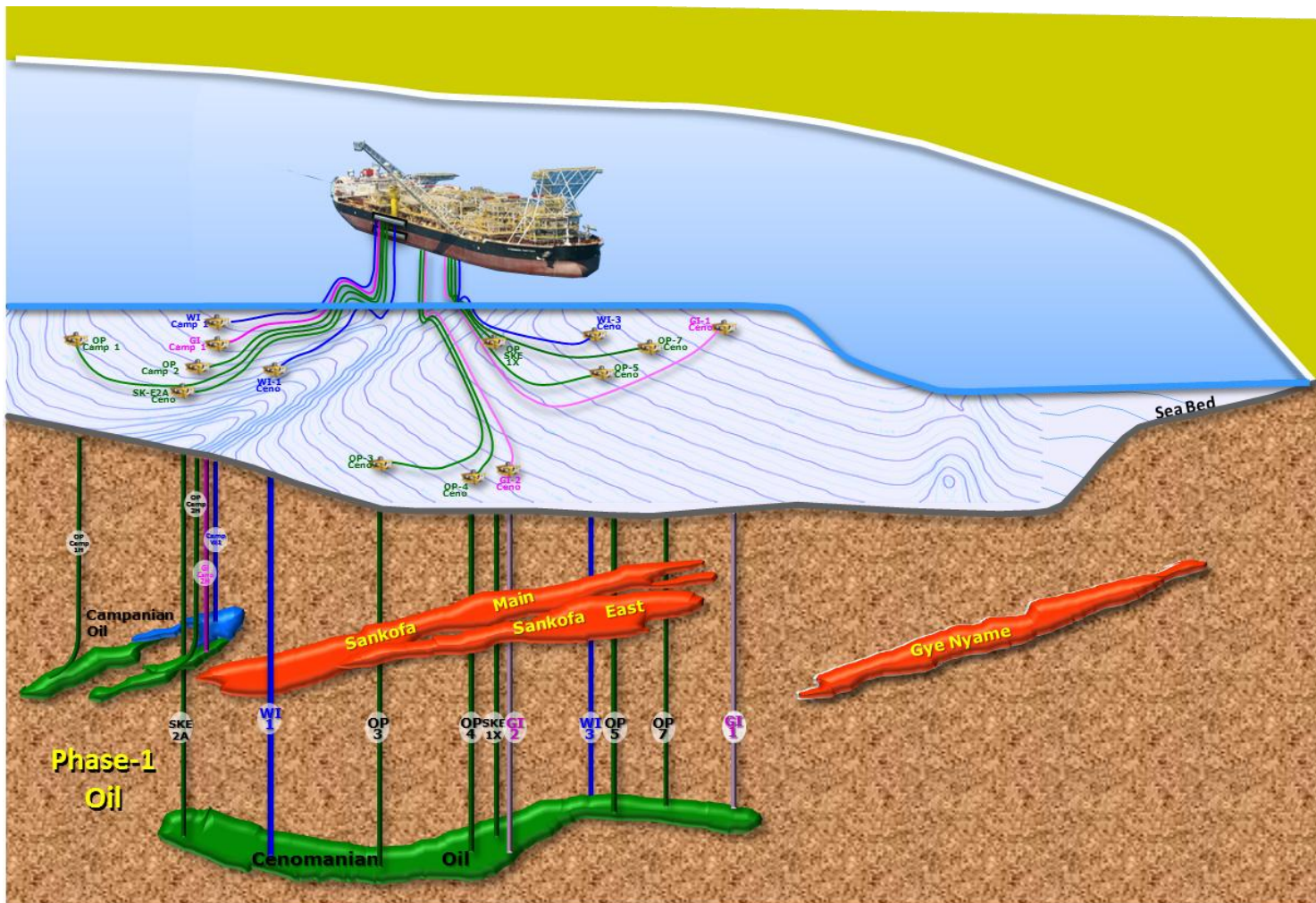




GHANA OFFSHORE CAPE THREE POINTS OIL BLOCK DEVELOPMENT

PHASE 1

FINAL ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

DOC 000415_DV_CD.HSE.0208.000_00



Eni S.p.A.
Exploration & Production Division



JULY, 2015

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Ghana OCTP Block Phase 1 ESHIA

ABSTRACT

This report outlines the conditions of the environment that will house the project, describing the identification of any potential significant and adverse environmental, social and health effects and identifying the environmental resources and social and health aspects that could be impacted.

17/06/2015	05	Final Version			F. Cavanna E. Lago
Date	Revision	Revision Description	Prepared	Checked	Approved

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Summary of Revisions

Date	Rev.	Revision Description	Prepared	Checked	Approved
16/06/2015	04	Issued for submission to Authorities	ESL-eni TEAM	J. Deffis G. Nicotra A.K. Armah	F. Cavanna E. Lago
20/01/2015	03	Issued for submission to Authorities	ESL-eni TEAM	J. Deffis G. Nicotra A.K. Armah	F. Cavanna E. Lago
02/10/2014	02	Issued for submission to Authorities	ESL-eni TEAM	J. Deffis G. Nicotra A.K. Armah	F. Cavanna E. Lago
09/04/2014	01	Issued for submission to Authorities	ESL-eni TEAM	M. Leonardi T. Bentil	J. Deffis A.K. Armah
20/03/2014	00	Issued for comments	ESL-eni TEAM	M. Leonardi T. Bentil	J. Deffis A.K. Armah

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1 INTRODUCTION

This introductory chapter presents and overview of the project, provides details of the E(SH)IA team and outlines the approach adopted to elaborate the E(SH)IA report. In addition the structure of the remainder of the report is outlined.

The EIA process as stipulated in the Ghanaian EPA regulation encompasses all environmental, social and health issues to be addressed and as such the use of Environmental Social and Health Impact Assessment (ESHIA) is synonymous with EIA; for the purpose of this report, E(SH)IA may be used in alternation with EIA throughout the document.

1.1 BACKGROUND OF THE PROJECT

The Offshore Cape Three Points (OCTP) Development is a significant oil and gas initiative being led by eni Ghana. The development involves three oil and gas fields all located about 60 km offshore the Western Region (see Figure 1-1). The development is being executed in two phases:

- Phase 1: Oil Production Project
- Phase 2: Gas Production Project

This E(SH)IA addresses the Phase 1 Oil Production Project.

The Offshore Cape Three Points (OCTP) block licence, is located approximately 60 km offshore in the Western Region of the Republic of Ghana west of the Jubilee block (Figure 1-1). The OCTP joint venture, composed of eni Ghana Exploration and Production Limited ("eni Ghana") Operator of the block holding 47.222% participating interest, Vitol Upstream Ghana Limited ("Vitol") holding 37.778% participating interest and GNPC 15% participating interest carried by the Contractor, made three (3) non-associated gas discoveries, Sankofa Main in 2009, Gye Nyame in 2011, and Sankofa East in 2012 (the "Gas Discoveries") and two oil discoveries in Sankofa East in 2012 (Cenomanian and Campanian reservoirs -the "Oil Discoveries").



Figure 1-1 Location of OCTP Development Permits (yellow blocks). Green polygons outline the oil reservoir, red polygons the gas reservoir.

The development scheme consists in:

- 14 subsea wells (8 oil producers of which 2 re-entry, 3 water injectors and 3 gas injectors)
- one new conversion FPSO unit to be installed above the fields to collect and process produced oil.
- a subsea network with flexible flowlines and risers

A new conversion double hull/double balcony FPSO unit will be installed above the main oil and non-associated gas reservoirs inside the OCTP Development and Production Areas (as defined in the PA), at about 63 km from shoreline (Sanzule), and it will be controlled and operated by the OCTP Operator.

The FPSO unit is expected to treat all crude oil and associated gas (to be re-injected for reservoir pressure support) produced from the OCTP license. Crude oil will be separated from associated gas and water, stabilized and stored into storage tanks in the FPSO unit before being metered and offloaded. Oil producers, gas and water injection wells will be connected directly to the FPSO unit (no manifolds are foreseen) through flexible risers and flowlines. Treated oil will be delivered to tankers and associated gas will be re-injected in the reservoir

Produced water will be separated and treated at the produced water treatment unit in order to comply with specifications for water injection then mixed with treated seawater before being injected in the reservoirs (both Cenomanian and Campanian) for pressure maintenance. Associated gas produced from the oil separation train will be compressed, dehydrated before being re-injected into the reservoirs (Cenomanian and Campanian) according to the specified demand. Part of this gas will be used as fuel for power generation on the FPSO.

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1.2 OVERVIEW OF OIL AND GAS INDUSTRY IN GHANA

Oil exploration in Ghana dates back to 1898. From that time until the late 1990s about one hundred exploration wells were drilled, all onshore, with no significant discoveries except for the offshore Saltpond oil find in 1970.

In June 2007, Ghana officially announced oil and gas discovery in commercial quantities in the offshore western part of the country. Since the discovery of this oil and gas resources, there have been huge expectations as to how Ghana is going to be transformed as a result of the discovery of the oil and gas in commercial quantities. The wealth from natural resource is a strong base for income creation and sustained economy.

At present an estimated 104,000 barrels of oil per day equivalent (bopd) are produced offshore Ghana from the Jubilee Field (Accorn, 2015), through a network of 9 producing wells and a single floating production, storage and offloading (FPSO) facility. Operations are supported largely from Takoradi, in the form of transfer of material and crews to offshore platforms by supply vessels. Gas is presently flared at the FPSOs, although a pipeline and onshore gas plant are under construction to generate power from that gas. Additional developments are planned in the Deepwater Tano Block, in the Tweneboa, Enyenra and Ntomme (TEN) fields, together with the project object of the present document within the OCTP.

Despite these developments and according to the US Energy Information Administration (EIA, 2014) Ghana imported 22 Bcf of natural gas in 2012. Ghana imports natural gas via the West African Gas Pipeline (WAGP), which runs from Nigeria to Ghana. WAGP was shut down from August 2012 to July 2013 for repairs following damage to the Togolese section of the pipeline. Gas flows through the pipeline have decreased since 2011 and remain unreliable, forcing Ghana to use heavy oil to supply its dual-fuelled power plants.

Ghana's energy ministry is considering plans to build a regasification terminal to import liquefied natural gas (LNG) in case imports from WAGP and domestic gas production are not enough to meet power generation demand in the medium to long term. According to Ecobank, Ghana is projected to need more than 800 MMcf/d of natural gas by 2017 for power generation and for reinjection into wells to enhance oil production.

As of the end of 2012, Ghana had an installed electricity capacity of almost 2.3 megawatts according to Ghana's national energy statistics. Ghana generated 12 billion kilowatt-hours (kWh) of power in 2012 of which 67% were from hydroelectricity and the remainder from fossil-fuel powered generation. Many Ghanaians, particularly in rural areas, rely on traditional biomass and waste, particularly firewood, for household cooking and heating. Firewood accounts for slightly more than 40% of Ghana's total primary energy consumption, according to Ghana's national energy statistics. Ghana must expand its installed electricity capacity and distribution system to provide electricity to almost 30% of its population that does not have access to electricity, according to the latest World Bank data.

The present Project is a next step in the growing energy sector in Ghana. It represents a foundation for production of natural gas in Ghana, bringing new sources to market for the benefit of industry and the people of Ghana. The Project will support the wider Ghana Gas Infrastructure Development Project which is part of the Western Region Spatial Development Framework (WRSDF). This development initiative includes the gas processing plant at Atuabo and other facilities.

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1.3 PROJECT PROPONENT

Eni Ghana Exploration and Production Limited was incorporated in Ghana on 26th May 2009, following the signature on the 25th March 2009 of a Farm-in Agreement between eni Ghana and Vitol Upstream Ghana Ltd. (VUGL). Eni Ghana is a wholly owned subsidiary of eni S.p.A, an integrated energy company. Active in 77 countries, with a staff of 78,400 employees, it operates in oil and gas exploration, production, transportation, transformation and marketing, in petrochemicals, oilfield services construction and engineering. Eni has become one of the leading global operators in the deepwater sector, one of the biggest challenges faced by the oil and gas industry. Eni is executing several worldwide deepwater exploration projects (depths greater than 450 metres) and in very deep waters (depths greater than 1,500 metres). The offshore activities in very deep waters, such as those being carried out in Ghana, are also ongoing in the Gulf of Mexico and along the coast of Mozambique and Brazil, where the company is involved, as operator or partner, in offshore exploration projects, some of which have already given positive results.

eni is a member of the International Association of Oil & Gas Producers (OGP) and the International Oil Industry Environmental Conservation Association (IPIECA). Eni operates globally and is in contact with a large variety of natural environments, from deserts to tundra, from rain forests to the Arctic and Antarctic polar regions, from the Mediterranean marquis to coral reefs. Eni has started assessment programmes and mitigation projects for the potential impacts of its own activities, considering the conservation of biodiversity as one of the objectives of environmental protection. More information is available on the eni Website – www.eni.com.

1.4 PURPOSE OF E(SH)IA

The Ghana Environmental Assessment Regulations (1999) stipulates that oil and gas field development is an undertaking that requires a mandatory full Environmental Impact Assessment (EIA) to be done as a means of ensuring environmental soundness and sustainability in the development of the undertakings. The undertaking also requires registration and authorisation by the Ghana Environmental Protection Agency (EPA). eni Exploration and Production Limited (eni E&P) has commissioned ESL Consulting (ESL) referred to as the EIA team to undertake the EIA for the OCTP Block Development Project.

Guidance on how to undertake the EIA is provided in the EPA Sector (Oil & Gas) Guidelines for Environmental Assessment and Management in Ghana.

The EIA process as stipulated in the Ghanaian EPA regulation encompasses all environmental, social and health issues to be addressed and as such the use of Environmental Social and Health Impact Assessment (ESHIA) is synonymous with EIA. For the purpose of this report E(SH)IA will be used.

The Environmental Assessment Regulations 1999 defines:

- environmental assessment as “the process for the orderly and systematic identification, prediction and evaluation of the likely environmental, socio-economic, cultural and health effects of an undertaking; and the mitigation and management of those effects”, and
- Environmental impact assessment as “the process for the orderly and systematic evaluation of a proposal including its alternatives and objectives and its effects on the environment including the mitigation and management of those effects; the process extends from the initial concept of the proposal through implementation to completion, and where appropriate, decommissioning.

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Furthermore, the purpose of the E(SH)IA is to provide information to regulators, the public and other stakeholders to aid the decision-making process.

Consequently, the present E(SH)IA study considers, the possible direct and indirect impacts on the bio-physical environment, the wellbeing of the people involved in the oil and gas operations (health) and those individuals/communities the oil and gas operations may affect (Community issues), at the pre-construction, construction, operation and decommissioning phases. In detail, the main objectives of the E(SH)IA are as follows:

- To define the scope of the project and the potential interactions of project activities with the natural and anthropic (socio-economics and health) environment that should be defined and assessed during the E(SH)IA.
- To review national and international legislation, standards and guidelines, to ensure that all stages of the proposed project through its complete lifecycle take into consideration the requirement of Ghanaian legislation, internationally accepted environmental management practices and guidelines, and project-related “Environmental Health and Safety” (EHS) policies and standards.
- To provide a description of the proposed project activities and the existing physical, chemical, biological, socio-economic and human environment that these activities may interact with.
- To assess the potential environmental and social impacts resulting from the project activities and identify viable mitigation measures and management actions that are designed to avoid, reduce, remedy or compensate for any significant adverse environmental and social impacts and, where practicable, to maximise potential positive impacts and opportunities that may arise due to the project.
- To provide the means by which the mitigation measures will be implemented and residual impacts managed, through the provision of an outline Environmental Management Plan (EMP). This will also require the development of monitoring plans for various environmental and social impacts and a mechanism for audit, review and corrective action.

1.5 THE ESHIS TEAM

The core ESHIS team involved in this ESHIS is listed below in the table.

Name	Role	Qualifications, Experience
Juan Deffis (eni Ghana)	HSE & Community investment Manager	M. Sc. 8 years
Giuseppe Nicotra (eni SpA)	HSE Project Manager	M. Sc. 7 years
A.K. Armah (ESL)	Project Director ESL	M. Phil, 20 years
Anthony Bentil (ESL)	Assistant Project Manager	M. Phil, 5 years
Adu-Nyarko Andorful (ESL)	Socio-Economic Expert	M. Phil, 8 years
Marco Leonardi (eni)	ESHIA Study Coordinator	M. Sc. 30 years
Luigi Trovarelli (eni)	Biological & Marine Environment Expert, Impact Assessment Expert	M. Sc. 25 years
Giuditta Di Caro (eni)	Air Quality & Noise Expert	M. Sc. 8 years
Luca Della Santa (eni)	Physical Environment Expert	M. Sc. 15 years
Valentina Invernizzi (eni)	Socio-economic, Health & Stakeholder Engagement Expert	M. Sc. 4 years

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1.6 ESHIS PROCEDURAL FRAMEWORK IN GHANA

Environmental Assessments are required to be carried out on specific projects in Ghana as a means of ensuring environmental soundness and sustainability in the development of projects.

The Environmental Assessment systems refer to the relevant procedures for ensuring that:

- the planning phase follows and satisfies the provision for environmental soundness and sustainability in the various decision-making processes, alternatives and options for the eventual preferred scheme of development.
- the operational phase follows the required management provisions to achieve environment soundness and sustainability in the implementation of the project.

The planning phase of a project is covered by an Environmental Assessment, while the operational phase is covered by Environment Management Plan. The Ghana Environmental Assessment Procedures involves a step-wise system with provisions for:

- Registration
- Screening
- Scoping/Terms of Reference
- EIA Study
- Review & Public Hearing
- Appeals
- Timelines for decision-making

Public Participation is expected to occur at all levels of the process (screening, scoping, EIA study and Review stages).

The overall process under the Ghana EPA's regulation is shown in Figure 1-2.

ADMINISTRATIVE FLOW CHART OF THE EA PROCEDURE

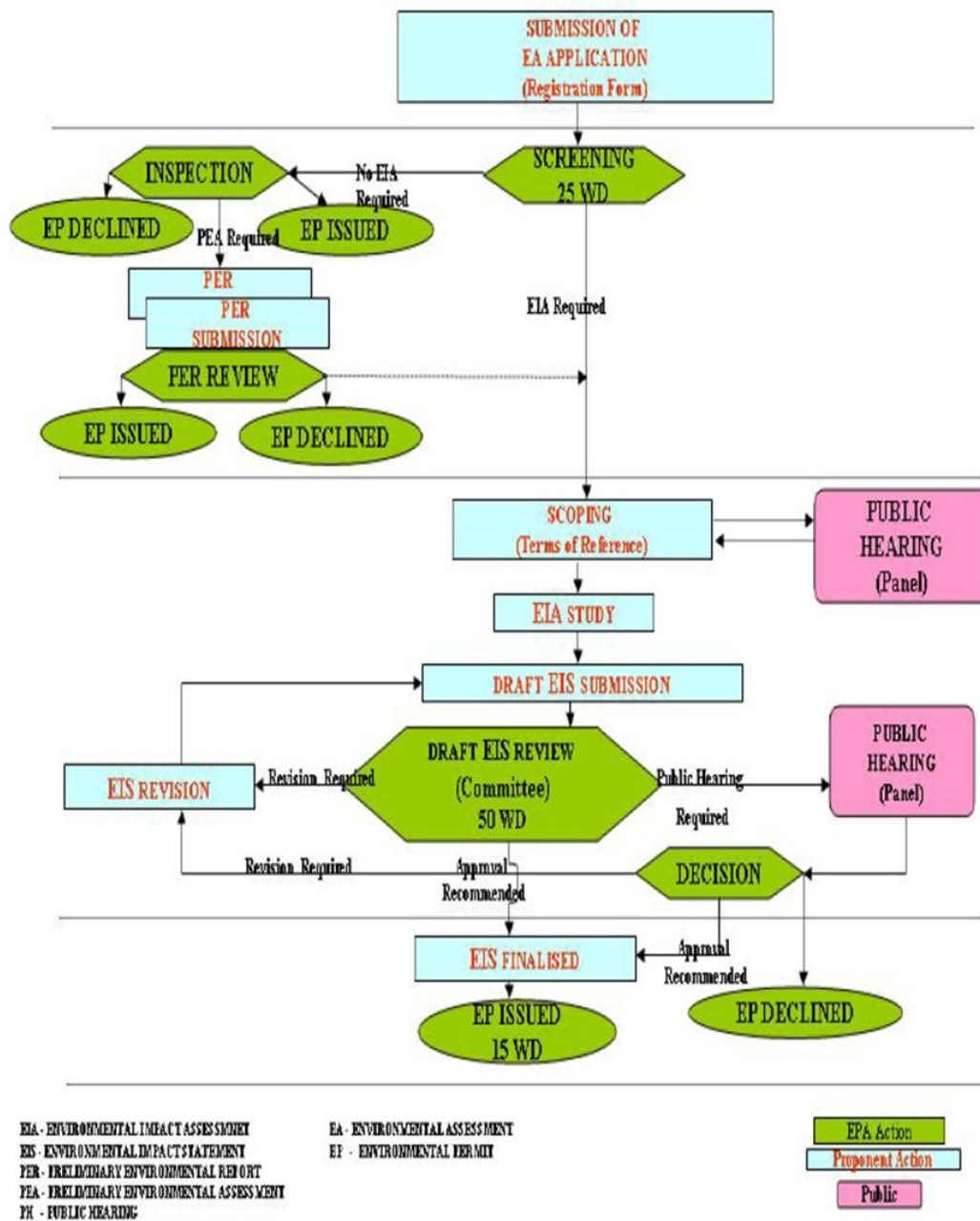


Figure 1-2 The Ghana Environmental Assessment Procedure

1.6.1 Registration

Ghana legislation requires in this phase that the Proponent accurately provide all relevant information concerning the proposal by preparing and submitting a registration document that addresses all the requirements. Full and accurate descriptions of the project location, proposed activities, the existing environment, potential impacts, and proposed mitigation are required.

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This phase coincides with the Submission of the EA Application (Registration Form). The ENI's OCTP Phase 1 development was submitted for registration with the EPA on the 13th of September 2013.

1.6.2 Screening

Screening is a preliminary assessment to determine whether a proposed project may cause significant environmental, social and health impacts. The EPA, within 25 days after the submission of the registration form, placed the development at the appropriate level of assessment. The EPA determined that the development falls into the category of undertakings (Sch. 3) for which a full E(SH)IA is required.

1.6.3 Scoping / Terms of Reference

The principal objective of scoping is to identify environmental, social and health sensitivities and those project activities with the potential to contribute to or cause impact to environmental, social and health receptors. Scoping involves the identification and the consultation with all relevant stakeholders (interested and affected parties/communities such as the government departments, ministries, local authorities, etc.) with the aim of identifying all key issues and to determine how the concerns of all parties will be addressed in the E(SH)IA.

This phase also helps to focus the E(SH)IA to be carried out on the key areas/issues of concern or impact. The output of scoping is the scoping report with the terms of reference (TOR) for the E(SH)IA.

The Terms of Reference (ToR) set out the scope or extent of the Environmental, social and Health Impact Assessment to be carried out, and included methodologies, apparatus and strategies that were to be utilized to direct the baseline data collection and the impact assessment.

The following steps were undertaken in the E(SH)IA scoping phase, and are described below.

- desktop review;
- stakeholder engagement visit; and
- preparation of the Scoping Report

Desktop Review

This step comprised the following:

- initial review of relevant legislative and guidance;
- identification and review secondary data;
- development of an outline description of the planned Project activities;
- and development of a plan for stakeholder engagement (Chapter 6 and Chapter 7.4) and consultations on the scope of the E(SH)IA.

Initial Legislative Review

Chapter 3 of this E(SH)IA Scoping Report provides a review of legislation and industry guidance relevant to the ESIA for the proposed Project.

Identification and Review of Secondary Data

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Existing baseline information on the environmental, socio-economic and health context of the Project area has been collected and reviewed and sources of other existing information identified.

The E(SH)IA team has undertaken an initial review of existing information sources that contributed to an understanding of the environmental, socio-economic and health context of the Project (see Chapter 6). Available data sources have been identified for the following subjects.

- Physical environment: oceanography, climate, geology, topography, bathymetry;
- Biological environment: benthos, fish, birds, marine mammals, turtles.
- Health (health status, common illness, healthcare delivery service etc.)
- Socio-economic environment: fisheries, demographics, livelihoods and cultural heritage.

This desktop review also focused on identifying where gaps in information exist and informed the data gathering requirements and the Terms of Reference for the remainder of the E(SH)IA.

Outline Project Description

The Project description in Chapter 2 of this E(SH)IA Scoping Report provides an overview of the various Project components and activities to a level that allows those activities with the potential to cause environmental, social and health impacts to be identified (e.g. physical presence, noise, emissions, wastes and discharges). Project planning, decision making and refinement of the Project description will continue throughout the assessment process as a result of the development of the Project and in response to the identified impacts.

Stakeholder Engagement

Project stakeholder engagement started at the E(SH)IA Scoping stage and will continue throughout the assessment and through operations to ensure that stakeholder concerns are addressed and regulatory as well as legislative requirements are met. The E(SH)IA team has developed a proposed process for engaging stakeholders (outlined in Chapter 6 and 7.4) to ensure that engagement is undertaken in a systematic manner, improves the E(SH)IA process and builds relationships whilst managing expectations.

Stakeholder Engagement Visit

A series of consultation meetings with national stakeholders in the Gt. Accra and key stakeholders in the Western Region (Takoradi and in the 6 coastal communities) were undertaken to provide Project information, collect baseline data and understand key stakeholder concerns.

Preparation of the Scoping Report

The Scoping Report, included Terms of Reference (ToR), was compiled as part of the E(SH)IA process in accordance with the regulatory requirements stipulated in Regulation 11 of the Environmental Assessment Regulations (1999). The Scoping Report and ToR were submitted to the EPA for their consideration for a thirty day period. The Scoping Report was also made available to stakeholders through the Project website, and hard copies provided on request.

1.6.4 From E(SH)IA to E(SH)IS

In accordance with the regulatory requirements stipulated in Regulation 13 of the Environmental Assessment Regulations (1999), the Agency informed eni Ghana to submit an environmental impact statement (EIS) based on the scoping report.

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The proponent commissions the Environmental Impact Assessment based on the agreed TOR. Environmental Impact Assessment normally involves baseline survey and inventory, development proposal options, potential impact identification, prediction, mitigation and alternative considerations and other requirements of the TOR.

During the study, eni Ghana as per legislative requirements initiated a public information programme for the area likely to be affected by the undertaking. Copies of all reports of the study shall be made available to EPA and relevant stakeholders. Public concerns shall be recorded and will be addressed in the EIS.

The findings of the Environmental Impact Assessment shall be compiled into an Environmental Impact Statement, which shall form the basis for the required decision-making on the undertaking for an Environment Permit. Twelve (12) copies of the draft EIS will be submitted to the EPA for review and decision making. In certain cases the EPA may request for additional copies of the draft EIS in order to distribute to key stakeholders.

Review of E(SH)IS and Public Hearing

The EPA Agency upon receipt of an environmental impact statement, publishes for 21 days a notice (which shall be in accordance with the form specified in schedule 4 of Environmental Assessment Regulations 1999, LI 1652) of the environmental impact statement in the mass media. It also posts at appropriate and opportune places such parts of the environmental impact statement as it considers necessary. The applicant shall also submit copies of the environmental impact statement as per Agency directions to sector Ministries, government departments and organisations of relevance to the undertaking.

Copies of the EIS are also placed at vantage points including the EPA Library, relevant District Assembly, EPA Regional Offices and the Sector Ministry responsible for a particular undertaking. The general public, relevant public agencies, organisations, NGOs, Metropolitan, Municipal and District Assemblies and local communities may review and make any comments, and suggestions on any matter in the draft EIS within 21 days of issuance of the public notice.

The draft EIS is also reviewed by a cross- sectoral Environmental Impact Assessment Technical Review Committee (EIA/TRC) made up of representatives of various Ministries, Departments and Agencies. The review committee is expected to assist the Agency in reviewing the EIS and make recommendations to the Executive Director as to whether the undertakings as proposed must be accepted and under what conditions, or not to be accepted and the reasons thereof, as well as provide guidance on how any outstanding issues/areas may be satisfactorily addressed. In certain instances the support of international EIA institutions and experts may be solicited to review EISs.

Upon receipt of the draft EIS the Agency may hold a public hearing on the undertaking as part of the review when:

- a notice issued under regulation 16 of the LI 1652 results in great public reaction to the commencement of the proposed undertaking;
- the undertaking will involve the dislocation, relocation or resettlement of communities and
- the Agency considers that, the undertaking could have extensive and far –reaching effects on the environment.

The outcome of the public hearings are expected to be addressed by the proponent and considered in decision making by the Agency. Where a public hearing is held, the review of the

draft EIS may extend beyond the prescribed timeline of 25 days required for EPA's actions and decision-making on the report.

1.6.5 Environmental Permitting Decision

Where the draft EIS is found acceptable, the proponent is notified to finalize the report and submit eight (8) hard copies and an electronic copy. Following submission to EPA, an Environmental Permit shall be issued to the proponent within 15 working days and a gazette notice published.

It is customary that Environment Permits are issued with a set of conditions. Key conditions include the requirements to:

- i. Submit Annual Environmental Reports every 12 months,
- ii. Submit Environmental Management Plans within 18 months of issuance of permit which are to be revised every three years,
- iii. Submit periodic monitoring reports (frequency will be specified),
- iv. Give notice of commencement of operation of the undertaking and
- v. Obtain Environment Certificate within 24 months of satisfactory operations and compliance with environmental permitting conditions.

1.7 REPORT STRUCTURE

The proposed structure of the ESHIS will follow that provided by the EPA. The content may alter slightly during the evolution of the Project and the EIA process however the content will align broadly within the suggested framework. An outline of the proposed contents of the final E(SH)IS is hereby provided.

Table 1-1 E(SH)IS Report Structure

Chapter	Title	Contents
1	Introduction	Introduction to the Project and Project proponent; Project purpose, E(SH)IA team and overview of EA procedure.
2	Project Description	Project justification; Technical description of the project and alternatives considered; Project contingency plan and execution schedule.
3	Legal Requirements and Policy Framework	An overview of relevant national and international legislation, and industry standards and guidelines
4	Biophysical Baseline	Description of the relevant, existing conditions of the natural environment
5	Socio-cultural Baseline	Description of the relevant, existing socio-cultural and economic conditions of the anthropic environment
6	Health Baseline	Description of the relevant, existing health conditions
7	Impact Identification and Assessment	Outline of impact assessment methodology; identification and evaluation of potential environmental, social and health impacts.
8	Mitigation and Management Measures	Description of mitigation and control measures approach; outline of proposed impact mitigation/enhancement and management measures
9	Environmental Management Plan	Summary of the monitoring and management that will be executed to verify environmental, social and health performance

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10	Decommissioning	Description of the decommissioning approach of facilities at end of Project/field's life
11	Summary and Conclusions	Summary of conclusions drawn from E(SH)IA study
12	References	A list of references and websites cited and analysed in report elaboration
Annex 1	Copy of Scoping Approval Letter	Copy of Scoping approval letter issued by Ghana EPA 10 th February 2014.
Annex 2	Evidence of Response to Ghana EPA Scoping Report Review Comments	A summary table highlighting how eni Ghana has taken into due consideration and provided response to review comments issued by Ghana EPA on the 10 th February 2014 to the Scoping Report for proposed Ghana OCTP Phase 1 Field Development Project
Annex 3	List of Attachments to Ghana OCTP Phase 1 E(SH)IA Report	Attachments to the present report are listed.
Attachment	Title	Contents
Att A	Stakeholder Engagement Report	Report on outcome of stakeholder analysis, consultations undertaken during the E(SH)IA process, comprehensive of list of stakeholders, meeting minutes, attendance registers and photos.
Att B	Baseline Results	Section B.1 provides additional biophysical baseline data. Section B.2 provides a detailed description of baseline methodology adopted for the E(SH)IA
Att C*	Fisheries Impact Assessment	Fisheries baseline; identification and evaluation of impacts on fisheries; proposed mitigation and management measures
Att D	HSE-PLAN-003 "Drilling Oil Spill Contingency Plan – OCTP Block"	The Plan contains organisational responsibilities, actions, reporting requirements and resources available to ensure the effective and timely management of an accidental oil spill; and supplies the Emergency Response Team (ERT) with a high level strategic document that covers the main procedures and information required during an oil spill response.
Att E	Waste Management Plan	This plan details the overall strategy adopted by eni Ghana for the management of waste to be generated during the course of conducting project operations (rigs, seismic, charter vessels, etc.). It covers collection, storage, treatment, transport, disposal, discharge, reporting and data management.
Att F	Additional PD details	Provides further information on the project description.
AttG	Impact Assessment Methodology and Mitigation Measures Guidelines	Provides details on the impact assessment methodology and guidelines utilised.

* a stand alone document to be delivered directly to the Ghana Fisheries Commission.

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2 PROJECT DESCRIPTION

2.1 INTRODUCTION

This chapter presents the technical details on the planned activities for the Phase 1 development of the OCTP Block concessional area of eni Ghana. The planned activities include; Wells drilling programme; Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system and offloading activities, Installation, operation of well heads, decommissioning and abandonment operations.

2.2 PROJECT JUSTIFICATION

This chapter presents the needs, benefits and value for the eni's proposed Offshore Cape Three Points (OCTP) phase 1 Wells drilling programme; Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO (Floating Production, Storage and Offloading)/ mooring system and Installation, operation/ removal of well heads as well as the envisaged environmental, social, health, economic and technical sustainability.

2.2.1 The Need for the Project

As previously stated, Ghana imported 22 Bcf of natural gas in 2012 via the West African Gas Pipeline (WAGP) from Nigeria, though this source of energy is considered unreliable as shown by the decrease in gas flow in recent years and even a recent temporary closure of the pipeline. As a consequence Ghana is forced to use heavy oil to supply its dual-fuelled power plants.

In addition, and according to Ecobank, Ghana is projected to need more than 800 MMcf/d of natural gas by 2017 for power generation and for reinjection into wells.

The present Project is a next step in the growing energy sector in Ghana. It represents a foundation for production of petroleum and natural gas in Ghana, bringing new sources to market for the benefit of industry and the people of Ghana.

