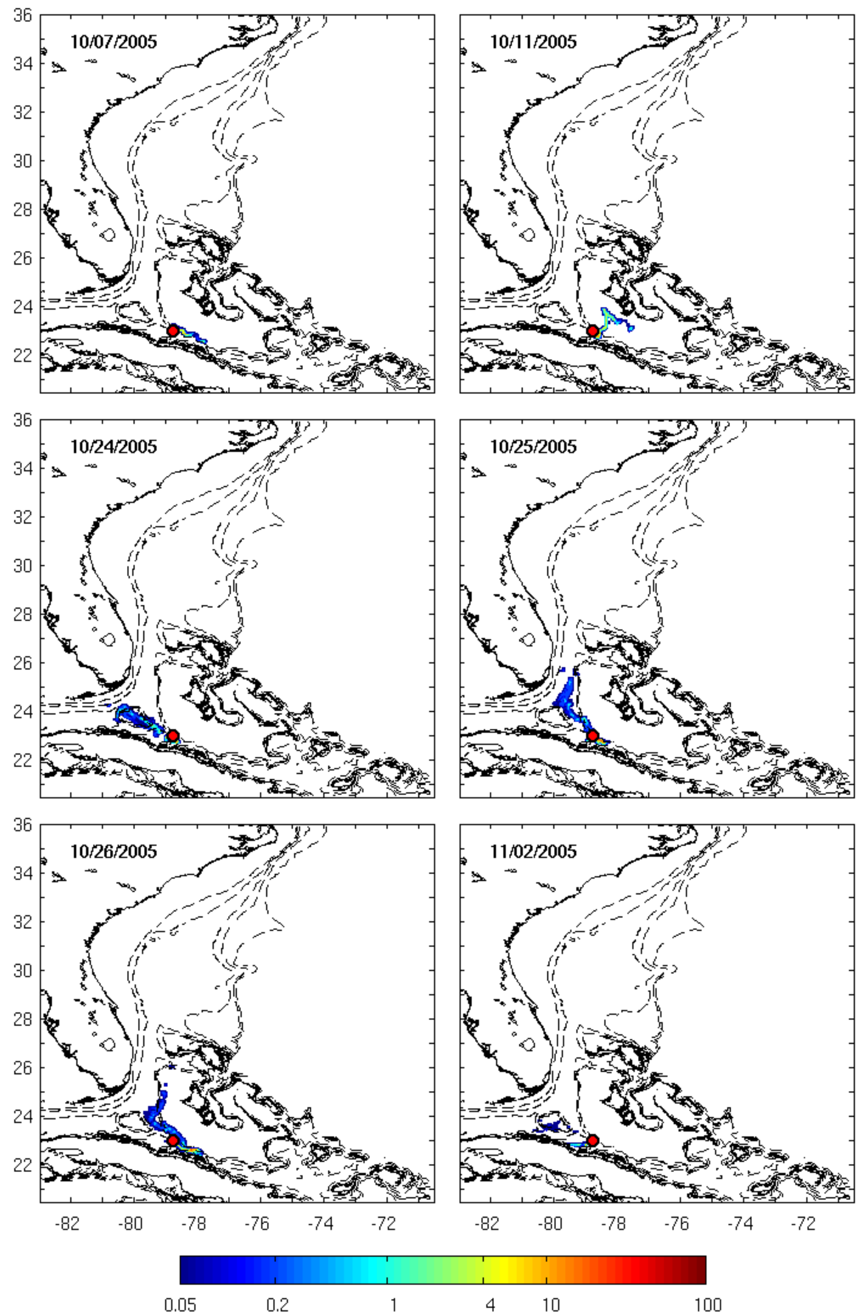


Fig. D.21d: Surface maps of oil slick thickness (CASE B3, in μm) on October 7, October 11, October 24, October 25, October 26, and November 2, 2005. The red circle indicates the origin of the spill. Animation provided separately, file D21.

APP7.10 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SEABED RELEASE/CASE B4)

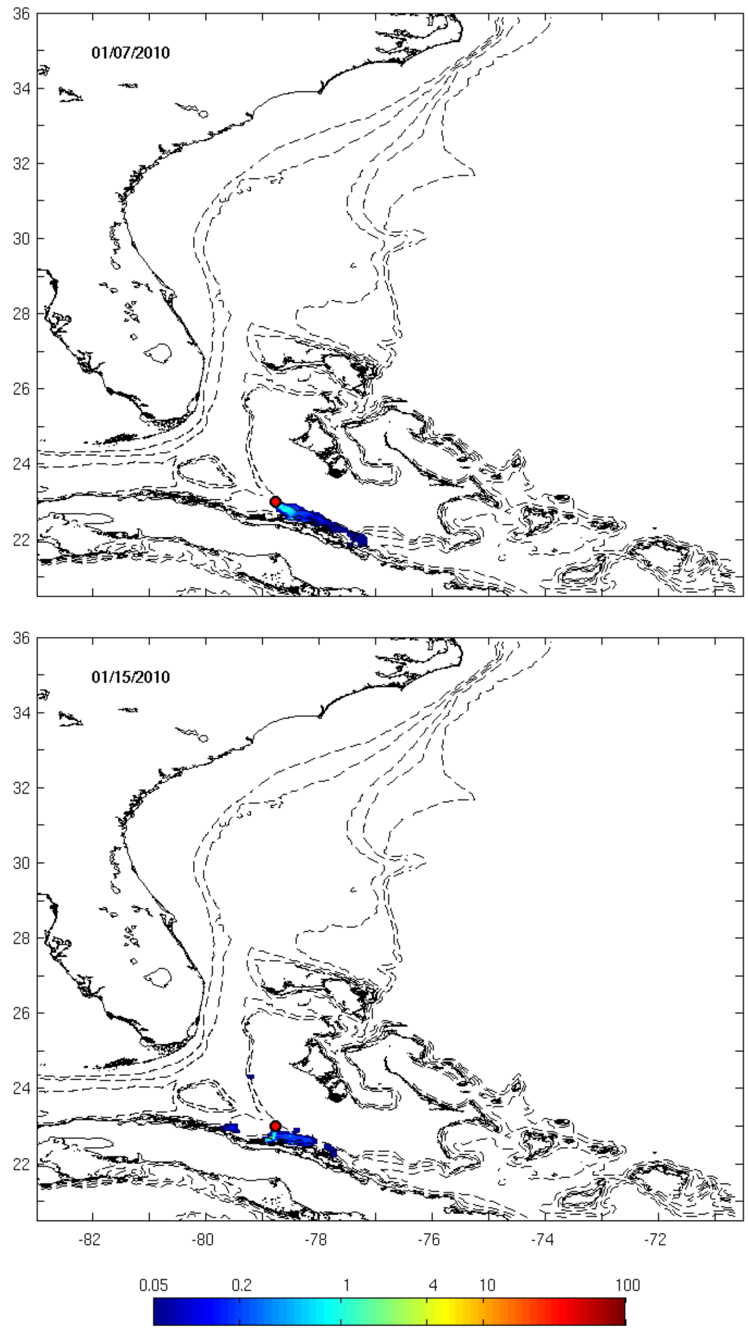


Fig. D.22a: Surface maps of oil slick thickness (CASE B4, in μm) on January 7 and January 15, 2010. The red circle indicates the origin of the spill. Animation provided separately, file D22.

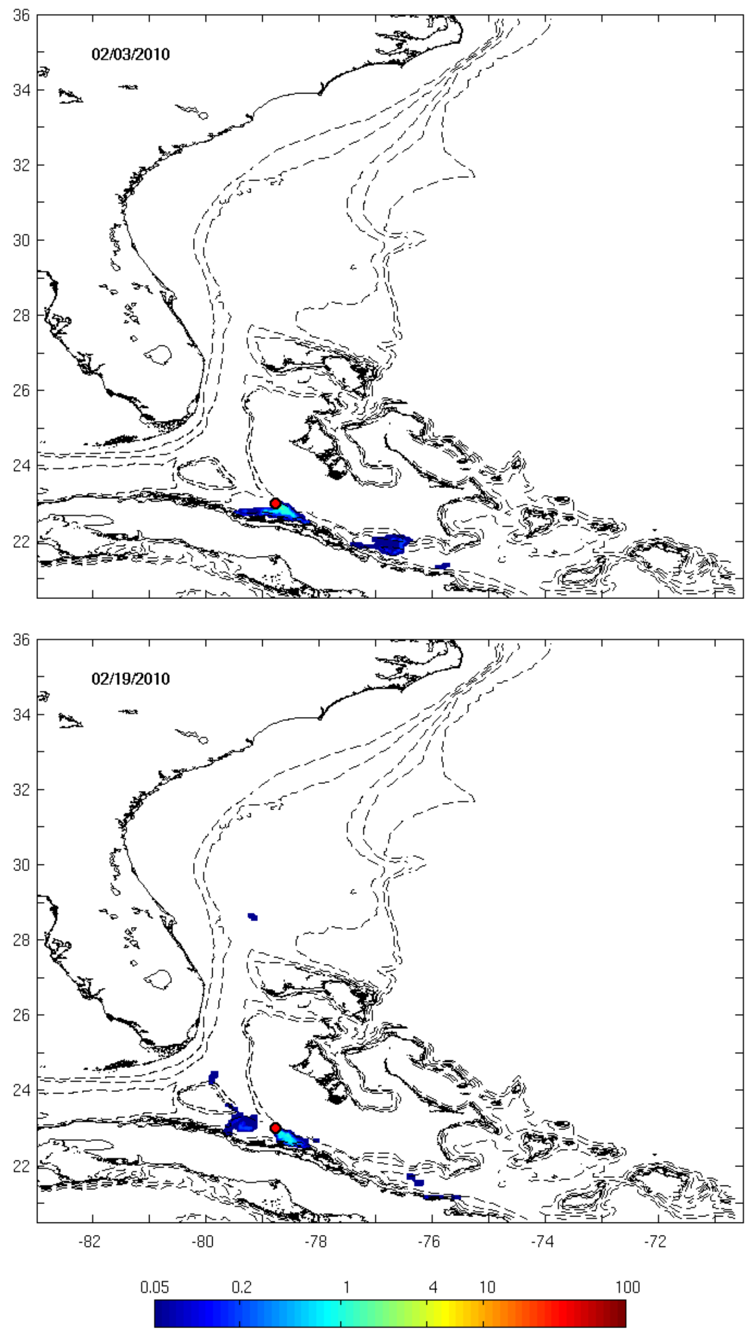


Fig. D.22b: Surface maps of oil slick thickness (CASE B4, in μm) on February 3[d] and February 19, 2010. The red circle indicates the origin of the spill. Animation provided separately, file D22.

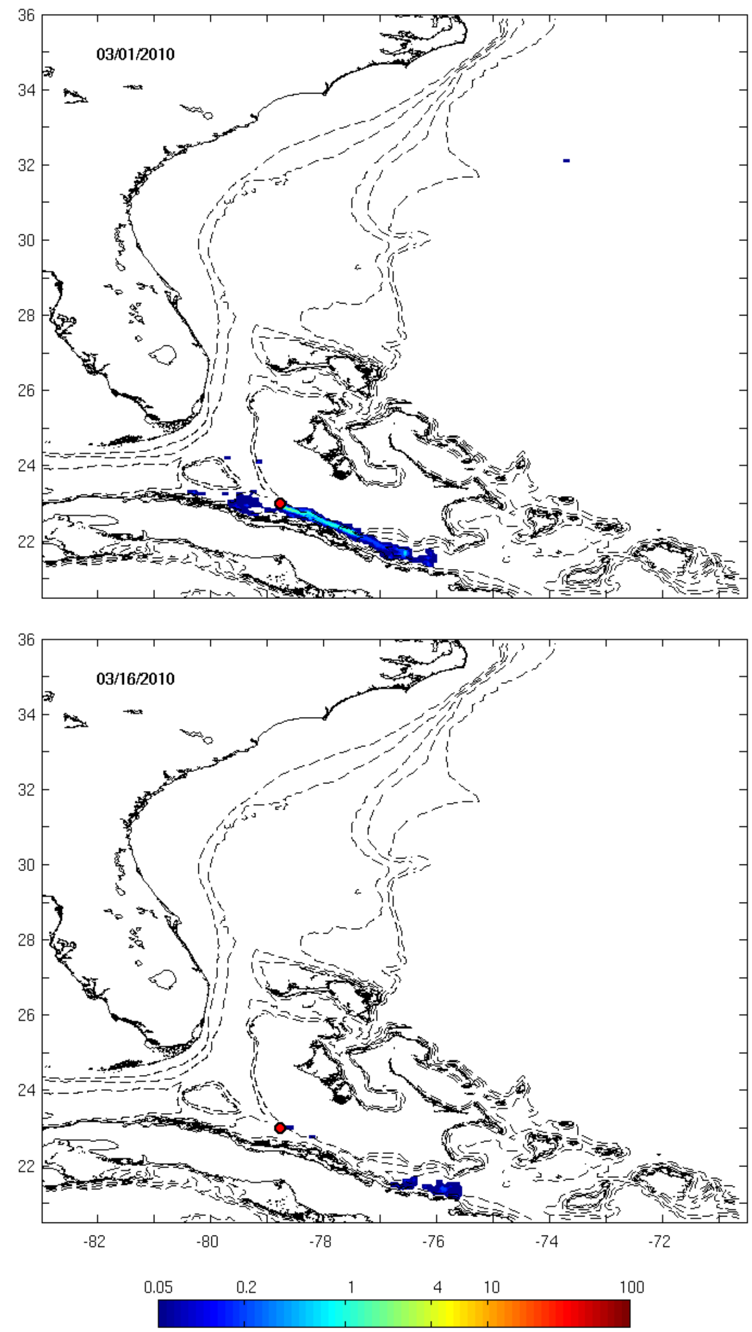


Fig. D.22c: Surface maps of oil slick thickness (CASE B4, in μm) on March 1st and March 16, 2010. The red circle indicates the origin of the spill. Animation provided separately, file D22.