In this context, the proposed project which involves the drilling, Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system etc., of a number of wells in the Ghana Offshore Cape Three Points (OCTP) block is specifically needed to:

- Increase oil production to ensure Ghana's energy independence,
- Maintain proper reservoir pressure for gas lifting for enhanced hydrocarbon recovery,
- Ensure that ENI complies with Ghana national policy on environmental protection,
- Support ENI Ghana's long term oil growth targets,
- Stimulate interest of stakeholder's,
- Increase economic reserves,
- Maintaining ENI Ghana's business profile.

2.2.2 Project Key Drivers and Benefits

The production start-up is foreseen in 2017. Peak oil production is expected to be in the range of 45-50K BOPD. According to these features, the project will allow to improve Ghana oil production, without compromising environment and sharing revenues with local industry and population.

Key drivers of the project are:

- Economics and time to production;
- Maximize local industry involvement;

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- Compliance with local laws and Company policy;
- Concept of “zero flaring”;
- Flexibility for future expansions.
- No sensitive impact on ecosystem

2.2.3 Envisaged Project Sustainability

Economic and Commercial Sustainability

Throughout its design life span, the proposed project is envisaged to be economically and commercially sustainable because of the confirmed large oil resource base within the OCTP Block and the current global high demand of petroleum products.

Technical Sustainability

The proposed project is technically sustainable because of the proven expertise and track record of ENI in offshore oil and gas exploration, development and production activities, as well as the adoption and application of best available technologies (BAT) by the company in this project execution. ENI E&P have considerable worldwide experiences in oil and gas-related design, construction, installation, and commissioning to oversee the project development and implementation. ENI will ensure that contractors adhere strictly to internationally and nationally acceptable engineering design and construction standards and codes of practice at all stages of development.

Also, incorporation into the design of several energy-efficiency measures that reduce fuel gas consumption – such as use of high efficiency turbines and, where practicable use of waste heat recovery mechanisms and heat exchangers in place of energy intensive heating and cooling systems will greatly enhance the technical sustainability of the project.

ENI will develop standard operating procedures manuals and appropriate documentation regarding the proposed activities. These materials will be used as the basis for providing facility-specific training to relevant personnel prior to start-up to further ensure technical sustainability of the project.

Environmental Sustainability

The OCTP Block project shall involve drilling, Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system etc; the project will be environmentally sustainable because of the impact minimization and mitigation measures designed into the project as documented in this ESHIA. The on-going monitoring and management programs to be implemented as recommended in the EMP will help ensure environmental sustainability of the project.

Social and Health Sustainability

Social and health sustainability will be guaranteed through impact minimization and monitoring according to the measures already planned for within the project document. Mitigation measures address impact areas such as sanitation (responsible use of fresh water supply), health (adequate health care so as to prevent spread of local and new diseases subsequent to the arrival of workers), livelihood resources (controlled use of, and interference with, locals' access to subsistence raw materials).

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2.3 PROJECT OVERVIEW

2.3.1 Background

The Government of the Republic of Ghana, Ghana National Petroleum Corporation (“GNPC”) and the Contractor entered into a Petroleum Agreement on March 2nd 2006 relating to the OCTP contract area which was ratified by the Parliament of the Republic of Ghana on March 15th 2006. Currently eni Ghana’s and Vitol’s participating interests (as Contractor) and GNPC’s participating interests under the PA are as follows

- eni Ghana (Operator) 47.222%
- Vitol 37.778%
- GNPC 15% (carried by the Contractor in accordance with the PA)

Three non-associated gas fields have been discovered in the Offshore Cape Three Points (OCTP) licence: Sankofa Main, Sankofa East and Gye Nyame. An additional oil field made of two separate pools at Campanian and Cenomanian has been discovered in 2012 by Sankofa East-1X and Sankofa East-2A. The discovered fields are located in the Republic of Ghana, Offshore at a distance of approximately 55 Km South of the town Atuabo and 60 km South of the village of Sanzule. Regionally they fall in the in the Tano sub-Basin, part of the wider Cote d’Ivoire Basin, limited southward by the Romanche Fracture Zone. They are located immediately off of the present-day continental shelf break at a water depth ranging between 500 and 1000 m.

To date, the OCTP JV (composed of eni Ghana, Vitol and GNPC) has made, in the OCTP Contract Area: (i) two (2) oil discoveries (Sankofa East Cenomanian and Sankofa East-2A Campanian reservoirs); and (ii) three (3) NAG discoveries (Sankofa Main, Sankofa East and Gye Nyame) with the potential of becoming the first Non-Associated Gas development in Ghana.

During the exploration and appraisal campaign (2009-2013), a total of eight (8) wells (Sankofa-1, Sankofa-2A and 2STA, Gye Nyame-1, Gye Nyame-2A, Sankofa East-1X, Sankofa East-2A and Sankofa East-3A) were drilled in the OCTP block. The campaign allowed to discover three non-associated gas fields (Sankofa Main, Sankofa East and Gye Nyame) and two oil fields (Sankofa East Cenomanian and Sankofa East-2A Campanian reservoirs).

During the exploration period, the Contractor fully complied with all the PA and requirements. In particular, the Contractor duly fulfilled its obligation with respect to training fee payments, surface rental, technology support payment, training on the job for GNPC’s resources. The minimum work programs and expenditures set out in the PA for the exploration period have been fully achieved. The total amount financed by the Contractor during the exploration period exceeds 600 M\$ (100%). In addition to the PA requirements, Contractor encouraged and supported specific local content training through international masters (petroleum engineering, HSE, energy and environmental-economics management). Moreover, and in the frame of its engagement with local communities, social projects were implemented in Jomoro and Ellembelle districts.

2.3.2 Overview

The Base Case field development is the exploitation with subsea wells connected to a stand-alone FPSO, oil will be exported with shuttle tankers; gas and production water will be re-injected in the reservoir after appropriate treatment and analysis, to maintain pressure and increase reserve recovery.

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For the exploitation of the oil and gas discoveries of the OCTP license, a development plan is foreseen based on 14 subsea wells (8 Oil Producers, 3 water injection, 3 gas injection), subsea facilities, one FPSO located inside the development area, flowlines system, risers and umbilicals. First oil is planned for 2017.

The development of the Sankofa and Gye Nyame fields is carried out by means of a spread moored FPSO, which collects both the oil and gas production from different regions of the fields to collect and process the Oil (dehydration and stabilization) (see Figure 2-1 for overall layout).

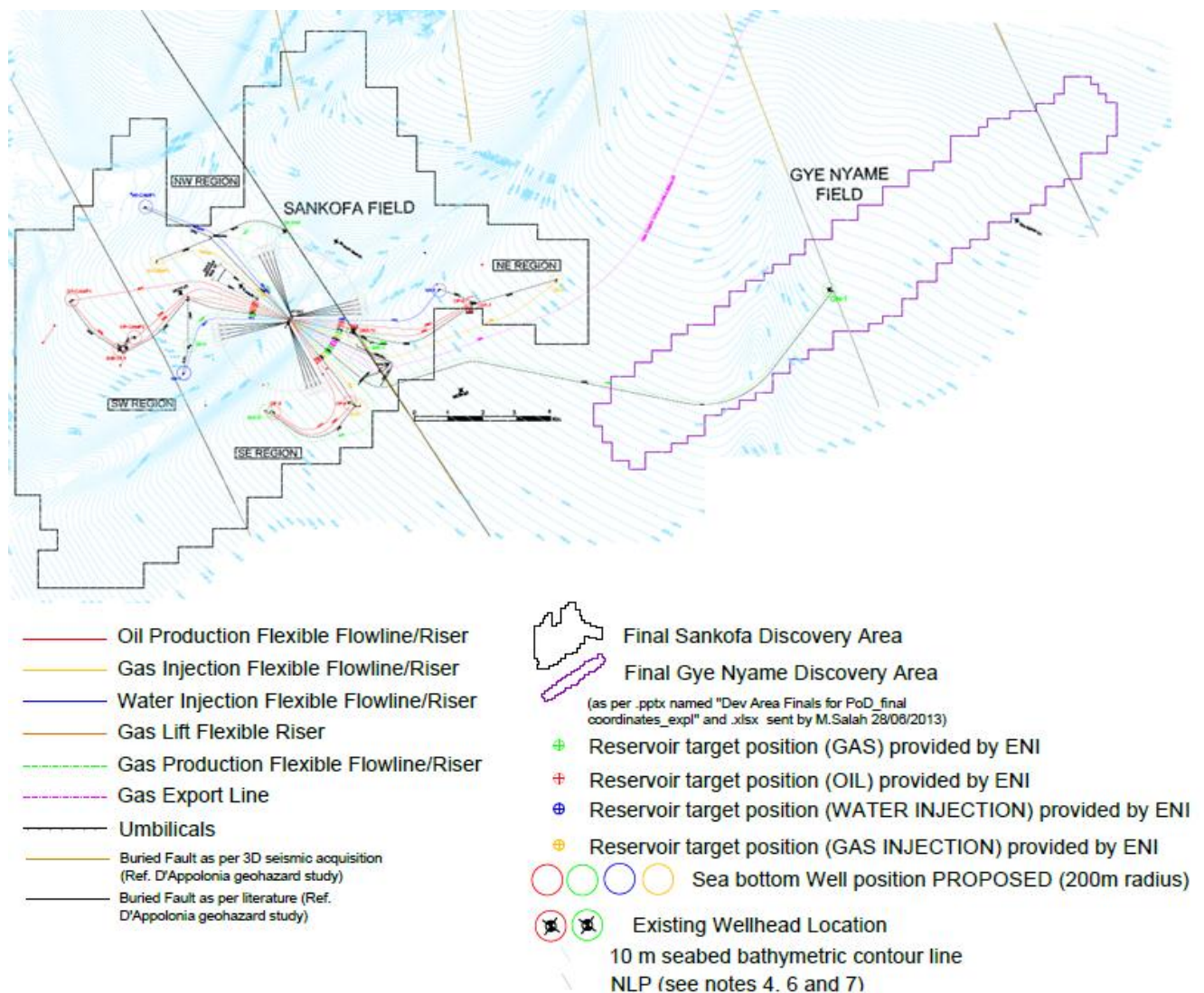


Figure 2-1 OCTP Block

The produced Oil will be separated from both water and associated gas, stabilized and stored into storage tanks in the FPSO prior to be properly metered and offloaded. Condensates produced later on, during the following non associated gas project, will be separated offshore and blended with the oil on the topside facility of the FPSO.

The produced water will be separated and treated in the produced water treatment unit in order to comply with specification for water injection before being mixed with treated seawater and to be re-injected into the Cenomanian reservoir for pressure maintenance.

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The Associated Gas (AG), produced from the oil separation train, will be dehydrated and compressed before being re-injected into the Cenomanian reservoir according to the specified demand. Part of this gas will be used for fuel for power generation.

Sankofa field can be divided in 4 regions: North East, North West, South East and South West, while Gye Nyame is around 15 km East.

Because of the well distance, the majority of the wells are satellite. Gas wells can be developed stand alone or in daisy chain with a single production line, Oil wells need to be looped in order to guarantee circulation and preservation strategy.

Oil production wells are arranged in a daisy-chained configuration around the FPSO, with 3 flow loops in the NE, SE and SW regions. The loops in the NE and SW regions are piggable. Each of these loops serves up to 3 OP wells, each of which is branched off from the main flowline by means of an actuated FLET (Flowline End Termination). There is a single well (OP-CAMP 2) in the SW which is on a dedicated heated flowline back to the FPSO.

Gas and Water Injection wells are also arranged in a satellite configuration around the FPSO. Each of these wells is branched off from the main flowline by means of a passive FLET with spare connector on the header, allowing the flowline to be extended for future expansion.

No routine flaring of gas was assumed and no regional gas gathering system has been considered available, therefore gas disposal through gas injection wells has been planned.

Depending on drilling and completion requirements, use of satellite wells may be envisaged for injection wells. Drilling centers will be tied-back to the FPSO by means of a flow-line and risers system. An umbilical system will provide control and chemicals to all sub-sea manifolds and trees from the FPSO. Crude oil will flow continuously from subsea trees through subsea flowlines via risers to the process facilities on the FPSO.

Figure 2-2 presents the schematic layout of the overall OCTP Project.

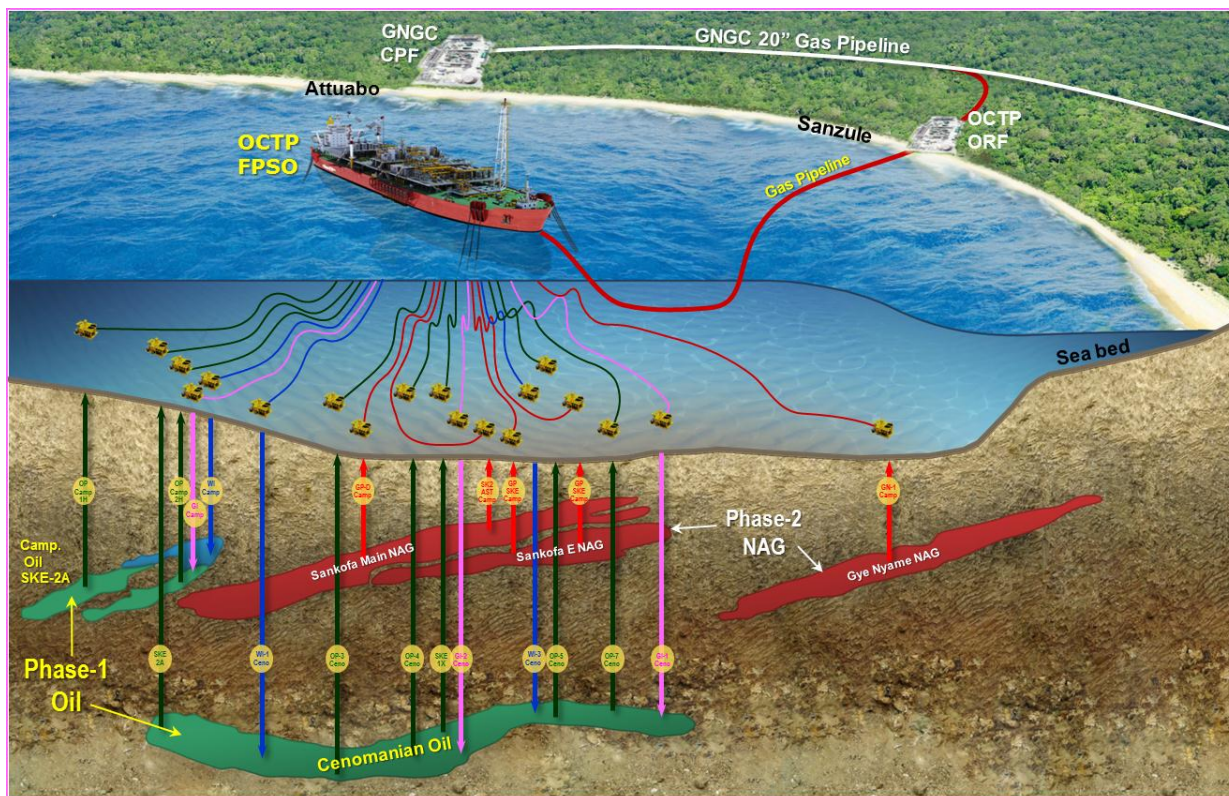


Figure 2-2 OCTP Phase 1 Schematic Layout (Green fields are Phase 1 oil reservoirs, red fields are Phase 2 gas reservoirs)

Processed crude oil will be stored in the cargo tanks. Shuttle tankers will periodically be moored to the FPSO and the stored crude oil will be pumped to the shuttle tanker via an offloading hose. Exported crude will be fiscally metered on board of the FPSO. The normal production will not be affected by the crude export operations.

The Phase I of the Project does not include any facility or activity onshore apart from the delivery of supplies and materials as well as vessel refueling, which constitute the main support services from onshore. These activities will take place at Takoradi Port. Similarly no camps for workers are envisaged onshore as all the workforce will be accommodated within the Project vessels and the FPSO.

2.3.3 Project location

The Offshore Cape Three Points (OCTP) block is located in the Gulf of Guinea, in the Republic of Ghana, and is situated approximately 55 km South of the town of Atuabo and 60 km South of Sanzule. The water depth in the development area ranges from approximately 800 m to 1,000 m. The reservoirs discovered are: Cenomanian and Campanian oil bearing of Sankofa East and Campanian non associated gas (Sankofa Main, Sankofa East & Gye Nyame fields) (see Figure 1-1 for details).

A total number of 14 wells will be drilled

- 8 Production wells
- 3 Gas injection wells
- 3 Water injection wells

The coordinates with the location of the proposed wells is presented in Table 2-1.

In addition to the wells, one of the main elements for the development of the Sankofa and Gye Nyame fields is a spread moored FPSO, which collects both the oil and gas production from different regions of the fields.

Canyon crossing by Project elements has been assumed as not feasible due to its depth and slope instability. Therefore the FPSO has been located above the canyon, in order to avoid flowline crossing, gathering the production from all the Sankofa field regions and Gye Nyame as well. Planned coordinates of the location of the FPSO are presented in Table 2-2.

Table 2-1 Wells to be drilled

Phase	Well Name	x (m) @target	y (m) @target	z (m) @target	x(m)@seabottom	y(m)@seabottom	WD (m)
1	OP-1 (SkE-2A)	544565.81	493151.73	3760	544565.81	493151.73	989
1	OP-3	548775	492106	3654	549071.47	491302.15	941
1	OP-4	550628	492579	3527	551303.31	491585.16	870
1	OP-5	553853	495047	3422	554864.57	494507.31	708
1	OP-6 (SkE-1x)	551399.84	493700.60	3500	551399.84	493700.60	826
1	OP-7	555176	495628	3403	554910.35	494492.78	708
1	OP-CAMP1	HDst 542665.15	HDst 493841.22	2657.99	543170.00	494598.00	997
		HDe 542333.46	HDe 493349.70	2662.37			
1	OP-CAMP2	HD start 544716	HD start 492894	2655	545000.00	493500.00	967
		HD end 544580	HD end 492684	2658			
1	WI-1	547088	491508	3682	546451.05	492455.66	1014
1	WI-3	553506	495987	3497	553922.96	494882.71	726
1	GI-1	557346	495142	3369	557346.00	495142.00	630
1	GI-2	551600	491490	3481	551600.00	491490.00	865
1	WI-CAMP1	544907	497702	2710	545329.36	497321.86	954
1	GI-CAMP1	545647	495692	2630	545647	495692	897

Table 2-2 FPSO Location

HEADING FPSO 210° N (TBC BY ENI)
FPSO COORDINATES 549548 848 mE, 494023, 114 mN

2.3.4 Project Execution Schedule

The activities listed below as reported in the project schedule, partially overlap in order to limit the environmental impacts and their total duration. The activities taken into consideration will start in April 2014 and will end on May 2018 for a total duration of about 4 years.

The expected duration of the production phase is of 20 years.

Table 2-3 Project Schedule

Activity	Duration (months)
Mobilization/Demobilization drilling rig	1
Wells Drilling and completion	40
FPSO	30
Flowlines, Risers, Umbilicals installation	22
Mooring/anchoring system installation	2.5
Production activities	20 years
Decommissioning/abandonment	6

2.3.5 Project Options

The preferred Project design is described in this Chapter and is the basis for the EIS. Annex F describes alternatives that were evaluated during design to maximize and ensure environmental and social sustainability of the Project and aiming to identify the option that allows meeting project objectives with less impacts on the environment. The alternatives evaluated include:

- do nothing alternative; and
- location alternatives.

Refer to Annex F1 for more details.

2.4 CONSTRUCTION PHASE

2.4.1 Well Drilling and Completion

The description of the Drilling Unit, along with a description of Safety Equipment, Design Choices Aimed at Reducing Environmental Impact and Resources Consumption, Waste Generation, Air and Noise Emissions During Drilling and Completion Activities, are provided in Annex F.

2.4.1.1 Sequence of operations

Pre drilling

The sequence foresees the positioning of the rig in the well location and the jetting of 36" conductor pipe. The drilling of 24" phase is made with sea water and viscous pillows, the cutting will be scattered on the sea bed because there isn't connection with the surface facilities through the marine riser. Then the 20" casing with wellhead housing is run and cemented in place.

The next sequence is to run the BOP stack with the marine riser and latch it on wellhead housing. After that all the drilling fluids and debris will be managed from the surface facilities of the rig. The operations will carry on in the same way until the 9 5/8" liner is set.

At that time the well is temporary suspended, the riser and BOP are recovered and the rig will move in the location of another well.

Re-entry and completion campaign

At the end of the drilling campaign will start the completion phase, so the rig will be back on the well, the corrosion cap will be removed and the Horizontal X-tree will be landed and installed with the BOP (Blow Out Preventer) on top.

The last 8 1/2 "drilling section is performed through X-Tree, then the cased hole logs are recorded. Now the well is completed with lower, gravel or frac pack, and upper completion, tubing string packer and safety valves.

The last operation before to install the corrosion cap on X-Tree will be the well clean up.

Well start up

At the end of all the drilling and completion activities is highly recommended a well production test. The main purpose of the operation is to eliminate all the debris from the well in order to avoid some damages of the downhole and surface equipments.

The test is usually done from the rig as soon as finished the completion job.

The period of the clean-up is quite short, around 3-4 hours, but it can hold up about 24 to better understand the productivity of the well.

2.4.1..2 Drilling Activities

Drilling process involves the use of a 'drilling string' made up of standard lengths of steel pipes. The drilling string is tipped with a drill bit, which grinds through the rocks as the drilling string is rotated. The drilling string is supported by a derrick (a steel framework tower) that is mounted on the drill floor with the rig. The derrick houses the winching equipment needed to lower and raise the drilling string, the rotating table used to turn the drilling string, and the power unit.

Drilling is achieved using a *bit* (Figure 2-3) set at the end of a *string* of hollow circular pipes, each approximately 10 meters long. These pipes are screwed together so that they can be lowered into, and removed from, the well. They transmit the rotary motion (generated at the surface by the *Top Drive System*), circulate the drilling mud and exert weight on the drilling tool.

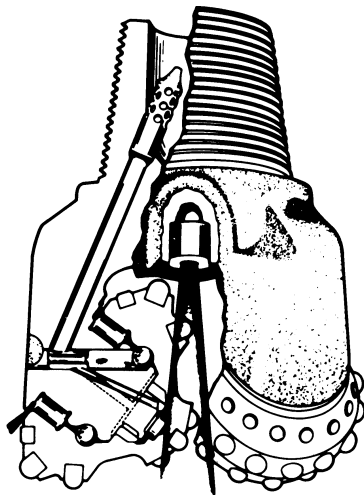


Figure 2-3 Example of a Drilling Bit

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As the drilling process proceeds, drilling has to stop periodically to replace the drill bit and to allow new lengths of pipes to be added to the string. Steel casing is run into completed sections of a borehole and cemented into place. This casing provides structural support to maintain integrity of the borehole and protect the water column from contamination by oil or drilling fluid.

The Drilling system: includes rotating parts, mud circuit and safety equipment. The rotary system transfers the rotary movement from the surface to the drill bit. It is made of an injection head, top drive and drill string. The top drive produces the rotary motion. The top drive is essentially made up of a high power engine the rotor of which is connected to the drill string. The top drive also includes the injection head (which can pump mud into the drill string while it is turning), a makeup-breakout system for connecting-releasing the drill string and a valve to control the mud pumped into the well.

The pipes that make up the drill string are divided into drill pipes and extra-heavy pipes (of greater diameter and thickness). An appropriate number of the latter are installed upstream of the bit to ensure that adequate weight is brought to bear on the bit itself. All pipes in the string are screwed together so as to ensure that the torsion is transmitted to the bit and hydraulic seal.

Mud Circuit

In a drilling system, the mud circuit is particularly complex since it must also include a system able to separate drilling debris and treat the mud itself.

The mud is fed into the drill pipes using high pressure pumps; it exits the special holes in the bit at the bottom of the well, incorporates the drilling debris and then rises back up to the surface. When exiting the well it passes through the Solids Treatment System composed of equipment such as vibrating screen, desilter, desander, etc. which separate the mud from the drill cuttings: before the mud is reconditioned in special tanks and then pumped back into the well; the latter are collected in specific containers, stocked and transported onshore via the supply vessels.

Various storage tanks are also part of the circuit; they keep an adequate reserve of mud on hand to handle any sudden needs that may arise due to leaks in circulation or absorption of the well. Circulation of the mud ensures that the debris created by the bit is removed from the well. The composition of the drilling mud is controlled to ensure that it meets specific density and viscosity characteristics. It also serves to counterbalance the pressure exerted by fluids in the rock being drilled through as well as provide support for the wall of the well during the drilling phase. The hydrostatic pressure exerted by the column of mud is, in fact, greater than the normal hydrostatic gradient and even abnormal pressures can be contained by adding substances that increase the density of the mud. Rotary drilling makes drilling of boreholes relatively simple, rapid, even when thousands of meters deep.

Once the borehole has been drilled, in order to insulate the rock formations passed through and provide support for the rock walls, the well is coated with steel pipes (i.e. the lining column called the casing) which are jointed together and cemented into the borehole itself. Then a bit having a smaller diameter is lowered into the casing to drill the next section which is then protected by another casing. The prospecting goal is achieved by drilling boreholes of decreasing diameter, each protected by a casing (see

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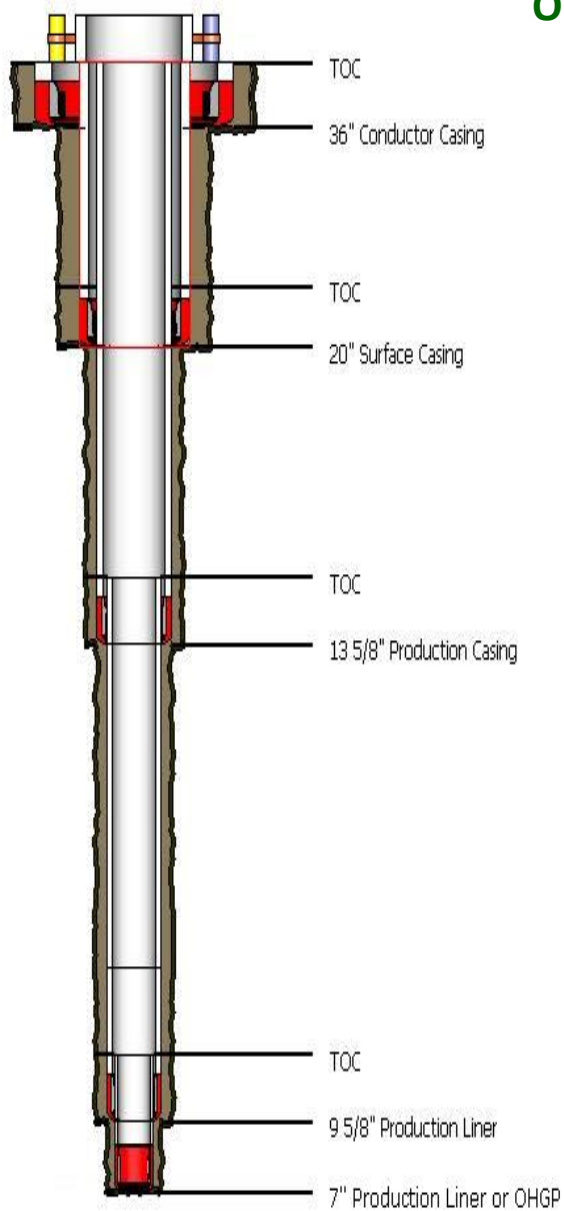


Figure 2-4).

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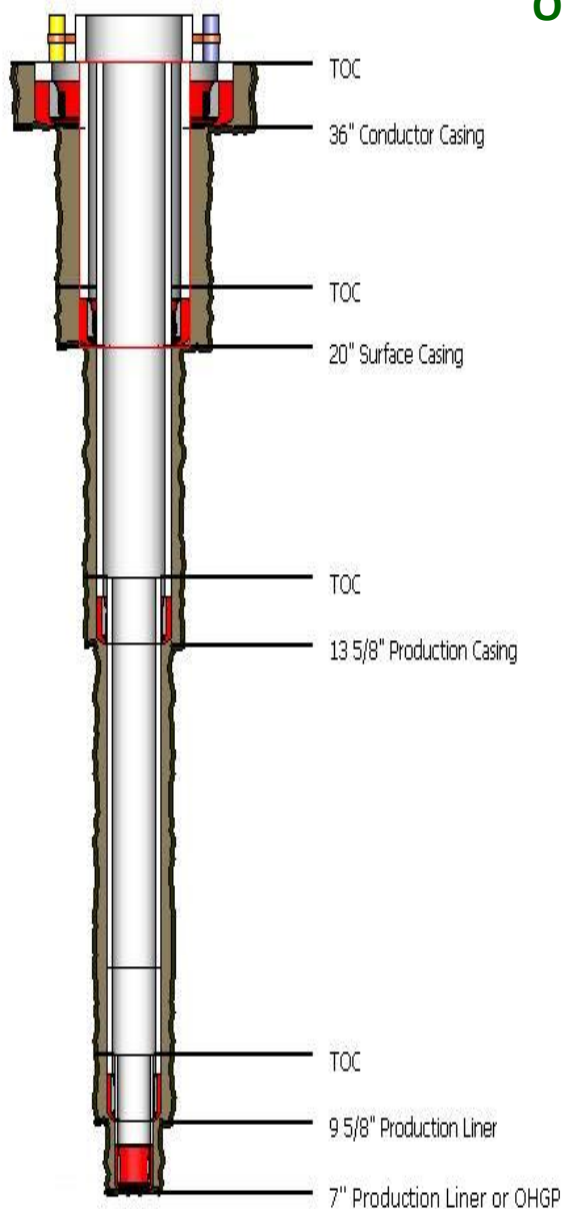


Figure 2-4 Oil well sketch

The drilling operations are continuous, performed over the entire 24 hour period.

The initial borehole diameter is several decimetres (16-30 inches), but it decreases according to the number of casing columns used. At the bottom it is reduced to 10-20 centimetres (4-8 inches). The borehole is normally vertical; only on rare occasions is it perfectly vertical but in most cases the deviation in verticality is kept within a few degrees and thus the shift in coordinates between the bottom of the well and the surface is on the order of a few dozen meters.

In some cases, in order to reach underground targets as much as a few hundred meters away, the borehole is intentionally deviated off vertical, reaching a slope of as much as 50 – 60°. Thus, from a single surface structure, it is possible to drill several wells that reach the reservoir from different, distant points.

In recent years, with the aid of special equipment and techniques, it has become possible also to drill horizontal bore sections (Figure 2-5). This technique makes it possible to cover considerable lengths, mining them through the system of fractures that allows hydrocarbons to drain through the reservoir rocks, thus improving recovery of the fluids throughout the production life of the well.

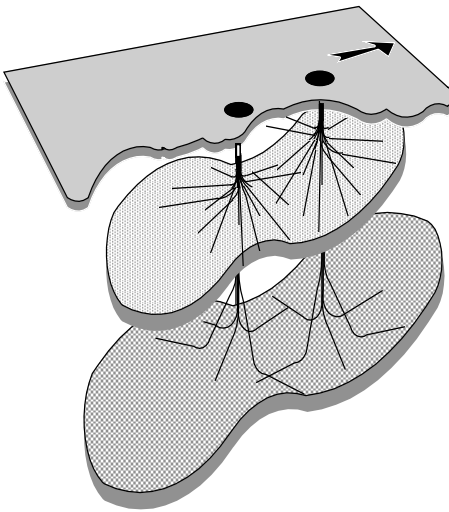


Figure 2-5 Scheme of Directional and Horizontal Wells

The type and pressure of the fluids contained in the rock being drilled through varies as the depth increases and such variation can be quite unpredictable.

One must be fully aware of the lithology, geological age of the succession of rock being passed through, meter by meter as well as the nature and pressure of the fluids contained therein. Such research must be performed both prior to drilling of the borehole — through a seismological survey — and during the course of drilling — through rock sequence analysis performed on drilling samples and through the use of special instruments (*logs*) that can take electronic measurements and process them to determine the characteristics of the rock and fluids contained therein.

Once the drilling operation will be completed, purposely made “production tests”, will give accurate information on the nature and pressure of the produce water

The well must be drilled in such manner as to prevent uncontrolled emissions of these formation fluids from the well. This is achieved using a mud whose density is able to offset the formation fluids and using a system of valves located upstream of well opening (well head and BOP) able to close the well.

When the borehole is being drilled (i.e. before lowering the casing column that insulates the borehole from the rock formations), the drill string and mud are in direct contact with the rock formations that have been laid bare.

During this transitory phase, instability of the newly drilled borehole is always possible and can lead to anomalies vs. smooth progression of the operations. Such anomalies can include: absorption of the mud into the fractures and pores in the rock, collapse of the walls of the borehole,

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catching of the bit or of the drill string against the ground, breakdown of the drill string due to difficult working conditions.

For production wells, the drilling phase is completed once the entire borehole is lined with steel casing pipes (production string) or, for barren wells, with complete abandonment well using cement plugs.

Drilling and Completion Fluids

The drilling fluids are normally made up of a liquid (water or oil) set in a colloidal state and weighted down with specific products. The colloidal properties achieved with special clays (bentonite) and enhanced by particular compounds (i.e. Carboxyl Methyl Cellulose - C.M.C.) that give the mud particular rheological properties, turning it into a gel able to keep the weighting additives and debris in suspension, even when circulation is cut off.

In sum, the purpose of the drilling fluids is to:

- Remove debris from the bottom of the well and carry it up to the surface thanks to its rheological properties.
- Cool and lubricate the drilling bit.
- Contain the fluids present in the rock formations thanks to its hydrostatic pressure.
- Consolidate the walls of the borehole and reduce infiltration into the formation by creating a panel to coat the borehole.
- To satisfactorily perform all its functions at once, the drilling fluids must be continually enhanced with chemicals and their rheological properties checked.

The type of mud (and its chemical components) is determined according to the rock being drilled and the temperature. In fact, the drilling fluids interact with the rock formations and thus using the correct type of mud will prevent borehole collapse and damage to the production formations. Moreover, excessive temperatures can alter the rheological properties of the mud (temperatures can exceed 200°C).

Selection and definition of the drilling fluids are based on experience accrued in the field. Past experience has shown that the main problems encountered could be:

- mud losses at the surface phases,
- reactive shale and uncertain mud density causing the pipe at the middle or phases deeper than 2000 m,
- tight hole.

Therefore a mud system with a high inhibitive capacity shall be selected for the deep phases. In terms of environmental protection — less impact on the marine environment, lower waste discharges — and operating difficulties Synthetic Oil Based Mud system SBM has been selected as the drilling fluid.

Given the above mentioned problems, some preventive and control plans shall be programmed. The various types of materials for circulation shall be stocked at the rig site in sufficient quantity to make up for losses along with suitable pills (to free stuck pipe).

The surface riserless intervals 24" and 42" will be drilled with Sea Water (Water Based Mud WBM) and Hi-Vis Sweeps. The sweeps will be circulated up to sea bed to keep hole cleaning.

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Non Aqueous Drilling Fluid (NADF) will be used to drill 17 ½”, 14 ¾”, pilot hole 8 ½” and sidetrack 12 ¼” and 8 ½” sections.

Table 2-4 Drilling Mud Type

Casing Size (in)	Hole Size (in)	Estimated Mud Type (Type)
36”	42”	Sea water + HV pill
20”	24”	Sea water + HV pill
16” LNR	17½”	NADF
13⅝”	14¾”	NADF
-----	Pilot hole - 8½”	NADF
9⅝”	Side track - 12¼”	NADF
7” LNR	8½”	DIF – Low Solid

NADF can be made with synthetic or low toxic mineral base fluid. These systems possess properties that are highly desirable and are not completely obtainable with water-based systems. One of these is the very low level of reaction with the formation, combined with minimal penetration of the fluid phase into the formation. This leads to maximum borehole stability over a long-lasting time span and lets the cuttings come to the surface solids removal equipment in such a size range that a significant portion can be removed. Moreover, fluid loss control is another important characteristic of non-aqueous fluid system.

The main advantages that lead to the choice of a non-aqueous drilling fluid can be summarized as follows:

- Maximum level of shale hydration inhibition. Gauge holes can be drilled in reactive formations.
- Consistent fluid properties.
- High tolerance to drilled solids contamination.

The drilling rig shall be equipped to properly process and handle the NADF and the cuttings in accordance with government regulations.

The margin between anticipated circulating pressures and fracture gradients is quite wide. In any case all precautions should be taken to avoid the risk of mud losses.

For the open hole section a Drill-in fluid will be used. Drill-in fluids (DIF) are drilling fluids used to penetrate the pay zone, reducing the potential formation damage. A drill-in fluid must provide hole cleaning, lubricity and inhibition with respect to interstitial clays and shale inter-beds, while being minimally damaging to the permeability of the formation. In order to realize the full potential productivity of a reservoir, formation damage from drilling fluid leaking off into formation as well as cake impairment must be eliminated. A DIF should be prepared avoiding the use of damaging solids (barite) that can block pore throats. Its filtrate has to be compatible with the formation, too. Calcium carbonate is normally used as bridging agent.

DIF can be water-based or oil-based. A water-based DIF is usually prepared starting from solid free brine, whose density depends on the type of salt. Sized calcium carbonate has to be used as bridging agent and not as weighting agent in order not to increase the solid volume fraction within the system to a too high level.

An oil-based DIF, in comparison with a water-based one, offers some advantages in terms of tolerance to contaminations, rock wettability alteration and permeability chemical impairment. Non

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damaging surfactants and weak wetting agent that can alter rock wettability and permeability are of primary importance.

Final choice of DIF type will be made taking into account formation damage minimization. Correct and suitable pills must be used to clean the wellbore e surface tanks before a different type of fluid (from Water Based Mud to SBM) is set into the hole.

2.4.1..3 Production Tests

The performance of specific “production tests” on conclusion of the drilling operations will provide accurate information concerning the presence of hydrocarbons on the strata investigated, their nature and their pressure characteristics; pointers to their quantity will also be obtained.

At present, the intention is to perform production tests on each field. These tests will vent the levels and provide estimates of their potential; the gas and the oil obtained will be sent to the flare.

2.4.1..4 Completion Activities

The term completion is used to indicate the operations performed on a well at the end of the drilling phase, before it is set into production. Completion serves to make permanent arrangements for production and to secure the drilled well.

The major construction principles used in completion of the drilled wells are as follows:

- The hydrocarbons are brought up to the surface from the deposit by a series of production pipes called the “completion string”. This string is composed of a series of tubings and other equipment that ensure well production function and safety.
- If there are several production levels in the wellbore, only one completion string is used, composed of several tubings able to independently produce from different levels.
- An SCSSV (“Surface Controlled Subsurface Safety Valve”) is installed along the completion string. This valve automatically closes the production string if operating emergencies arise (i.e. well head failure).

An indication of the main completion equipment is provided below:

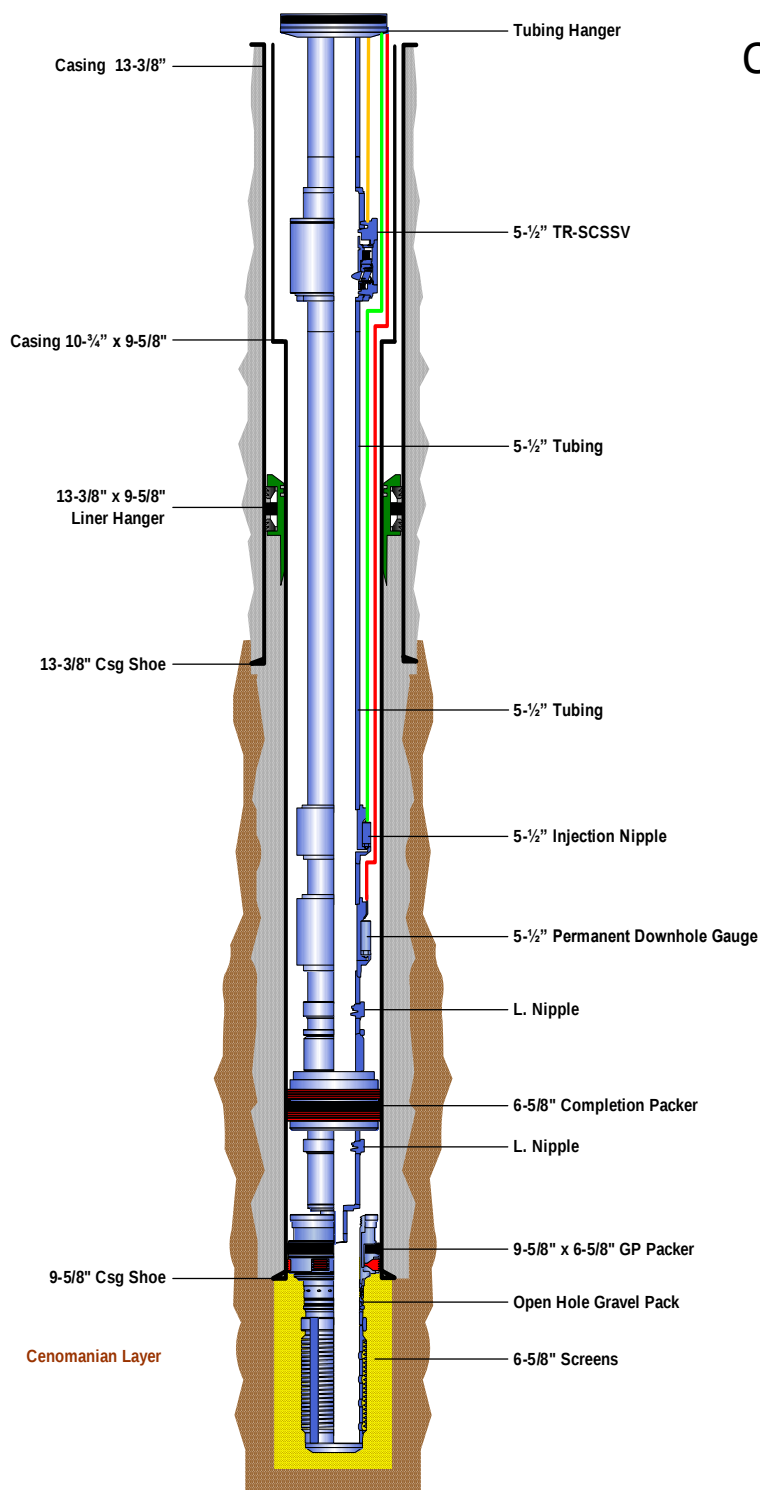
- Completion String
 - Tubings
 - Packer
 - Safety Valves
- Completion Wellhead
 - Tubing Spool
 - Christmas Tree

Completion String

Tubings: these pipes generally have small dimensions (4 1/2” - 2 1/16”) but high pressure resistance; they are screwed together in series according to the depth of the well.

Packer: a metal unit with rubber gaskets to ensure a tight seal. They hydraulically insulate the section in communication with the production zones from the rest of the string. For safety purposes, it is kept full of completion fluid. The number of packers in a string depends on how many production levels the well has.

Safety Valves: these are installed in the pipe string. They are used in gusher wells and serve to automatically close the entire tubing if the well head fails, thus blocking hydrocarbon flow to the surface.



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Figure 2-6 Oil Well Completion Sketch

Completion Well-head

Above the first elements in the well head, additional well head completion elements are hooked and flanged onto the casings installed during the drilling phase. These elements provide the well head with enough valves to control production. The main parts of the completion well head are:

Tubing spool: the lower part of this spool holds the production column tightness elements while the upper part holds the housing for the steel block with gasket, called the "tubing hanger" which supports the completion string.

Christmas tree: a well completion unit connected to the well head by special mechanical or hydraulic connectors. It consists of a series of gated cut-off valves having a hydraulic or pneumatic actuator, or manual valves located on a T or V cross.

- Xmas Tree estimated dimensions [m]: 4(L) x 4(W) x4(H)
- Xmas Tree Estimated Weight: 50,000 kg
- FLET draft dimension [m]: 4(L) x 2(W) x2(H)
- FLET/XT arrangement (well jumper estimated length < 150m)

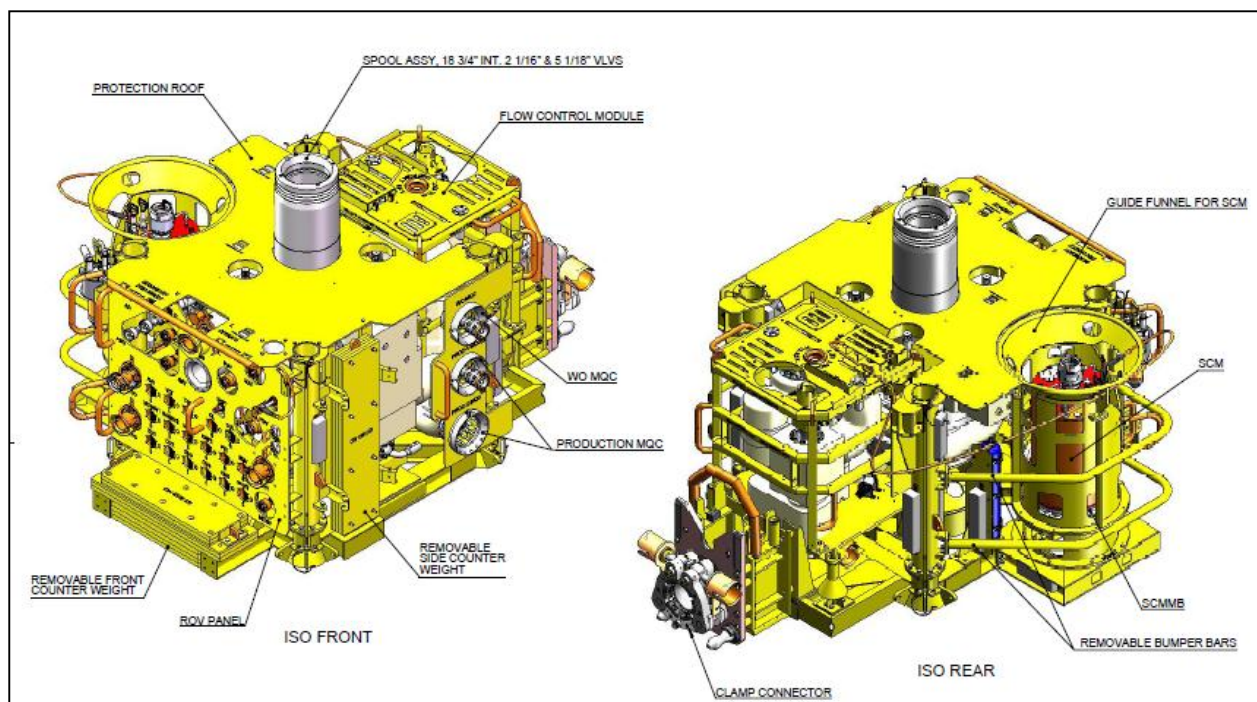


Figure 2-7 X-mas tree Scheme

Design Criteria for Trees and Manifolds

Based on nearby developments subsea production trees are preliminarily assumed to be 5" x 2" nominal bore, horizontal type, 345 bar (5000 psi) design pressure.

Design temperature rating for subsea production trees is preliminarily assumed from 5,5°C (10°F) below either the normal ambient seafloor temperature or the lowest normal temperature (that can be seen during manufacturing and operation onshore or offshore, whichever is colder) to 120°C (250°F). Choke, wing valve connector and seal assembly downstream of choke is assumed to have a preliminary low design temperature of -29°C.

Gas injection trees rating is assumed to be from -29°C (-20°F) to 120°C.

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Water injection trees rating is assumed to be from 5.5°C below either the normal ambient seafloor temperature or the lowest normal temperature to 120°C.

Each tree shall include a choke valve, sand sensor, and pressure and temperature gauges. The valves shall be operable by electro-hydraulic control system or by remotely operated vehicle (ROV). All the valves to be remotely operated (including chokes and downhole valves) will be equipped with hydraulic actuator. Chokes will feature electronic position sensor.

The Subsea manifolds shall be 4-slot standard production or injection manifolds that shall be easily expandable with a 2-slot production or injection expansion module to increase capacity up to 6 wells. The 2-slot expansion module shall be easily applied to the manifold before installation or after installation by removing the pigging loop or the pressure caps at the end of the manifold. As an alternative to expandable 4+2 slots manifold, a conventional 6 slot manifold can be foreseen. The subsea manifolds are preliminary assumed to have 345 bar of design pressure and a temperature rating from -29°C to 120°C (from 5,5°C below either the normal ambient seafloor temperature or the lowest normal temperature to 120°C for water injection manifolds only). The subsea manifolds shall have suction piles foundations and shall serve as a central gathering point for production from subsea wells for each drilling centre. Production manifolds will be run and retrieved independently of their foundations. The manifold will be installed from a MODU or by a construction vessel.

Connection between manifolds and between trees and manifolds will be via rigid pipe jumpers with vertical connectors or flexible jumpers connectors as an alternative. Connection between the manifolds and flowlines could be by rigid jumpers (in case of rigid pipeline) or direct connection with the use of a gooseneck connector (in case of flexible lines). As an alternative also other connection systems may be proposed.

If Injection wells (water or gas injection) are arranged as satellites, in case of flexible flowlines, these will be directly connected to the tree flowbases.

All production wells shall be equipped with a subsea multiphase meter.

2.4.1..5 Techniques to Prevent Environmental Risks during Drilling

Pollution Prevention Measures

The systems are "impermeabilised" or sealed; in other words they are able to prevent any type of dumping of rainwater, drilling mud or bilge oil into the sea.

All work decks (derrick floor, main deck, cantilever deck, B.O.P deck, helideck) are tight and fit with coaming. In addition, drainage pits are present around the edge of the platform and these are connected by a manifold so that, by force of gravity, they collect rainwater, system wash water and any mud spills on the decks.

The liquids collected are periodically pumped into tanks on the supply-vessel located in the immediate vicinity of the plant and are then carried to land for treatment and disposal in suitable receptacles. There are no dispersions of these liquids in the environment.

Civil wastes (sewage, water from washbasins, showers, the caboose) are treated with approved systems, as to achieve legal concentration limits, before being discharged into the sea.

The machine room, pump zone and engine area located below the main deck are also fitted with coaming and bilge to collect oily liquids. These fluids can also be derived in all areas where

lubrication oil spills may occur. The fluids are gathered and sent to an oil-water separation system. The water separated out is sent to the liquid waste collection tank while the oil is stored in special drums to be transferred to land for disposal.

The drilling system is manned from a supply vessel that not only serves as temporary storage for drilling materials (diesel fuel, water, bentonite, barite) but also holds drums of dispersant and equipment with special arms for deployment in the sea in the case of accidental oil spills.

Drilling Mud

Given its hydrostatic pressure, the mud serves to prevent formation fluids from entering the borehole (see **Figure 2-8**). To do so, the hydrostatic pressure exerted by the mud must always be greater than or equal to that of the fluids (water, oil, gas) contained in the permeable rock formations being drilled through. For this reason, the drilling mud must be weighted to achieve adequate density. The surface sections will be drilled with a sea water-bentonite mud system and high viscosity pills. During the deepest phases, a synthetic oil-based mud system will be used. To the purpose of reaching the residual oil content fitting regulation's limits, it will be necessary to install a vertical centrifuge besides of the standard solids removal equipment, to allow the discharge of drilled cuttings.

Under particular geological conditions, the pressure of the formation fluids may be higher than incurred by the normal hydrostatic gradient alone. In such cases, there may be a sudden inflow of formation fluids into the borehole and, since such fluids are less dense than the mud, they will rise to the surface.

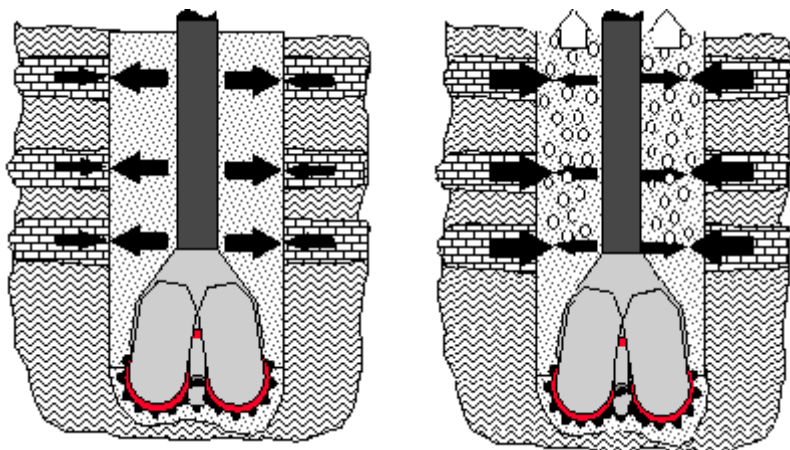


Figure 2-8 Scheme of the Drilling Mud Functions

The condition just described, the so-called *kick*, is unmistakable as it induces an increase in the volume of the mud in the tank. During this phase of well control, to prevent eruptions, some safety equipment must be installed upstream of the underwater well head. These units go by the name of *blow-out preventers* (B.O.P.) and they always close the well — both when it is free and when it contains equipment (pipes, casings, etc.). The two fundamental types of B.O.P. are annular and ram.

Special shut-off cocks (*inside BOP and kelly cock*) are arranged to ensure that, once the B.O.P. has closed the ring, no formation fluid can flow into the drilling pipes on the drill string and into the top drive.

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2.4.1.6 Drilling Parameters Monitoring

Drilling parameters are monitored by two independent systems of sensors that operate in continuous mode and throughout all drilling operations (such monitoring is essential as it permits prompt recognition of any operating anomalies). The first monitoring system is inserted into the drilling rig, the second is composed of a computerized unit manned by skilled personnel and installed on the drilling rig. The latter provides geological assistance and controls drilling activities.

2.4.1.7 Estimated Drilling and Completion Duration

An estimated drilling and completion total duration has been planned for 40 months barring offsets situations and drilling difficulties.

2.4.2 Laying of Risers And Flowlines (R&F)

Following Project Procurement Strategy, this package consists of an Engineering, Procurement, Construction (EPC) Contract for the supply of all flexible lines' systems.

Oil development consists in the development of a total of 14 wells consisting of 8 (eight) oil producers, 3 (three) water injectors, 3 (three) gas injectors, all tied-back to topsides by means of flexible flowlines and risers.

Oil production wells are arranged in 3 (three) daisy chained loops by means of single branch flowline end terminations (FLET), while the WI, GI and GP wells, plus OP-CAMP2 are arranged in a satellite configuration. Artificial gas lift is required at SkE-2A riser base (SW production loop).

All risers and flowlines are made of unbounded flexible pipes. Well jumpers are made of rigid pipes.

All flexible lines are designed to withstand the external environmental to which they will be exposed and to be suitable to the Project operating conditions requirements, throughout their design life (20 years).

Risers Configuration

The Lazy Wave riser configuration has been selected on the basis of the studies carried out to evaluate the most promising solution between two different riser configurations (Free Hanging and Lazy Wave arrangements).

The main advantage of the Lazy Wave configuration is the capability to decouple the vessel motions from the TDP. Lazy waves are, however, prone to configuration alterations if the internal pipe fluid density changes during the riser lifetime.

The Lazy Wave configuration (see Figure 2-9) foresees a set of buoyancy module made of synthetic foam which has the property of low water absorption; the buoyancy module need to be clamped tightly to the riser to avoid any slippage which could alter the riser configuration and induce high stress in the armor wires. Buoyancy modules tend to lose buoyancy over time and wave configurations shall be designed in detail phase in order to accommodate a certain buoyancy loss.

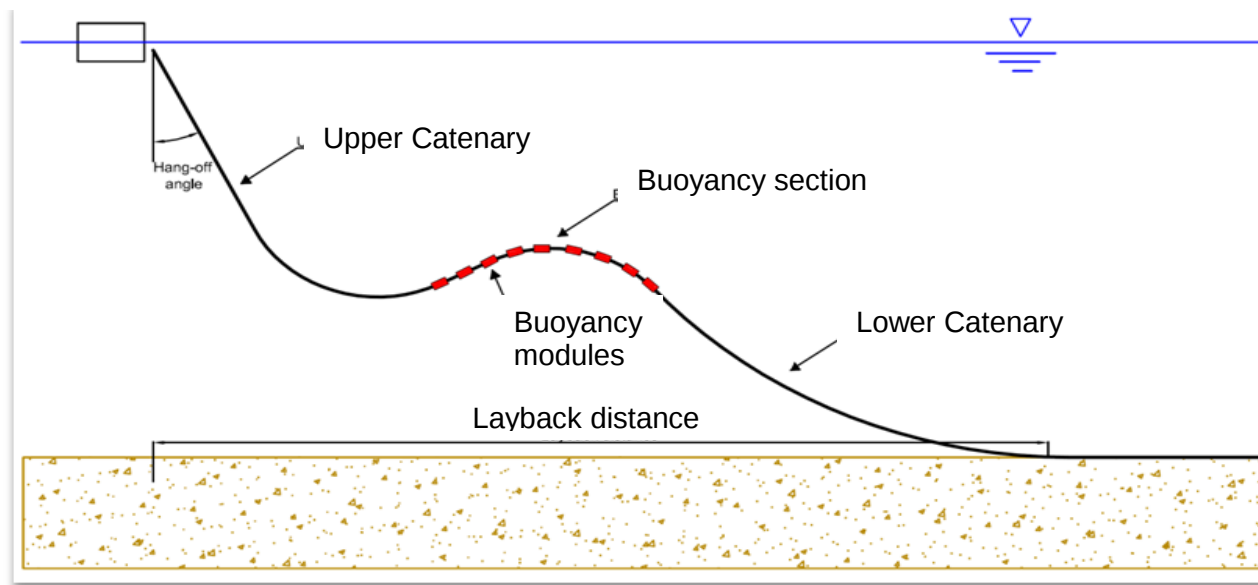


Figure 2-9 Typical Lazy Wave configuration

The quasi-static analysis provides the static equilibrium configuration due to static loading: weight, buoyancy, top tension, current, equivalent wave; static analyses have been performed using a nonlinear FE approach.

Following the setting and the quasi-static results obtained in the configuration assessment study a global dynamic analysis has been performed and discussed in terms of strength response and mutual interference between all the involved lines (flexible risers, umbilicals and mooring lines).

The above riser configuration shall be checked against interference issues, which is an analysis part of the detailed engineering of EPC Contractor.

Table 2-5 Risers & Flowlines Design Data

	PHASE 1						
	Oil Production				WI	GI	GL
ID [inch]	4"	6"	8"	10"	6"	6"	4"
Design Life [years]	20	20	20	20	20	20	20
Design WD [m]	1300	1300	1300	1300	1300	1300	1300
Max Op. WD [m]	1000	1000	1000	1000	1010	1000	1000
Service Type	Sour	Sour	Sour	Sour	Sour	Sour	Sour
H2S content [ppmv]	40	40	40	40	50	40	40
OHTC [W/m2K]	4	4	4	4	NA	NA	NA
Min Op. Pressure (Note 4) [bara]	TBD	TBD	TBD	TBD	TBD	415	1
Max Op. Pressure (Note 4) (normal conditions)	254	254	58	68	376	460	100

[bara]							
Max Op. Pressure (Note 4) (shut-in) [bara]	267	267	267	267	410	495	112
Pressure built-up due to chemical injection (Note 4) [bara]	345	345	345	345	583	583	NA
Design Pressure [bara]	345	345	345	345	583	583	345
Min Op. Temperature (Note 5) [°C]	-43	-29	-29	-29	4	4	-30
Max Op. Temperature@shut-in [°C]	60	103	103	97	60	70	100
Max Op. Temperature (normal conditions) [°C]	60	103	103	97	60	70	100
Design Temperature [°C]	80	120	120	120	80	80	120
Fluid Density (shut-in) [kg/m3]	850	850	850	850	1035	410	160
Min. Fluid Density (operation conditions) [kg/m3]	flowline	268	162	162	990	310	35
	riser	245	143	49			
Max Fluid Density (operation conditions) [kg/m3]	flowline	644	644	360	1025	395	52
	riser	515	305	317			
Ref. height for above max and min pressures [m WD]	1000	1000	1000	1000	1010	1010	878

Flexible Lines' Preliminary Lengths

The following tables summarize required risers and flowlines lengths for Oil and Gas Development Project.

Lengths will be confirmed by T&I EPCI Contractor which, as part of his SoW, shall review and optimize the Subsea Field Layout.

Table 2-6 Risers and Flowlines Preliminary Lengths

Project Phase	Wells	COMPANY Reference	Application	OHTC [W/m2K]	ID [inch]	Length [m]
1	OP-CAMP1, SKE-2A Production Loop	ROP1	Production Riser	4	10	2554
		FOP1	Production Flowline	4	10	4639
		FOP8	Production Flowline	4	10	2029
		FOP2	Production Flowline	4	10	2616
		ROP2	Production Riser	4	10	3593
1	OP-CAMP2	ROP6	Production Riser (DEH)	4	4	2514
		FOP6	Production Flowline (DEH)	4	4	3245
1	OP-3, OP-4 Production Loop	ROP3	Production Riser	4	6	2349
		FOP3	Production Flowline	4	6	3294
		FOP4	Production Flowline	4	6	2837
		ROP4	Production Riser	4	8	3500
1	OP-5, OP-7, SKE-1x Production Loop	ROP5	Production Riser	4	8	3597
		FOP5	Production Flowline	4	8	2406
		FOP9	Production Flowline	4	8	100
		FOP10	Production Flowline	4	8	125
		FOP7	Production Flowline	4	8	3694
		ROP7	Production Riser	4	8	2399
1	WI-1	RWI1	Water Injection Riser	NA	6	2665
		FWI1	Water Injection Flowline	NA	6	2027
1	WI-3	RWI3	Water Injection Riser	NA	6	3425
		FWI3	Water Injection Flowline	NA	6	1845
1	WI-CAMP1	RWI-CAMP1	Water Injection Riser	NA	6	2462
		FWI-CAMP1	Water Injection Flowline	NA	6	3634
1	GI-1	RGI1	Gas Injection Riser	NA	6	2618
		FGI1	Gas Injection Flowline	NA	6	6481
1	GI-2	RGI2	Gas Injection Riser	NA	6	2861
		FGI2	Gas Injection Flowline	NA	6	1038
1	GI-CAMP1	RGI-CAMP1	Gas Injection Riser	NA	6	2443
		FGI-CAMP1	Gas Injection Flowline	NA	6	2944
1	ROP2 Riser Base	RGL1	Gas Lift Riser	NA	4	3564

Table 2-7 Flexible Lines Preliminary Lengths – Overall Quantities

		Oil Production				Water Injection	Gas Injection	Gas Lift
	ID [inch]	4"	6"	8"	10"	6"	6"	4"
Flexible Risers	Qty	1 off	1 off	3 off	2 off	3 off	3 off	1 off
	Total Length [m]	2514	2349	9496	6147	8552	7922	3564
Flexible Flowlines	Qty	1 off	2 off	4 off	3 off	3 off	3 off	-
	Total Length [m]	3245	6131	6325	9284	7506	10463	-
		5759m	8480m	15821m	15431m	16058m	18385m	3564m

84km

Figure 2-10 and Figure 2-11 present the OCTP proposed subsea layout, plotted on the slope.

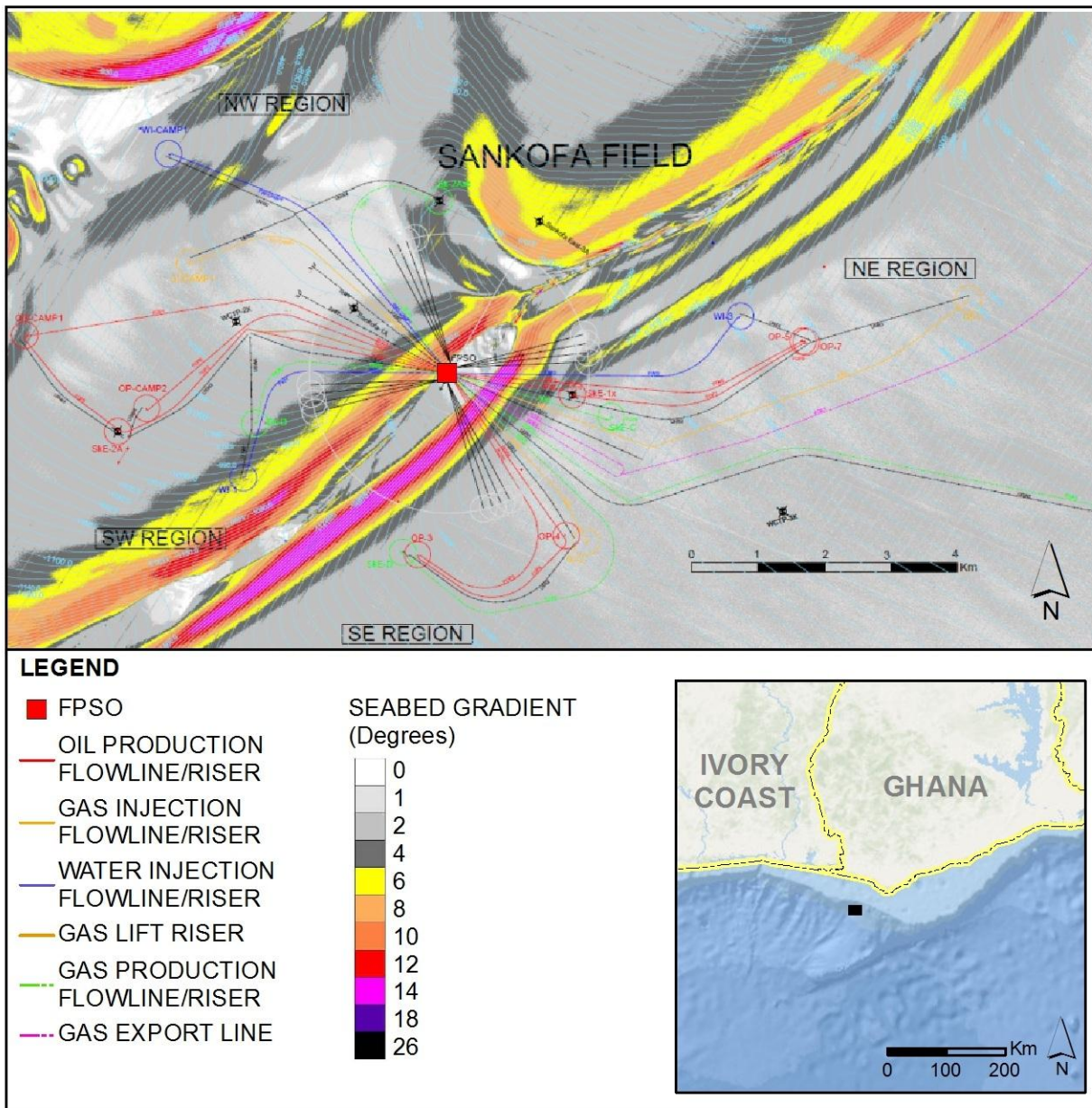


Figure 2-10 OCTP proposed subsea layout plotted on the slope – Sankofa field

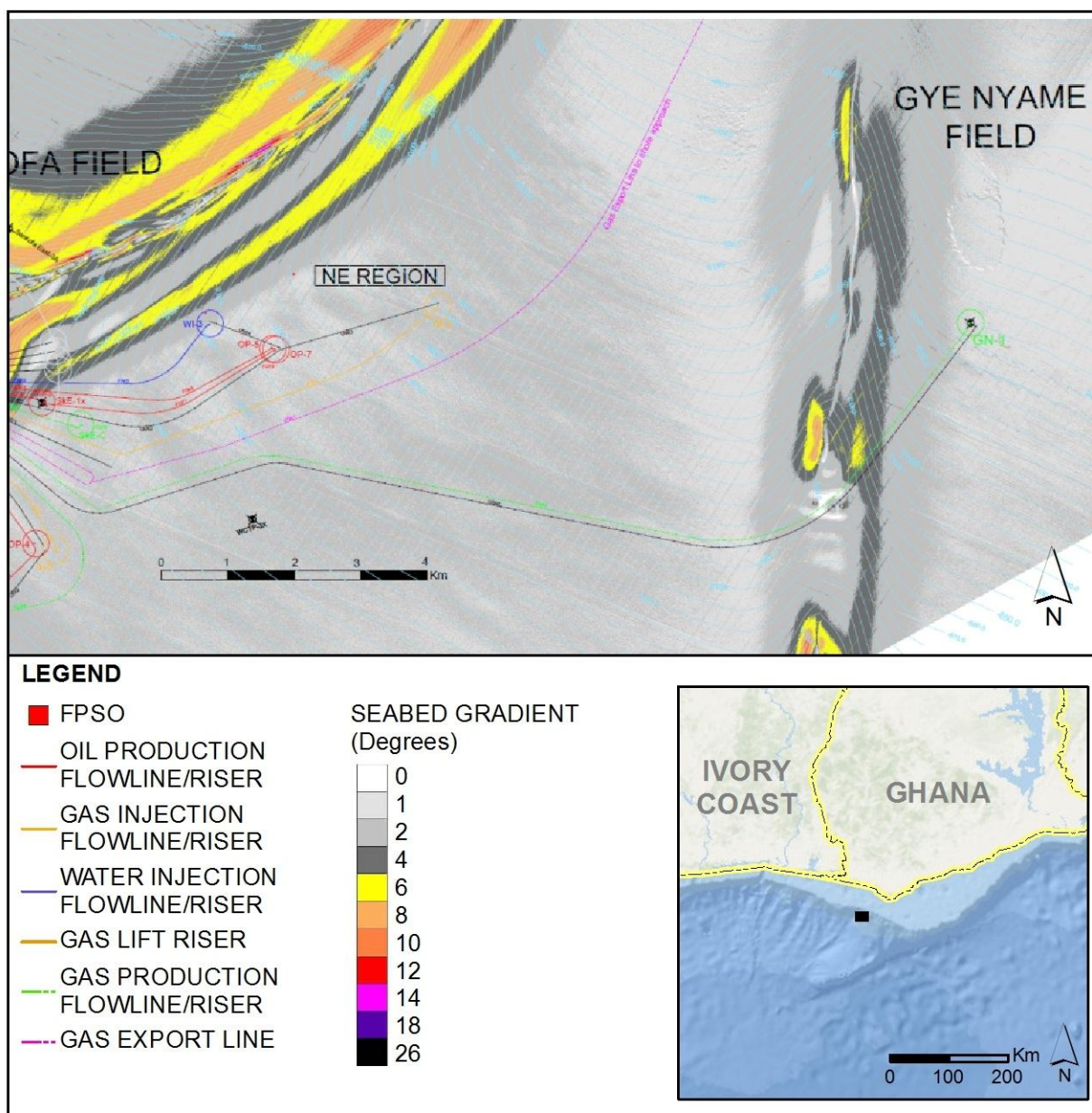


Figure 2-11 OCTP proposed subsea layout plotted on the slope – Gye Nyame field

For additional details on subsea production systems, flow assurance / production chemistry, or transport and installation philosophy, see sections 1.3 to 1.5 of Attachment B.