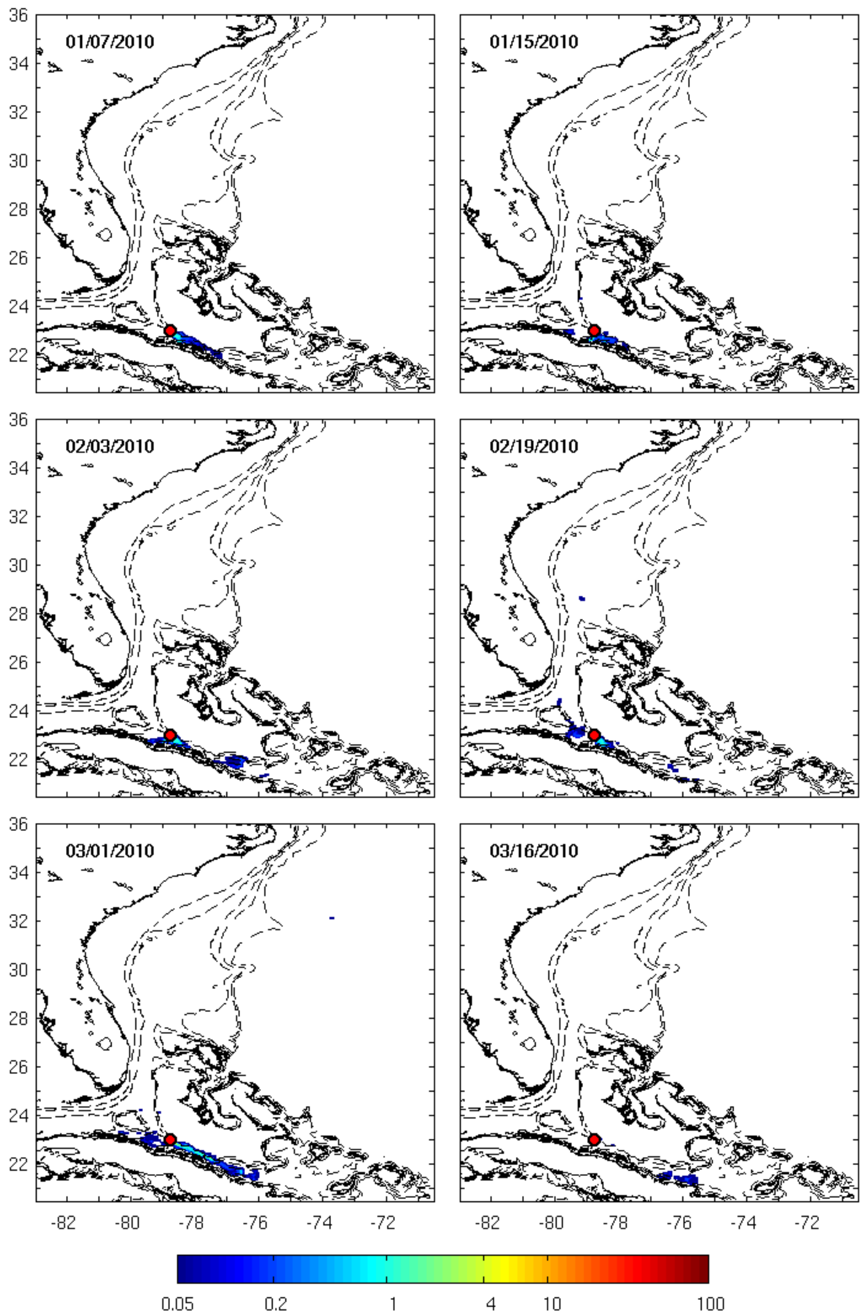


Fig. D.22d: Surface maps of oil slick thickness (CASE B4, in μm) on January 7, January 15, February 2nd, February 19, March 1st, and March 16, 2010. The red circle indicates the origin of the spill. Animation provided separately, file D22.

APP7.11 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SEABED RELEASE/CASE B5)

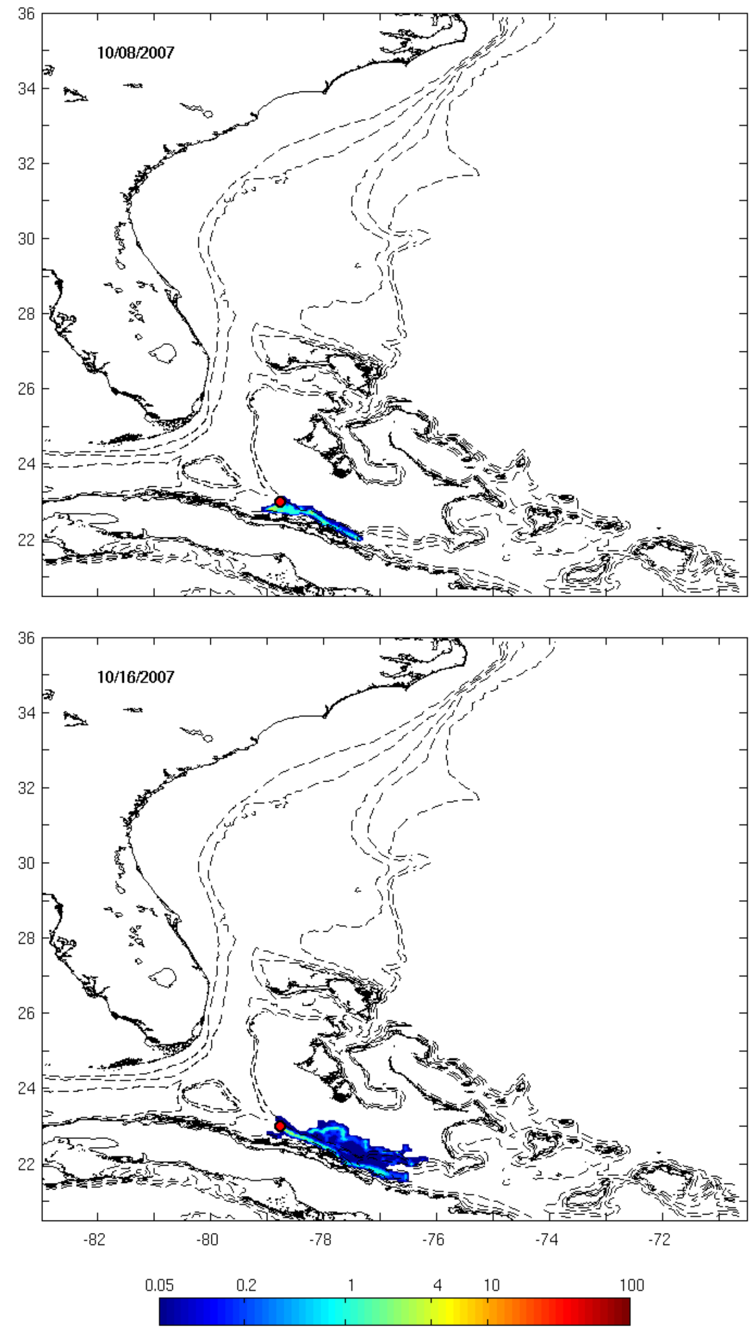


Fig. D.23a: Surface maps of oil slick thickness (CASE B5, in μm) on October 8 and October 16, 2007. The red circle indicates the origin of the spill. Animation provided separately, file D23.

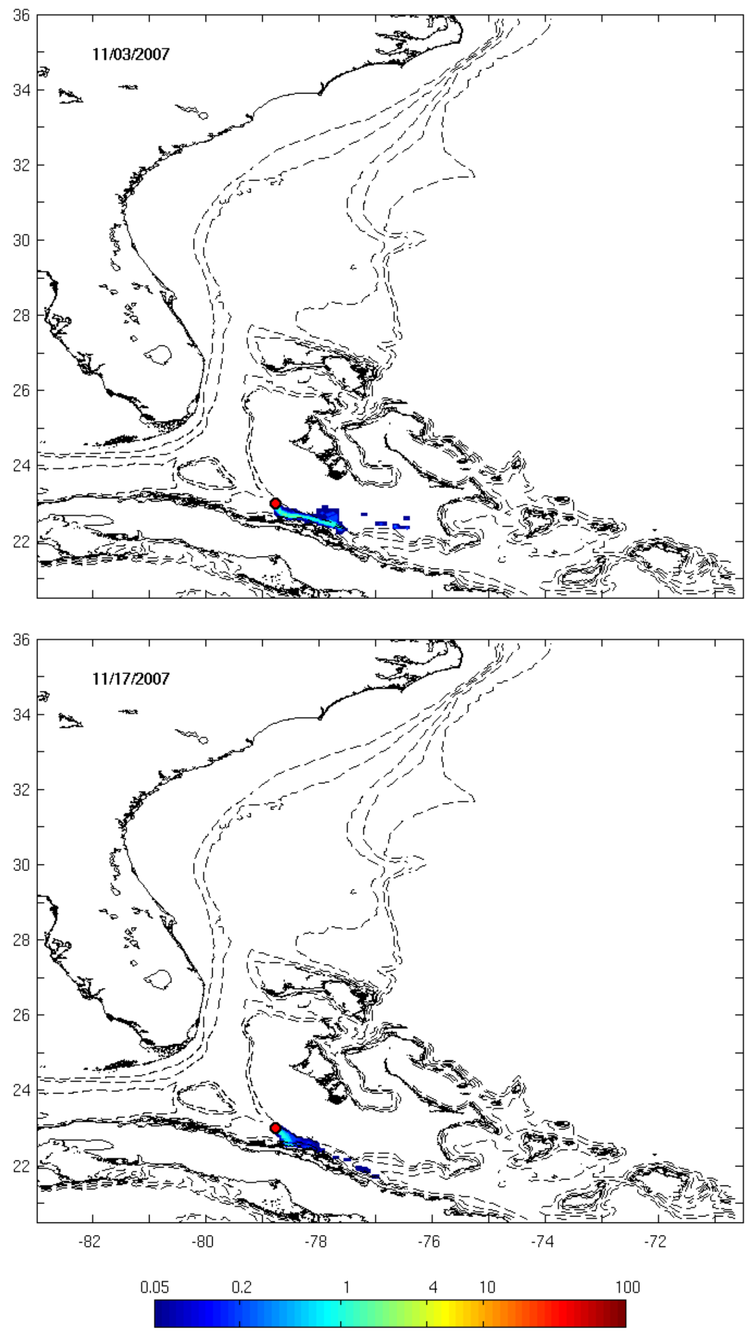


Fig. D.23b: Surface maps of oil slick thickness (CASE B5, in μm) on November 3 and November 17, 2007. The red circle indicates the origin of the spill. Animation provided separately, file D23.

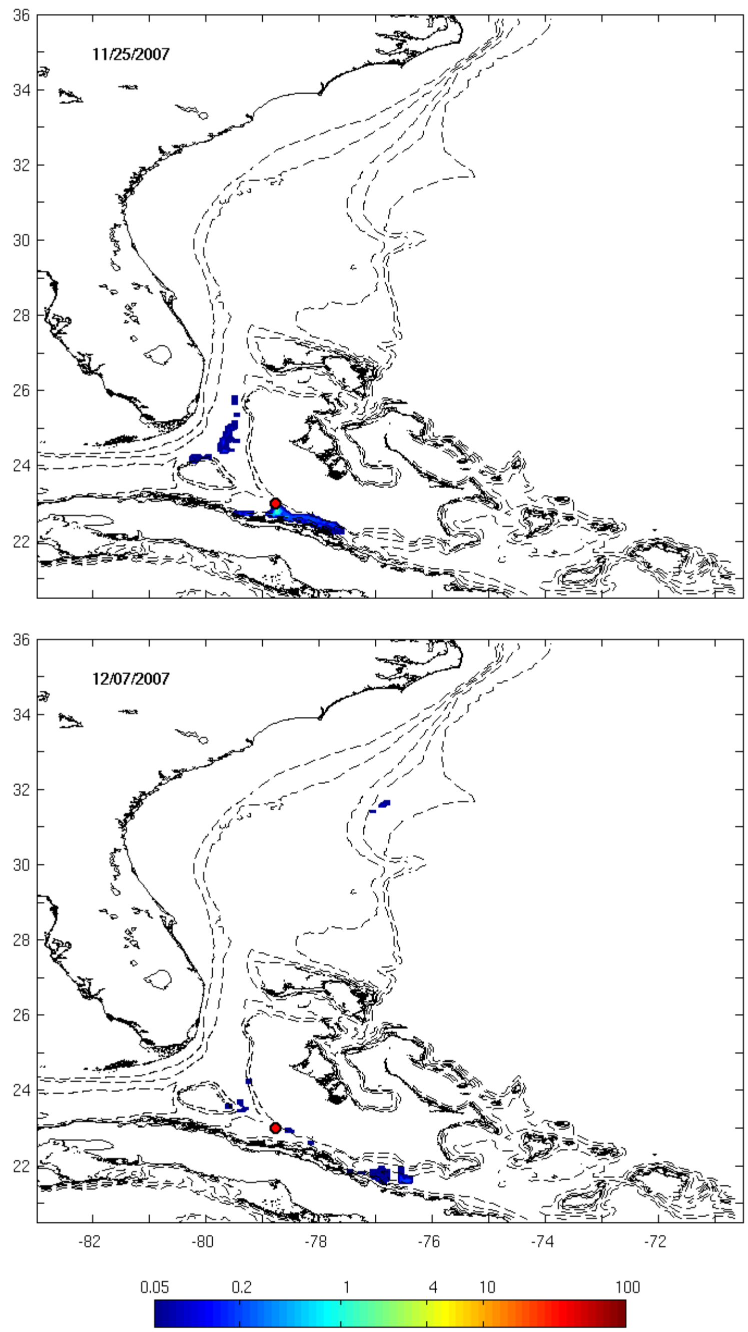


Fig. D.23c: Surface maps of oil slick thickness (CASE B5, in μm) on November 25 and December 7, 2007. The red circle indicates the origin of the spill. Animation provided separately, file D23.

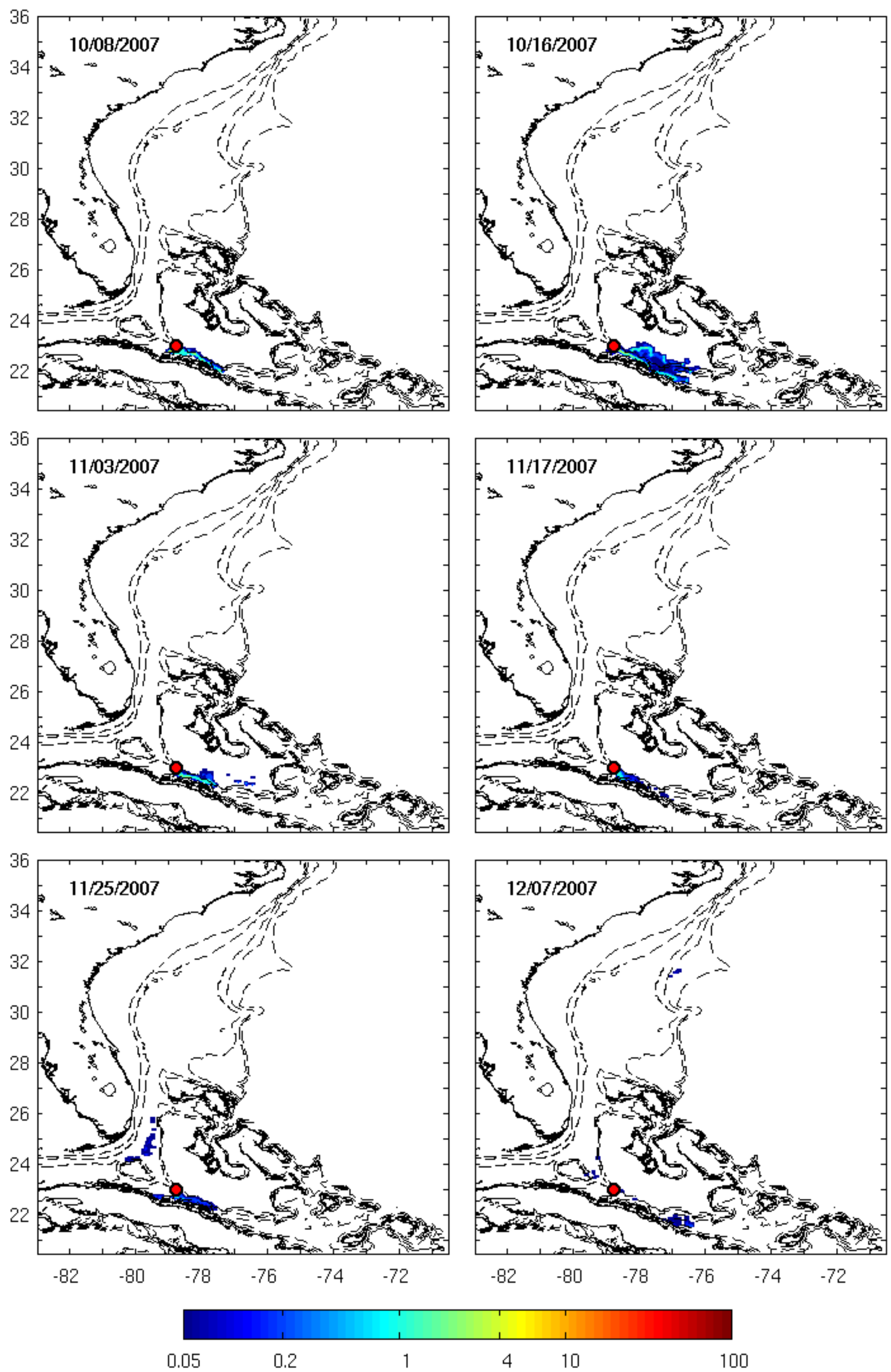


Fig. D.23d: Surface maps of oil slick thickness (CASE B5, in μm) on October 8, October 16, November 3, November 17, November 25, and December 7, 2007. The red circle indicates the origin of the spill. Animation provided separately, file D23.