2.4.3 FPSO AND MOORING SYSTEM INSTALLATION

FPSO

The OCTP FPSO unit will be designed for the following main purposes:

- Separate, Process, Store and Offload both oil and condensates at export specification
- Separate, Dehydrate, Compress and Re-inject the Associated Gas
- Separate, Treat and inject or Dispose of the Produced Water
- Lift, Treat and Inject Sea Water

- Separate, treat through a Dew Point Control Process the future Not Associated Gas (NAG)
- Separate Condensates from the NAG and mix them with the Oil production

The FPSO unit will have all necessary utilities for the safe operation during the most harsh weather conditions that have been reported in the project design basis.

Crude oil will flow continuously from subsea trees through subsea pipelines via risers to the process facilities on the FPSO (Floating, Production, Storage and Off-loading). Processed crude oil will be stored in the cargo tanks. Shuttle tankers will periodically be moored to the FPSO and the stored crude oil will be pumped to the shuttle tanker via an offloading hose. Exported crude will be fiscally metered on board of the FPSO. The normal production will not be affected by the crude export operations.

The FPSO systems shall allow efficient and safe operations of Unit at site, providing the following main functions:

- to mitigate oil pollution risks by means of appropriate measures;
- to store crude oil, ballast water and operational fluids in dedicated segregated tanks;
- to allow the transfer of stored liquids from tanks to the final utilisation equipment;
- to offload oil into shuttle tankers;
- to provide accommodation for operations personnel;
- to provide the full range of hotel services which are required to support operations;
- to provide the full range of utility services to guarantee the process and vessel functionality;
- to guarantee the safety of personnel and environment both during normal and emergency conditions;
- to allow the control and management of all the on board activities.
- to provide electrical power supply to both topside and vessel users.

The FPSO and mooring systems will be designed using International Standards. In particular, the following International Conventions are applicable;

- IMO – “International Convention for Safety of Life at Sea”, (SOLAS) 1974, as actually amended.
- IMO – “International Convention for Prevention of Pollution from Ships”, (MARPOL) and amendments.
- DNV “Mobile Offshore Units - Position mooring (POSMOOR)”
- API RP 2SK “Recommended Practice for Design and Analysis of Station keeping Systems for Floating Structures”
- OCIMF Prediction of Wind and Current Loads on VLCCs

FPSO Topsides Facilities

The FPSO unit nameplate capacities are reported in the following table:

Table 2-8 FPSO unit nameplate capacities

FPSO (New conversion)	Design
Min Oil storage	1.4 MMbbls
Mooring & Risers System	Spread Moored Double balcony

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Oil Treatment	58,000 bblsd Including Cond's and 10% over design
Gas Injection	150 MMScfd
Water Injection	55,000 bblsd
NAG Treatment	210 MMScfd
NAG Booster Comp.	210 MMScfd

Oil Process Description

Inlet System

The production fluids from the Cenomanian reservoir will be produced separately in dedicated flowline loops and risers before being routed to a separate oil manifold. This manifold will transport the fluids to the inlet separator, operated at 20 bar.

The production fluids from the OPCamp2 well will have a dedicated manifold routing the production to a dedicated HHP separator which will be operating at higher pressure as the arrival pressure at the FPSO is expected to be significantly higher than the other oil wells.

Oil Stabilization and Storage

Initially, the oil will be stabilized in multiple separation stages (HHP, HP, MP and LP). Process heating has been designed to prevent wax deposition within the process train. Additional Dehydration and Desalting facilities are provided to reach the export specifications.

A single oil processing train will be designed to deliver a stabilized product to the storage tanks in the FPSO for subsequent export. Oil will be fiscally metered before export.

In order to prevent wax formation within the subsea system, the well OPCAMP2 requires a dedicated direct electrical heating system within its flowline.

Gas Compression and Dehydration System for Gas injection

Gas liberated from LP separator is compressed in reciprocating LP compressor and combined with MP gas collected from MP production separators before being sent to a reciprocating MP gas compressor.

After MP compression, the gas is mixed with HP gas from HP separator and sent to the first stage of the centrifugal HP gas compressor train.

Associated Gas separated from the Oil stabilization train is compressed to approximately 70 bar before Gas Dehydration using a TEG unit. The total amount of expected associated gas is 150 MMScfd.

A further two stages of compression are needed to reach the pressure required at the topside for gas injection, 430 bar.

Gas Process Description

Inlet System

The production fluids from the Campanian reservoirs will be produced separately in dedicated flowlines and risers before being routed to a separate condensate manifold. This manifold will transport the fluids to the inlet slug catcher, initially operated at 70 bara. The slug catcher will additionally be designed to separate gas, condensate and a mixture of MEG (Mono Ethylene Glycol) and water.

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Future Booster compression (expected 2026) is required to handle the decline in arrival pressure from 70 bara to 20 bara.

Condensate Stabilization and Storage

Condensate, separated from the slug catcher and the dew-point control, unit is mixed before heating to 30 deg C. The heated condensate is further stabilized in the condensate separator operating at 3 barg. The liberated flash gas from the condensate separator is relatively rich in LPG and is therefore further compressed before being sent to the dew-point control unit.

Gas Dew-point Control Unit

Gas from the slug catcher and condensate separator is pre-cooled in a Gas/Gas Exchanger before further chilling across a Joule-Thompson valve. The resulting condensate shall be separated in a low temperature separator whilst the conditioned gas will pass through the Gas/Gas Exchanger before being routed to the onshore receiving plant.

MEG is also injected within the process to prevent the formation of hydrates.

The dew point control unit is targeted at ensuring an acceptable HC/water dew-point to prevent significant liquid drop out in the pipeline to the onshore receiving plant. However, the design also ensures that stabilized liquid that can be mixed or spiked into the crude oil without exceeding export specifications.

Main Utilities

Utility units are design to satisfy both Oil and Non Associated Gas (NAG) process requirements.

Chemical Injection System

The chemical injection system consists of all equipment and distribution piping (tubing) associated with chemical injection, including storage tanks, injection pumps, transfer pumps, and all required instrumentation up to the individual points of injection (or as the chemical leaves the FPSO for subsea injection points).

Chemical injection facilities provide a means of assisting the production facilities system to meet product specifications and disposed fluid specifications as well as protect the production facilities from corrosion and hydrate plugging.

The chemical injection facilities supply specific chemicals through injection rate controlling devices at their identified injection points throughout the process facilities at the dosage rate necessary for achieving the above. An injection rate-controlling device is also installed on the pipe manifold area to allow proper distribution to the end users.

Stand-by pumps (N+1 configuration) have been provided at all chemical units to guarantee continuous performance, even for high volume pumps. Each injection point is in the centre of the pipe.

Dosage rates for the metering pumps can be manually set up at each pump or controlled using the injection rate controlling devices. Each injection point has online flow meter (transmitter). For single-headed pumps, the pump is stopped if no chemical injection is required for that injection point. For multi-headed pumps where chemical is pumped to both high and low pressure points, individual pump head can be offloaded back to the storage tank via a back pressure control valve if no injection is required.

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Flare, Vent and Blowdown System

The System is designed to satisfy the zero flaring philosophy that has been adopted by the project.

The Flare / Vent System provides safe egress of hydrocarbon fluids that are relieved from process equipment and/or from PSVs, BDVs, and PCVs/ PVs during start-up and/or process upset conditions. Major equipment associated with the flare is listed below:

The facility is equipped as a minimum with 2 (two) independent flare systems, one operating at high pressure (HP) and the other at low pressure (LP). The system is designed for emergency burning and also has a backup of the ignition system. The systems are designed to operate simultaneously.

The HP Flare system is provided with a sonic flare tip whereas the LP Flare system is provided with a pilot type flare tip.

The flare system is designed and constructed in accordance with API 520 Design and Installation of Pressure Relieving Systems and with API STD 521 Pressure-relieving and De-pressuring Systems.

The system is designed to do not exceed allowable noise or radiation limits as shown on API STD 521, when continuously relieving and burning the full gas production rate or blowing down the process system.

Glycol Regeneration for Hydrate Inhibition

This unit is considered as option as it is only related to the NAG production.

Flowline MEG Regeneration & Reclamation System is required for salt removal and regeneration of water-rich MEG that is recovered from produced fluids from the gas/condensate reservoirs. Lean MEG is injected subsea to inhibit hydrate formation.

In the early years of production, when formation water has not yet broken-through the reservoir, the MEG/water produced with the gas reservoir fluids will be salt free. Hence, no reclamation process is required for recovery of the MEG. During this period, the rich MEG from the Flowline MEG Separation System is sent to the Process MEG Regeneration System for treating. In this design, the capacity of the Process MEG Regeneration System is sized to accommodate the capacity of the rich MEG from the Flowline MEG/ Condensate system as well as MEG from the Process MEG/Condensate System. During the early production years, when the rich MEG from the flowline system is directed to the process MEG Regeneration System.

According to the latest production profile there is an opportunity to avoid the future installation of this unit if there is no presence of free water throughout the full life of the field. Presently the Unit is considered as a "FUTURE" item, and provisions for space, utilities and tie-ins are already foreseen in current topside design of the FPSO.

Fuel Gas System

The Fuel Gas Conditioning System provides clean, superheated natural gas, suitable for gas turbine combustion (fuel gas requirements to be specified by chosen turbine supplier), and delivers superheated fuel gas to each of the other end users at their required flow rates and pressure levels.

The Low Pressure Fuel Gas Conditioning System (for blanketing the process equipment, purging of flare headers) is designed for low pressure fuel gas users.

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Fuel gas system is designed for a flowrate about of 30 MMscfd. Treated gas enters the fuel gas conditioning system from the downstream of the TEG Outlet Coalescer within the Gas Dehydration System. The pressure is let down and sent to the HP Fuel Gas Scrubber. Any condensed liquid is separated in the scrubber and returned to the Safety Gas Knockout Drum. The gas from scrubber passes through a Coalescing Filter where finer filtration of liquid droplets is done before being heated in the Fuel Gas Heater to provide a minimum superheat. This process ensures Generator Gas and Booster Gas Turbine (optional NAG future turbo-compressor) fuel gas quality requirements are met. The fuel gas then flows through the Fuel Gas Filter to remove any fine particulates. The superheated gas is then distributed to each of the turbines, compressor seal gas panels and other users.

Fuel gas for low pressure consumers is let down from the turbine fuel gas pressure level. This gas is used as a low pressure fuel gas supply to the flare header purges, flare tip pilots, for blanketing of vessels as well as for marine boilers. As part of fuel gas system to boilers, the following are installed; deck gas valve skids, gas valve enclosures, extraction air fans. Fuel gas system is designed to have sufficient hold-up volume to permit smooth switchover (without shading any running electrical loads) of all the running power generation turbines from fuel gas to diesel fuel.

Power Generation System

Main power generation

The main power generation for the entire FPSO Unit shall be provided by gas turbines/engines driven synchronous generators. The electrical power generation unit must ensure adequate capacity to feed both Topsides and Vessel loads, and in general all the electrical loads of the FPSO, in all the operating conditions, with a minimum sparing philosophy of N+1 (with N=2 as a minimum). This means that, in the event that one main power generator is not available for shutdown or maintenance, the others shall be able to run the production at 100%.

The firm capacity of the main power generation system (with “N” of the “N+1” generators in operation) shall be capable of supplying continuously the 120% of the load balance, at the maximum design ambient temperature. This contingency may be eroded during detailed design development, but on completion of the project a margin of at least 10% spare capacity shall exist.

Essential power generation

Essential diesel generators shall be provided in order to cover the loads necessary for life, support, accommodation, communication, the loads necessary during navigation and when the FPSO is not producing, plus the loads classified as emergency and safety and the loads required to start up the first main power generator.

Facilities to synchronize and operate in parallel the Essential Diesel Generators shall be provided. The sparing philosophy for essential power generators shall be N+1.

Emergency power generation.

A diesel power generation shall be provided to ensure the emergency power supply to all emergency users of the FPSO (both topside and vessel) and shall be located in a dedicated shelter/container.

On loss of main power, the emergency electrical system shall ensure the shutdown of the production facilities in a safe manner, while the emergency control, the management and life support systems shall continue to function, normally and safely. A minimum autonomy of 24 hours shall be guaranteed.

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Produced Water Treatment

The purpose of the Produced Water System is to remove oil from the produced water stream and sand management in order to comply with injection requirements and applicable overboard discharge regulations in case of unavailability of the water injection system.

The Produced Water System is sized to process 45,000 bblsd of produced water with an output oil in water content of 20ppm.

Fire fighting system

The FPSO shall be protected by various fire-fighting systems depending on the location and the risks associated with the area to be protected.

Topsides shall be protected by a pressurized water and foam deluge system, which shall be activated manually from the CCR or automatically via fire detectors, depending on areas to be protected.

The cargo tank, deck, helideck, and offloading station shall be protected by a low-expansion foam system. The cargo tank deck underneath the topsides modules shall be covered by a fixed foam spray system.

Machinery and equipment spaces shall be equipped with the fixed Hi-expansion foam fire extinguishing systems or clean agent extinguishing system depending upon requirements for the space.

Figure 2-12 presents the FPSO main system layout.

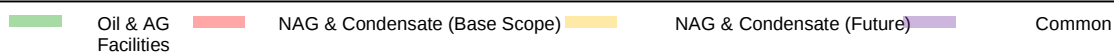


Figure 2-12 FPSO Main System Layout

Hull and Offloading

The FPSO unit shall have a minimum design life of 20 years starting from the date of completion of the vessel conversion (VLCC – fig. above). The FPSO unit shall be CLASSED for uninterrupted service, without the needs for dry-docking during the expected service life, with on-site class surveys for classification status maintenance.

The required storage capacity for the OCTP development project is **1.4 MMbbls** which will be guaranteed in the case of converting a VLCC as the standard storage capacity of such vessel is

around 2 MMbbls. The expected tanker hull to be used for the FPSO conversion will be of “Double Hull” type meeting the minimum requirements specified by eni and applicable international standards.

The offloading configuration is foreseen as Tandem type offloading using an offloading hose (see Figure 2-13).

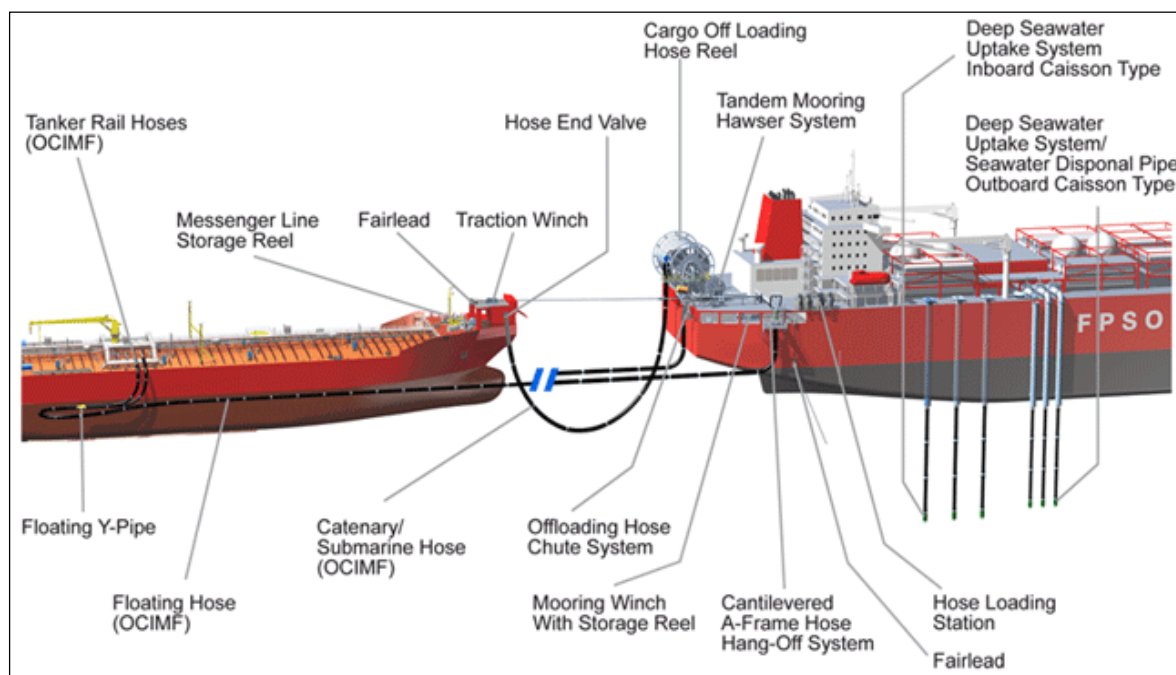


Figure 2-13 Pictorial of tandem offloading configuration

Mooring System

The FPSO selected mooring system is the Spread Mooring System with a double balcony riser approach (see Figure 2-14), allowing higher flexibility in number of riser slots and in adding future risers (if required).

The FPSO unit design will foresee a minimum of 30 risers needed for production, gas injection, water injection, umbilical and gas export. A reasonable number of spare slots (3) is considered to accommodate future developments and expansions.



Figure 2-14 Pictorial of double balcony FPSO

Figure 2-15 presents the mooring system layout, while Figure 2-16 presents the scheme of the mooring system.

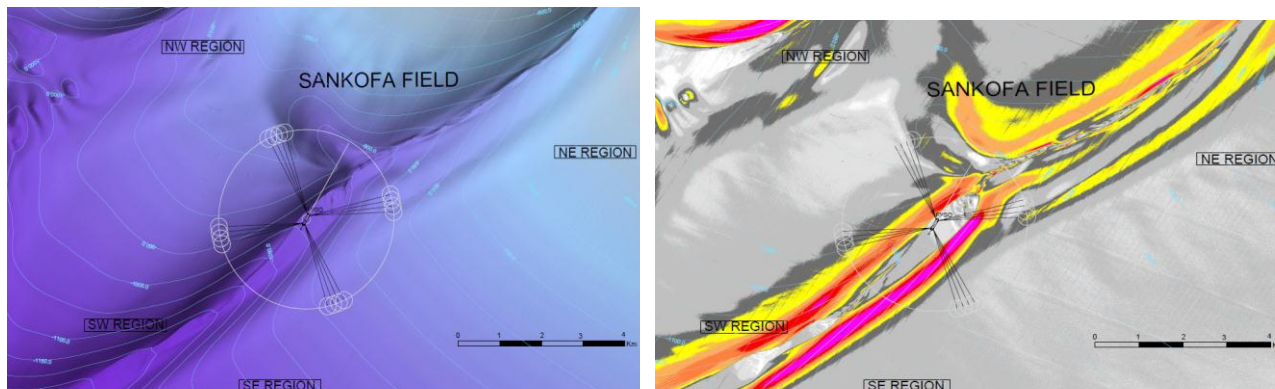


Figure 2-15 Mooring Layout (hotter colours indicate steeper slopes along the canyon)

The mooring system shall be designed according to the following criteria:

- The anchoring will provide sufficient restoring in order to retain the vessel riser tie-in location within excursion limitations ensuring the feasibility of the under-water riser system.
- The maximum anchor leg tensions will be kept as low as possible in order to minimise, within the full respect of the Factors of Safety, the size and cost of the mooring system components.
- The anchoring system suspended weight applied to the FPSO will be minimised, to avoid heavy supporting structures. The anchor legs will nevertheless be terminated on their FPSO extremity by a small length of chain, for several reasons:
 - allow the use of chain-stoppers, which permit a relatively easy adjustment of each anchor leg pretension during installation;
 - a chain segment in the splash zone is more robust than a wire rope in case of collisions against any (unidentified) floating object.

The design of the mooring system will be based on a spread mooring configuration with 4x4 lines (16 total) chain, steel wire, anchoring with suction piles L=20m e D=5m; the offset is 5% of water depth with intact lines and 8% of water depth with one line damaged. Figure 2-17 presents the schematic of an FPSO with a spread mooring system.

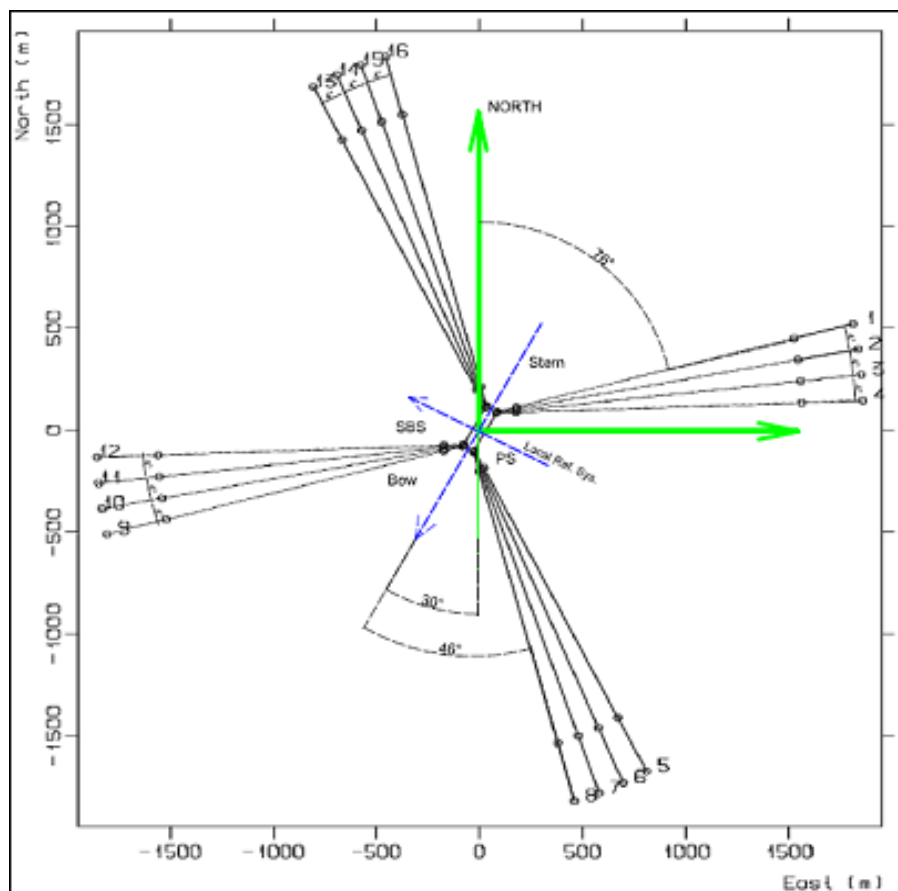


Figure 2-16 Scheme of the Mooring System

Table 2-9 Lines characteristics

Line segment characteristics							
Segment type (16 Lines)	Segment length [m]	Dia meter [mm]	EA [kN]	E [kN/m ²]	MBL new [kN]	MBL corroded [kN]	Submerged weight [kN/m]
Ground chain stainless A35	300	107	9.2737E+05	1.0313E+08	10103	8805	1.932
Rope spiral stand wire rope sheathing	1600	102	8.4272E+05	1.0313E+08	9364	-	0.447
Top chain stainless A35	130	114	1.0527E+06	1.0313E+08	11287	9938	2.193

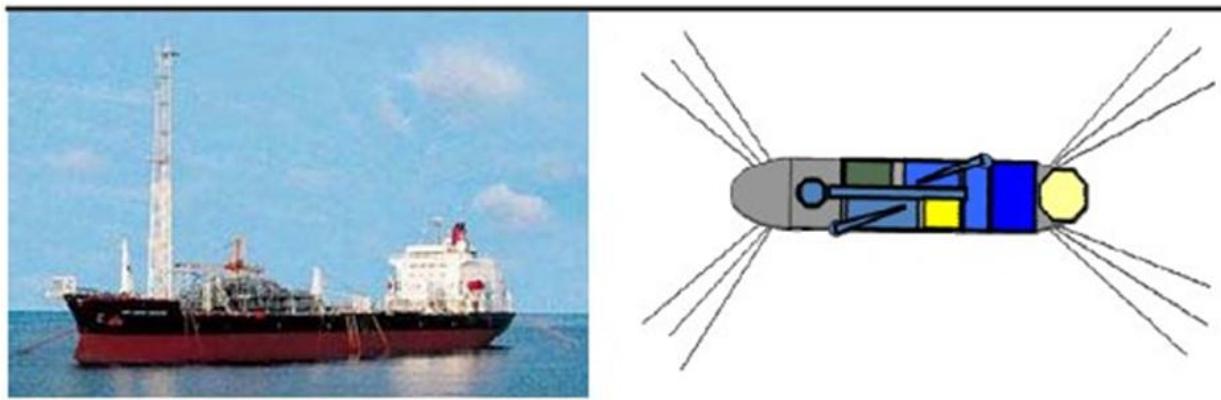


Figure 2-17 FPSO with a Spread Mooring System

The initial activity will be to install three mooring spread and a temporary support buoy to support the lines prior to the FPSO hook-up.

The work will be undertaken using a pair of large anchor handling vessels (AHVs) or anchor handling tug supply (AHTS) vessels and will last approximately two to four weeks.

The FPSO will retain the original marine engine and propulsion systems for the transit from the conversion and pre-commissioning site to the installation site in Ghana. Hook-up of the FPSO to the mooring spread will be performed by a Dynamically Positioned (DP) construction vessel with the assistance of three AHVs mentioned above. The vessel will pick up the upper end of the preinstalled mooring lines, move toward the FPSO and connect the mooring wires to the FPSO.

In case of DRAG anchor the required hypothesized marine spread could be:
1 vessel anchor handling as following ARMADA THUA 104-105, as presented in Figure 2-18.



Figure 2-18 Example of a Vessel Anchor Handling

2/3 tug vessel 30/40 ton as following Armada Tuah 26 (see Figure 2-19).



Figure 2-19 Example of a tug vessel

In case of Vertical Load Anchor (VLA) or Suction pile the required hypothesized marine spread could be:

1 vessel anchor handling as following Normand Installer (see Figure 2-20).



Figure 2-20 Vessel Anchor Handling: Normand Installer

2.5 COMMISSIONING PHASE

Field installation plan will be elaborated with the aim of reducing the requirements relevant to the installation spread and its duty and with the objectives of shortening the time lag between the arrival on site of the FPSO and the first oil. Therefore, all those installation activities, which do not require the presence of the FPSO, shall be performed before the FPSO arrival on site.

The basic philosophies for the performance of the Commissioning and Start-up Operations are:

- Commissioning sequence starting with safety and life support systems and completed with hydrocarbon system;
- Optimisation of commissioning of vessel systems related to class inspection and class test in order to avoid duplications.

The subsea system will be controlled by a multiplexed Electro-Hydraulic (EH) control system routed from the FPSO facility via a control umbilical to each subsea system. The umbilical shall consist of hydraulic lines and electrical power/communication lines from topside control system to

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each subsea manifold and then to the trees (Well heads). An umbilical system will provide control and chemicals to all subsea manifolds and trees from the FPSO.

Hydraulic lines will be routed from the Hydraulic Power Unit (HPU) to the Topside Umbilical Termination Unit (TUTU), and through the subsea umbilicals up to the UTAs. In the same way, through the subsea umbilicals electrical lines will be routed from the Electrical Power Unit (EPU) and Master Control Station (MCS) to the TUTU, and then up to the UTAs. The hydraulic power distribution system shall have fluid supplies at two pressure levels (345 bar (LP) and 690 bar (HP)) with each pressure level having an active redundant line in the umbilical. These lines are assumed to have a minimum of 3/8 inch I.D.

One hydraulic flying lead and two electrical flying leads will connect the UTA to a SDU mounted on the manifold. The SDU will distribute hydraulic fluid, chemicals, electrical power and signal to all wells and manifold SCMs. Each SCM will be retrievable from its mounting base permanently installed in the hosting tree or manifold.

Electric and hydraulic umbilical services will reach the well from the manifold mounted SDU by means of Hydraulic Flying Lead (HFL) and Electrical Flying Leads (EFL). One HFL and two EFL are assumed per well. Two additional EFLs will connect the SCM of each well to the related MPFM incorporated in the well jumper. All the SCM hydraulic connections, as well as the cabling connecting the SCM to the tree instrumentation, will be routed through the related SCM mounting base, which will be populated with the necessary quick connectors.

The umbilicals connected to the FPSO shall be installed in a lazy wave configuration with distributed buoyancy; alternative configuration may be analysed in the study. The (dynamic) umbilical riser section and its associated (static) seafloor umbilical will be manufactured as a continuous length section. Chemicals injection is preliminary assumed to be through dedicated hoses/tubes in the umbilicals. This depends however on the injection rates that will eventually be required. Chemicals to be injected are preliminarily assumed as follows:

- **Methanol.** Methanol is assumed to be injected only during start-up and planned shutdown of each well. The wells are assumed not to be started and stopped simultaneously meaning methanol hoses/tubes in the umbilical can be sized only for the most demanding well. This chemical is assumed to be delivered through the umbilical to the SDUs, containing subsea manifolds that will distribute it to the individual wells via the respective HFLs.
- **Scale Inhibitor.** Scale inhibitor is assumed to be injected downhole into each well simultaneously, on a continuous basis at an appropriate pressure. If the total quantity of injection points does not allow for individual injection hoses/tubes in the umbilical, subsea distribution of this chemical inside the SDU will be necessary as per the methanol. In this case, due to the need for simultaneous injection, each well will need to be equipped with remote operated flow regulation valves and flow metering devices to ensure correct injection rate of this chemical in each individual well.
- **Low Dose Hydrate Inhibitor (LDHI).** The system shall be capable of injecting LDHI downhole through the scale DHCI system during slow well start-ups until the well tubing warms up. If the Scale Inhibitor can be distributed to each well by individual injection lines in the umbilical, injection of the LDHI will be performed via these same lines (with chemical mixing on the FPSO). The Scale Inhibitor system shall also be capable of handling up to 10 bpd of LDHI. In case this is not possible, the LDHI will need to be injected via an independent system similar to that of the Scale Inhibitor, down to upstream the flow regulation valves, where the two chemicals will be mixed.
- **Wax Inhibitor and Corrosion Inhibitor.** Wax and corrosion inhibitors if required will need to be provided on a continuous basis into the production manifold at each production header.

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Each injection point is assumed to have an individual line in the umbilical. Injection pressures are the flowing tubing pressures at the manifold. Minimum injection hose/tube I.D. for this combination of chemicals is assumed to be 1/2 inch.

All chemical injection tubes/hoses are assumed to have a minimum of 3/8 inch I.D., and to have MAWP of 345 bar (5000psi). A common 3/4" Annulus Service Line (ASL) preliminarily rated to 345 bars shall be provided to all production wells serviced through each umbilical. As an alternative the Annulus Service Line can be foreseen piggy-backed to the production lines.

2.6 OPERATIONS PHASE

2.6.1 FPSO Operational Components

Cargo Systems

The main purpose of the cargo system is:

- To receive, distribute and store on-spec crude oil from the process facilities into the cargo tanks,
- To receive and store off-spec crude oil from the process facilities into the dedicated off-spec cargo tank,
- To offload the crude oil stored in the cargo tanks into a shuttle tanker at regular intervals

The main operating targets of the cargo oil system are:

- Continuous loading of stabilised crude oil (from the process facilities).
- Offloading at regular intervals into a shuttle tanker.
- Simultaneous loading and offloading
- Fiscal metering of the crude oil parcel to be conducted on board the unit during offloading
- Inspection and maintenance of cargo tanks and piping systems to be conducted on board the unit in between offloads.
- Crude oil washing of cargo tanks (in between offloads and during offloading).
- Water washing of cargo and shop tanks.
- Stripping of the cargo tanks and discharging to the slop tanks.