APP7.12 INTERACTION OF OIL SLICKS WITH LAND WITH TIME (SEABED RELEASE/CASE B6)

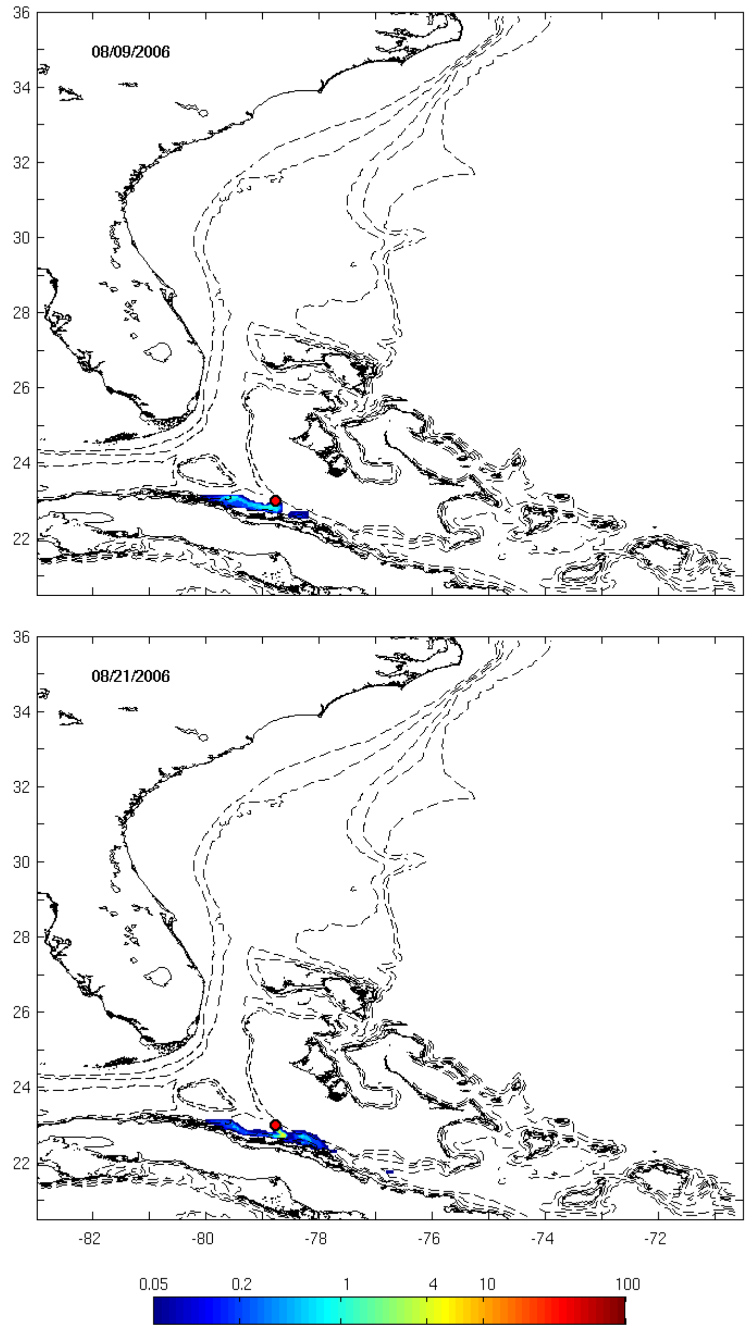


Fig. D.24a: Surface maps of oil slick thickness (CASE B6, in μm) on August 9 and August 21, 2006. The red circle indicates the origin of the spill. Animation provided separately, file D24.

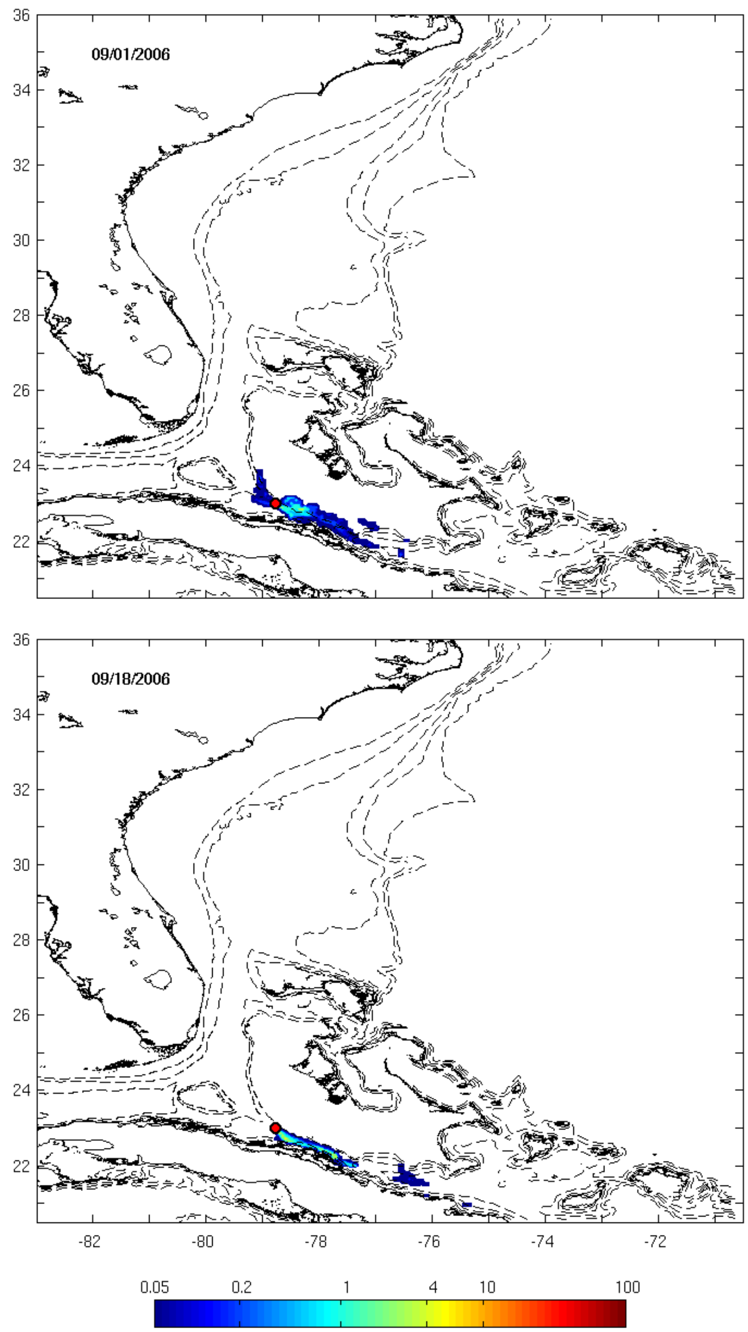


Fig. D.24b: Surface maps of oil slick thickness (CASE B6, in μm) on September 1st and September 18, 2006. The red circle indicates the origin of the spill. Animation provided separately, file D24.

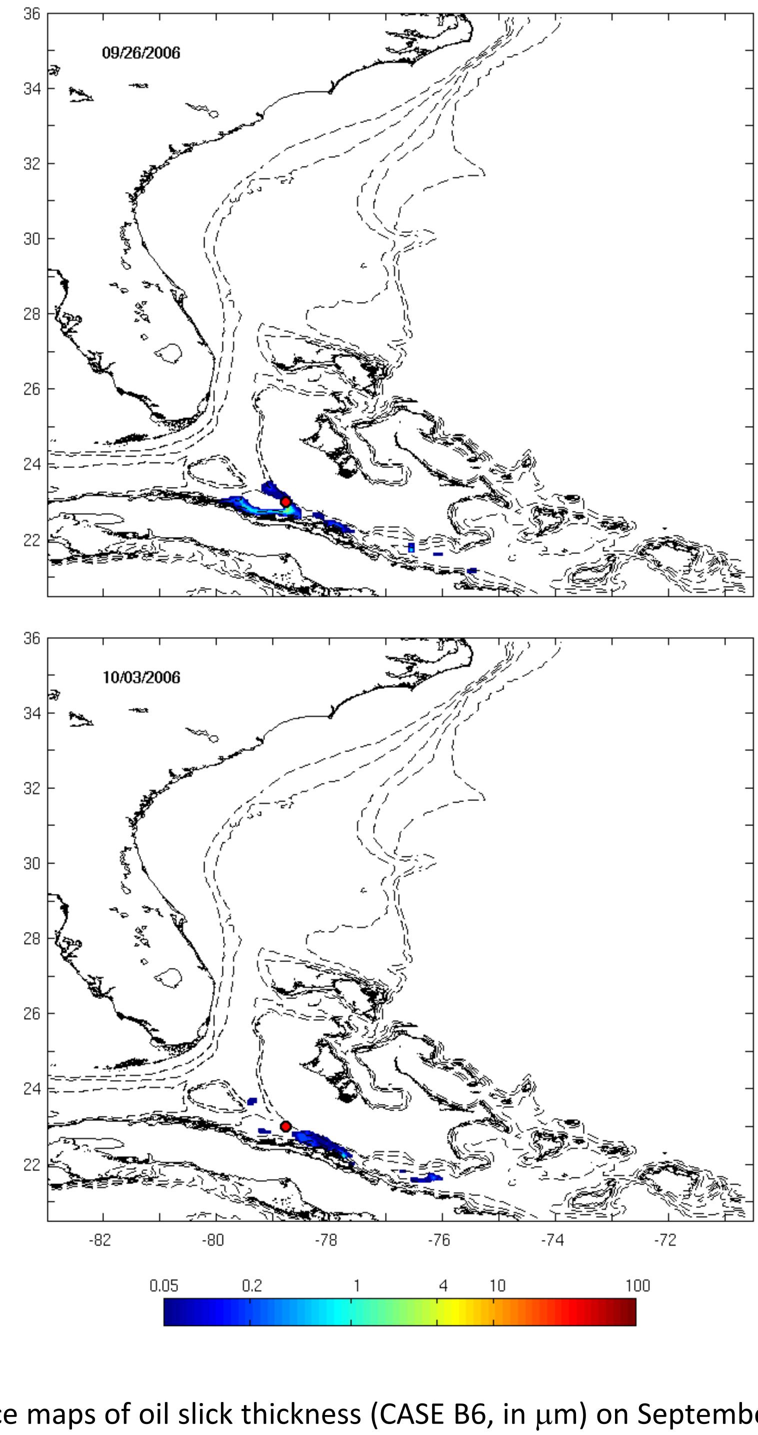


Fig. D.24c: Surface maps of oil slick thickness (CASE B6, in μm) on September 26 and October 3, 2006. The red circle indicates the origin of the spill. Animation provided separately, file D24.

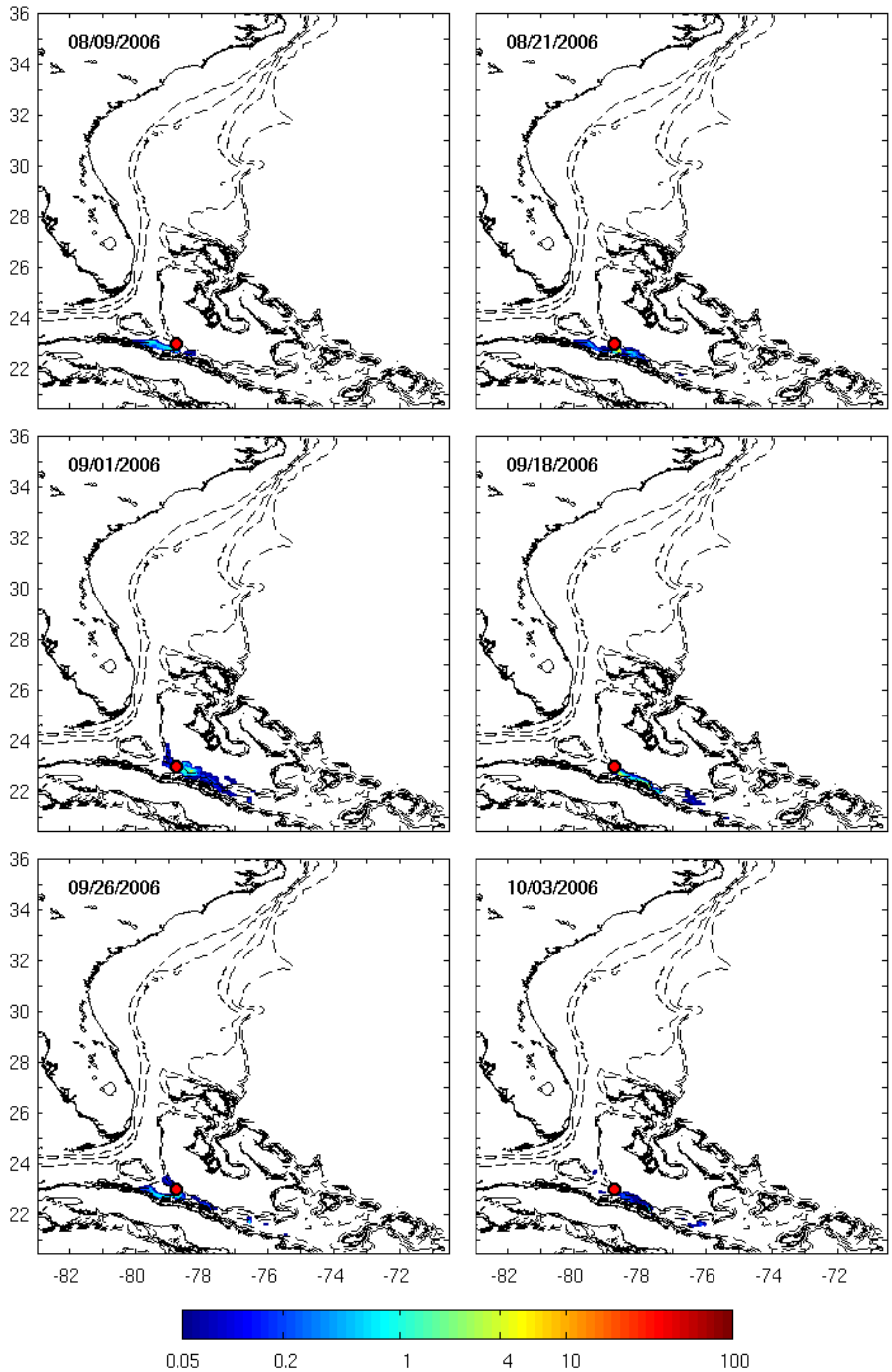


Fig. D.24d: Surface maps of oil slick thickness (CASE B6, in μm) on August 9, August 21, September 1st, September 18, September 26, and October 3, 2006. The red circle indicates the origin of the spill. Animation provided separately, file D24.

APP7.13 OIL BUDGET AND PARTITIONS OVER TIME (SURFACE RELEASE/CASE B1)

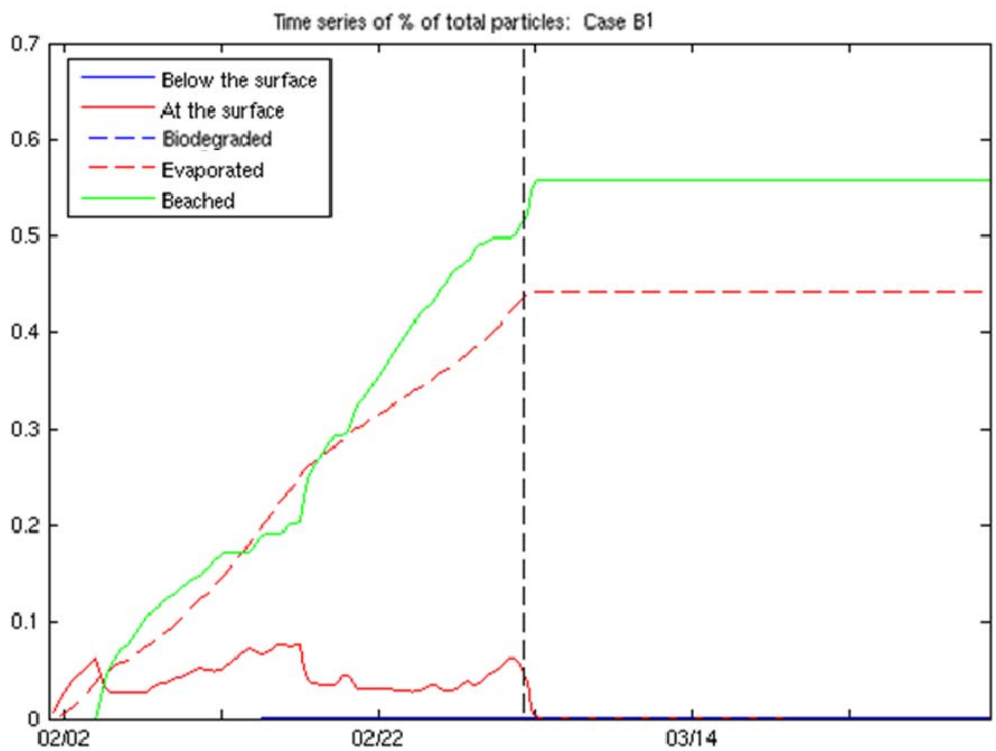


Figure D.25: Shortest time of oil to shore (Case B1: surface release Case 1) - Oil spill fate through time from February 1 to April 2, 2009. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 30 days and is indicated by the dotted vertical black line.

APP7.14 OIL BUDGET AND PARTITIONS OVER TIME (SURFACE RELEASE/CASE B2)

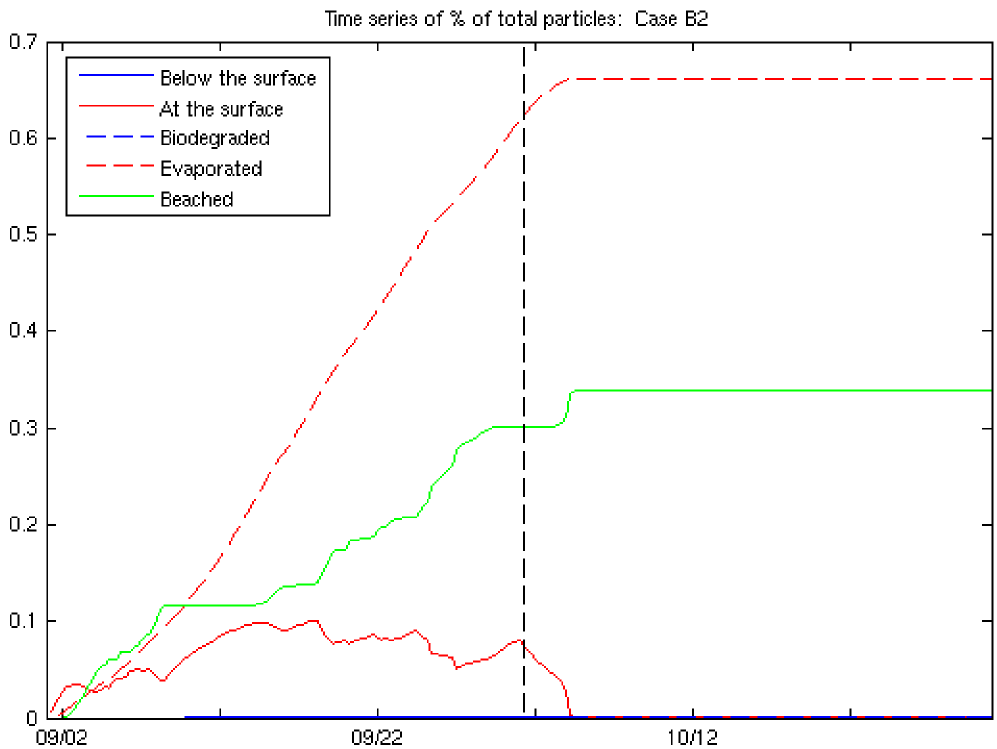


Figure D.26: Maximum shoreline area oiled (Case B2: surface release Case 2) - Oil spill fate through time from September 1st to October 31, 2008. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 30 days and is indicated by the dotted vertical black line.

APP7.15 OIL BUDGET AND PARTITIONS OVER TIME (SURFACE RELEASE/CASE B3)

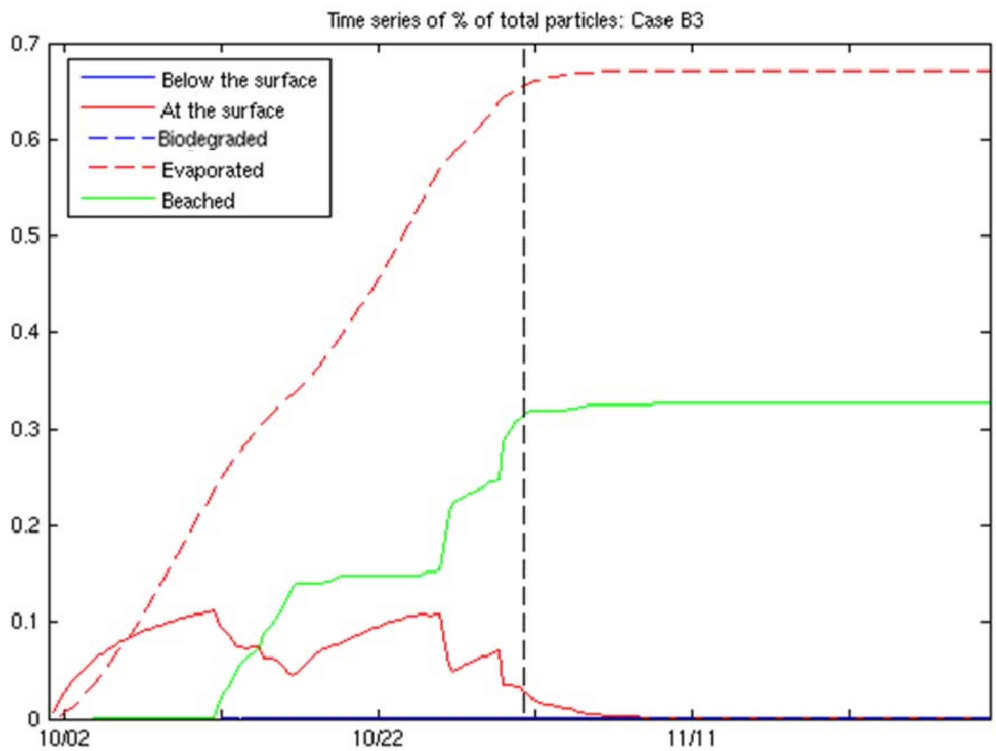


Figure D.27: Hurricane Wilma case (Case B3: surface release Case 3) - Oil spill fate through time from October 1st to November 30, 2005. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 30 days and is indicated by the dotted vertical black line.

APP7.16 OIL BUDGET AND PARTITIONS OVER TIME (SEABED RELEASE/CASE B4)

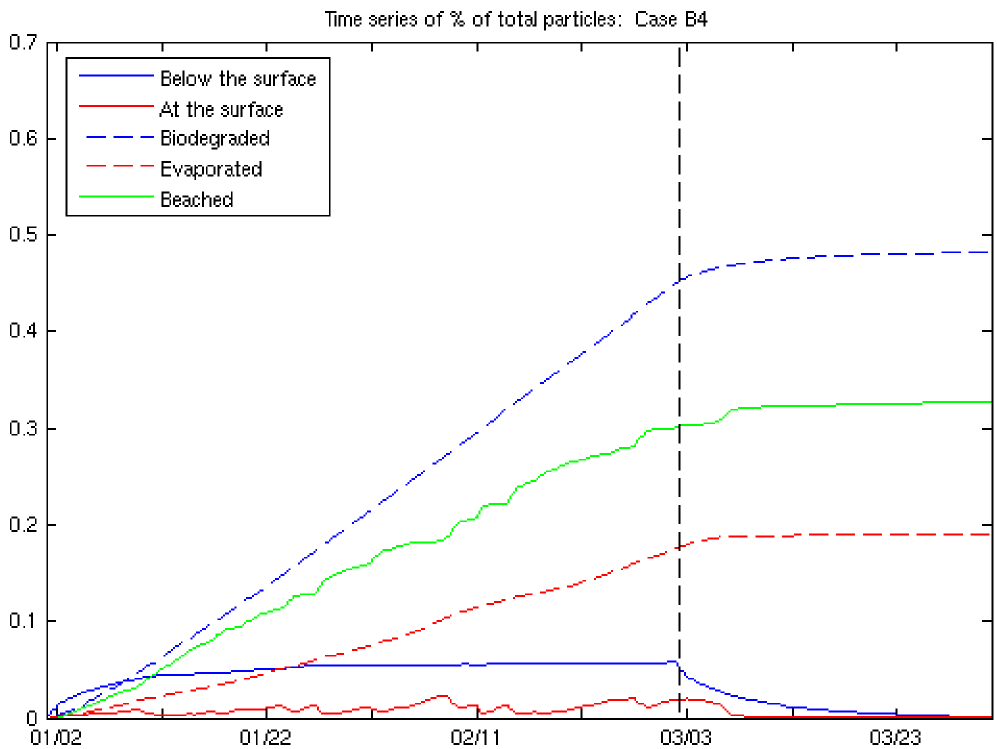


Figure D.28: Situation with shortest time of oil to shore (Case B4: seabed release Case 1) - Oil spill fate through time from January 1 to April 1st, 2010. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 60 days and is indicated by the dotted vertical black line.

APP7.17 OIL BUDGET AND PARTITIONS OVER TIME (SEABED RELEASE/CASE B5)

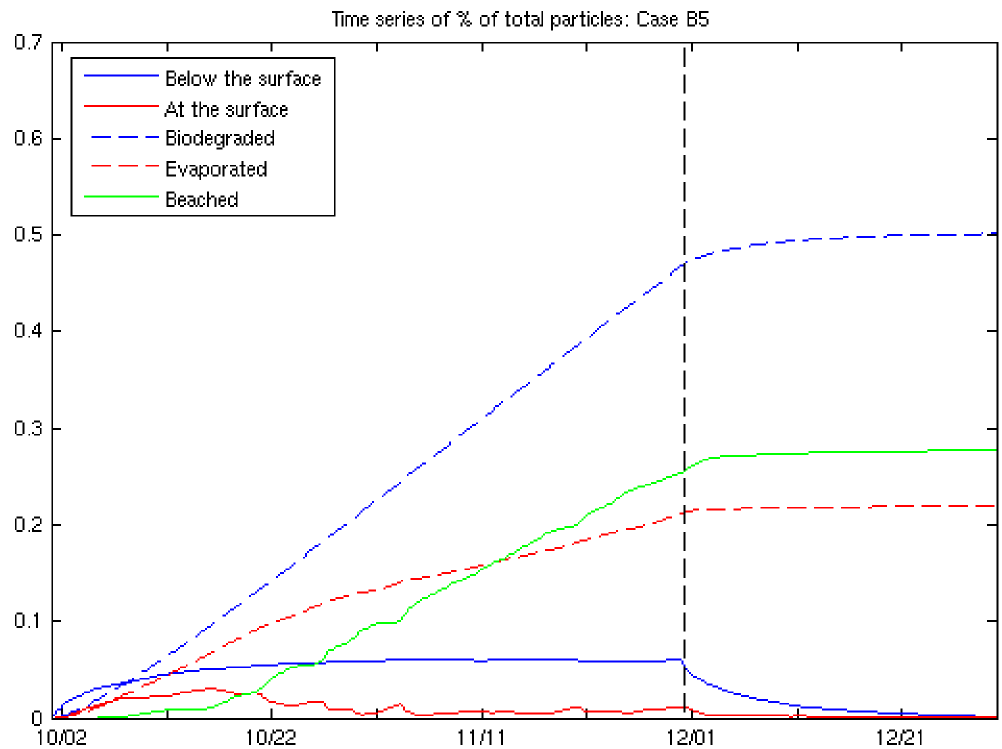


Figure D.29: Situation with maximum shoreline area (Case B5: seabed release Case 2) - Oil spill fate through time from October 1st to December 30, 2007. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 60 days and is indicated by the dotted vertical black line.

APP7.18 OIL BUDGET AND PARTITIONS OVER TIME (SEABED RELEASE/CASE B6)

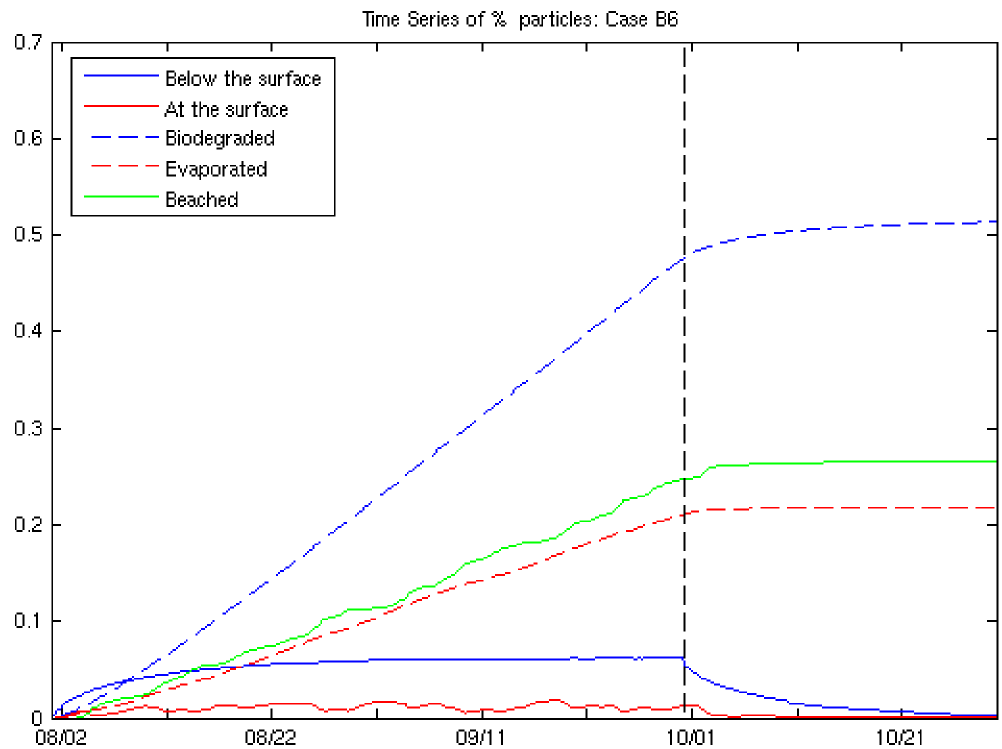


Figure D.30: Situation with maximum volume of oil entrained in the water column (Case B6: seabed release Case 3) - Oil spill fate through time from August 1st to October 30, 2006. The fate of the oil is represented as the fraction of oil discharged partitioned between the following components: 1) below the surface as suspended hydrocarbons in the entire water column; 2) at the surface of the ocean in the form of oil slicks or mats; 3) biodegraded; 4) evaporated from the sea surface in the form of volatile hydrocarbons; 5) beached oil making landfall. Percent of oil is scored against the total mass of oil spilled. The duration of the spill is 60 days and is indicated by the dotted vertical black line.