Besides the above primary operations the following operations will be also performed by the system:

- Metering the crude oil partially offloaded during offloading,
- Transfer of crude oil between cargo tanks,
- Transfer of off-spec crude to process facilities,
- Transfer of crude to the pigging pump on Topsides,
- Stripping water from the bottom of cargo tanks and discharging to produced water / slop tanks,
- Crude oil washing of a cargo tank during offloading,
- Crude oil washing of cargo tanks in between offloading,
- Hot water washing of a cargo tank or produced water / slop tank in between offloading,
- Flushing of the export hose,
- Emergency ballasting of cargo tanks with seawater,
- Inspection and maintenance of cargo tanks and piping systems in between offloading.

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- Transfer of polluted ballast water to the slop tanks.

The vessel and cargo operating requirements and philosophies developed are relevant to the following systems:

- Cargo Oil and Ballast Systems.
- Inert Gas and Tank Venting System.
- Crude Export System.

Cargo Oil and Ballast Systems

The purpose of the ballast water system is to maintain hull trim/list, balance the hull stress and provide extra stability without complete dependence on the cargo oil tanks to do the same.

The main operating targets of the cargo oil and ballast system are:

- Continuous loading of stabilised crude oil (from the process facilities).
- Offloading at regular intervals into a shuttle tanker.
- Simultaneous loading and offloading.
- Fiscal metering of the crude oil parcel to be conducted on board the unit during offloading.
- Inspection and maintenance of cargo tanks and piping systems to be conducted on board the unit in between offloads.
- Crude oil washing of cargo tanks (in between offloads and during offloading).
- Water washing of cargo and slop tanks.
- Stripping of the cargo tanks and discharging to the slop tanks.

Inert Gas and Tank Venting System

The main operating targets of the inert gas and tank venting system are:

- Initial inerting of empty cargo tanks and slop tanks,
- Topping-up,
- Re-inerting of a cargo tank or slop tank after tank inspection / maintenance,
- Purging of a cargo tank or slop tank,
- Temporary inerting of ballast tanks when required.

Crude Export System

The main operating targets of the crude export system are:

- The amount of cargo, which is transferred from the FPSO to the shuttle tanker shall be determined by a metering unit.
- The offloading hose string will be according to the latest OCIMF recommendations and will consist of one main line. The length will be such that the largest expected shuttle tankers can be accommodated.
- In the event of an emergency on board the shuttle tanker, e.g. fire, explosion or extreme environmental conditions, a quick release mechanism will be provided to enable the operators to release the mooring hawser from the FPSO. The system will continuously monitor and record the load measurements and will have local and remote alarms fitted, at the mooring station and the Central Control Room.

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System Isolation and Blow- down Philosophy

The following Guidelines regarding the Topsides process system isolation are proposed:

The Oil Production Train and the Compression Trains will be equipped with actuated isolation valves to allow the possibility of remote isolating sections of the production facilities in case of emergency (i.e. fire). Definition of these isolation sections will be performed as part of the basic/FEED engineering. Each section will be equipped with actuated depressurisation valves to allow the possibility of remote depressurising sections of the production facilities in case of emergency. The Emergency Flare & Blow-down System will be sized for the contemporary discharge of all the sections. Implementation of any sequence for a phased blow-down procedure shall be evaluated during the basic/FEED engineering.

The blow- downstream gathering philosophy is aiming to avoid the mixing of cold high pressure gas streams (i.e. from the Compression Trains, leading to cold stream after the blow-down valves) with wet gas/liquid streams coming from the Oil Production Train.

This philosophy should prevent possible ice formation in case of simultaneous discharge. Therefore:

- Outlets from depressurisation valves and PSVs installed on the Gas Compression Trains shall be routed to the high-pressure KO drum and HP flare.
- Outlets from depressurisation valves and PSVs installed on the Oil Production Train (except for high pressure separator) are routed to the low-pressure KO drum and LP flare.

The Flare KO Drums final design will be performed during basic/FEED engineering according to API requirement and Project Safety Philosophy.

2.6.2 FPSO Control & Safeguarding Systems

General Description

The Control and Safeguarding System includes Process Control System (PCS), Emergency Shutdown System (ESD) and Fire & Gas System (FGS).

The Process Control System (PCS)

The process control allows the operator to monitor the process condition and apply corrective actions when necessary. The control functions during the start-up period will be executed from the central control room or locally, dependent upon the complexity of the start-up sequence of each process area or module. Where local operation is required, a dedicated local human machine interface will be provided. The concept of a distributed control system is also applied to the process package units, which have their own standard control system. The start-up and normal stop control functions shall be executed from the location where the control equipment is located. The necessary signals, which are relevant to remote control and monitoring in conjunction with other process area, are interfaced with the PCS through an agreed standardized protocol (i.e. MODBUS or Ethernet).

Process Control System (PCS) is fully independent from the Emergency Shutdown System (ESD). The system architecture follows a decentralized concept with local control panels on the Topsides modules and in the Local Equipment Room (LER). The Fire & Gas System (FGS) is a centralized system consisting of marshalling field termination and system cabinets. The FGS is installed in the LER with hardwired connection to the FGS interfaces, i.e. F&G matrix, PA/GA, ESD and telecom.

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A computer cabinet, consoles, printers and Human Machine Interface (HMI) stations comprising keyboard and monitor are installed in the CCR. Additional HMI stations are installed in the LER. The system components described above are linked by means of a dual redundant network. Hardwired connections are used for critical safety related signals. Local remote I/O panels are installed on the on the largest topsides modules in order to minimize hook-up cabling work. The processor units are located in the LER.

Safeguarding System

The goal of the safeguarding system is to protect against un-safe operation of the process and to perform corrective or suppressive actions in case of hazardous conditions on the FPSO.

This safeguarding system however consists of the following sub-systems:

- Emergency Shutdown System, which is indicated as ESD, to perform the safeguarding of equipment against abnormal values of process variables.
- Fire & Gas system (FGS), which performs the safeguarding against hazardous fire and gas situations.
- Public Address/General Alarm system (PA/GA) to alert personnel on the existence of a potential hazard and to transmit instructions.

The ESD is based on hierarchical levels of shutdown. The design of the ESD System is fail-safe and the design of FGS is fault-tolerant (i.e. by the use of voting system, line monitoring function and enhanced component diagnosis). The design of the safeguarding system also takes into consideration the possibility of regular system testing, which allows the desired reliability level to be maintained.

Telecommunication Systems in The FPSO

The existing Telecommunication system, after refurbishment of system and Telecommunication Room, will provide FPSO of the following requirements.

Internal Communications

A Public Address/General alarm (PA/GA) system is installed to facilitate public announcements and provide audible and visual alarm signals. Means will also be provided for "talk-back" at key locations. System loudspeakers are installed to enable audible alarms to be heard throughout the FPSO. In addition, status lamp assemblies shall be provided for visual alarm indication in areas with high background noise. The system is certified for use in hazardous areas where applicable. The system interfaces with the FGS. Talk-back stations are installed at key locations.

An automatic telephone system is installed with an electronic public exchange switchboard and telephone sets throughout the FPSO. Telephones are certified for use in hazardous areas where applicable and where installed in areas of high background noise, are provided with audio/flash unit and a noise protection booth.

External Communications

GMDSS (Global Maritime Distress & Safety System): A radio console (compliant with the GMDSS A3 regulations) shall be located in the Communication Room.

Satellite Communication: A VSAT (Very Small Aperture Terminal) shall be installed for voice, fax and data communication with other ships and shore and the existing IMMARSAT B Satellite Communication Systems will be used for backup.

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Aeronautical Communication: The VHF (AM) radios enable communication between the vessel and aircraft. A non-directional beacon provides a means for aircraft to locate the FPSO in conditions of poor visibility.

Operational MF/HF: This unit is fitted in the Telecommunications Room for communication between the shore and other vessels.

SART/EPIRB: The FPSO is equipped with SARTs (search and rescue transponders) and EPIRBs (satellite emergency position indicating radio beacons).

VHF (FM) SYSTEM: This equipment is fitted in the Central Control Room for communication between the FPSO and other vessels in the field.

UHF (FM) SYSTEM: The UHF system provides internal radio communications for the production and maintenance department's personnel.

Personnel Safety

Personnel safety shall be the highest priority of the OCTP development project. The goal shall be an accident-free workplace. Personnel safety will be the first priority in decisions that will involve design options, construction procedures, and cost/schedule trade-offs. The OCTP project HSE Plan shall describe the overall approach to safety management together with specific safety requirements and deliverables. Safety of design shall be another important aspect. It will require assessment of hazards and risks as described below. The goal of safety of design shall be to ensure the facility is safe for personnel and has reduced risks to facilities and the environment to the lowest practicable level.

Human Factors: Good Human Factors practices will be used in evaluating access to and viewing of operating data, manipulation of controls, installation of isolation devices, removal and replacement of equipment (e.g. equipment and personnel access and egress, lifting points, etc.). Human factors engineering will focus on facility modifications and equipment additions, while retaining consistency with existing systems where changes would otherwise increase the chance of human error. Human factors will be addressed with project specifications provided within ITT for EPC.

Risk Management: The general approach shall be to identify and eliminate hazards during the design through appropriate design selection and risk management. Where hazards cannot be eliminated, their significance will be evaluated and those that are considered significant shall be reviewed to ensure that appropriate risk reduction measures are employed.

A Risk Screening will be adopted for assessing tolerability criteria. However, as far as possible, the approach of applying the most restrictive standards will be followed, in order to guarantee a safe design from the early steps. Within this approach, the Risk Screening methodology will not be used to justify any derogation from the applicable standards; it will be used just to improve safety of the plant beyond the application of the standards.

All identified hazards will undergo preliminary screening to establish their classification. In first instances this will form part of the HAZID studies that will be conducted using the Risk Matrix and Severity Scales shown below

Dropped Objects: As general approach, the risk from dropped object shall be reduced by proper design of the piping arrangement and of the handling procedures:

- lifting of items above hydrocarbon equipment shall be avoided as far as possible;

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- as general rule, items shall be lowered from their usual position to deck level, and then moved at deck level to a lay down area (e.g. by a trolley).

However, despite a good design of the piping arrangement and of the handling procedures, in some points a protection against dropped object could be necessary. The design criteria for equipment protection from dropped object loads are dependent on the impact energy, their location and the frequency with which lifting operations will be performed. Where significant dropped object potential exists, impact protection criteria for equipment shall be based on the risks associated with potential dropped objects.

Vessel Impact: The supply boat landing is located alongside the ballast tank. The hull side at the supply boat landing shall be protected from collision with a supply boat. The impact of other vessel collisions will be evaluated and practical, cost effective measures developed to mitigate risks. The FPSO will be double hulled.

Fire and Blast: In general blast walls or reinforced structure have to be incorporated into the design based on the result of overpressure analysis, rather than subjecting the cost of the installation to Cost Benefit Analysis. As alternative design criteria, qualitative judgement may be used with some limitation, i.e. only when it is based on assumptions that can easily demonstrated, and when the approximations are towards higher safety.

The design intention for the FPSO shall be to minimize explosions on the main (cargo) deck by minimizing the routing of any topsides process hydrocarbon lines on this deck.
The cargo deck will be closed and vented far from topside equipment.

In addition, means of minimizing gas clouds from riser/fluid transfer line releases reaching this deck shall be developed by appropriate layout/location of equipment such that possibility of leaks onto main deck will be minimized.

Evacuation, Escape and Rescue: As the whole section, the following considerations have to be considered in conjunction with the HSE Philosophy. However, general requirements for the FPSO shall be as follows:

- Each of the topsides designated areas and/or modules that may be manned shall have at least two means of escape. Equipment, pipework and their supporting structures shall be positioned to encourage development of this escape philosophy. This requirement also shall apply to enclosed areas and rooms that are not continuously manned
- Stairs shall be installed to ensure proper and easy access between all levels of the facilities
- All escape ways and related doors/openings shall be clearly marked with luminescent signs or painting. The markings shall function during loss of main illumination in an emergency and in poor visibility or smoke. All exits used as escape ways (including stairs) shall be sized to accommodate personnel with full fireman suits and gear and for easy transportation of injured person on a stretcher.
- Facilities shall be provided to rescue persons from the water and to safely recover them to a place of safety.
- Appropriate helicopter crash equipment shall be provided adjacent to the helideck of each facility.
- Boat landings and a helideck will also provide an evacuation location for the facilities.
- Life rafts, buoys, lifejackets, and other safety equipment will be provided as defined in HSE Philosophy.

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Active Fire Protection: Active fire protection needs to be applied to all vulnerable vessels, pipework, support structures and other plant and equipment.

Other Protection: Total saturation suppression systems in accordance with API, ABS and SOLAS rules are to be provided in the relevant rooms. The company Philosophy is to avoid the use of Carbon Dioxide in enclosed manned space.

Miscellaneous Fire Fighting Equipment: Portable fire extinguishers shall be located in all areas of the installation. Type, size and locations shall be selected based on the encountered risk and in accordance with company specifications. Firefighting equipment, including firefighting suits and gear, shall be provided in accordance with the applicable standards and with the emergency response plan. The equipment provided shall be stored in a cabinet/locker located near the primary muster area for each facility.

The company Philosophy is to avoid the use of Carbon Dioxide in enclosed manned space.

Passive Fire Protection: Passive fire protection (PFP) will be used where necessary throughout the facilities. For further detail see HSE Philosophy Requirements for PFP shall be reviewed during basic design to take into account the applicable fire loads.

Fire and Gas Detection: A suitable number and type of Fire and gas detectors will be used throughout the facility.

Occupational Health: Occupational Health Hazards will be identified during reviews of the facility modifications and focus on changes to the existing FPSO systems. The reviews will focus on specific occupational issues including, but not limited to:

- Noise,
- Chemical exposures,
- Exposure to carcinogens, and Lighting.
- Lighting

ITT for EPC shall contain the Design Specifications for Health. MOH will perform design verification before construction. In addition, industrial hygiene surveys will be conducted after facility start-up to assess chemical exposures, noise levels and lighting adequacy to confirm design specifications were achieved. The schedule of the surveys will be reported in the relevant document of the installation.

Noise Control: Noise limits for offshore facilities will be provided to the contractors in the specifications for detailed design. A maximum sound pressure level of 85-dB(A) will be used for external working areas. The objective of this engineering control shall be to minimize noise levels and eliminate the need for hearing protection. Special areas such as offices, control rooms, living quarters, etc. will have specific tighter sound level limits as it will be specified in the HSE Philosophy and other specific design documents. The contractor shall provide data and calculations to the company to substantiate that the plant noise complies with the workplace noise criteria as described in the design documents.

ESD System: An automatic and hierarchical Emergency Shut-Down System (ESD) shall be foreseen on the FPSO including a vessel shutdown system, a topsides shutdown system.

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Flaring: The installation design incorporate a blow-down system to minimize the consequences of equipment rupturing by reducing the quantity of inventory that may feed a fire or gas cloud. The installation flare system will provide a safe and efficient way of collecting and disposing of hydrocarbons associated with the following scenarios:

- discharge from the safety valves during pressure relief conditions
- partial or total installation depressurization

Thermal Radiation: A flare radiation study and flare location assessment is required. The API 521 rules shall be applied in a early stage of the project before place order for flare system.

Power Generation: An emergency Power Generator shall be foreseen on the FPSO. It shall be located in a dedicated safe area, far from Main Power Generation system and a specific protection shall be considered during design for the system integrity against fire or explosion events. An Uninterruptible Power Supply system shall be provided, located in a dedicated safe area

Telecommunication: Dedicated telecommunication systems shall be provided on the FPSO to support safety and efficient operations; these systems include internal communication, telemetry systems, telecommunication network and external communication

Helideck: A helicopter deck shall be installed on the FPSO, in compliance with Company specification (Doc. N° 17002.VOF.OFF.PRG, “Aeronautical Design Criteria for Helidecks on offshore installation”) and with relevant International Regulation Authorities.

Asbestos removal: A complete asbestos removal shall be foreseen.

2.7 DECOMMISSIONING AND ABANDONMENT PHASE

At the completion of the projects life span the wells head, flowlines, FPSO and associated facilities shall be decommissioned and abandoned in accordance with International Guidelines for abandonment of oil and gas facilities. A detailed programme of abandonment and decommissioning shall be issued based on results from drilling and well testing.

As a minimum however, the reservoirs shall be sealed off with cement plugs and mechanical barriers while the wellhead shall be securely capped. Also, all equipment and debris shall be removed from the site while warning signs shall be posted to discourage adventurers from tampering with the capped wellhead structures left at the site.

Wells, production facilities, flowlines and risers, and infrastructures when they have reached the end of their design life shall be decommissioned and either dismantled and removed, or abandoned in accordance to statutory requirements. Sites shall be left in a safe and environmentally acceptable condition.

In the following the preliminary assumptions are described.

FPSO

The process equipment on the FPSO will be cleaned out, purged and certified gas free. The mooring lines will be removed and the seabed anchoring system will be left in position. The FPSO will be towed from site for re-use, refurbishment, decommissioning or dismantling.

Flowlines & Risers

The subsea flowlines, risers and umbilicals will be flushed through and possibly removed.

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Subsea System

Subsea trees and well-heads shall be abandoned on the sea floor.

Subsea Wells

All permeable zones shall be plugged individually to avoid any cross flow.

Cements plugs shall be set with top and bottom at least 50 meters above and below each zone.

The top of the cement plugs shall be located and verified by mechanical loading.

A cement plug , at least 150 m long, shall be placed with its top 50 m below the seabed.

2.8 NATURAL RESOURCES CONSUMPTION, WASTE GENERATION, AIR AND NOISE EMISSIONS DURING FPSO OPERATION

See details in section 1.8 of Attachment F.

2.9 PROPOSED PROJECT CONTINGENCY PLAN

ENI Ghana acknowledges the risks involved in its operations and the benefits to be gained from developing sound environmental protection practices; to this end, the company has developed a comprehensive contingency plan covering every aspect of the proposed project. The contingency plan has been developed from a six-point strategy for environmental protection based on the following parameters:

- Safe working practices.
- Preventive measures to contain operational and accidental spills, fire/explosions and Personnel injuries.
- Understanding of the risk.
- An effective emergency response organization with sufficient trained personnel and equipment to deal with the defined threat / hazard.
- A training and maintenance program to ensure an efficient response
- Co-operation with those who may share the risk and can participate in the response.

The emergency plan clearly identifies the actions necessary in the event of an emergency. These include communication network, the individual responsibilities of key personnel and the procedures for reporting to the authorities, and arranging the logistics of extra labour as may be needed.

Details on the plan are presented in Chapter 7 (Environmental Management Plan).

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3 LEGAL REQUIREMENTS AND POLICY FRAMEWORK

This chapter outlines Ghana's legal and policy framework as well as, international treaties and industry standards that are applicable to the oil and gas sector, particularly offshore developments.

3.1 NATIONAL LEGISLATION

Environmental Protection Agency

The EPA was established under the Environmental Protection Agency Act (Act No. 490 of 1994) as the leading public body responsible for the protection and improvement of the environment in Ghana. The Act describes its functions and responsibilities, provides powers for enforcement and control and gives provisions for administration and operations.

The EPA is responsible for issuing environmental permits and pollution abatement notices for controlling waste discharges, emissions, deposits or other source of pollutants and issuing directives, procedures or warnings for the purpose of controlling noise. EPA also directs the National Efforts for Tier 2 spillages and is one of coordination and provision of technical advice, logistic and maintenance support, materials and equipment, and training for Tier 3 spillages. EPA, in accordance with relevant Memoranda of Understanding and relevant International Conventions (such as Abidjan Convention), may also assist or receive assistance from neighbouring countries in relation to oil spill incidents

Guidance regarding mitigation of impacts to environmental resources and guidelines for minimizing environmental impacts of extractive industry activities are provided in the Ghana environmental laws and regulations. The EPA has the authority to require an EIA, is responsible for ensuring compliance with EIA procedures and is the lead EIA decision-maker

3.1.1 The Ghanaian Constitution

The 1992 Constitution of the 4th Republic, which came into force on 7th January 1993, is the fundamental law of Ghana and provides the foundation on which all other laws stand. Within the directive principles of State policy, the Constitution has a provision on Environmental protection and management which states in Article 36(9) that:

"The State shall take appropriate measures needed to protect and safeguard the national environment for posterity; and shall seek co-operation with other states and bodies for purposes of protecting the wider international environment for mankind".

This constitutes the basis on which Government initiates policy actions and legislation to promote sound environmental protection and management. Also Article 41(k) in Chapter 6 of the constitution of Ghana requires that all citizens (employees and employers) protect and safeguard the natural environment of the Republic of Ghana and its territorial waters.

Based on the framework established by the Constitution of the 4th Republic of Ghana, the government initiates policy actions and legislation to promote sound environmental protection and management. It is also in response to the provisions of the Constitution that the Parliament promulgated the Environmental Protection Agency Act 1994 which establishes the EPA who is responsible for enforcement of environmental laws.

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3.1.2 Environmental Protection Act

The authority, responsibility, structure and funding of the Ghana Environmental Protection Agency (EPA) is established by Environmental Protection Agency Act (Act 490 of 1994).

Part I of the Act mandates the EPA with the formulation of environmental policy, issuing of environmental permits and pollution abatement notices and prescribing standards and guidelines. Furthermore, the Act establishes and mandates the EPA to seek and request information on any undertaking that in their opinion can have adverse environmental effects and to instruct the proponent to take the necessary measures to prevent the adverse effect.

It also defines the possibility of the Board to appoint committees and establish the Hazardous Chemicals Committee, which plays a vital role in the management of chemicals in Ghana. The Act (Part II) empowers the EPA to request that an EIS process be undertaken and set the requirements for and responsibilities of the Environmental Protection Inspectors.

Part III of the Act establish the national Environment Fund, and defines its objective and management.

Finally, Part IV of the Act sets the administration and general provisions of the EPA.

3.1.3 Environmental Assessment Regulations

In Ghana, the Environmental and Social Impact Assessment process is established by the Environmental Assessment Regulations (Legal Instrument [LI] 1652, 1999), as amended in 2002.

The Environmental Assessment Regulations constitutes the principal enactment within the Environmental Protection Act (Act 490 of 1994). According to the LI 1652, all activities likely to have an adverse effect on the environment must be subject to environmental assessment and issuance of a permit before commencement of the activity. The Regulations sets out the requirements for the following:

- Preliminary Environmental Assessments (PEAs);
- Environmental Impact Assessments (EIAs);
- Environmental Impact Statement (EIS) (also termed the ESIA Report);
- Environmental Management Plans (EMPs);
- Environmental Certificates; and
- Environmental Permitting.

Schedules 1 and 2 of the Environmental Assessment Regulations also provide the list of activities for which an environmental permit is required and EIS is mandatory, respectively. For the activities listed below, an environmental assessment is mandatory:

- agricultural (including fishing) and related services;
- all forms of mining;
- manufacturing;
- construction;
- communication and other utilities; and
- power generation and transmission.

The regulations require that an application for an environmental permit be submitted to the Agency.

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The Agency will then screen this application and compile a report stating whether the application has been approved, is objected to, requires submission of a preliminary environmental report or requires the submission of an environmental impact statement. This decision will be communicated to the applicant within 25 days from the date of receipt of the permit application.

The regulations also provide specific requirements for stakeholder engagement within the EIS process.

3.1.4 Environmental Guidelines

The EPA has issued formal guidance on regulatory requirements and the ESIA process. Among these we find the following documents:

- Environmental Assessment in Ghana, a Guide to Environmental Impact Assessment Procedures (EPA, 1996);
- Environmental Quality Guidelines for Ambient Air (EPA);
- EPA Guidelines for Environmental Assessment and Management in the Offshore Oil and Gas Development (EPA, 2010);
- Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies (EPA);
- General Environmental Quality Standards for Industrial or Facility Effluents, Air Quality and Noise Levels (EPA); and
- Ghana Oil & Gas Operational Guidelines (EPA).

3.1.5 Petroleum Legislation

Ghanaian Petroleum legislation relevant for the Project includes the following Act and laws:

- the Ghana National Petroleum Corporation Law, 1983 (Act 64);
- the Petroleum (Exploration and Production) Law, 1984 (Act 84);
- the National Petroleum Authority Act, 2005 (Act 691); and
- the Petroleum Commission Act, 2011 (Act 821).

Ghana National Petroleum Corporation Act 1983, (ACT 64)

The Ghana National Petroleum Corporation Act (Act 64 of 1983) established the Ghana National Petroleum Corporation (GNPC) as mandated to:

- promote exploration and planned development of the petroleum resources of the Republic of Ghana;
- ensure the greatest possible benefits from the development of its petroleum resources;
- obtain effective technology transfer relating to petroleum operations;
- ensure the training of citizens and the development of national capabilities;
- prevent adverse effects on the environment, resources and people of Ghana as a result of petroleum operations.

Apart from allowing the GNPC to engage in petroleum operations and associated research, the law empowers the GNPC to advise the Minister of Energy on matters related to petroleum operations, with the exception of those related to upstream petroleum activities which have been adopted by the Petroleum Commission as per the Act 821 of 2011.

The Petroleum Exploration and Production Act, 1984

The Petroleum Exploration and Production Act, 1984 (Act 84, 1984) establishes the legal and fiscal framework for petroleum exploration and production activities in Ghana. The Act sets out the rights,

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duties and responsibilities of contractors; details for petroleum contracts; and compensation payable to those affected by activities in the petroleum sector. *Act 84* gives regulatory authority to the Petroleum Commission on behalf of the State. All petroleum operations are required to be conducted in such a manner as to prevent adverse effects on the environment, resources and people of Ghana. *Act 84* requires that a Plan of Development (PoD) for proposed developments be submitted and approved by the Minister of Petroleum before development of the field. In addition, an Environmental, Health, and Safety (EHS) Manual, containing details on health, safety, and environmental issues, policies and procedures must be submitted to the PC (Petroleum Commission) for review before commencement of development activities. The Act further requires that EHS audits of operations be conducted by the EPA and the PC (Petroleum Commission). The Act requires that emergency plans for handling accidents and incidents are discussed and agreed upon with the PC (Petroleum Commission) and the EPA before the commencement of operations.

For petroleum exploration, development, and production activities fall under the purview of the Ministry of Energy. Petroleum operations are governed by the Petroleum Exploration and Production Act of 1984. The Modern concession system, a hybrid between a Production Sharing Agreement (PSA) and the traditional concession system, is the basic contract between the State, the Ghana National Petroleum Corporation (GNPC), and private companies.

The Petroleum Commission Act (Act 821 of 2011)

The Petroleum Commission Act establishes the Petroleum Commission for the regulation and the management of the utilization of petroleum resources and to provide for related purposes. The Act establishes its responsibilities, functioning and governance, as well as the interaction of this commission with other government bodies in relation to petroleum resources.. *Act 821* requires also the Petroleum commission to advise the Minister on development plans as this Act has repealed all regulatory and advisory functions of the GNPC in relation to upstream petroleum activities.

3.1.6 Maritime Legislation

Beaches Obstructions Ordinance 1897 (CAP. 240)

The Beaches Obstructions Ordinance, 1897 (CAP. 240) details the permissions and authorisations required prior to the removal of sand from the beach and coastal areas as well as digging of channels etc. The legislation also details repercussions for any activities or persons causing obstructions for navigation

Ghana Maritime Authority (Amendment) Act 2011, (Act 825)

The Ghana Maritime Authority Act (2002) established the Ghana Maritime Authority (GMA) as responsible for the regulation and coordination of activities in the maritime industry and for the implementation of the provisions of enactments on shipping.

Due to the discovery of oil within Ghanaian waters, the GMA was confronted with many new challenges. In particular, it became necessary to develop the necessary policy, administrative, legislative and human capacity to support offshore oil and gas development.

Thus, the objective of this amendment is to make specific provision for the Minister to promulgate regulations for the purposes of fixing specific levies, fees and charges, to cover the administrative costs associated with the discharge of the functions and duties specified in the Ghana Maritime Authority Act, 2002.

Ghana Shipping (Amendment) Act, 2011, (Act 826)

The amendment was intended to inject local content into the oil and gas development by encouraging Ghanaians to participate in the shipping activities relating to offshore business. The Ghana Shipping Act, 2003 (Act 645) imposed restrictions on the trading of foreign registered ships

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in Ghanaian waters by preserving local trade in Ghanaian waters to Ghanaian ships. However, the current definition of Ghanaian waters is limited to the 12 nautical mile territorial sea.

The main object of this amendment is to extend the definition of Ghanaian waters to include the waters within the 500 metre safety zone generated automatically under the United Nations Convention on the Law of the Sea (UNCLOS) around installations in the exclusive economic zone beyond the territorial sea. This amendment would in effect extend the scope of local trade to include the trade from shore to the any oil and gas installations that will be established beyond the 12 nautical miles territorial sea such as the Jubilee field which is approximately 63 nautical miles offshore.

The amendment also makes provision for the grant of permit to foreign vessels to trade in Ghanaian waters in instances where there are no Ghanaian vessels available or capable of providing those services so as not to create operational bottlenecks.

Ghana Maritime Security (Amendment) Act, 2011 (Act 824)

The Maritime Security Act, 2011 (Act 824), amendment of the previous Act 675 of 2004 gives effect to Chapter XI-2 of the International Convention for the Safety of Life at Sea (SOLAS, 1974). The amendment intends to extend the previous application of the Ghana Maritime Security Act to offshore installations. The Act aims to enhance maritime safety and security; to create a legal framework for effective compliance with the International Ship and Port Facility Code (ISPS), defined under the International Convention; and to provide for related matters.

In addition to the legislation mentioned above, other maritime legal instruments relevant for the project include:

- Ghana Shipping (Protection of Offshore Operations and Assets) Regulations 2011.
- Ghana Maritime Authority (Maritime Safety Fees and Charges) Regulations 2012 (L.I 2009).

Ghana Shipping (Protection of Offshore Operations and Assets) Regulations

The Ghana Shipping (Protection of Offshore Operations and Assets) Regulations (LI 2010, 2012) stipulate conditions for offshore installation safety zones including the protection of such zones and entry conditions; the establishment of exclusion zones and protection mechanisms; and pipeline protection areas and cable protection areas. The regulations include specific conditions for mobile offshore drilling units (MODUs) requirements for the operation of MODUs (e.g. requiring a safety operating permit and a design, construction and equipment meeting the requirements of IMO resolutions A.414 and A.649); and requirements for the safety permit. The regulations also set out miscellaneous provisions including offenses and penalties.

Fisheries Act

The Fisheries Act, 2002 (Act 625), repealing the former Fisheries Commissions Act, 1993 (Act 457), aims to consolidate and amend the law on fisheries. The Act provides for the regulation, management and development of fisheries and promotes the sustainable exploitation of fishery resources.

Part I of the Fisheries Act (2002) deals with the establishment, functioning and responsibilities of the Fisheries Commission, and its mandate to manage national fishery resources. Part II establishes the composition and the functioning of the administration. Part III regulates the management and development of fishery resources, including conservation measures, while Part IV relates to jurisdiction and evidence related to non-compliance with the Fisheries Act.

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Amongst other, Section 91 allows for the establishment of marine reserves and prohibits fishing, dredging and removal of sand or gravels and the disturbance of natural habitat without permission of the Minister. Section 92 prohibits the pollution of water such that there is an adverse effect on aquatic resources and provides details of penalties.

Section 93 requires that the Fisheries Commission be informed of any activities likely to have substantial impact on fishery resources before commencement of the activity and allows the Fisheries Commission to require reports and recommendations by the proponent on the likely impact of the activity and possible means of preventing or minimising adverse impacts which shall be taken into account in the planning of the activities.

With reference to fish production and fisheries management, the Fisheries Act conforms to the relevant sectors of the United Nations Food and Agriculture Organisation (FAO) Code of Conduct for Responsible Fisheries with particular emphasis on gear selectivity and an effective institutional framework. The Fisheries Act also gives legislative backing to the recently established Monitoring, Control and Surveillance Division (including the Ghanaian Navy) with clearly defined legal powers to regulate fishing operations.

Fisheries Regulations

The Directorate of Fisheries under the Ministry of Food and Agriculture has developed fishery management plans for marine fisheries. The Fisheries Regulation (LI 1968 of 2010) further sets up the specific rules and regulations for the implementation of the Fisheries Act. The Fisheries Regulations address prohibited fishing methods (e.g. lights to attract fish, explosives and poisons, and pair trawling), fishing within oil and gas infrastructure exclusion zones, minimum mesh sizes, the use of Fish Aggregating Devices (FADs), and fishing vessel licensing requirements.

3.1.7 Water Resources Legislation

The Water Resources Commission Act 1996 (Act 522)

The Water Resources Commission Act (Act 522 of 1996) establishes a commission to regulate and manage the water resources of the Republic of Ghana. The commission is tasked with establishing comprehensive plans for the use, conservation, protection, development and improvement of Ghana's water resources and is able to grant rights for the exploitation of water resources. No water may be used without the granting of water rights, which may be granted, on application, by the Commission. The Act lays out the requirements and process for the application and subsequent transfer of such rights.

3.1.8 Pollution Control

There is currently no single integrated pollution legislation in Ghana. Pollution control exists as part of the environmental and water resource legislation and marine pollution is dealt with by the Oil in Navigable Waters Act 1964(Act 235) (see below).

Section 2(f) of the Environmental Protection Act (1994) enables the EPA to issue pollution abatement notices for: *"controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment [...]"*

Section 2(h) of the Act also allows the EPA to prescribe standards and guidelines relating to air, water, land and other forms of environmental pollution. And, Section 2(j) requires the EPA to co-operate with District Assemblies and other bodies to control pollution.

The Water Resources Commission Act (see Section 3.4.5 above) also addresses the control of water pollution. Section 24 of the Act prohibits the interference, altering, pollution or fouling of

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water resources beyond levels prescribed by the EPA and prescribes penalties for non-compliance.

Two additional texts are currently in draft stages of the legislative process:

- A Maritime Pollution Bill which, when enacted, will empower the GMA to regulate marine pollution and will provide a legal framework to prevent and control marine source pollution. This bill will incorporate international conventions such as the International Convention for the Prevention of Marine Pollution from ships, 1973 as modified by the protocol of 1978 relating to it (MARPOL) 73/78 (Annexes I-IV), and the Oil Pollution Preparedness Response, among others. Additionally it will include non-convention provisions: a duty to report discharges of oil, insurance for operators of oil rigs and platforms, provisions regulating the transfer of oil and provision for the Minister of Transport to make Regulations. It seeks to repeal the oil in Navigable Waters Act of 1964, (Act.235).
- Marine Pollution Prevention and Control Regulations which will provide rules for offshore installations to prevent pollution of the marine environment by substances used or produced in offshore petroleum exploration and exploitation.

Currently in Ghana there no specific regulation covering disposal of waste material, produced water and drilling fluids, emissions to air (NO_x, VOC, Flaring, CO₂ separated from produced gas), use and discharge of chemicals or injection of cuttings or CO₂, water containing oil.

Oil in Navigable Waters Act 1964 (Act 235)

The pollution control within the marine environment is established by the specific Oil in Navigable Waters Act, 1964 (Act 235). The Act was enacted in 1964 to give effect to the International Convention for the Prevention of Pollution of the Sea by Oil (1954) and also addresses oil pollution in inland waters.

Section 1 of the Act seeks to regulate the discharge of oil into prohibited areas of the sea. It establishes the prohibition to discharge oil in prohibited sea areas, and to discharge any mixture containing more than 100 ppm of oil. Those acts are considered as an offence. The Act extends the prohibition of pollution to the high seas by ships registered in Ghana and requires that Ghanaian ships be fitted so as to prevent oil fuel leakages or draining of oil into the bilges (unless the oil in the bilges is not discharged).

Section 3 of the Act deals with the responsibility for the discharge of oil into Ghanaian waters, defined by sub-section 2 as:

‘(a) the whole of the sea within the seaward limits of the territorial waters of Ghana, and (b) all other waters (including inland waters) which are within those limits and are navigable by sea-going ships.’

The responsibility for the discharge is on the owner or master of the ship, or the occupier of the land, or person in charge of the apparatus from where the oil was discharged. They may be charged and found guilty of the offense.

As per sub-section 3, ballast water of vessels may be discharged in specific areas and under specific conditions to be established by the Port Authority.

Section 5 establishes that all Ghanaian ships which use oil as fuel shall be fitted to prevent oil fuel from leaking or draining into bilges, unless effective means are provided to ensure that that oil is not discharged.

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Section 7 sets that the master of every Ghanaian ship of 80 tons gross tonnage of over which uses fuel oil shall maintain a record of security oil discharged, oil discharged as a result of ship damage, and other discharges (i.e. ballast, oil-water separation, etc). Those records shall be maintained for a period of two years.

Section 8 establishes that vessels that may carry more than five tons of oil shall maintain a record relating to the transfer of oil to and from the vessel while within the limits of the territorial waters of Ghana.

3.1.9 Radiation Protection Instrument

The Radiation protection Instrument 1993 (Li 1559) establishes the Radiation Protection Board which licenses importers and users of radioactive materials and instrumentation. The Board is responsible for ensuring operations relating to devices that use radioactive materials are carried out without risk to public health and safety and the installations and facilities are designed, installed, calibrated and operated in accordance with prescribed standards.

3.1.10 Protection of Coastal and Marine Areas

Ghana subscribes to a number of international conservation programmes. However, Ghana has at present no nationally legislated coastal or marine protected areas and there are no international protection programmes specifically covering the Project Area.

Ramsar Sites

The Wetland Management (Ramsar Sites) Regulations (1999) are developed under the Wild Animals Preservation Act (Act No. 43 of 1961) and provide for the establishment of Ramsar sites within Ghana. For designated sites, activities that are not permitted include pollution of water, use of chemicals, hunting wild animals, grazing livestock, fishing using certain gear and in certain seasons and other activities that may have an adverse effect on the environment. Nevertheless, the Minister of Forestry can designate areas within a Ramsar site where certain activities can be carried out (e.g. sand and soil removal).

There are five designated Ramsar wetland sites along the coast of Ghana including: Keta Lagoon Complex; Densu Delta; Muni-Pomadze; and Sakumo; and Songor.

There is a sixth Ramsar site (Owabi Wildlife Sanctuary) situated inland which does not lie close to the Project Area.

The neighbouring wetlands to the project area (Amansuri Wetlands) have been proposed (but not designated) wetland site under the Ramsar Convention based on Criterion 4¹ and 6² of Ramsar Convention³. Limits of this proposed RAMSAR site are not yet publicly available and, therefore, the distance from the onshore project components to the proposed RAMSAR site is unknown.

3.1.11 Labour and other Social Responsibility Laws

The **Labour Act (Act no 651 of 2003)** consolidates and updates the various pieces of former legislation, and introduces provisions to reflect International Labour Organisation (ILO) Conventions ratified by Ghana (see Section 2.4.6). The Labour Act covers all employers and employees except those in strategic positions such as the armed forces, police service, prisons service and the security intelligence agencies.

¹ Criterion 2: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

² Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

³ Source: http://www.birdlife.org/datazone/userfiles/file/IBAs/Ramsar/IBAs_Ramsar_Africa/Ghana.pdf

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Major provisions of the Labour Act include the following:

- establishment of public and private employment centres;
- protection of the employment relationship;
- general conditions of employment;
- employment of persons with disabilities;
- employment of young persons;
- employment of women;
- fair and unfair termination of employment;
- protection of remuneration;
- temporary and casual employees;
- unions, employers' organizations and collective agreements;
- strikes;
- establishment of a National Tripartite Committee;
- forced labour;
- occupational health and safety;
- labour inspection;
- establishment of the National Labour Commission.

Part XV of the Labour Act contains provisions relating specifically to occupational health, safety and environment. These include general health and safety conditions, exposure to imminent hazards, employer occupational accidents and diseases reporting.

Children's Act

The Children's Act (Act No. 560 of 1998) defines a child as a person below the age of eighteen years. Sections 12 and 87 prohibit engaging a child in exploitative labour, defined to mean labour depriving the child of its health, education or development.

Commission on Human Rights and Administrative Justice Act

The Commission on Human Rights and Administrative Justice Act (Act No. 456 of 1993), establishes a Commission on Human Rights and Administrative Justice to investigate complaints of violations of fundamental human rights and freedoms, injustice and corruption, abuse of power and unfair treatment of persons by public officers in the exercise of their duties, with power to seek remedy in respect of such acts or omissions.

National Vocational Training Act

The National Vocational Training Act (Act No. 351 of 1970) and the National Vocational Training Regulations (Executive Instrument 15) oblige employers to provide training for their employees for the attainment of the level of competence required for the performance of their jobs and to enhance their career.

Labour Provisions of the Shipping Act

The Shipping Act (Act No. 645 of 2003) regulates the engagement and welfare of seafarers, in particular with respect to crew agreements, wages, occupational safety and health, required provisions and water on board, protection of seafarers from imposition and relief and repatriation. Part VII regulates safety of life at sea. The Act applies to Ghanaian ships wherever they may be and other ships while in a port or place in or within the territorial and other waters of Ghana (section 480).

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3.1.12 The Local Content Policy

The Ghana Local Content and Local Participation Regulations, 2013 (LI 2204) stipulates that Ghanaian citizens should be prioritised in terms of employment in the petroleum industry, and should benefit from the country's resources. The regulation was passed in November 2013. The implementation of this new law is expected to ensure that Ghana's natural resources benefit Ghanaians, while the foreign oil companies also get fair returns on their investment.

The active involvement of Ghanaians in the oil and gas development, through local content and participation, has become a major policy issue. The production of the oil and gas will contribute to the socio-economic development of Ghana and indeed bring prosperity to Ghanaians. It is the desire of the Government and people that the control as well as the benefits from the oil and gas discovery and production will remain with Ghanaians.

In fact, the law – Legislative Instrument (LI) 2204 – seeks to *“promote the maximisation of value-addition and job creation through the use of local expertise, goods and services, business and financing in the petroleum industry value chain and their retention in the country; develop local capacities in the petroleum industry value chain through education, skills transfer and expertise development, transfer of technology and know-how and active research and development programmes; achieve the minimum local employment level and in-country spend for the provision of the goods and services in the petroleum industry value chain; increase the capability and international competitiveness of domestic businesses; and achieve and attain a degree of control for Ghanaians over development initiatives for local stakeholders”*.

The law also requires that a *“contractor, sub-contractor, licensee, the corporation or other allied entity carrying out a petroleum activity shall ensure that local content is a component of the petroleum activities engaged in by that contractor, sub-contractor and licensee, the corporation or allied entity”; and that “an indigenous Ghanaian company shall be given first preference in the grant of a petroleum agreement or a licence with respect to petroleum activities subject to the fulfilment of the conditions specified in the regulations”*.

Another important part of the law's requirements is the clause that *“there shall be at least a five percent equity participation of an indigenous Ghanaian company other than the corporation to be qualified to enter into petroleum agreement or a petroleum licence”*.

Ultimately, the Government of Ghana is committed to deploying an effective local content and local participation policy as the platform for achieving the goals for the oil and gas sector with full local participation in all aspects of the oil and gas value chain of at least 90% by 2020. The policy directions are geared to achieve the following;

- Mandatory local content in Oil and Gas
- Interest of a citizen of Ghana in petroleum Exploration, Development and Production
- Provision of goods and services by national entrepreneurs
- Employment and training of citizens of Ghana
- Technology transfer
- Local capability development
- Gender in oil and Gas
- Legislation of Local Content, Local Participation and Implementation
- Establish Oil and Gas Business development and Local Content Fund.

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3.1.13 Summary of main applicable laws

Table below presents a summary of the implication of the main laws indicated above on the Project.

Table 3-1 Main Relations between the main Ghanaian legislation and the Project

Legislation	Project implications
Environmental Protection Act (Act 490 of 1994)	Environmental standards issued by the EPA that are applicable to the Project are derived from this law.
Environmental Assessment Regulations (LI 1652, 1999)	Project is subject to the realization of an Environmental Impact Assessment and issuance of a permit before commencement of the activity. A full EIS is required by this project.
Ghana National Petroleum Corporation Act, 1983 (Act 64)	Ghana National Petroleum Corporation promotes exploration and planned development of the petroleum resources of the Republic of Ghana and is engaged in the Project as a shareholder representing the Republic of Ghana.
Petroleum Exploration and Production Act, 1984 (Act 84)	It establishes the legal and fiscal framework for petroleum exploration and production activities in Ghana that need to be adopted by the current Project. It also sets the rights, duties and responsibilities of contractors; details for petroleum contracts; and compensation payable to those affected by activities in the petroleum sector
Petroleum Commission Act, 2011 (Act 821)	Ghana's petroleum resources are managed according to the commission regulations. The Plan of Development of the Project needs to be approved by the Minister of Petroleum and the Petroleum commission can provide advice on the topic.
Ghana Maritime Security Act (Amendment) Act 824	This regulation affects all Project vessels, ensuring they adopt specific measures on maritime security following SOLAS convention
Ghana Shipping Act, 2003 (Act 645) and Ghana Shipping (Protection of Offshore Operations and Assets) Regulations 2011	This regulations impose restrictions on the trading of foreign registered ships in Ghanaian waters by preserving local trade in Ghanaian waters to Ghanaian ships, including the oil and gas installations beyond the 12 nautical miles territorial sea.
Oil in Navigable Waters Act 1964(Act 235)	Discharges from project vessels and the associated pollution, specially of oil is regulated by this legislation
Maritime Pollution Bill	This law will provide the legal framework regulationg discharges of wastewater and other wastes into maritime waters, that will be applied to all Project vessels and offshore activities.
Marine Pollution Prevention and Control Regulations	The offshore installations foreseen by the Project will have to follow the requirements of this law in terms of waste discharges, emissions, deposits or other source of pollutants
Maritime Zones (Delimitation) Law (PNDCL 159 of 1986)	By this law, which sets the EEZ in 200 nm, all project acitivities will be realized within Ghanaian waters and therefore subject to Ghanaian regulations.
The Fisheries Act (Act 625 of 2002)	The Project needs to prepare a series of reports and studies to infotm the Fisheries Comission about the potential effects of the project on Ghanaian fisheries
Water Resources Commission Act (Act 522 of 1996)	The exploitation of water resources for industrial purposes by the Project requires an approval by the commision.

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3.2 INTERNATIONAL CONVENTIONS, INDUSTRY BEST PRACTICES AND STANDARDS

3.2.1 International Environmental and Social Performance Standards

This section outlines the most important environmental and performance standards generally required by financial institutions and which the project will be taken into consideration.

The Equator Principles (EPs) are an approach by financial institutions to determine, assess and manage environmental and social risk in project financing. The EPs emphasize that lenders will seek to ensure that the Project is developed in a manner that is socially responsible and reflects sound environmental management practices. These Principles have been adopted by a wide range of banks and lenders all over the world in order to manage the social and environmental risks associated with their potential investments and are listed below.

- Principle 1 Categorization of projects
- Principle 2 The borrower has to conduct an Environmental and Social Impact Assessment (EIA)
- Principle 3 Applicable Social and Environmental Standards
- Principle 4 Action Plan and Management System
- Principle 5 Consultation and Disclosure
- Principle 6 Grievance Mechanism
- Principle 7 Independent Review
- Principle 8 Covenants
- Principle 9 Independent Monitoring and Reporting
- Principle 10 Equator Principles Financial Institutions (EPFI) Reporting

The Principles, inter alia, require that the borrower conduct an environmental and social impact assessment of the proposed project, develop an environmental management system including plans and performance standards, and carry out adequate consultation and public disclosure during project implementation.

The **IFC Performance Sustainability Framework and Performance Standards** comprises three elements:

- Policy on Environmental and Social Sustainability;
- Performance Standards' on Environmental and Social Sustainability; and
- Access to Information Policy.

The Performance Standards considered relevant to this Project and are outlined below:

- Assessment and Management of Social and Environmental Risks and Impacts;
- Labor and Working Conditions;
- Resource Efficiency and Pollution Prevention;
- Community Health, Safety and Security;
- Biodiversity Conservation and Sustainable Management of Living Natural Resources.

The IFC's EHS Guidelines serves as a technical reference document to support the implementation of the IFC PS particularly those relating to PS3 (Resource Efficiency and Pollution Prevention), IFC PS 6 (Biodiversity Conservation and Sustainable Management of Living Resources), as well as certain aspects of Occupation and Community Health and Safety (IFC PS 4). For the ENI Phase 1 development, the relevant EHS guidelines that would apply include;

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- EHS General Guidelines
- EHS Guidelines for Offshore Oil and Gas Development
- EHS Guidelines for Shipping
- EHS Guidelines for Crude Oil and Petroleum Products Terminals.

The **African Development Bank Policies and Guidelines** has a number of policies and guidelines which will apply to this Project, and must be taken into account through the development of the Project and EIA process. These are:

- The Bank Group Policy on the Environment (2004);
- Integrated Environmental and Social Impact Assessment (IESIA) Guidelines (2003); and
- Bank Group's Handbook on Stakeholder Consultation and Participation (2001).

3.2.2 International Protocols & Conventions

In addition to national policies and laws, there are also statutory provisions with broad requirements for conservation and protection of certain species and habitats and prevention of pollution emanating from international conventions and agreements. The Republic of Ghana is a signatory to a number of international conventions on environmental protection and conservation (Amlalo 2005), the following are applicable to Eni Ghana's planned operations:

- Ramsar Convention on Wetlands of International Importance, especially Waterfowl Habitats (Ramsar, Iran), 1971;
- Convention on Biological Diversity (CBD), 1992;
- United Nations Framework Convention on Climate Change (UNFCCC), 1992;
- Vienna Convention for the Protection of the Ozone Layer, 1985.

The coastal and offshore waters of Ghana are protected from pollution through a range of international laws:

- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78);
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969;
- International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969;
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND) of 1971.

Ghana is now party to the International Convention on Oil Pollution Preparedness, Response, and Cooperation (OPRC), 1990 (International Maritime Organization website, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>).

Ghana is party to the 1982 United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS sets up a comprehensive legal regime for the sea and oceans and includes rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment.

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) provides regulations aimed at preventing and minimizing pollution from ships. Table 3-2 summarizes the MARPOL 73/78 regulations applicable to offshore exploration activities.

Table 3-2 Environmental Provisions of MARPOL 73/78 Applicable to Offshore Exploration Activities

Environmental Aspect	Provisions of MARPOL 73/78
Machine space drainage from ships	Ship must be proceeding en route, not within a “special area,” and oil must not exceed 15 ppm (without dilution). Vessel must be equipped with an oil filtering system, automatic cut off, and an oil retention system.
Garbage	Disposal of wastes other than ground food wastes (to the required 25 mm screen mesh) is prohibited
Drainage water	Oil must not exceed 15 ppm without dilution
Transfer of oil contaminated wastes	Oil loading terminals and repair or other ports must have shore facilities for the reception of oily wastes. Facilities are required to meet the needs of the ship without causing undue delay.
Bulked chemicals	Prohibits the discharge of noxious liquid substances, pollution hazard substances, and associated tank washings. Vessels are required to undergo periodic inspections to ensure compliance. All vessels must carry a Procedures and Arrangements Manual and Cargo Record Book
Dangerous goods	Packaging, storage, marking, and labelling in accordance with internationally recognized codes
Accidental oil discharge	Oil Spill Contingency Plan is required.
Sewage discharge	Discharge of sewage is permitted only if the ship has approved sewage treatment facilities, the test result of the facilities are documented, and the effluent shall not produce visible floating solids nor cause discoloration of the surrounding water.

Eni Ghana’s proposed activities have the potential to impact adversely, albeit not to a large extent, on local marine resource users and several sections of the Convention on Biodiversity (CBD) are relevant, specifically the following articles:

Art. 8: requires in-situ ecosystem conservation and protection of threatened species or populations, as well as of customary use and traditional practices of local communities;

Art. 10: obliges states to adopt measures to minimise effects on biological diversity, to protect customary community practices, and to support local efforts to remedy degradation of biodiversity;

Art. 11: requires creation of economic and social incentives,

Traditional sea tenure and access to marine living resources should receive support under Articles 8(j) and 10(c), which require protection of sustainable customary use of biological resources, and preservation of traditional knowledge and practices of local communities relating to conservation and sustainable use. Article 10(d) requires a Party to support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced”.

3.2.3 Industry Best Practices, Standards and Guidelines

There are several industry good practices for offshore development. Those relevant to the ENI Phase 1 development include but not limited to;

- OGP (2007) Environmental, Social Health Risk and Impact Management Process
- OGP (1997) Environmental Management in Oil and Gas Exploration and Production
- OGP (2010) HSE Management Guidelines for Working Together in a Contact Environment

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- OGP (1993) Waste Management Guidelines
- IPIECA (2010) Alien invasive species and the oil and gas industry
- IPIECA (2011) Guidance on Improving Social and Environmental performance: Good practice Guidelines for the Oil and Gas Industry.

3.3 ENI HSE POLICIES AND STANDARDS

Eni has an in-house Environmental, Social and Health Impact Assessment Standard, elaborated in alignment with the highest international standards on Impact Assessment and Sustainability Performance.

According to the eni ESHIA Standard Doc N° 1.3.1.47 the ESHIA is an iterative process that is an integral part of all stages of project design and implementation, from opportunity evaluation through operations and decommissioning. It helps to ensure that environmental, social and health considerations become an integral part of planned activities, and it allows these issues to be addressed in a timely and cost-effective way throughout the individual project's lifecycle.

The ESHIA process, its phases and relative activities might vary, depending on the requirements of the host country and the project. Nevertheless, the eni Standard foresees a common structure including several key steps that can be defined as shown in Figure 3-1.

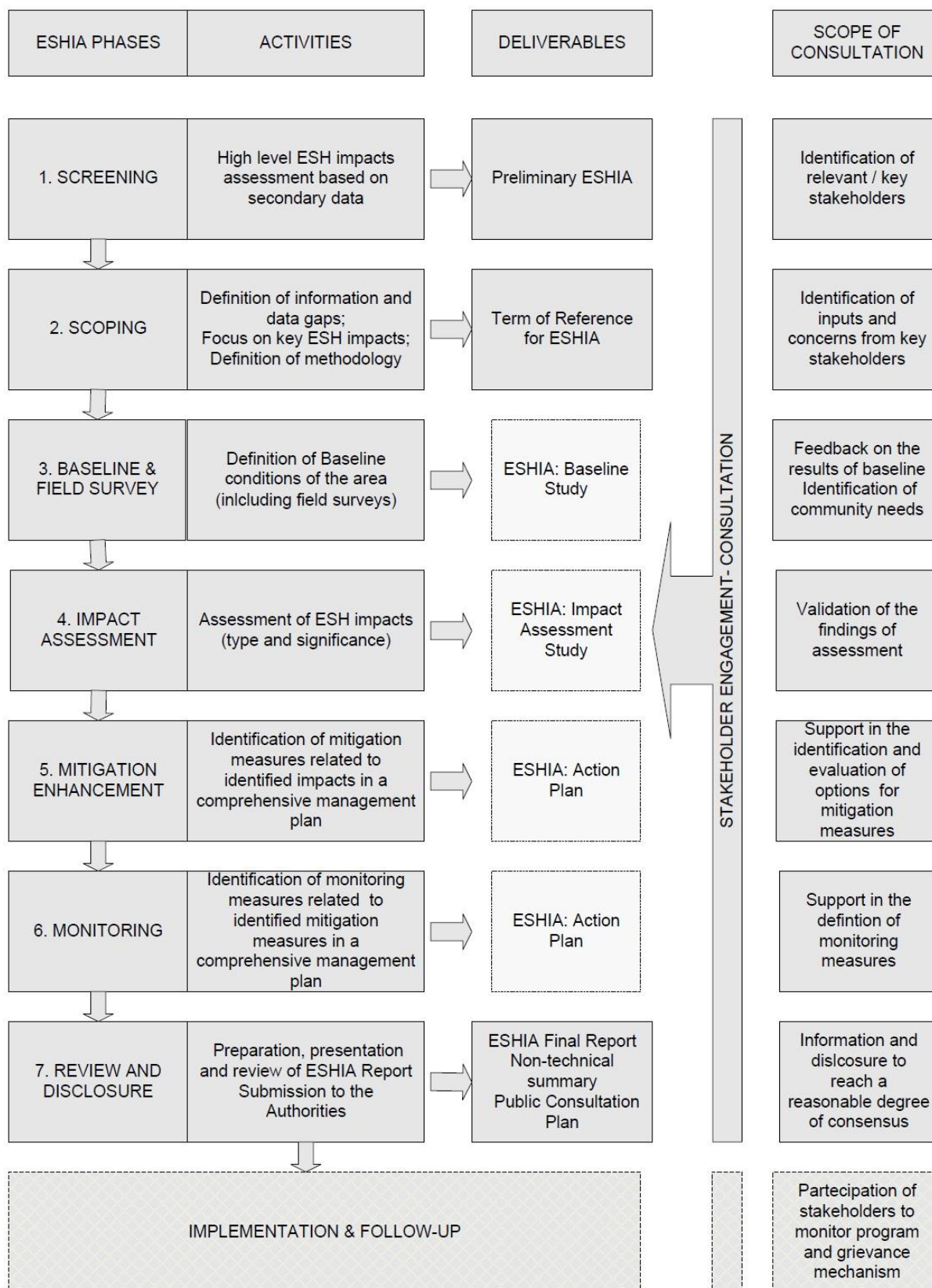


Figure 3-1 eni Standard basic ESHIA phases, activities and related deliverables

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As shown in the previous figure, a key aspect of the process is the “Stakeholder Engagement”. Stakeholders should be identified, engaged and consulted throughout all the phases of the ESHIA process. This is an iterative process, involving a wide range of players (statutory and non-statutory) and will vary depending on the phase and the significance of the potential environmental, social and health impacts for individual stakeholder groups. Stakeholder engagement will continue till the decommissioning stage of an operating project.

Many host countries require formal public consultation as part of the ESHIA approval process. Even if not formally required by law, a stakeholder engagement process, including information disclosure and consultation with local communities, helps to improve project design and management and it is therefore highly recommended. For projects potentially affecting sensitive issues, such as areas of high biodiversity or ecosystem services value, or those requiring involuntary resettlement or affecting indigenous people or cultural heritage, international standards recommend the guarantee of effective and appropriate public participation during the ESHIA and project development processes.

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4 BIOPHYSICAL BASELINE

The present chapter provides a description of the current environmental and social baseline. It underlines the main environmental and social-economic aspects related and influenced by the project activities.

4.1 GEOPHYSICAL AND ENVIRONMENTAL SURVEY

The environmental baseline survey was conducted along the intrafield flowlines of the proposed OCTP offshore site of Sanzule, Ghana. The survey was conducted to determine the physico-chemical and biological status of the seabed and water column prior to development.

Geophysical Survey

The survey (Phase 1) comprised acquisition of a suite of geophysical data via an AUV (Autonomous Underwater Vehicle) to provide regional acoustic characterization of seabed and sub-seabed conditions to inform the selection of infield pipe routes. Analysis of AUV data was supported by a range of reference information, largely supplied by ENI, and a limited amount of geological and geotechnical data. The survey area comprised an irregular 29 km by 23 km study area, covering 630 km², ranging in depth from 82 m (to the north) to 1390 m (to the south-west). In the paragraph 4.4 the results will be explained as Bathymetry, Seabed features in continental shelf and slope, seabed feature as manmade features, seabed sediments and shallow geology of continental shelf and slope.

Environmental Survey

The offshore environmental survey was targeted at:

- Acquiring baseline data to characterize sediment and water quality, including benthos and plankton
- Verifying homogeneity of the offshore area, in order to orient and optimize environmental monitoring prior to drilling operations.

This strategy was chosen since the timing for the baseline data acquisition was necessarily in advance of a final detailed project layout.

The environmental survey comprised acquisition of seabed grab samples, water column profiles and water column samples. Sampling stations largely coincided with geotechnical survey locations.

The total number of stations was pre-determined as 13 (12 for sediment sampling, three for water sampling). Stations were located around the subsea facilities area and along the flowline corridors with equal spacing for site coverage. The locations of all sampling stations are presented in Figure 4-1.

Environmental Sampling Locations

Benthic samples were obtained using a 0.1 m² dual van Veen grab at 12 stations. Three samples were collected at each station, two for macrofaunal analysis (FA and FB) and one sub-sampled for physico-chemical analysis (PC).

The water sampling strategy in the deepwater area was chosen assuming low water quality/plankton areal variation with respect to the variation expected in the shelf above 200 m water depth. As a result, water sampling (WS) and profiling (WP) was undertaken at three stations, including two of the 12 stations sampled for macrofauna / PC, as well as at an additional station. The three water samples span different depths in locations representative of the whole field

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(Sankofa phase 1 and Gyename phase2 gas wells), and were chosen considering prevalent currents directions below 50 m depth (see Section 4.3.1).

Water samples were collected at three depths; the first at 1 m, the second at 100 m and the third at 200 m. Sampling locations are provided in Annex B2.

Figure 4-1 presents the seabed bathymetry showing environmental sampling locations in the wells area.

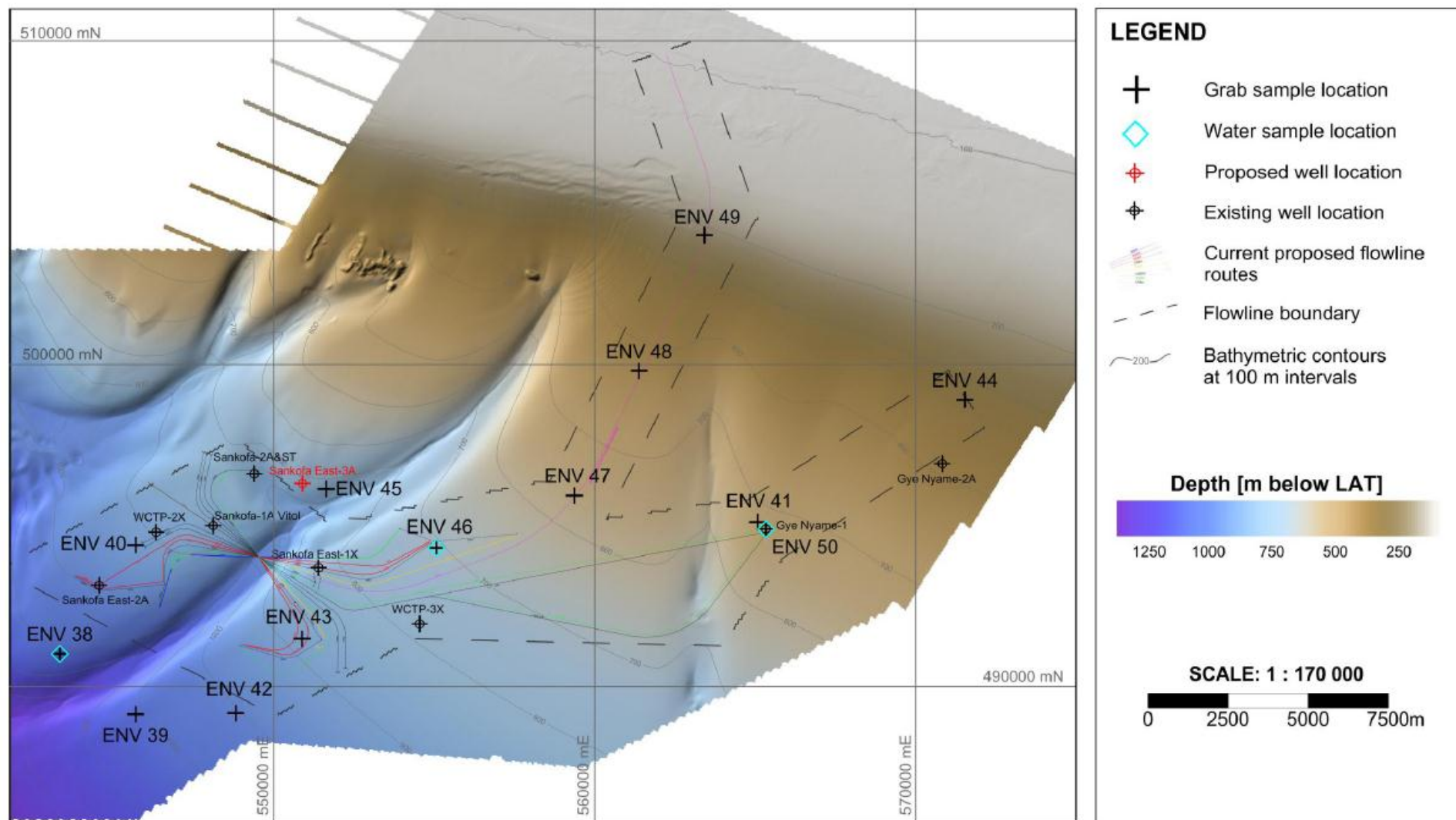


Figure 4-1 Seabed bathymetry showing environmental sampling locations in the wells area

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The following paragraphs will explain the results of environmental survey carried out between 24 and 27 April 2013 by Fugro.

The results data for each environmental component will be compare, where possible, to the nearby EBS survey carried out by TDI-Brooks International in 2008 (TDI Brooks, 2008). This data is summarized in the Environmental Impact Assessment (EIA) for the Jubilee Field, prepared by Environmental Resources Management (ERM) and Tullow Ghana Limited (ERM, 2009).

Results from this survey will be referenced throughout the report as TDI Brooks (2008).

Furthermore secondary baseline analysis data will also be compared, where possible, to Environmental Baseline results summarized in the Environmental Impact Assessment (EIA) for the Jubilee Field, prepared by Environmental Resources Management (ERM) and Tullow Ghana Limited (ERM, 2009).

In particular considering sediment and water results of the current survey, they will be compare, where possible, to the results from the Phase 2 and 4 study although differences in water depths are considered when drawing comparisons (see Annex B1). In addition, comparisons will also made with data from a previous environmental survey carried out in 2009 as part of the EAF Nansen project (a joint effort between the Ghana Environmental Protection Agency (EPA), University of Ghana, University of Cape Coast, Survey Department, Marine Fisheries Research Division and Tullow Oil) (EAF Nansen, 2010).

Results from this survey will be referenced throughout the report as EAF Nansen (2010).

Sampling stations in the EAF Nansen (2010) survey ranged from 28 m to 1300 m, however only data from stations at similar depths to those surveyed in the current survey, i.e. 250 m to 1300 m, were used for comparative purposes. This included data from the following EAF Nansen survey stations: GE4, GE5, GE6, GW4, GW5, GW6, GP4, GP5, J7-1, J7-2, J7-3 and J7-4 (refer to Annex B2). Analytical methodologies between this previous survey and the current survey were assessed and generally were thought to be comparable.

Considering benthic data results reported in TDI Brooks (2008), only benthic stations in water depths ranging from 942.5 m to 1264.3 m at the Jubilee Field have been selected for benthic comparative purposes (Stations EBS001, EBS002, EBS004, EBS006 and EBS007) (see Annex B1). Figure 4-2 illustrates the different sampling positions of benthic water stations off the coast of Ghana recorded in the TDI Brooks Report.

In general the discussion will be organized considering each environmental component and for each one the comparison among secondary and primary data.



Figure 4-2 TDI Brooks (2008) - Map of Sampling Locations

4.2 CLIMATE AND METEOROLOGY

Tullow considered the Noble-Denton (2008) meteocean report and Ghana meteorological recording stations placed in Takoradi and Axim in the western coast to characterize climate and weather of the Jubilee field. The eia team considers as primary data the Metocean design basis 350300FORB00010 (2012) developed by Saipem S.p.A.

Considering the meteorological and climatic characterization, our primary data confirm the results and the remarks highlighted in the Environmental Baseline Survey explained in GHANA JUBILEE FIELD PHASE 1 DEVELOPMENT.

The regional climate in the Gulf of Guinea is influenced by two air masses, one over the Sahara desert (tropical continental) and the other over the Atlantic Ocean (maritime). These two air masses meet at the Inter-Tropical Convergence Zone (ITCZ) and the characteristics of weather and climate in the region are influenced by the seasonal north-south migration of the ITCZ.