APP7.19: DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) (SEABED RELEASE/CASE B4)

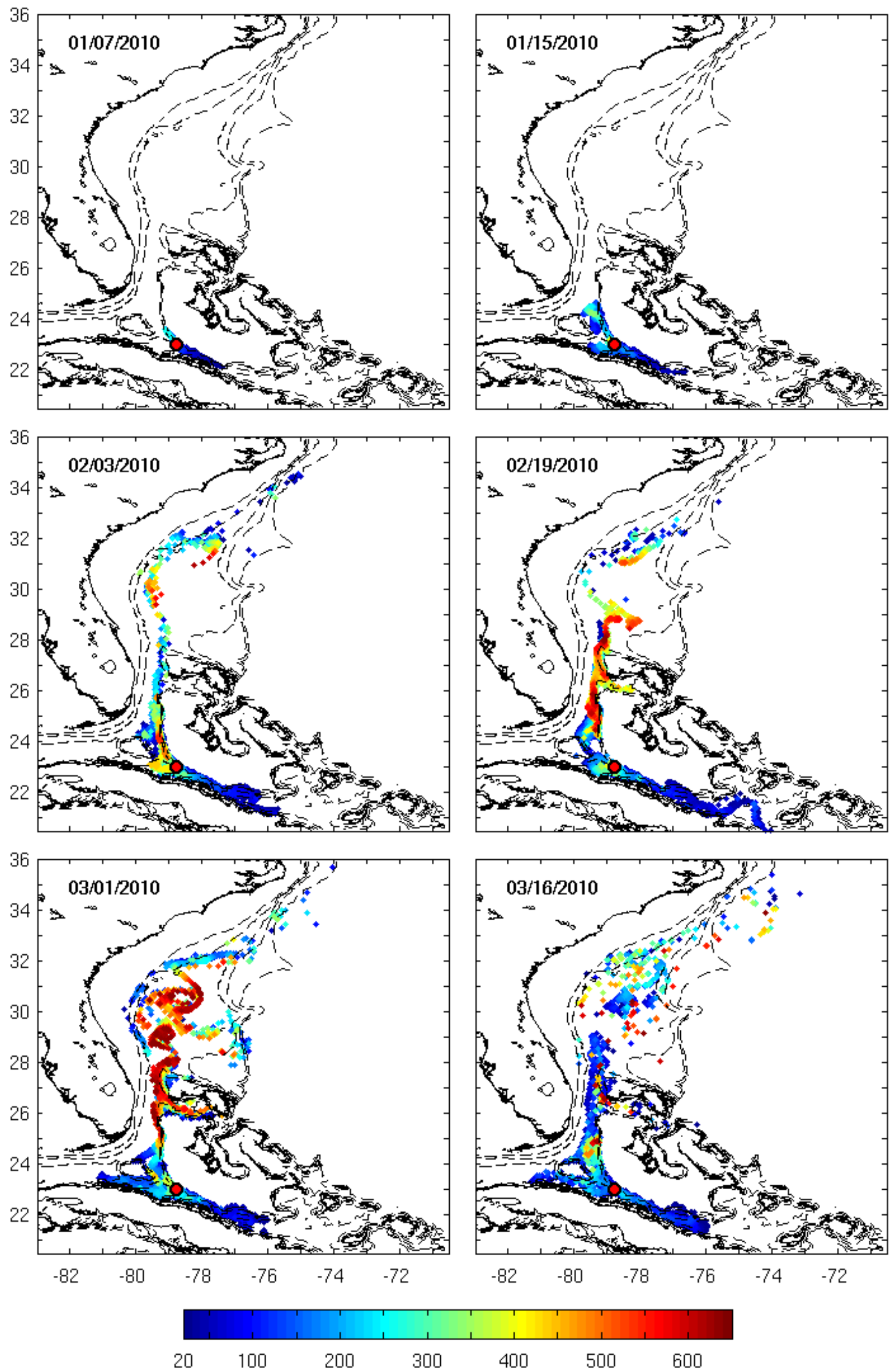


Fig. D.31: Two-dimensional maps of the depth of the submerged oil droplets in suspension (below 20m) (seabed release/CASE B4). These maps are not indicative of the oil concentration or toxicity.

APP7.20: DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) (SEABED RELEASE/CASE B5)

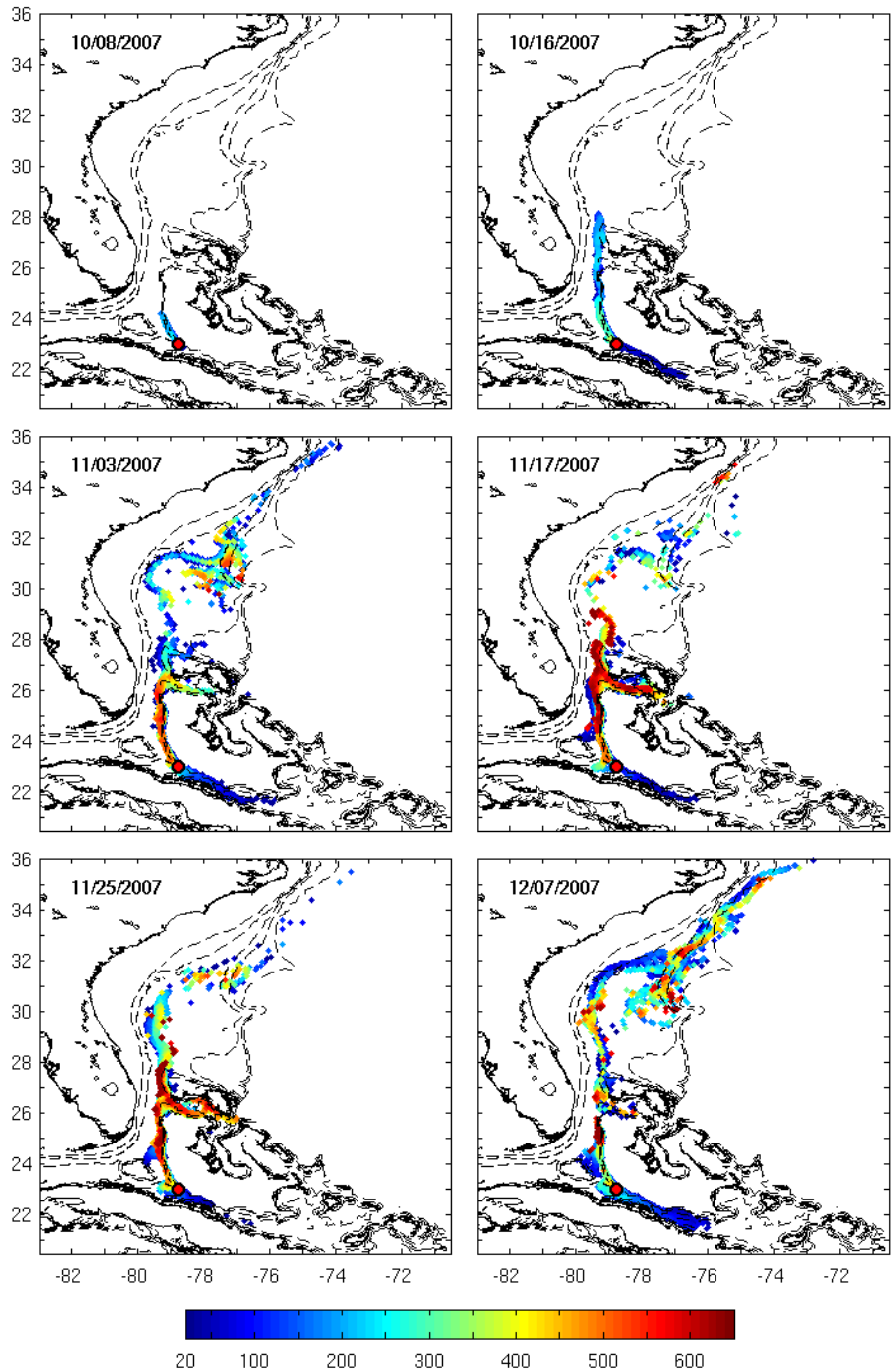


Fig. D.32: Two-dimensional maps of the depth of the submerged oil droplets in suspension (below 20m) (seabed release/CASE B5). These maps are not indicative of the oil concentration or toxicity.

APP7.21: DEPTH DISTRIBUTION OF THE SUBMERGED OIL IN SUSPENSION (below 20m) (SEABED RELEASE/CASE B6)

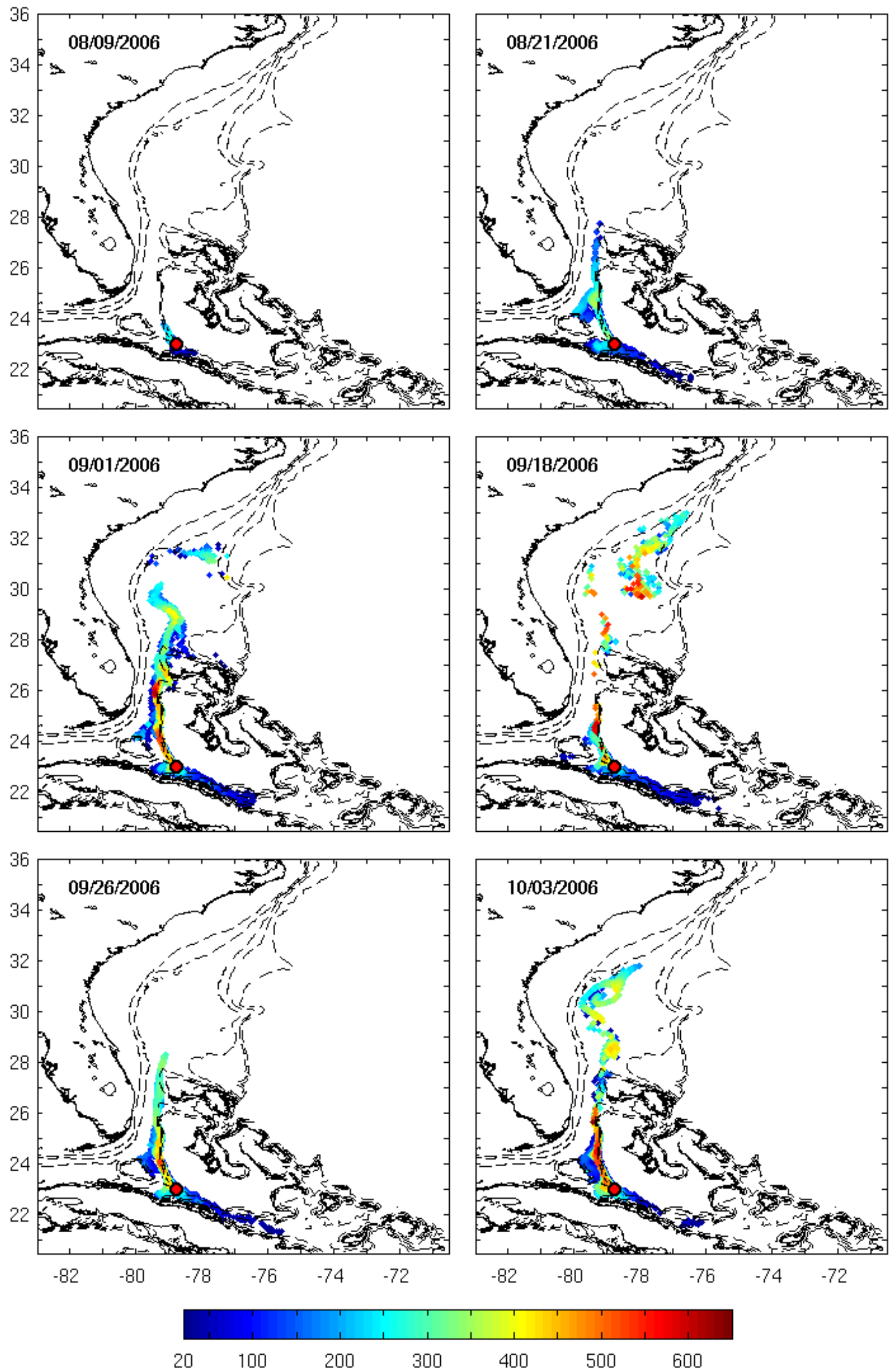


Fig. D.33: Two-dimensional maps of the depth of the submerged oil droplets in suspension (below 20m) (seabed release/CASE B6). These maps are not indicative of the oil concentration or toxicity.

APP7.22 THREE DIMENSIONAL ANIMATIONS OF A SPILL SCENARIO (SEABED RELEASE/CASE B4)

D34: “Animation provided separately, file D34”

Note: This animation is not indicative of the oil concentration or toxicity.

APP7.23 THREE DIMENSIONAL ANIMATIONS OF A SPILL SCENARIO (SEABED RELEASE/CASE B5)

D35: “Animation provided separately, file D35”

Note: This animation is not indicative of the oil concentration or toxicity.

APP7.24 THREE DIMENSIONAL ANIMATIONS OF A SPILL SCENARIO (SEABED RELEASE/CASE B6)

D36: “Animation provided separately, file D36”

Note: This animation is not indicative of the oil concentration or toxicity.

APP7.25 SUBMERGED OIL PLUME (SEABED RELEASE/CASE B4)

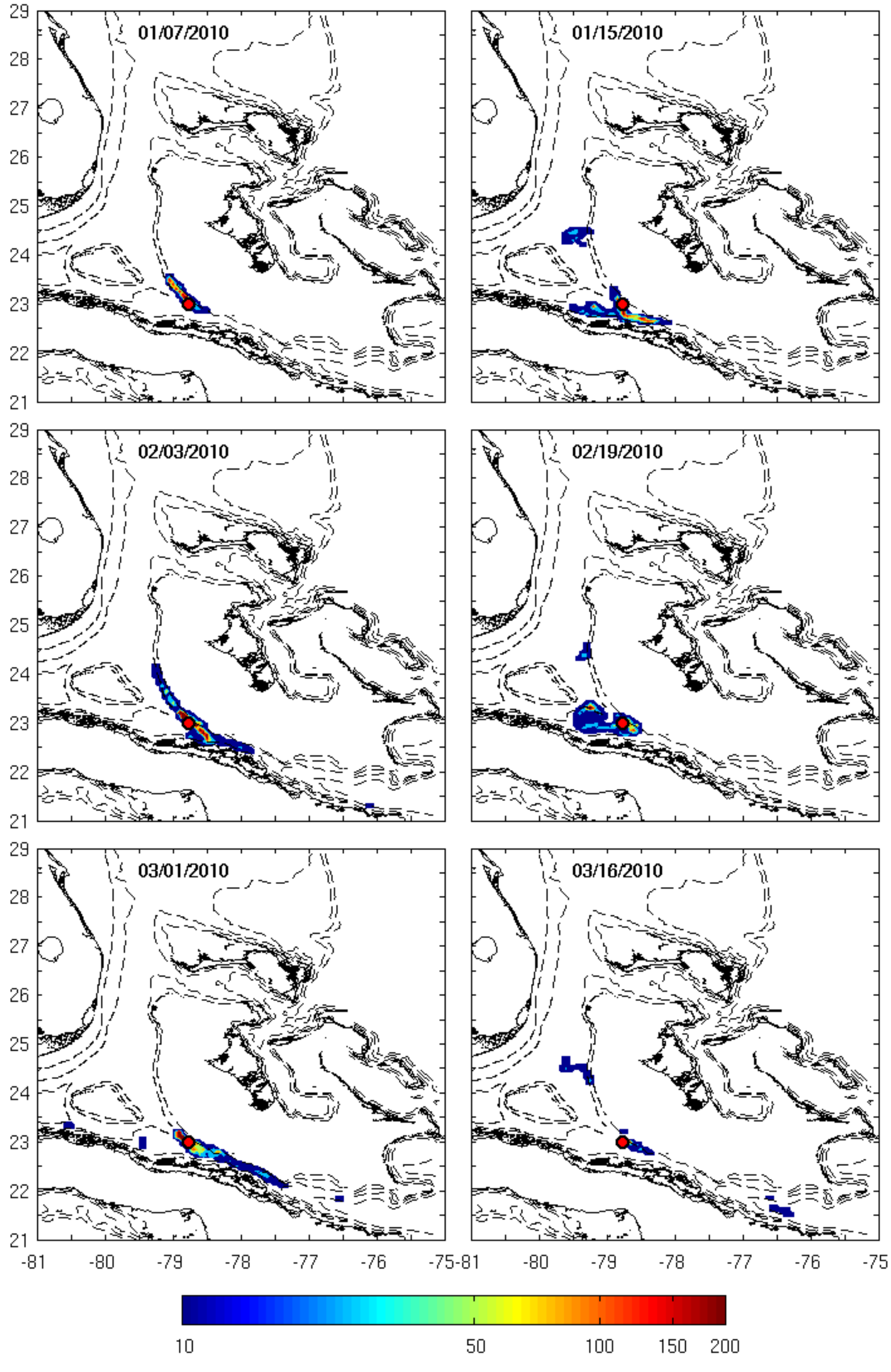


Fig. D.37: Two-dimensional maps of the maximum concentration (ppb) of submerged oil plume (seabed release/CASE B4)