The maritime (humid) air mass originating from the Atlantic Ocean is associated with the south-western winds. This air mass is commonly referred to as the southwest monsoon; the continental (dry) air mass originating from the African continent is associated with the north-eastern Harmattan winds (trade winds). The ITCZ reaches its northernmost extent during the northern hemisphere summer and its southernmost extent during the northern hemisphere winter.

Considering temperature and rainfall data, Tullow considered data recorded by Ghana meteorological recording stations located in Takoradi and Axim covering the period 1999-2008, while our primary source (Metocean design basis) collect and elaborate data taken from African Pilot (Africa Pilot. Volume I Admiralty Charts and Publications, 1982) that cover the period 1931-1960 and taken from Russia's Weather Server of Abidjan station covering the period 2001-2011.

4.2.1 Rainfall

Considering rainfall throughout the year, both group of data show a bimodal pattern that means two peaks of precipitation respectively in May-June and September-October. The trend of average monthly rainfall in Takoradi considering data collected from 1999 to 2008 (Tullow - Ghana meteorological recording station Figure 4-3) and the other that cover the period 1931-1960 (Saipem- Metocean design basis Figure 4-4) are similar with difference for the peaks value.

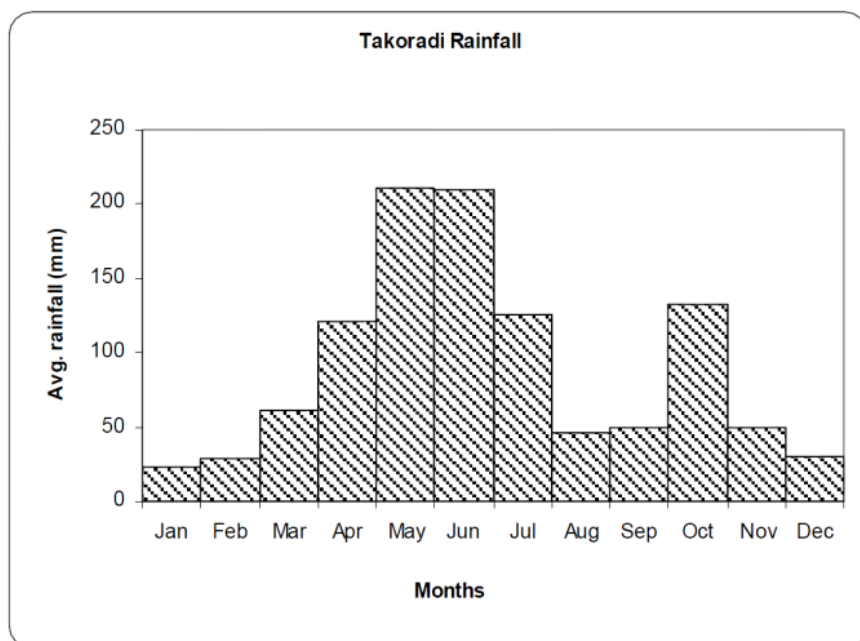


Figure 4-3 Takoradi average rainfall (Tullow - Ghana meteorological recording station)

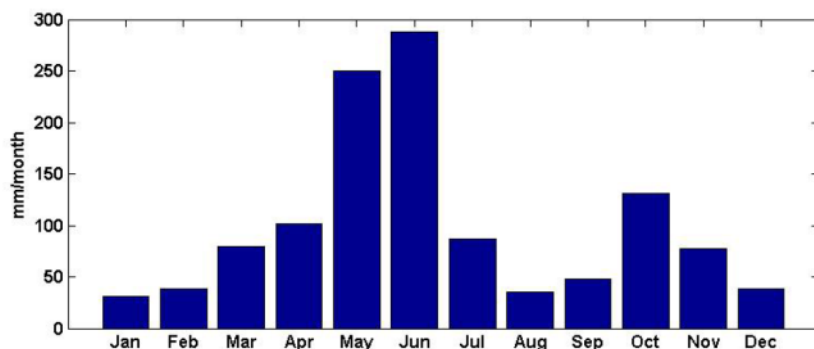


Figure 4-4 Monthly cycle of precipitation at Takoradi (Saipem- Metocean design basis)

4.2.2 Temperature

Considering temperature the data recorded by Ghana meteorological recording stations located in Takoradi (Tullow), show high value (comprised between 27-28 °C) from February to May and from November to December with an annual average range between 24°C-30°C. The coolest period is usually in August (Figure 4-5). According to African Pilot (1931-1960) (Saipem- Metocean design basis) the monthly average air temperature range from 22°C-30 °C, the coolest periods are in August and December/January while the highest ones are from February to April Figure 4-6 and Table 4-1)

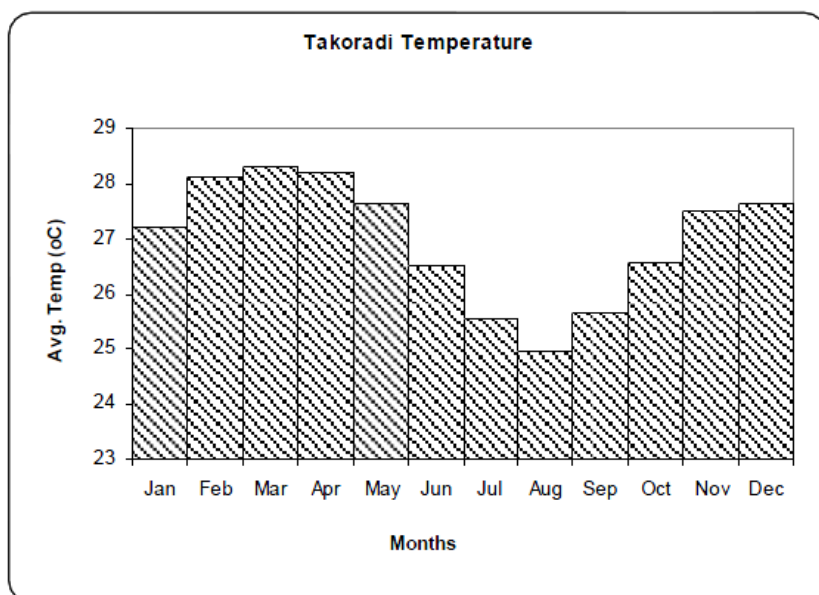


Figure 4-5 Takoradi average temperature (Tullow - Ghana meteorological recording station)

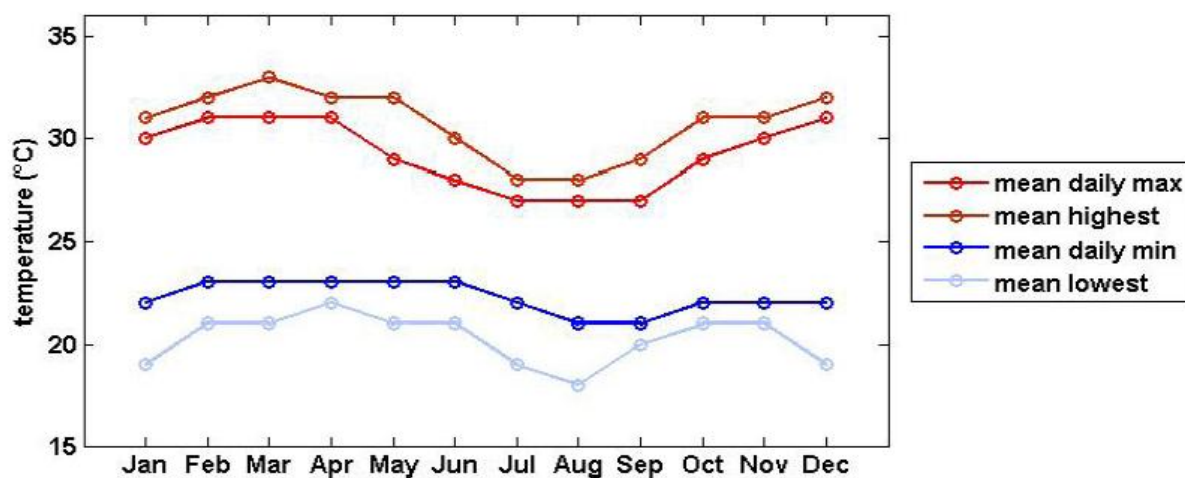


Figure 4-6 Monthly cycle of temperatures at Takoradi (Saipem- Metocean design basis)

Table 4-1 Monthly cycle of mean daily maximum temperature, mean highest temperature, mean daily minimum temperature and mean lowest temperature (°C) at Takoradi (Saipem- Metocean design basis)

Month	Mean daily	Mean highest	Mean daily	Mean lowest
	Max temperature (°C)	temperature (°C)	Min temperature (°C)	temperature (°C)
Jan	30	31	22	19
Feb	31	32	23	21
Mar	31	33	23	21
Apr	31	32	23	22
May	29	32	23	21
Jun	28	30	23	21
Jul	27	28	22	19
Aug	27	28	21	18
Sep	27	29	21	20
Oct	29	31	22	21
Nov	30	31	22	21
Dec	31	32	22	19

4.2.3 Relative Humidity

Regarding the relative humidity, the data recorded by Ghana meteorological recording stations located in Takoradi and Axim (Tullow) show that morning values range from 89.7 percent to 93.7 percent and 94.0 percent to 96.6 percent for Axim and Takoradi respectively. Humidity shows an inverse relationship with temperature (Figure 4-7).

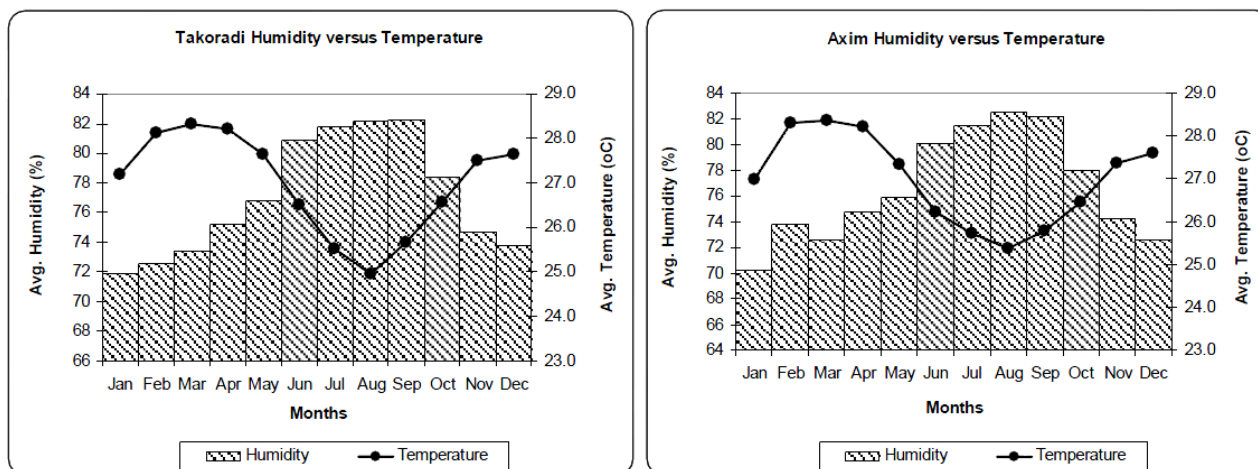


Figure 4-7 Takoradi and Axim Humidity versus Temperature (Tullow - Ghana meteorological recording station)

Data taken from Russia's Weather Server of Abidjan station covering the period 2001-2011, show a similar trend even if the values are generally higher (Figure 4-8 and Table 4-2).

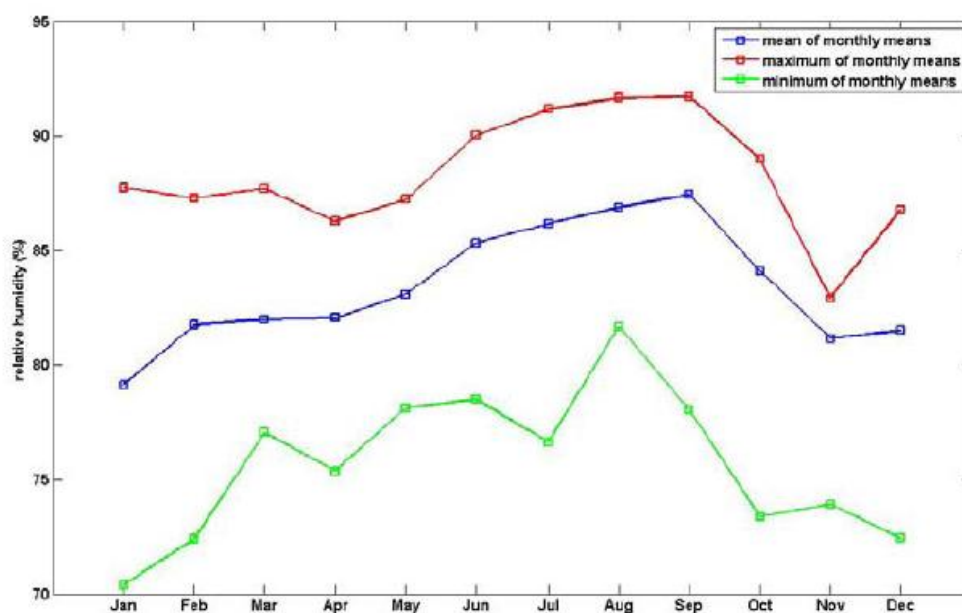


Figure 4-8 Monthly cycles of mean (blue line), maximum (red line) and minimum (green line) relative humidity at Abidjan (Saipem- Metocean design basis)

Table 4-2 Monthly cycle of mean, maximum and minimum of monthly mean relative humidity (%) at Abidjan (Saipem- Metocean design basis)

Month	Mean of monthly mean Relative humidity (%)	Max of monthly mean Relative humidity (%)	Min of monthly mean Relative humidity (%)
Jan	79.1	87.7	70.4
Feb	81.7	87.3	72.4
Mar	82.0	87.7	77.0
Apr	82.1	86.2	75.4
May	83.1	87.2	78.1
Jun	85.3	90.0	78.5
Jul	86.2	91.2	76.6
Aug	86.9	91.6	81.6
Sep	87.4	91.7	78.0
Oct	84.1	89.0	73.4
Nov	30.0	31.0	22.0
Dec	31.0	32.0	22.0

4.2.4 Barometric pressure at MSL

The barometric pressure at mean sea level ranges from 1008 to 1016 (Russia's Weather Server of Abidjan station covering the period 2001-2011) as shown in Figure 4-9 and Table 4-3.

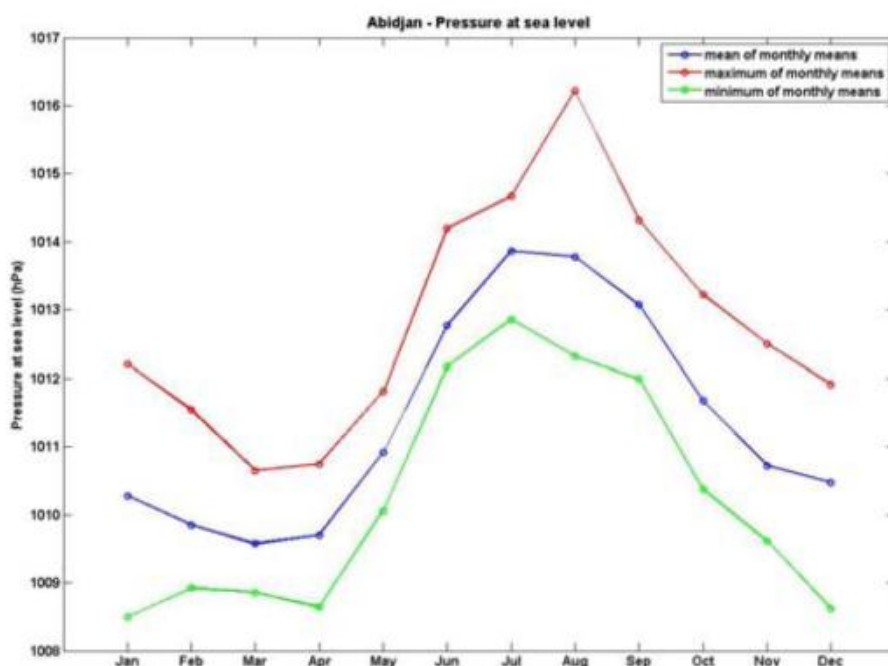


Figure 4-9 Monthly cycle of mean (blue line), maximum (red line) and minimum (green line) air pressure at Mean Sea Level at Abidjan (Saipem- Metocean design basis)

Table 4-3 Monthly cycle of mean, maximum and minimum of monthly air pressure at MSL (hPa) at Abidjan (Saipem- Metocean design basis)

Month	Mean of monthly air pressure at MSL (hPa)	Max of monthly mean air pressure at MSL (hPa)	Min of monthly mean air pressure at MSL (hPa)
Jan	1010	1012	1008
Feb	1010	1012	1009
Mar	1010	1011	1009
Apr	1010	1011	1009
May	1011	1012	1010
Jun	1013	1014	1012
Jul	1014	1015	1013
Aug	1014	1016	1012
Sep	1013	1014	1012
Oct	1012	1013	1010
Nov	1011	1012	1010
Dec	1010	1012	1009

4.2.5 Wind

Data on wind speed and direction are presented in par. 4.3.2.

4.3 MARINE ENVIRONMENT (OCEANOGRAPHY)

4.3.1 Currents

Water masses offshore the Ghanaian coast consist of five principal layers (Longhurst, 1962). The topmost layer is the Tropical Surface Water (TSW), warm and of variable salinity which extends down to a maximum of about 45 m depending on the seasonal position of the thermocline. Below the thermocline (which varies from 5 to 35 m) occurs the South Atlantic Central Water (SACW, cool and high salinity) down to a depth of about 700 m. Below this are consecutively, three cold layers, namely the Antarctic Deep Water (ADP, 700-1,500 m), the North Atlantic Deep Water (NADP, 1,500-3,500 m) and the Antarctic Bottom Water (ABW, 3,500-3,800). Sea surface temperature typically vary between 27 and 29°C, although strong seasonal cooling occurs during the season related to coastal upwelling processes.

The principal current along the Ghana coastline is the Guinea Current which is driven by westward wind stress. When this subsides during February to April and October to November, the direction of the current is reversed. A small westward flowing counter current lies beneath the Guinea Current. Below 40 m depth the westward flowing counter current turns to the south-west with velocities ranging between 0.5 m/s to 1.0 m/s and 0.05 m/s to 1.02 m/s near the bottom. The cold subsurface water could be a branch of the Benguela Current that penetrates and dominates the Equatorial Counter Current.

The Guinea Current reaches a maximum strength between May and July during the strongest South-West Monsoon Winds. For the rest and greater part of the year, the current is weaker. Near the coast, the strength of the current is attenuated by locally generated currents and winds. The current is less persistent near-shore than farther offshore. Geotropic effects induce the tendency of the Guinea Current to drift away from the coast especially during its maximum strength.

The coastal surface currents are predominantly wind-driven and are confined to a layer of 10 to 40 m thickness. The direction of tidal current around the coast of Ghana is mostly north or north-east. The velocity of the tidal current is generally less than 0.1 m/s and the maximum velocity of tidal

current observed in a day of strong winds is about 0.5 m/s. The wave induced longshore currents are generally in the west to east direction which is an indication of the direction the waves impinge the shoreline. The longshore currents average approximately 1 m/s and vary between 0.5 and 1.5 m/s. The magnitude increases during rough sea conditions.

As described in Metocean design basis 350300FORB00010 (2012), the data used to estimate the total current speed climate and extremes for the Ghana area are the 5-year, 3-hour hindcasted data provided by SAT-OCEAN.

For each point the omnidirectional and directional distribution of current at bottom (points 1,2,5,6,7,8) and for each water depth (points 3,4) are shown to define the directional distribution of current speed (Figure 4-10 and Table 4-4). The currents affecting the area are the large scale currents, such as surface and subsurface currents, the tidal current and the local currents. The large scale currents have almost constant patterns while local currents can be highly variable. The discussion below will take into consideration only the first six points as part of the offshore area.



Figure 4-10 Locations of current measurement points from SAT-OCEAN

Table 4-4 Locations of current points from SAT-OCEAN

Point	Lon (°E)	Lat(°N)	WD (m)	Description
1	-2.550	4.300	1000	off-shore fields
2	-2.500	4.400	750	off-shore fields
3	-2.450	4.490	400	floater
4	-2.440	4.520	200	between floater and platform
5	-2.400	4.550	100	platform
6	-2.395	4.600	75	route
7	-2.395	4.700	50	route
8	-2.367	4.800	20	route
9	-2.367	4.850	10	route

Point 1 (about 1000 m depth) and Point 2 (about 750 m depth), representative of offshore fields, revealed that at the bottom prevalent directions are going to SE and NW, related to the presence of the westward Guinea Undercurrent (the NW component) and reflecting the complex dynamics characterizing the area (e.g. upwelling phenomena, the eastward North Intermediate Current).

Point 3, representative of floater location, was analyzed at different depth (surface, 20m b.s.l., 50m b.s.l., 100m b.s.l., 200m b.s.l. and 400m b.s.l.). At surface prevalent directions are going to E-SE reflecting the large scale Guinea current present about until 50m b.s.l. which dominate also on tidal components. Surface current displays also other directions confirming the presence of local phenomena. From 50m b.s.l. to the bottom prevalent directions are from SE and NW, related to the presence of the west-ward Guinea Undercurrent (the NW component) and the complex dynamics characterizing the area (e.g. upwelling phenomena, the North Intermediate Countercurrent).

Point 4 was analyzed to study directional distribution of current speed at the bottom (about 200 m depth). The analysis shows that prevalent directions are going to SE and NW, related to the presence of the westward Guinea Undercurrent (the NW component) and reflecting the complex dynamics characterizing the area (e.g. upwelling phenomena, the eastward North Intermediate Current).

Point 5, representative of the platform location, was analyzed at different depth (20m b.s.l., 50m b.s.l. and 100m b.s.l.). The results of the analysis show the same characteristics reported in Point 3 that are: surface prevalent directions going to E-SE present about until 50m b.s.l. and from 50m b.s.l. to the bottom prevalent directions are from SE and NW.

Point 6 was analyzed to study directional distribution of current speed at the bottom (about 75 m depth). The analysis shows that at the bottom prevalent directions are going to SE, related to the presence of the eastward Guinea Current.

4.3.2 Wind

The surface atmospheric circulation in the region is influenced by north and south trade winds and the position of ITCZ.

According to the wind characterization of jubilee field area (GHANA JUBILEE FIELD PHASE 1 DEVELOPMENT – Environmental Impact Statement realized by Tullow Oil), achieved using hindcast models and data from 3 locations in the vicinity of field, the predominant wind direction is south-western with average speed of 3.7-4.0 m/s and maximum of 8.8-10.8 m/s.

Metoccean design basis 350300FORB00010 (2012) considers WANE database that provides time series of wind parameters, covering the period 1985-1999 with a spatial resolution of 0.3125 deg

lat by 0.625 deg long and used West Africa Gust (WAG) joint industry project – Phase 1. Fugro GEOS Reference No: C56110/3219/R1. December 2004 to study parameters relative to the squall. The results about the annual directional distribution and the omnidirectional monthly distribution of the wind speed and the wind direction are in accordance with the studies achieved by Tullow Oil. (Figure 4-11).

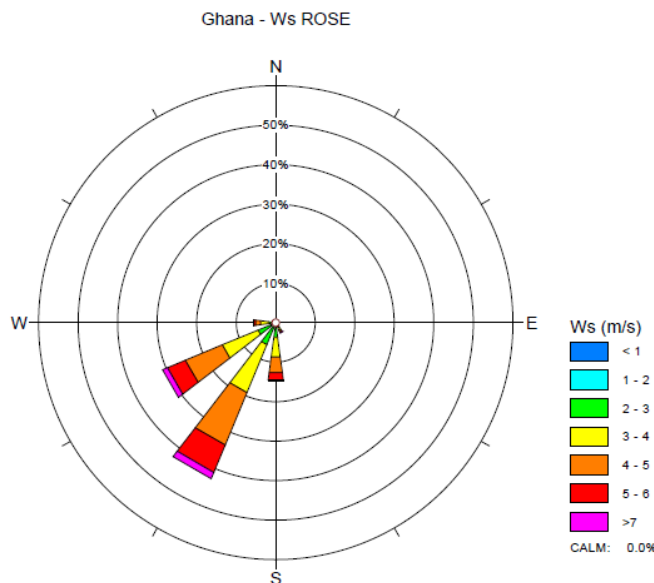


Figure 4-11 Polar diagram of the directional distribution (%) of the wind speed

4.3.3 Squall

According to the Metocean design basis 350300FORB00010 (2012) there are two squall seasons which correspond with the migration of the ITCZ; one season when the ITCZ migrates to the North (June – November) and the second when the ITCZ migrates to the South (December – May). Squall events produce the strongest winds in the area, but generate only weak currents and low wave heights due to the limited fetch and duration. These remarks are done considering results from JIP WAG (West Africa Gust (WAG) joint industry project – Phase 1. Fugro GEOS Reference No: C56110/3219/R1. December 2004) for the Nigerian off-shore. This dataset is the most reliable in the area and the results of the analysis are considered applicable also for Ghana off-shore due to the latitude and climatological similarity.

4.3.4 Wave

According to the wave climate characterization of jubilee field area (GHANA JUBILEE FIELD PHASE 1 DEVELOPMENT – Environmental Impact Statement realized by Tullow Oil), waves reaching the shores of Ghana consist of swells originating from the oceanic area around the Antarctica Continent and seas generated by locally occurring winds. The significant height of the waves generally lies between 0.9 m and 1.4 m. The most common amplitude of waves in the region is 1.0 m but annual significant swells could reach 3.3 m in some instances. Swells attaining heights of approximately five to six meters occur infrequently with a 10 to 20 year periodicity. The swell wave direction is almost always from the south or south-west. Other observations on the wave climate include a long swell of distant origin with wavelengths varying between 160 and 220 m. This swell has averaged height between 1 to 2 m and generally travel from southwest to north-east.

Metocean design basis 350300FORB00010 (2012) used the 15-years, 3-hourly hindcasted data of the WANE project performed by Oceanweather, to estimate the sea state climate and extremes for the Ghana off-shore area.

Point with coordinates Lat. 4.375° N and 2.5° W (point 1 – 1000 m depth) has been selected as representative of wave conditions at Sankofa and Gye Nyame fields (Figure 4-12).



Figure 4-12 The Locations of wave measurement points

The analysis of data put in evidence that waves in Ghana off-shores are prevalently swell waves being the wind sea component generally much smaller than swell component and that the most relevant waves are generally from S and SE and the sea wave from S and SW (Figure 4-13, Figure 4-14, Figure 4-15)

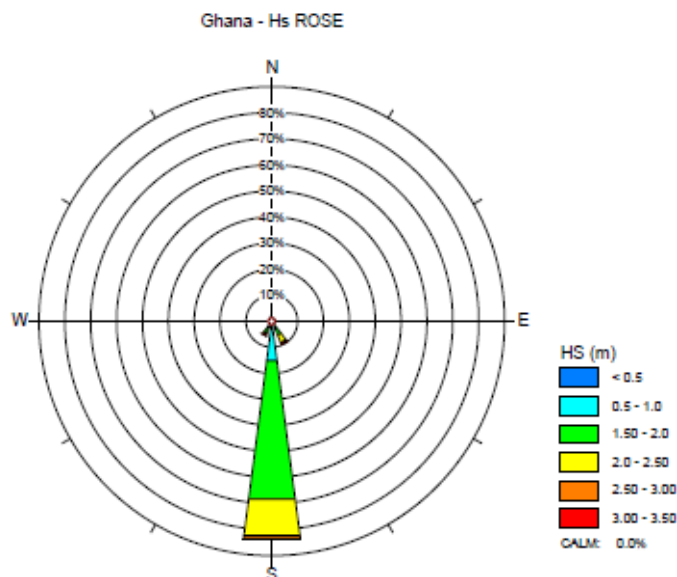


Figure 4-13 Polar diagram of the directional distribution (%) of the significant total sea wave height: the highest waves come from S

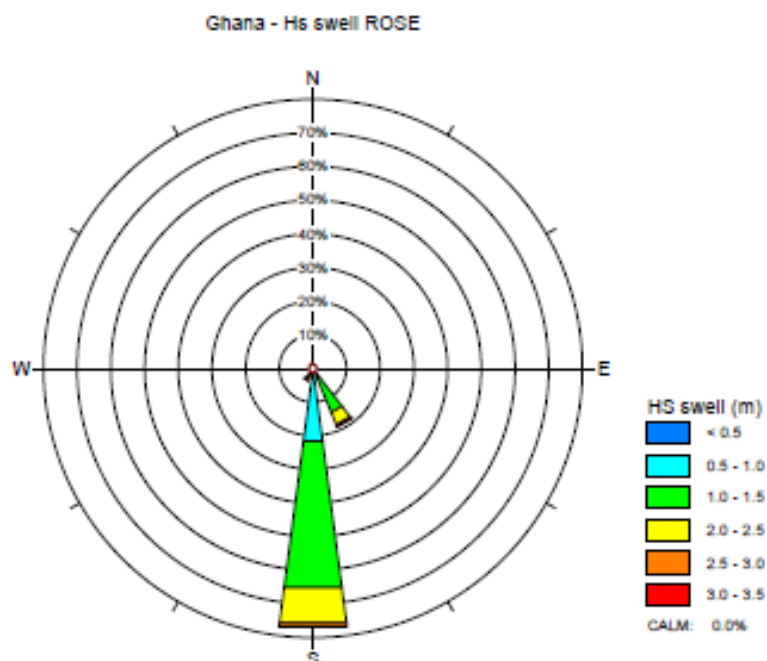


Figure 4-14 Polar diagram of the directional distribution (%) of the significant swell wave height: the highest waves come from S.

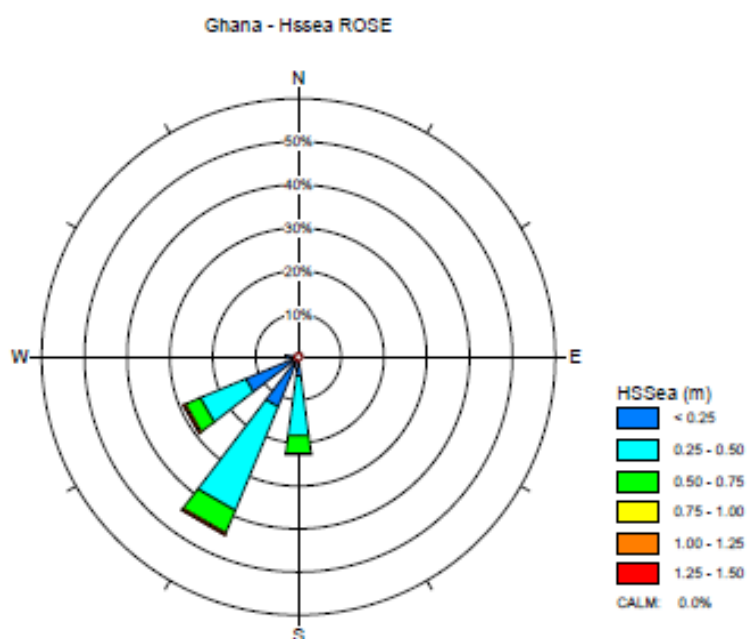


Figure 4-15 Polar diagram of the directional distribution (%) of the significant wind sea wave height: the highest waves come from SW

4.3.5 Tides

Tides considerations reported on Metocean design basis 350300FORB00010 (2012) for the Sankofa and Gye Nyame field area, are based on the output of the Global Inverse Tide model TPXO6.2 (Egbert, G.D., *et al* 2002). The model outputs come from the elaboration and extraction of 18.6 years of tidal elevation data. The table below (Table 4-5) shows the results:

Table 4-5 Tidal level elevations (m)

Tide level	Elevation (m)
LAT	-0.80
MLWS	-0.62
MLWN	-0.25
MSL	0.00
MLWN	0.23
MHWS	0.60
HAT	0.79

4.4 BATHYMETRY, SEABED TOPOGRAPHY

4.4.1 Bathymetry

The bathymetry of the survey area is characterized by water depths that range from a minimum of 82 m in the north to a maximum of 1390 m in the south-west part.

The northern parts of the survey area, to a depth of about 125 m, consists of a very gently dipping (0.5°) shelf. The width of the shelf surveyed varies from 6 km in the west to 3 km in the east. Gradients increase at the shelf break reaching a maximum of about 10° (west) to 7° (east) in water depths of between 175 m and 300 m. In the deeper waters beyond the 300 m contour, the seabed gradients are moderate to an average of around 2°.

Superimposed on this surface are a profusion of topographic features, including complex canyon systems, sedimentary mounds, scour features and high standing knolls. Seabed dips reach values in excess of 40° on the flanks of some of these features and exceed 14° over large areas (Figure 4-16).