APP7.26 SUBMERGED OIL PLUME (SEABED RELEASE/CASE B5)

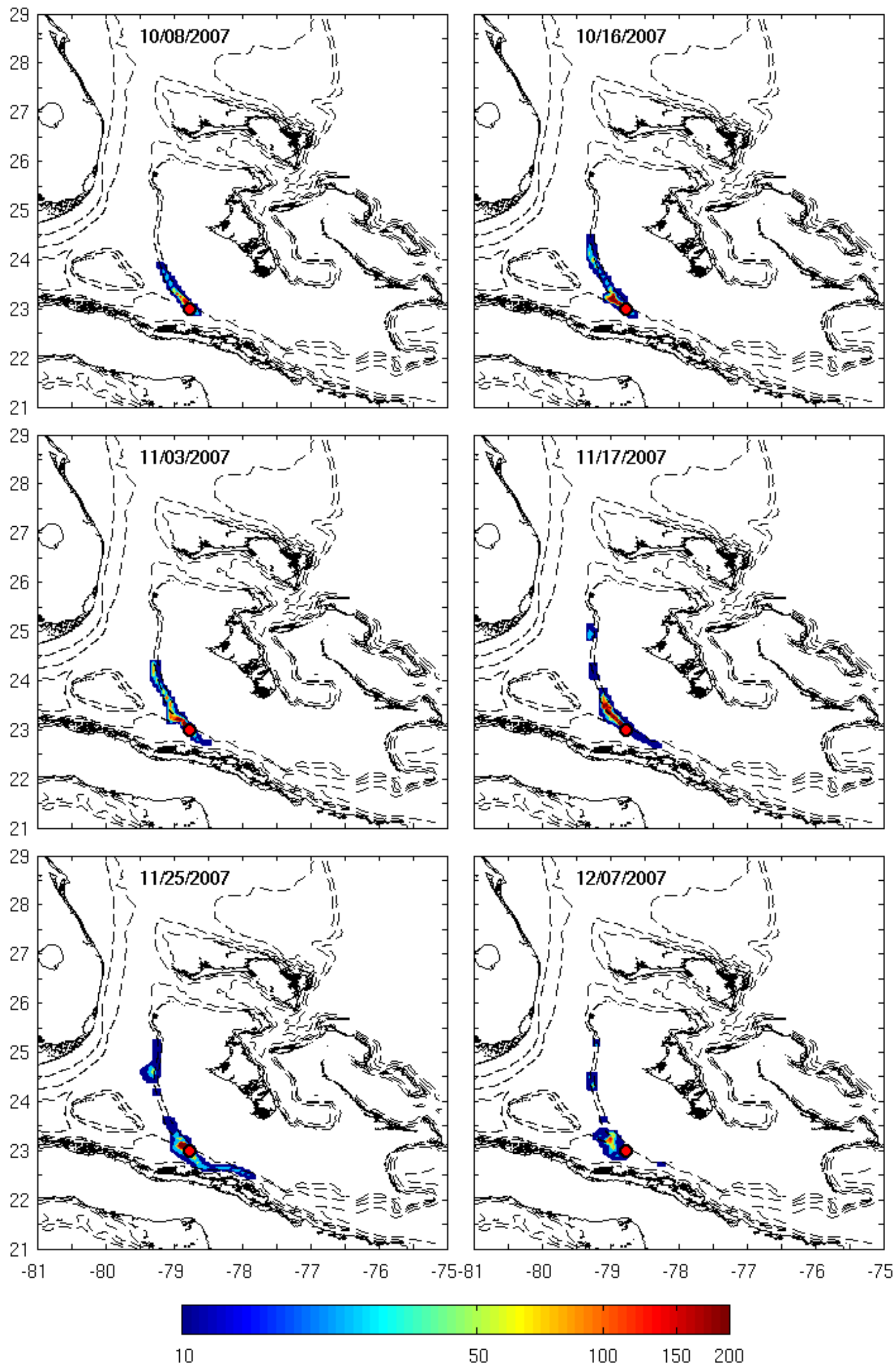


Fig. D.38: Two-dimensional maps of the maximum concentration (ppb) of submerged oil plume (seabed release/CASE B5)

APP7.27 SUBMERGED OIL PLUME (SEABED RELEASE/CASE B6)

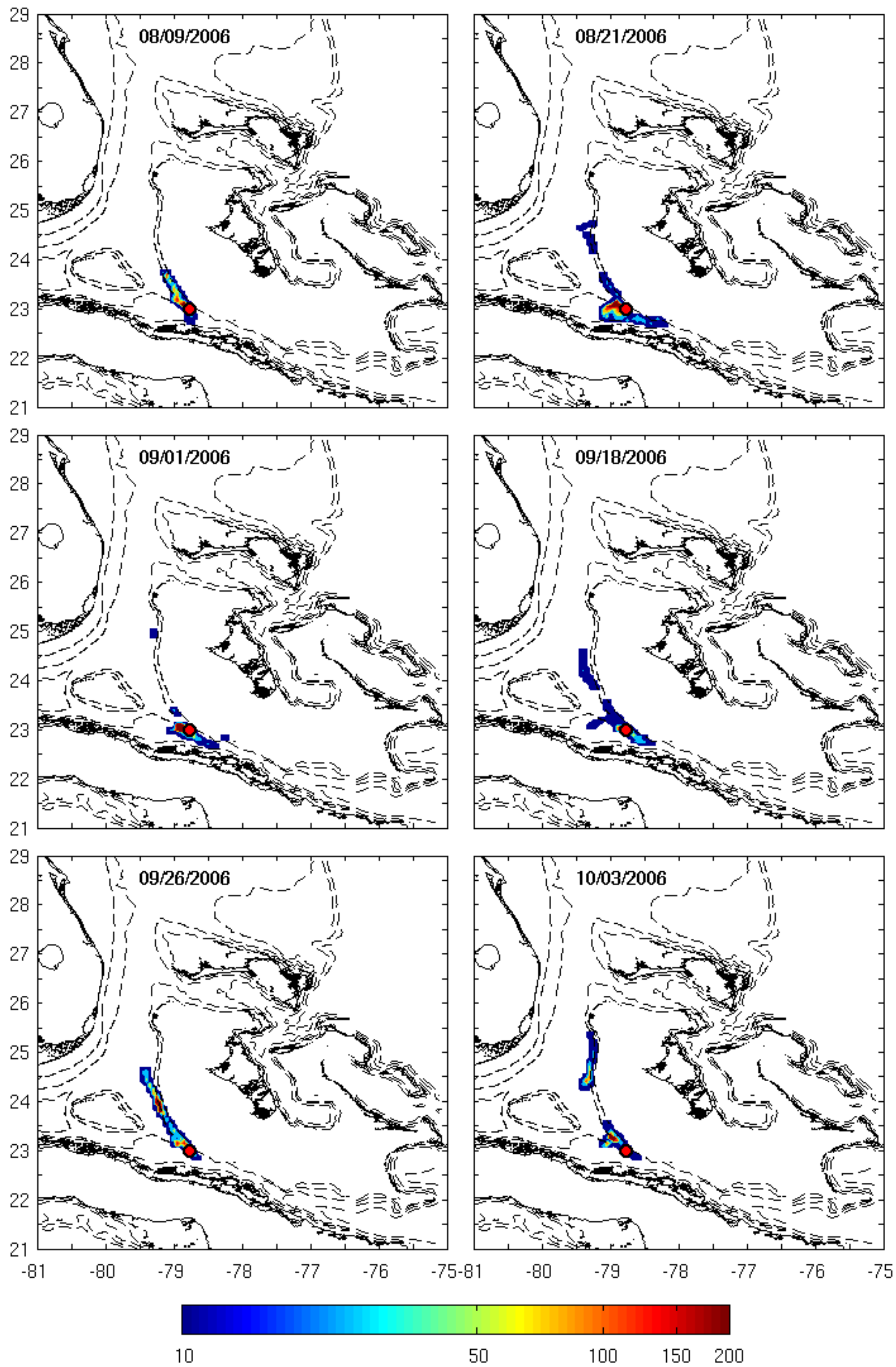


Fig. D.39: Two-dimensional maps of the maximum concentration (ppb) of submerged oil plume (seabed release/CASE B6)

APP7.28 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (SEABED RELEASE/CASE B4)

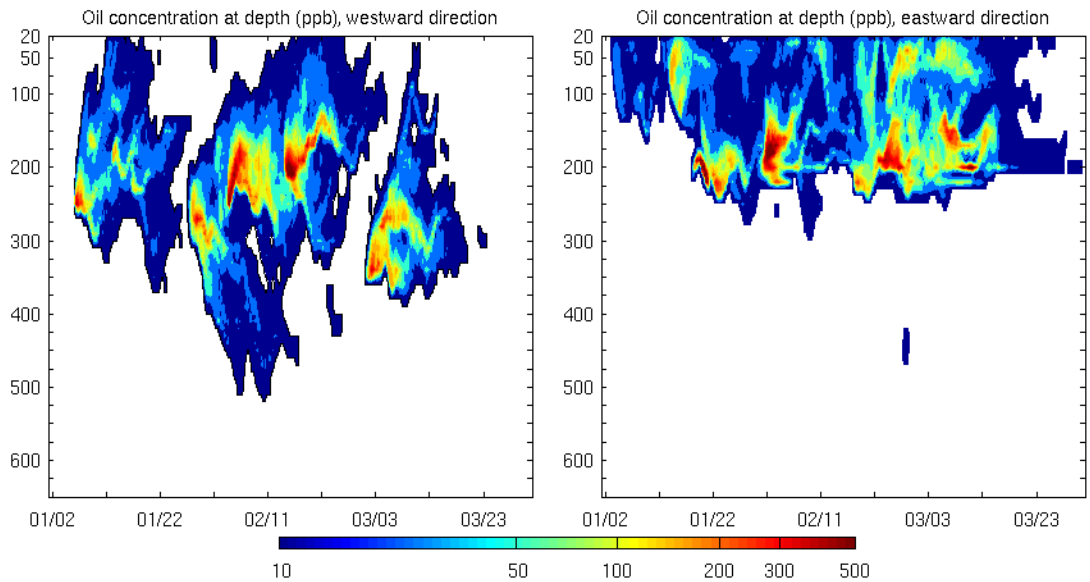


Fig. D.40: Impact of a potential oil spill on the water column: Vertical profile of the maximum oil density (ppb) in the water column through time (seabed release/CASE B4), west of the release point (left) and east of the release point (right).

APP7.29 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (SEABED RELEASE/CASE B5)

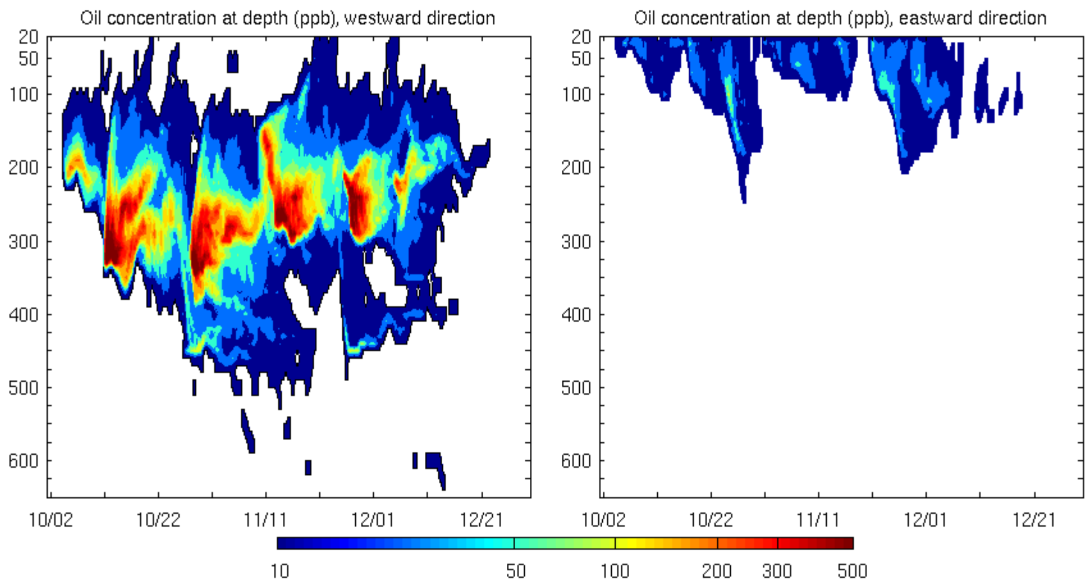


Fig. D.41: Impact of a potential oil spill on the water column: Vertical profile of the maximum oil density (ppb) in the water column through time (seabed release/CASE B5), west of the release point (left) and east of the release point (right).

APP7.30 IMPACT OF A POTENTIAL OIL SPILL ON THE WATER COLUMN (SEABED RELEASE/CASE B6)

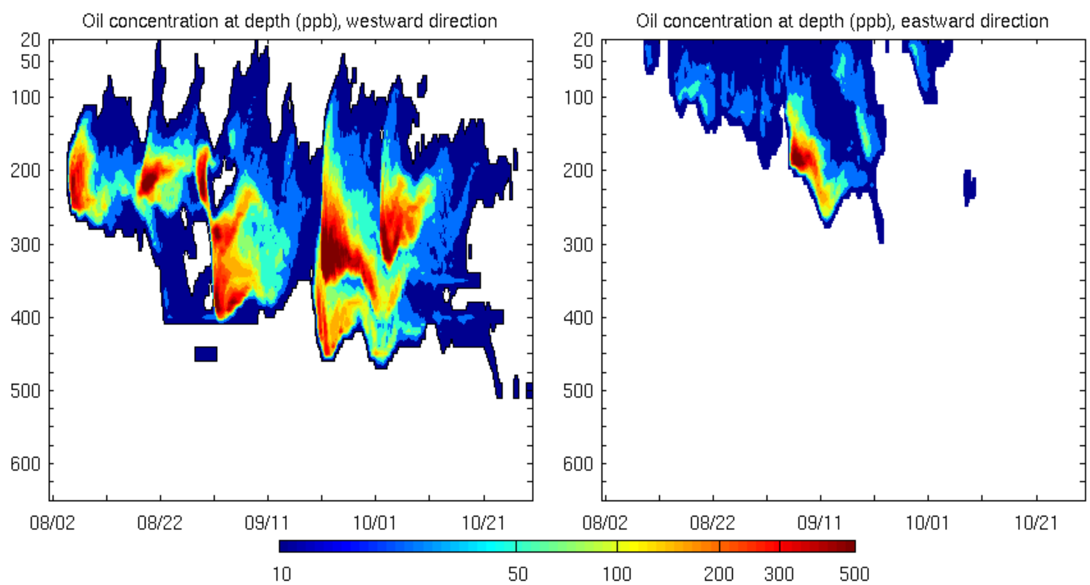


Fig. D.42: Impact of a potential oil spill on the water column: Vertical profile of the maximum oil density (ppb) in the water column through time (seabed release/CASE B6), west of the release point (left) and east of the release point (right).

REPORT BRIEF

In Response to the specific BPC questions Q1-Q2

Prepared by

Villy Kourafalou, Ph.D.

January 4, 2012

Q1. The oil was characterized as High Sulfur crude, with 42% medium carbon fractions (half-life of 50 hrs), 18 % low carbon (10 hr half-life) and 40 % heavy carbon (250 hr half-life). The report does not say whether the half-lives were for surface or submerged conditions. Surface conditions have shorter half-lives because of evaporation of the oil.

The half lives correspond to evaporation rates, which were all calculated for the oil reaching the upper 20m of the surface. The submerged oil is biodegrated with a temperature-dependent relationship.

Q2. A specific location was used in the oil transport modeling. If the well location were moved, but still in the same block, how would the results change? Note, this is not a request for more modeling at this site, but rather a qualitative description of changes in impact areas due to relatively small changes in well location.

Two different factors should be taken into account: a) the hydrodynamic model which provides the velocity field; b) the oil module, which allows interpolation within a hydrodynamic model cell. Below we give a detailed description on how the oil module interpolation takes place in space and time (section A). It should be noted that in any tracer studies, results are highly dependent on the dominant current field. Therefore, changes within the same block would have small impact. We have performed analysis of current fields (annually averaged current speed and East-West and North-South components) at 9 points at considerable distances (3.5 to 5 km) away from the BPC release location to examine maximum average changes expected in the current field surrounding the release point (section B).

A) OIL MODULE INTERPOLATION WITHIN THE SAME BLOCK

The Connectivity Modleing System (CMS) that supplies the oil module precisely interpolates (at each time step) the current velocity field in 3D based on 64 points around a given location.

The CMS does a tricubic interpolation over space: There are 4 x 4 x 4 = 64 neighboring nodes needed for this interpolation (see Figure 1). The tricubic interpolation is done over each of the three dimensions. A third-degree (cubic) polynomial is fitted to the values on the four points along the dimension. This cubic polynomial can then be used to calculate the value on any point between the grid points.

To advect an oil particle in a changing ocean velocity field, the CMS interpolates linearly between consecutive ocean velocity files. When the flow field is quite uniform across neighboring grid cells, the change of location within one grid cell will have a negligible effect in the outcome of the tracer transport.

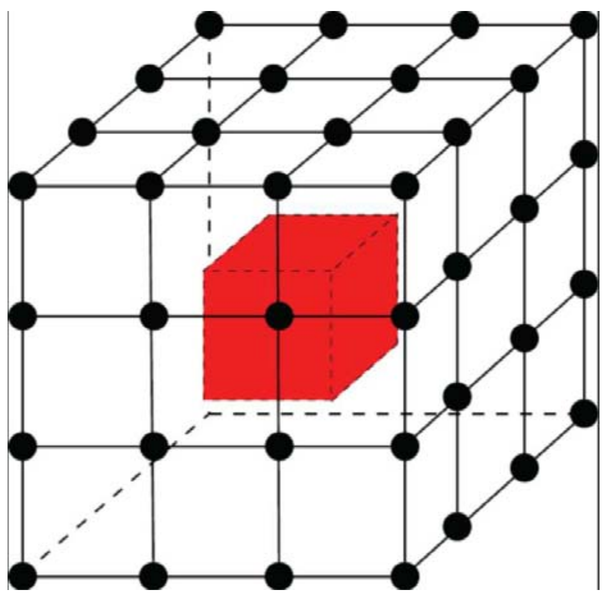


Figure 1: the 64 points (4 to the 3d power) used for the 4 nodes in the tricubic interpolation of the 3-dimensional field surrounding an oil particle.

B) STATISTICS ON THE VELOCITY FIELD SURROUNDING THE RELEASE POINT

Annual average of current velocities (from daily hydrodynamic model archives) at several depths was performed for the BPC release point and 8 points (Figure 2) at several kilometers distance to establish maximum changes in average velocity values. The results are shown in Table 1 for current speed, Table 2 for the velocity U component (East-West, positive toward East) and Table 3 for the velocity V component (North-South, positive toward North). A fairly homogeneous current field is apparent in all calculations, with differences generally slightly larger for the points at the larger distance of 5 km. However, most differences are at the second digital point. Differences in currents below 0.10 m/s should be ignored, as these flows are too small for changes to matter.

P1. 78.8000W 23.0333N	P4. 78.7600W 23.0333N	P7. 78.7200W 23.0333N
P2. 78.800W 22.9965N	P5.(BPC point) 78.7557W 23.0025N	P8. 78.7200W 22.9965N
P3. 78.8000W 22.9597N	P6. 78.7600W 22.9597N	P9. 78.7200W 22.9597N

Figure 2: Locations of the 9 points used to extract annual average values of current velocity (shown in Tables 1-3). The red letters mark the BPC release location point and 4 points that are at a 3.5 km distance to the West (P2), East (P8), North (P4) and South (P6). Diagonal points P1 (Northwest), P7 (Northeast), P3 (Southwest) and P9 (Southeast) are at a distance of 5 km.

Table 1: Annually averaged current speed (in m/s) for the 9 points shown in Figure 2.

Depth	P1	P2	P3	P4	P5	P6	P7	P8	P9
0m	0.36	0.35	0.35	0.38	0.37	0.36	0.38	0.38	0.38
50m	0.37	0.37	0.37	0.37	0.38	0.38	0.35	0.37	0.39
100m	0.29	0.29	0.30	0.26	0.28	0.30	0.22	0.25	0.28
150m	0.16	0.17	0.18	0.14	0.15	0.16	0.13	0.13	0.14
175m	0.13	0.13	0.14	0.14	0.13	0.13	0.15	0.14	0.13
200m	0.13	0.13	0.12	0.16	0.14	0.13	0.16	0.16	0.15
250m	0.14	0.14	0.14	0.15	0.15	0.16	0.12	0.14	0.15
300m	0.12	0.13	0.13	0.09	0.11	0.12			

Table 2: Annually averaged U-component of current velocity (in m/s) for the 9 points shown in Figure 2.

Depth	P1	P2	P3	P4	P5	P6	P7	P8	P9
0m	0.16	0.18	0.18	0.18	0.18	0.19	0.18	0.20	0.22
50m	0.20	0.22	0.22	0.21	0.22	0.23	0.19	0.22	0.24
100m	0.15	0.17	0.18	0.14	0.16	0.18	0.11	0.14	0.17
150m	0.05	0.07	0.10	0.02	0.05	0.08	-0.01	0.02	0.06
175m	0.01	0.03	0.05	-0.02	0.01	0.03	-0.05	-0.02	0.01
200m	-0.02	0.01	0.02	-0.04	-0.02	-0.01	-0.06	-0.04	-0.02
250m	-0.04	-0.03	-0.03	-0.04	-0.04	-0.04	-0.03	-0.03	-0.04
300m	-0.03	-0.03	-0.03	-0.02	-0.02	-0.03			

Table 3: Annually averaged V-component of current velocity (in m/s) for the 9 points shown in Figure 2.

Depth	P1	P2	P3	P4	P5	P6	P7	P8	P9
0m	-0.23	-0.22	-0.21	-0.24	-0.24	-0.23	-0.25	-0.25	-0.24
50m	-0.24	-0.23	-0.22	-0.25	-0.25	-0.24	-0.23	-0.24	-0.24
100m	-0.16	-0.17	-0.17	-0.14	-0.16	-0.17	-0.10	-0.13	-0.15
150m	-0.03	-0.05	-0.07	0.02	-0.02	-0.05	0.05	0.02	-0.01
175m	0.04	0.01	-0.02	0.08	0.05	0.02	0.09	0.08	0.05
200m	0.09	0.06	0.04	0.12	0.10	0.08	0.12	0.12	0.11
250m	0.12	0.12	0.11	0.13	0.14	0.14	0.10	0.12	0.14
300m	0.11	0.11	0.11	0.08	0.09	0.11			

REPORT BRIEF

Evaluation of oil half-life ratios between deep and near surface waters

Prepared by

Villy Kourafalou, Ph.D.

February 2, 2012

The Brief Report addresses Question 69 *(Oil spill modeling, Appendix A)*:

The oil was characterized as High Sulfur crude, with 42% medium carbon fractions (half-life of 50 hrs), 18 % low carbon (10 hr half-life) and 40 % heavy carbon (250 hr half-life). The report does not say whether the half-lives were for surface or submerged conditions. Surface conditions have shorter half-lives because of evaporation of the oil.

At the surface, the half-life of the oil is driven by evaporation. The evaporation depends on the oil fraction, ranging from 10 hours for the lighter fraction to 250 hours for the heaviest. The half lives correspond to evaporation rates, which were all calculated for the oil reaching the upper 20m of the surface. The half life of the submerged oil depends on biodegradation, which is a function of the temperature of the surrounding waters.

The biodegradation rate is given in Adcroft et al. (2010), where the decay rate is:

$R^{-1} = 12\ \textit{days} * 3^{(-(T-20)/10)}$

The associated half-life is $t_{1/2} = \ln(2) * R^{-1}$, where $\ln(2) = 0.693$.

During deep-release experiments, the residence depth of the deepest oil particles is mainly close to the initial release. After the release of oil, large oil droplets will rise to the surface, while the smallest ones will remain at depth. Since the biodegradation depends on the water temperature, the biodegradation rate of the submerged plume is essentially dependent on the temperature near the release depth. Moreover, as the biodegradation typical time scale decreases when the temperature rises, particles in the upper parts of the water column will have a shorter lifetime than the ones staying close to the release depth.

We have calculated the ranges of change between oil half-lives near surface and at depth, for the area surrounding the BPC release location.

First, we examine the vertical variability of Temperature, in the context of seasonal changes. We have derived time series of Temperature at different depths (0m, 50m, 100m, 150m, 200m, 250m, 300m and 400m) around the release location and for a full year (2004 was chosen as a typical example). The results are shown in Figure 1. It is evident that seasonal variability reduces with depth, with the 400m time series being the most stable. At a near surface layer of 0m to 100m, there is increased warming during the wet season (June to November, approximately days 150 to 330).

The vertical variability is examined in more detail through temperature profiles at selected days (marked with dashed lines in Figure 1). The days were chosen for different conditions of vertical distributions. The profiles are exhibited in Figure 2, while a composite of all profiles is shown in Figure 3.

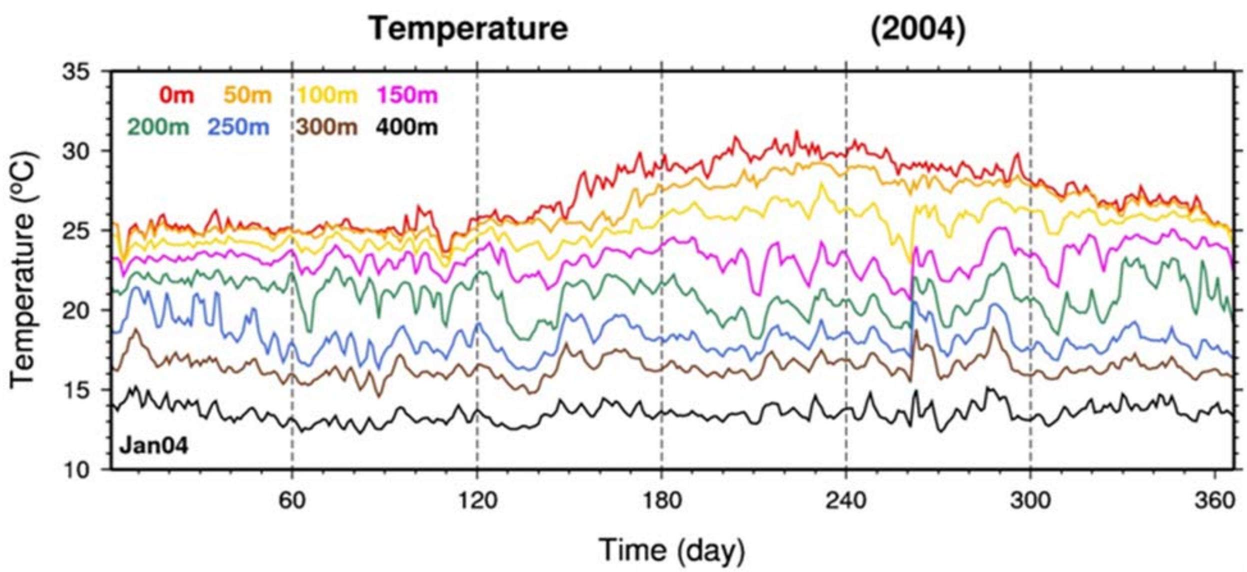


Figure 1: Time series of Temperature at 0m (red), 50m (orange), 100m (yellow), 150m (magenta), 200m (green), 250m (cyan), 300m (brown) and 400m (black) for the entire year 2004. The vertical dashed lines mark Julian days for which vertical Temperature profiles are computed in Figure 2.

The vertical profiles exhibit certain differences, especially in the upper part of the water column where they are characterized by warmer values during summer and fall (wet season). All profiles mark a distinct similarity, with the thermocline at ~150m depth. Below 150m, the profiles have similarity in slope.

Finally, we examine the rates of half lives due to biodegradation at specific depths (250m, 300m and 400m) over those due to evaporation near the surface (for each of the 3 oil fractions). Table 1 gives all related parameters: the temperature values used to calculate biodegradation, the biodegradation dependent half-lives and the ratios. For instance, the ratio of half-life at 400m over half-life near surface is: 406/250=1.63 (heavy); 406/50=8.12 (medium); 406/10=40.6 (low). The temperature standard deviations are used to calculate additional details in the ranges.

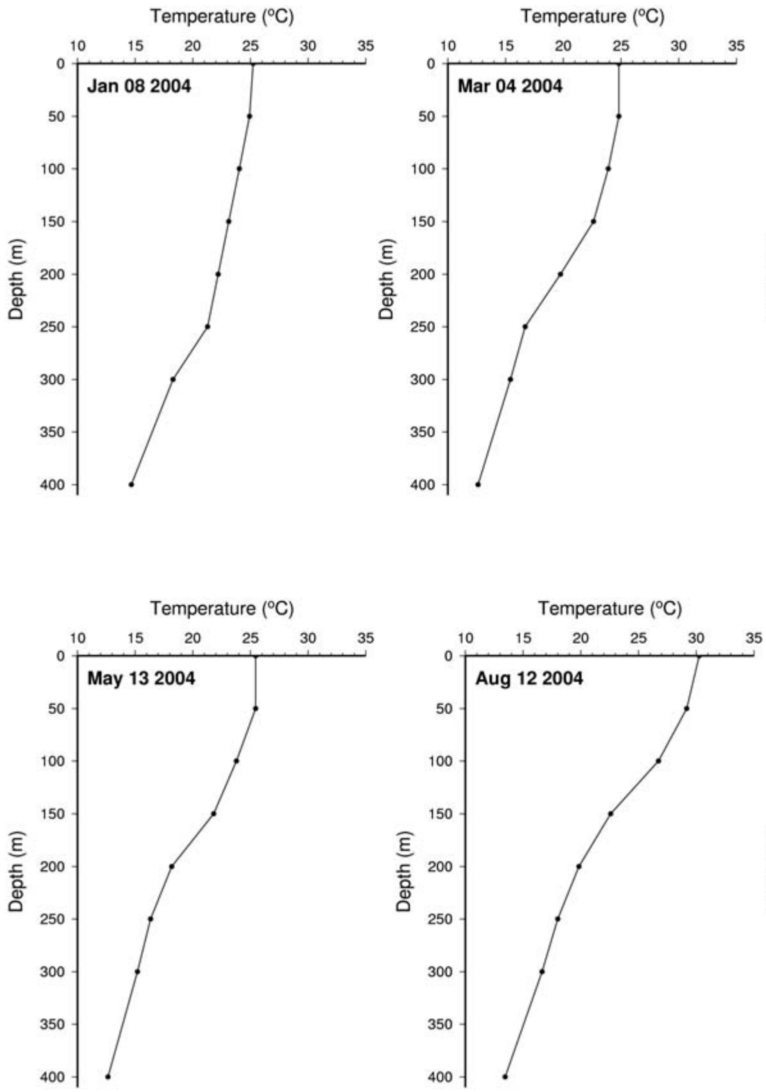


Figure 2: Vertical profiles of Temperature for the days of 2004 marked in Figure 1 (top left to bottom right: January 8, March 4, April 17, May 13, August 12, September 20).

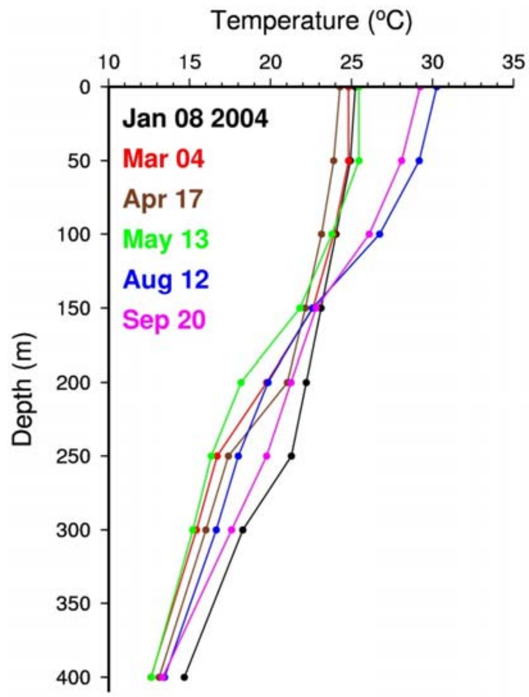


Figure 3: A composite of all vertical Temperature profiles given in Figure 2.

Depth	Mean Temp (°C)	Temp standard deviation (°C)	biodegradation half-lives (h)	Half-life ratios **low** (divide by 10h)	Half-life ratios **medium** (divide by 50h)	Half-life ratios **heavy** (divide by 250h)
250m	18.25	1.022	242 (±27)	24.2 (±2.70)	4.84 (±0.54)	0.97 (±0.11)
300m	16.41	0.678	296 (±22)	29.6 (±2.20)	5.92 (±0.44)	1.18 (±0.09)
400m	13.53	0.563	406 (±25)	40.6 (±2.50)	8.12 (±0.50)	1.63 (±0.10)

Table 1: Temperature (mean and standard deviation), biodegradation dependent half-lives and ratios of half lives (at depth due to biodegradation divided by those near surface, due to evaporation for each of the 3 oil fractions), as a function of depth (± denotes the plus or minus values, based on the Temperature standard deviation from the mean).

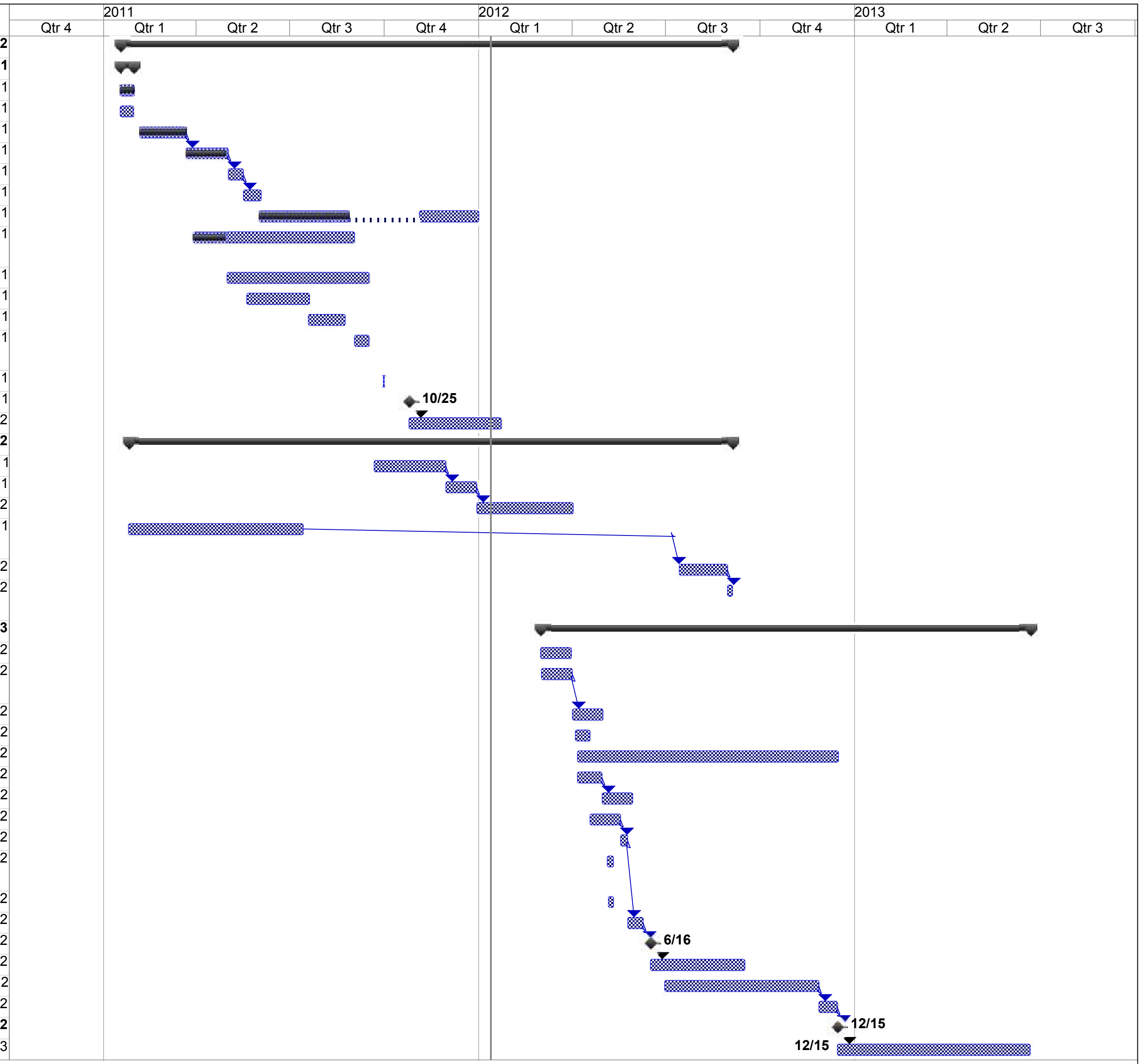
In conclusion, for the low oil fraction, the average oil loss is expected to be about 40, 30 and 25 times slower at 400m, 300m and 250m, respectively, as compared to the near surface loss. For the medium oil fraction, these numbers become about 8, 6 and 5; while, for the heavy oil fraction, they become about 1.6, 1.2 and 1, respectively. These values are based on typical annual mean temperature dependence. Deviations from the mean are generally 2.5 times (low fraction), 0.5 times (medium fraction) and 0.1 times (low fraction). This corresponds to deviations of about 6% to 10%. The seasonal variability does not have a substantial impact in the above estimates.

REFERENCES

Adcroft, A., R. Hallberg, J.P. Dunne, B.L. Samuels, J.A. Galt, C.H. Barker, and D. Payton, 2010. Simulations of underwater plumes of dissolved oil in the Gulf of Mexico, Geophys. Res. Lett., doi: 10.1029/2010GL044689.

Appendix B
Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
1	**EXPLORATION STUDIES**	**594 days?**	**Mon 1/17/11**	**Mon 9/3/12**
2	**Site Survey/ Shallow Hazard Survey**	**13 days**	**Mon 1/17/11**	**Sat 1/29/11**
3	2D Seismic Survey	13 days	Mon 1/17/11	Sat 1/29/11
4	Side Sonar/Echo Sounder	13 days	Mon 1/17/11	Sat 1/29/11
5	2D Seismic Processing	45 days	Sat 2/5/11	Mon 3/21/11
6	2D Seismic Interpretation	41 days	Tue 3/22/11	Sun 5/1/11
7	Rank 2D Prospects	15 days	Mon 5/2/11	Mon 5/16/11
8	Identify Initial Location	17 days	Tue 5/17/11	Thu 6/2/11
9	Negotiate Farm in	146 days	Wed 6/1/11	Sat 12/31/11
10	Environmental Impact Assessment (EIA) Compilation	157 days	Tue 3/29/11	Thu 9/1/11
11	Current Study and Oil Spill Modeling	138 days	Sun 5/1/11	Thu 9/15/11
12	Multi-beam Seabed Acquisition	61 days	Fri 5/20/11	Tue 7/19/11
13	Multi-beam Processing	36 days?	Tue 7/19/11	Tue 8/23/11
14	BPC review of General EIA with an outlinefor EMP	14 days	Fri 9/2/11	Thu 9/15/11
15	Delivery of Final EIA	1 day	Fri 9/30/11	Fri 9/30/11
16	EIA Submission to GOB	0 days	Tue 10/25/11	Tue 10/25/11
17	GOB comment period	90 days	Tue 10/25/11	Sun 1/22/12
18	**3D Seismic Survey**	**586 days**	**Tue 1/25/11**	**Mon 9/3/12**
19	3D Siesmic Fast-track Processing	70 days	Wed 9/21/11	Tue 11/29/11
20	3D Seismic Fast-track Interpretation	30 days	Wed 11/30/11	Thu 12/29/11
21	Identify potential drill sites from 3D	94 days	Fri 12/30/11	Sun 4/1/12
22	3D Pre-stack Depth Migration Processing	170 days	Tue 1/25/11	Wed 7/13/11
23	3D Seismic Interpretation	45 days	Sat 7/14/12	Wed 8/29/12
24	Refine potential drill sites and well plan from 3D	5 days	Thu 8/30/12	Mon 9/3/12
25	**DRILLING**	**410 days**	**Thu 3/1/12**	**Thu 6/20/13**
26	Assemble Drilling Team	30 days	Thu 3/1/12	Fri 3/30/12
27	Identify Survey Company (Site Specific EMP)	30 days	Fri 3/2/12	Sat 3/31/12
28	Site Survey	30 days	Sun 4/1/12	Mon 4/30/12
29	Negotiate Contract for Well Specific EMP	14 days	Wed 4/4/12	Tue 4/17/12
30	Drilling Program Design	240 days	Fri 4/6/12	Sat 12/15/12
31	Identify Drilling Company	24 days	Fri 4/6/12	Sun 4/29/12
32	Secure Contract for Drilling	30 days	Mon 4/30/12	Tue 5/29/12
33	Well Specific EMP	30 days	Wed 4/18/12	Thu 5/17/12
34	BPC review of Well Specific EMP	7 days	Fri 5/18/12	Thu 5/24/12
35	Obtain drilling methodology from Drilling Company	6 days	Sat 5/5/12	Thu 5/10/12
36	Design input to EMP	5 days	Sun 5/6/12	Thu 5/10/12
37	Final Well Specific EMP	15 days	Fri 5/25/12	Fri 6/8/12
38	EMP Submission to GOB	0 days	Sat 6/16/12	Sat 6/16/12
39	GOB comment period	90 days	Sat 6/16/12	Sat 9/15/12
40	Order Well Head, Tubular & Casings	140 days	Sat 6/30/12	Mon 11/26/12
41	Mobilization of Drill Rig	14 days	Tue 11/27/12	Fri 12/14/12
42	**Spud Well #1**	**0 days**	**Sat 12/15/12**	**Sat 12/15/12**
43	Well #1	135 days	Sat 12/15/12	Thu 6/20/13



Project: Exploration Timeline 13Jan12
Date: Fri 1/13/12

Task	Project Summary	Inactive Task	Duration-only	Finish-only
Split	External Tasks	Inactive Milestone	Manual Summary Rollup	Progress
Milestone	External Milestone	Inactive Summary	Manual Summary	Deadline
Summary	Inactive Task	Manual Task	Start-only	

Appendix C
Sensitivity Map

(Fold-out Attached)

Appendix D
Ryder Scott Competent Person's Report

Appendix E
Standards for Bahamas Petroleum Company Proposed by BEST Commission

THE BAHAMAS ENVIRONMENT, SCIENCE AND TECHNOLOGY COMMISSION
Ministry of the Environment

REF: MTE/BEST/EIA/

<u>SENT VIA FACSIMILE</u>

February 15th, 2012

Roberta W. Quant
Environmental Scientist
Bahamas Petroleum Company Ltd.
Montague Sterling Center
P. O. Box SS-6276
Nassau, Bahamas

BAHAMAS PETROLEUM COMPANY PLC.
FEB 17 2012
RECEIVED

<u>RE: STANDARDS FOR BAHAMAS PETROLEUM COMPANY "BPC"</u>

Your letter dated 30th January 2012 refers.

The Bahamas Environment, Science and Technology (BEST) Commission has examined various standards for oil and gas exploration and production, at this time we do not have to make final decision. In addition to the OSPAR standards appended to your above referenced letter and in the absence of specific Bahamian Standards, the following are considered to be appropriate and applicable to the oil and gas industry:

1. ***Environmental Management in Oil and Gas Exploration and Production***, Joint E&P and UNEP Technical Publication. Standards within the publication include:
   - Provides air quality operational discharge standards from the World Health Organization air quality guidelines,
   - Operational discharge standards prescribed by regional conventions
   - Offshore discharge limits for oil in produced wastewater prescribed by various national legislation

2. ***NPDES General Permit for discharges from the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico off the coasts of Louisiana and Texas***, U.S. Environmental Protection Agency Region 6. This document is the general wastewater discharge permit for offshore oil exploration activities. It provides effluent limits for the discharge of wastewater, drilling fluids, and drill cuttings.

3. ***Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development***, International Finance Corporation (IFC), World Bank Group. Effluent limits for the following are provided:
   - Drilling Fluids and Cuttings for Non-Aqueous Drilling Fluids,
   - Drilling Fluids and Cuttings for Water Based Drilling Fluids,
   - Produced Water,

- Completion and Well Workover Fluids,
- Produced Sand, Hydrotest water, Cooling Water, Desalination Brine, and
- Sewage, Foodwaste, Storage displacement water, bilgewater, and deck drainage complies with MARPOL 73/78.

4. ***Annexes 13 and 14 of MARPOL 73/78*** – Provides standards for SOx, PM, and NOx.

5. ***Overview of Outer Continental Shelf Regulations,*** Bureau of Ocean Energy Management, Regulation and Enforcement. The document outlines:
    - Oil Spill Plan Requirements in the US for offshore oil exploration activities
    - Air Emissions permitting

At this juncture the BEST Commission is not in a position to finalize the standards to govern the oil/petroleum industry without the extensive national consultation required as well as the required regulatory review.

Sincerely,

DIRECTOR

/hl

cc: Permanent Secretary (Actg.), Ministry of the Environment
Director, Department of Legal Affairs
Energy Officer, Ministry of the Environment

Andy Byers
Senior Environmental Project Manager
Black and Veatch International