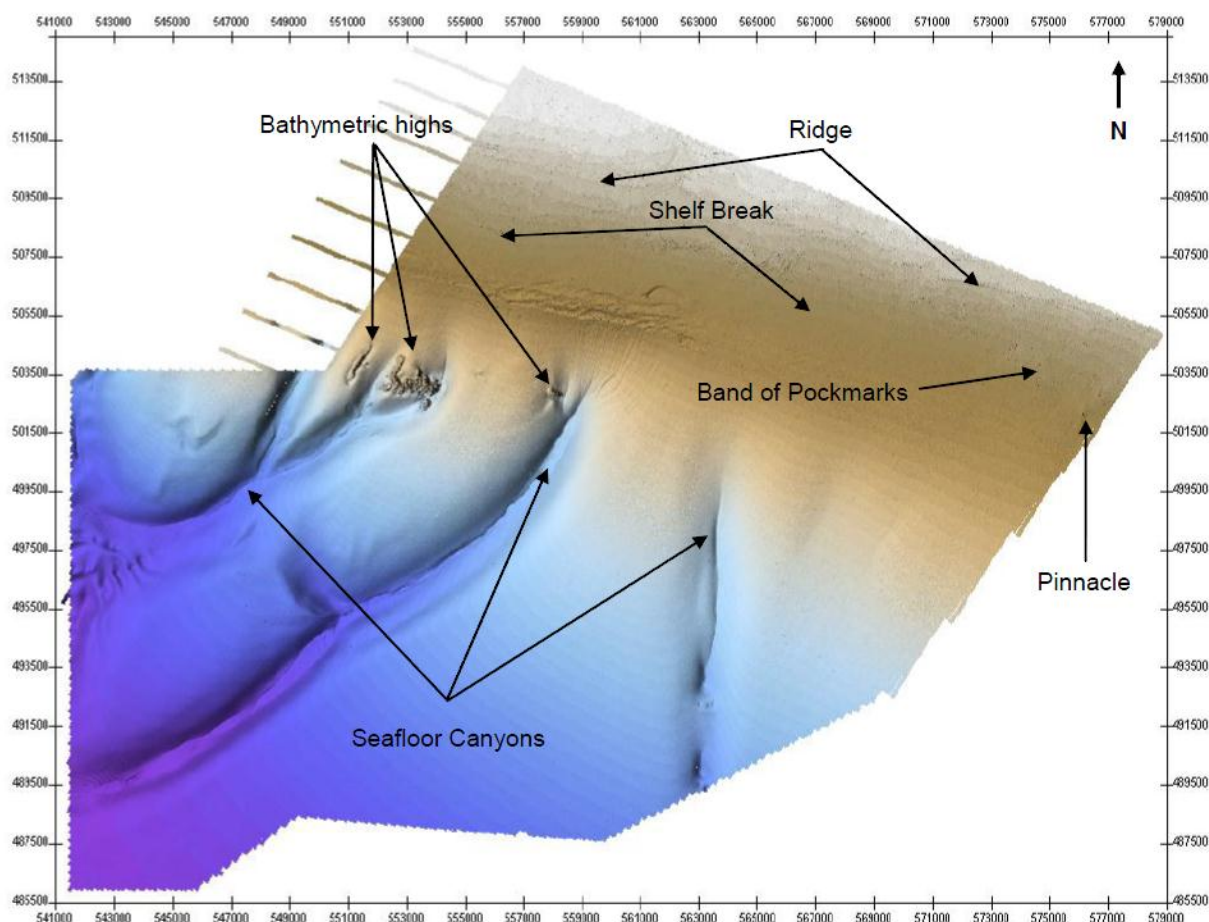


Figure 4-16 Bathymetry of the Wells area from AUV Missions

4.4.2 Seabed morphology

The seabed features interpretation is based on an assessment of bathymetry, seabed backscatter and seabed gradient.

Continental Shelf

The Ghanaian continental shelf extends over the northern extremes of the survey area in water depths of between 82 m and approximately 125 m. The shelf is generally very gently dipping at a gradient of about 0.5°. Although flat, the shelf is far from smooth. In water depths of less than 115 m strike trending outcrops create a rough texture (Figure 4-17). These outcrops appear to be emergent ridges at the top of a truncated Tertiary progradational wedge and generally have about 5 m of relief and flanks dipping at up to 17° (Figure 4-18). The most significant breach in these outcrops is aligned with the largest canyon on the slope, in the western parts of the study area.

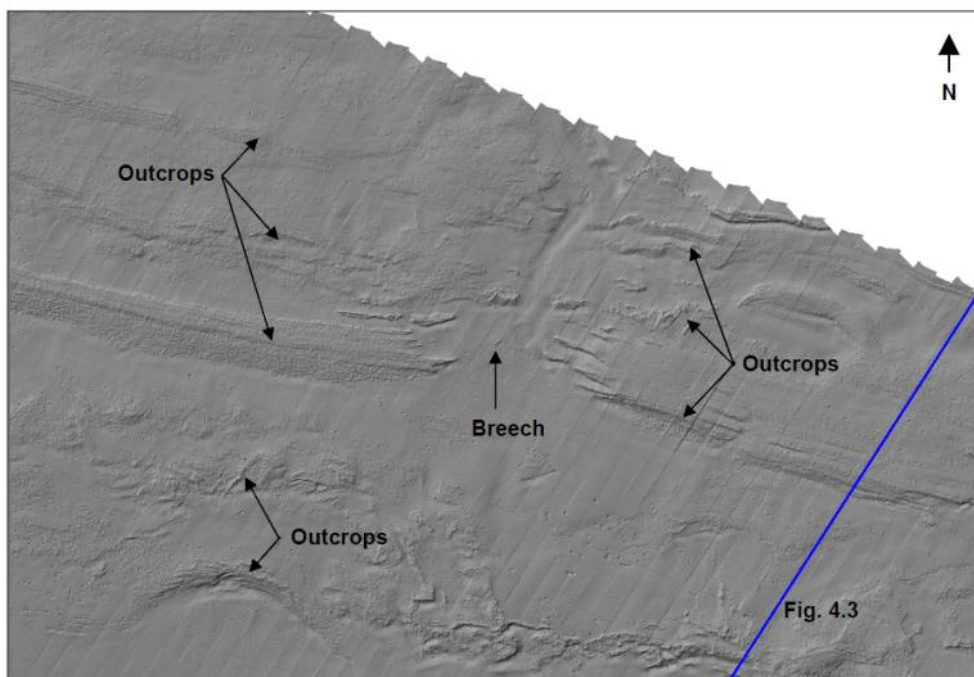


Figure 4-17 Shaded relief image of seabed, outcrops on shelf (5.0 km x 7.2 km area)

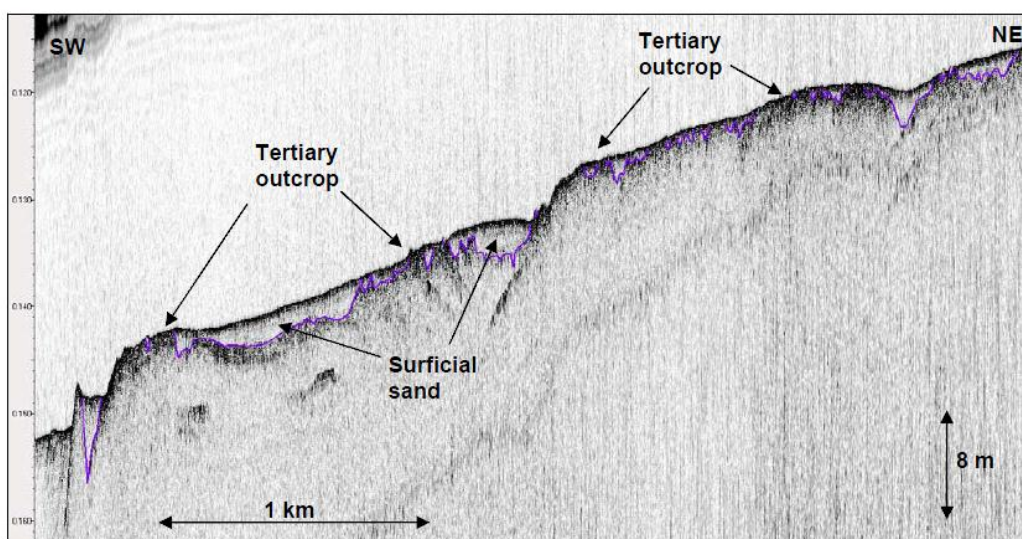


Figure 4-18 Line 083_2 profiler data, shelf showing outcrops

This may indicate that this canyon was fed by a cross slope channel during geologically recent low stand conditions. This interpretation is speculative as the limited profiler penetration on the shelf means that the sub-seabed expression of the breach cannot be directly imaged.

In many areas the outcrops define steps in the shelf profile, perhaps partly by the damming effect the outcrops have on the most recent sand deposits of the shelf and partly a greater resistance to erosion in the older packages further north (Figure 4-18).

Preliminary vibrocore logs indicate that these outcrops probably consist of CALCARENITE.

In greater detail the seabed of the shelf is very largely covered by circular seabed depressions of two distinct size classes. Figure 4-19 shows an absolutely typical portion of the shelf.

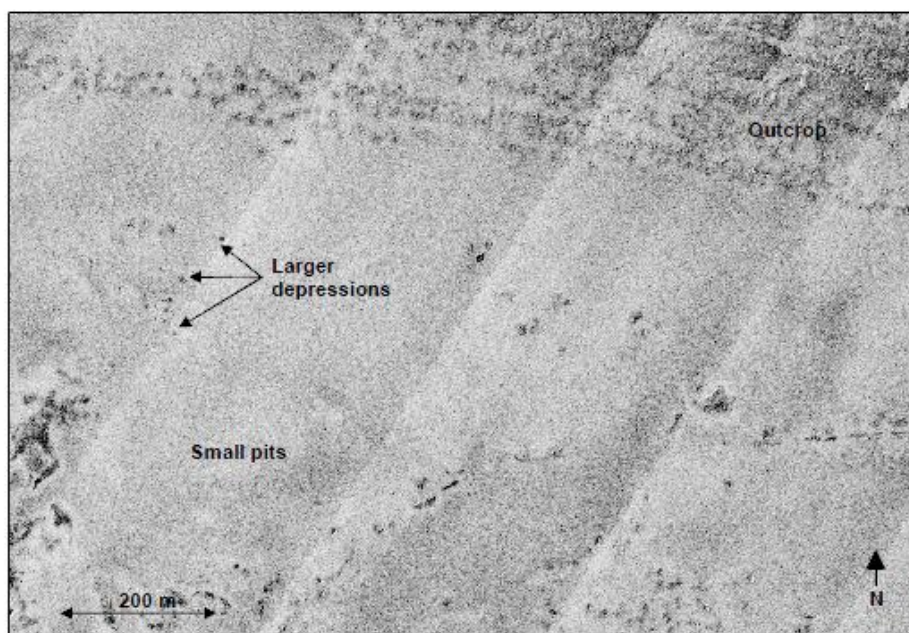
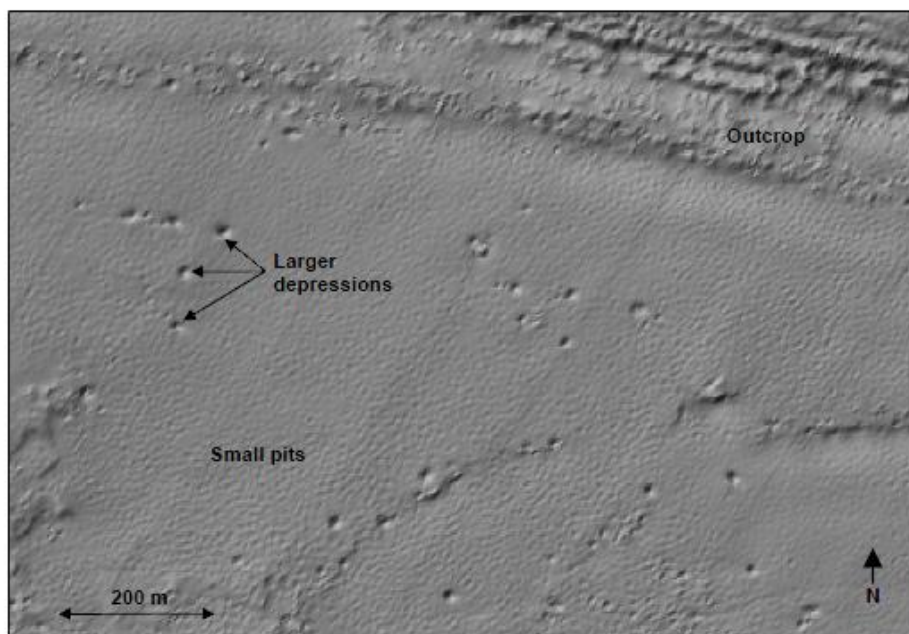


Figure 4-19 Images of seabed on shelf, two classes of seabed depressions (800 m x 1150 m area, shaded relief image above side scan sonar mosaic below)

The entire seafloor is covered by very small closely spaced pits up to 5 m in diameter to a water depth of about 275 m. These pits are so closely spaced that they are impossible to avoid; the affected areas are saturated with small depressions. These small pits are probably best considered as a seabed texture. The bases of these small pits are approximately 0.1 m to 0.2 m below the surrounding seafloor.

A class of larger depressions is generally located on and around the areas of outcrop, these features measure about 15 m to 30 m in diameter and up to 1 m deep. These larger depressions are less widespread and occur in belts and patches of lower density. The larger depressions are avoidable.

There is no direct evidence for any of these seabed depressions being caused by gas or fluid release. Depressions associated with gas release often show great irregularity and patterns of clustering. It is also difficult to envisage fluid release depressions forming two distinct size classes. The depressions could be a result of bottom current action combined with very low levels of sediment input. The shallow waters of the shelf are within the photic zone; biological activity could be playing a part in the development or maintenance of these depressions.

Continental Slope-Seabed Scour

Immediately south of the shelf seabed dips increase to between 7° (east) and 10° (west) moderating in water depths beyond 325 m to an average of about 2° to the south-west. In general the seabed of the slope is smooth, though there are several areas affected by scour.

Six patches of scour are located over the apex of inter-canyon banks. These areas extend to a water depth of about 500 m and have well defined edges. Currents appear to have eroded the surficial sediment off the crests of these high standing areas to a depth of about 1 m (Figure 4-20 and Figure 4-21).

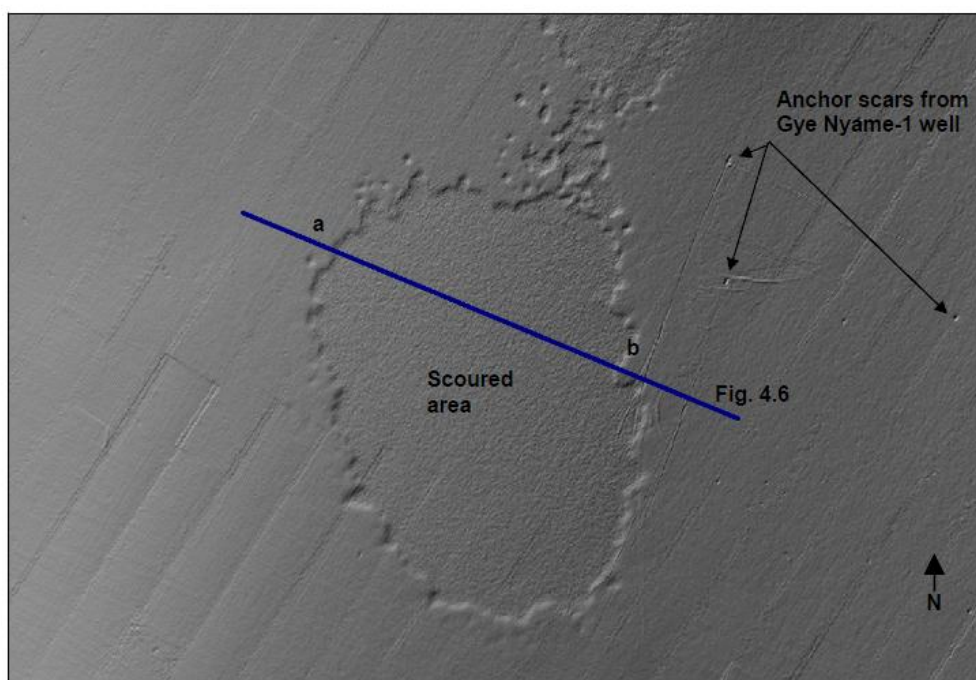


Figure 4-20 Shaded relief image of seabed, seabed scour (1.5 km x 2.5 km area)

The three easternmost patches coalesce into a single belt of scoured seabed which extends up dip to a water depth of about 325 m. These areas of scour do have a texture that contrasts with the unaffected seabed. Figure 4-20 shows that the seabed within the scoured area is rougher; Figure 4-21 shows that this surface roughness does reduce the sub-seabed penetration of profiler data.

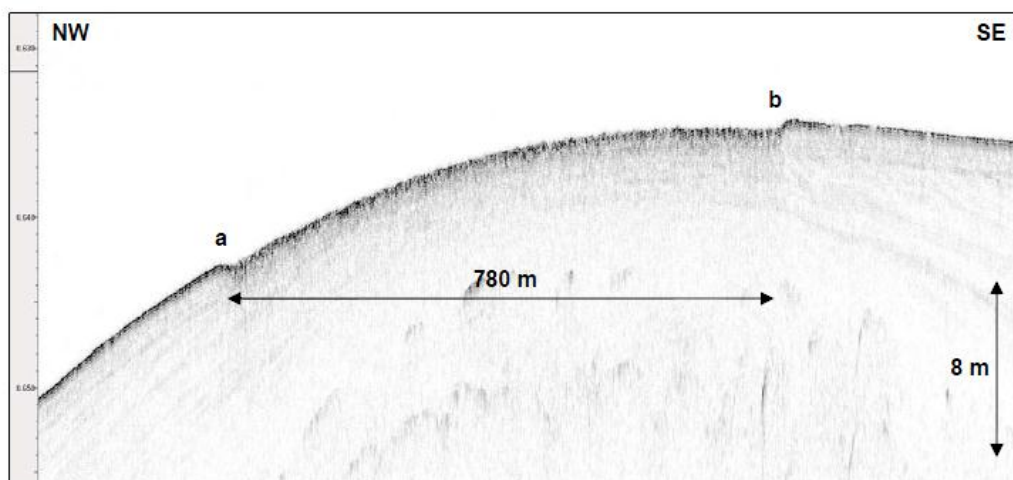


Figure 4-21 Line 009_1 profiler data, seabed scour

The most extreme area of scour is located in the west of the area affecting an 11 km wide swathe of the upper slope in water depths between 130 m and 250 m (Figure 4-22). Preliminary interpretation concluded that this seabed texture was a result of sediment creep. This interpretation has changed due to the fact that the features are entirely negative in their expression and large in scale; the base of these features is up to 10 m below the surrounding seabed. The area also lacks the regularity which can be associated with creep.

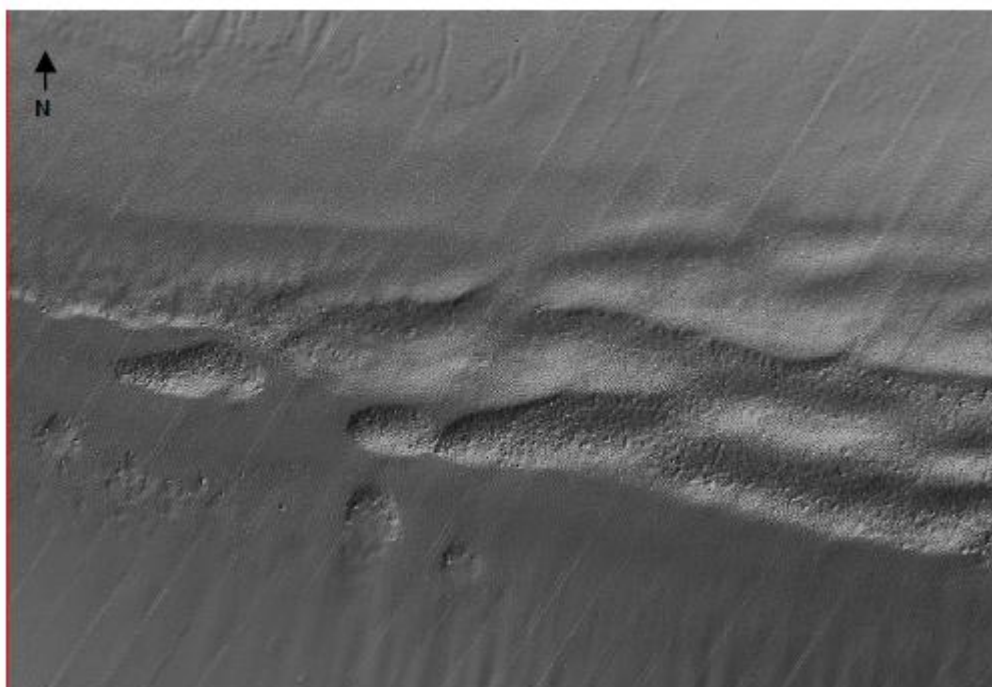


Figure 4-22 Shaded relief image of seabed, seabed scour (2.0 km x 3.7 km area)

Continental Slope-Sediment Failures

Figure 4-23 shows an area of very shallow seated (approximately 1 m thickness) sediment failure which has been interpreted over western parts of the upper slope. This failure occurred in water depths of between 115 m and 140 m.

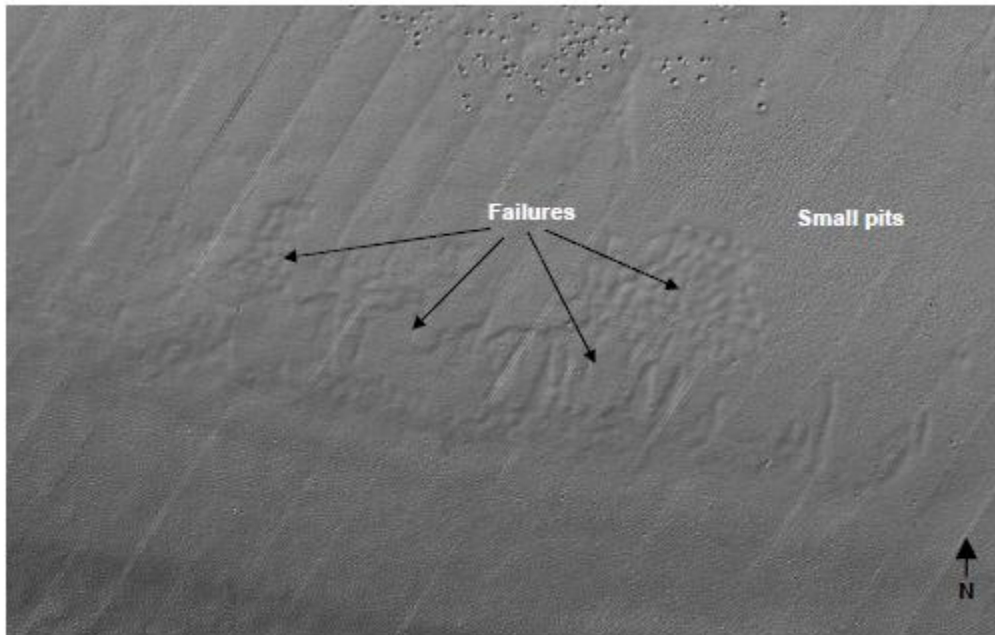


Figure 4-23 Shaded relief image of seabed, seabed failure (1.6 km x 2.8 km area)

The thickness of this zone of failure appears broadly consistent with the depth of the scour over the inter-canyon banks (as seen in Figure 4-20, Figure 4-21 and Figure 4-23).

There is evidence for a much larger ancient slope failure at the limit of profiler data interpretation on the slope.

It can be stated that wherever a significant thickness of relatively recent sediment is present at a dipping seabed then slope failure is at least possible.

Continental Slope-Canyons

Two large scale canyons trend to the south-west in the western parts of the study area.

The canyon to the far west forms a crude Y shape; three proximal branches, which have their origin in water depths of 350 m, converge at a water depth of about 825 m. This canyon has up to approximately 100 m of relief with flanks that commonly dip in excess of 16° and up to 25° on parts of the western flank. In water depths beyond 975 m the canyon floor becomes very broad, fanning out into a 4 km wide low lying area of mounded deposits (Figure 4-24).

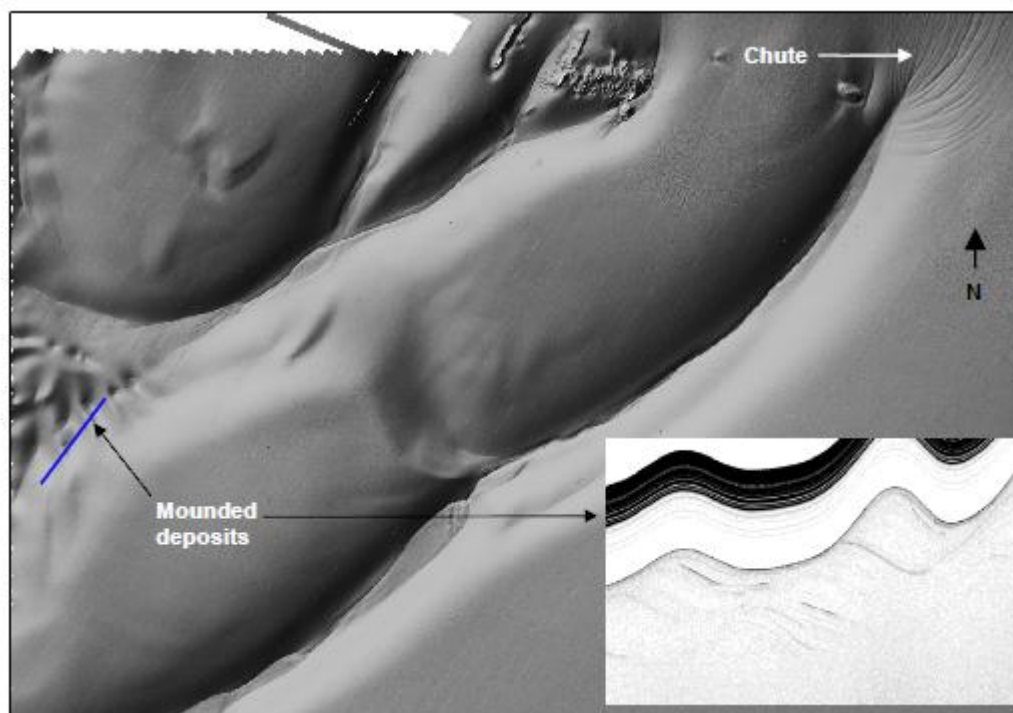


Figure 4-24 Shaded relief image of seabed, western canyons (13.9 km x 20.0 km area)

The area's largest canyon is positioned 5 km east of the canyon described above. The up dip limit of this canyon occurs at a water depth of 475 m. Up dip of this point a symmetrical arcuate chute feeds into the head of the canyon. This chute resides in water depths between 475 m and 250 m and is about 4 km wide. The chute contains numerous dip-orientated gullies.

The gullies are 100 m to 200 m apart and 1 m to 2 m deep. Detail examination shows that the gullies are cut into a surface which is now covered by 1.5 m of drape (Figure 4-25 and Figure 4-26).

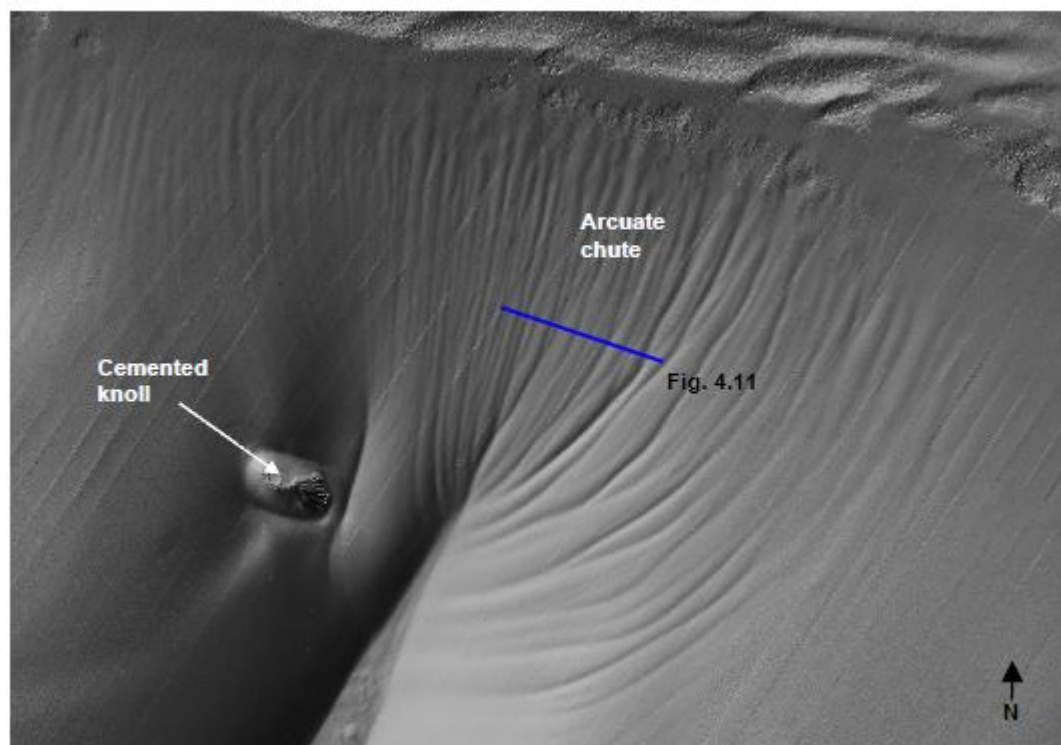


Figure 4-25 Shaded relief image of seabed, canyon head chute (4.3 km x 6.3 km area)

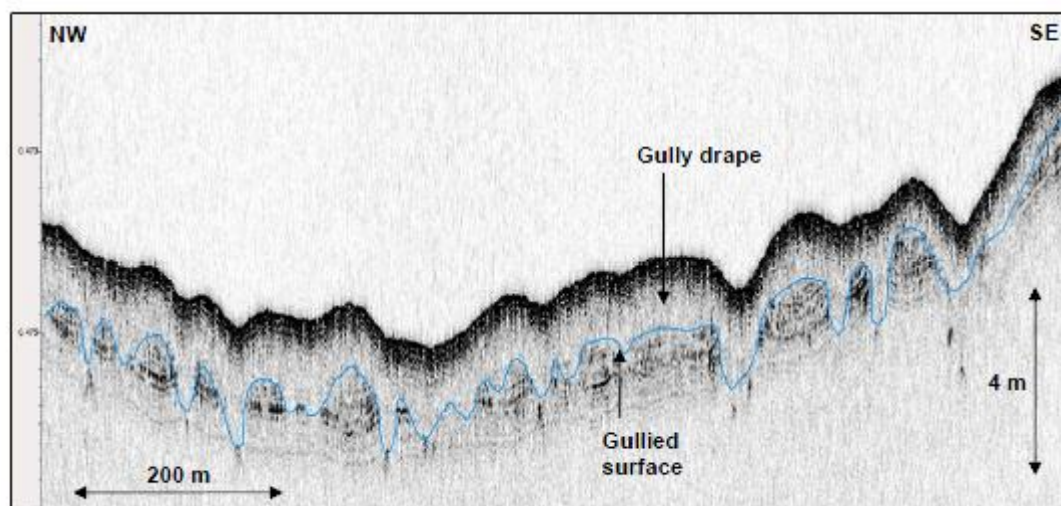


Figure 4-26 Line 006_2 profiler data showing draped chute gullies

The canyon extends to the south-west limit of data coverage and is approximately 2 km wide with a floor around 150 m below the surrounding seabed. To a water depth of approximately 950 m the canyon has a V shaped profile; in greater water depths the canyon has a flat floor up to 600 m wide. The flanks of this largest canyon dip more gently than those of the canyon to the west. Dips are commonly in the order of 12°, locally reaching about 20° on the lower east flank.

A far more subtle canyon trends due south in the eastern parts of the area. The eastern canyon's northern limit is at the 450 m contour; this canyon's up dip limit is below the shelf break. The canyon is gently 'V' shaped with a floor some 40 m below the surrounding seabed to a water depth of approximately 675 m. At this point the canyon becomes far less pronounced but appears to re-

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establish itself close to the southern limit of the data coverage. Dips on the flanks of this canyon reach a maximum of 14°.

The area's three canyons, while having superficial similarities, have many contrasting characteristics, indeed in detail they differ in almost every respect. Perhaps the most significant contrast is the differing orientations. The best developed western canyons trend south-west toward the ocean basin past the Cote d'Ivoire-Ghana Ridge whereas the canyon to the east trends south toward a lower slope bounded by the ridge; this may be why this eastern canyon is a relatively weak feature.

While many canyons have flanks which are faceted by a history of top down sediment failures that is not the case here. The reasons for this are unclear.

Continental Slope-Knolls

Three large knolls occur in association with the two canyon systems in the west of the study area. The knolls are positioned on the upper slope in water depths of between 375 m and 500 m (Figure 4-27).

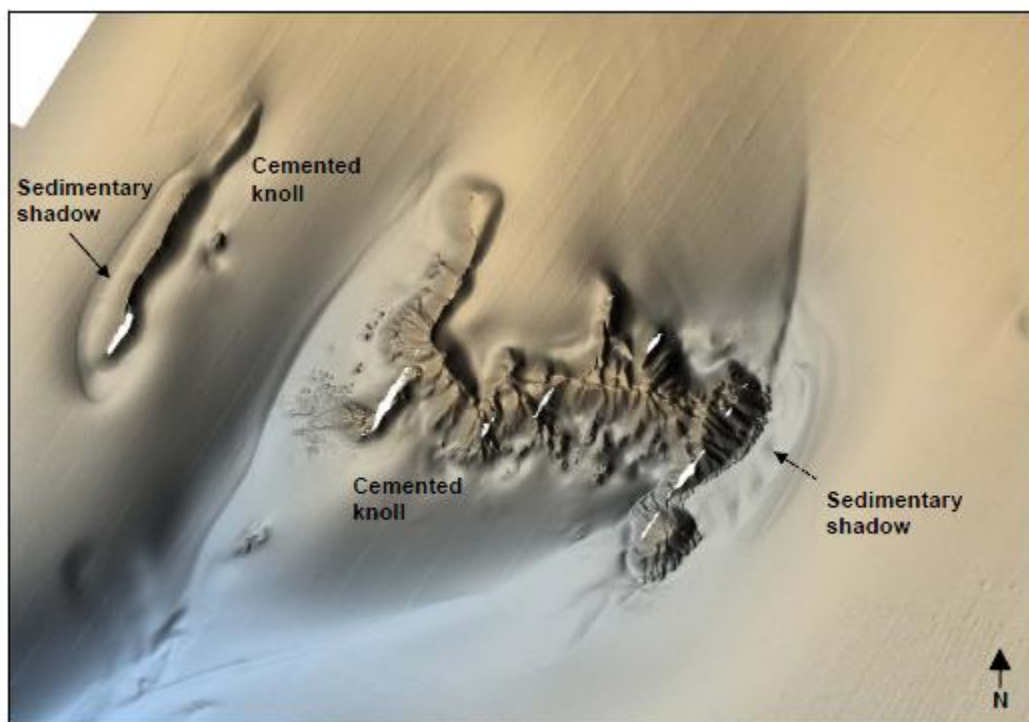


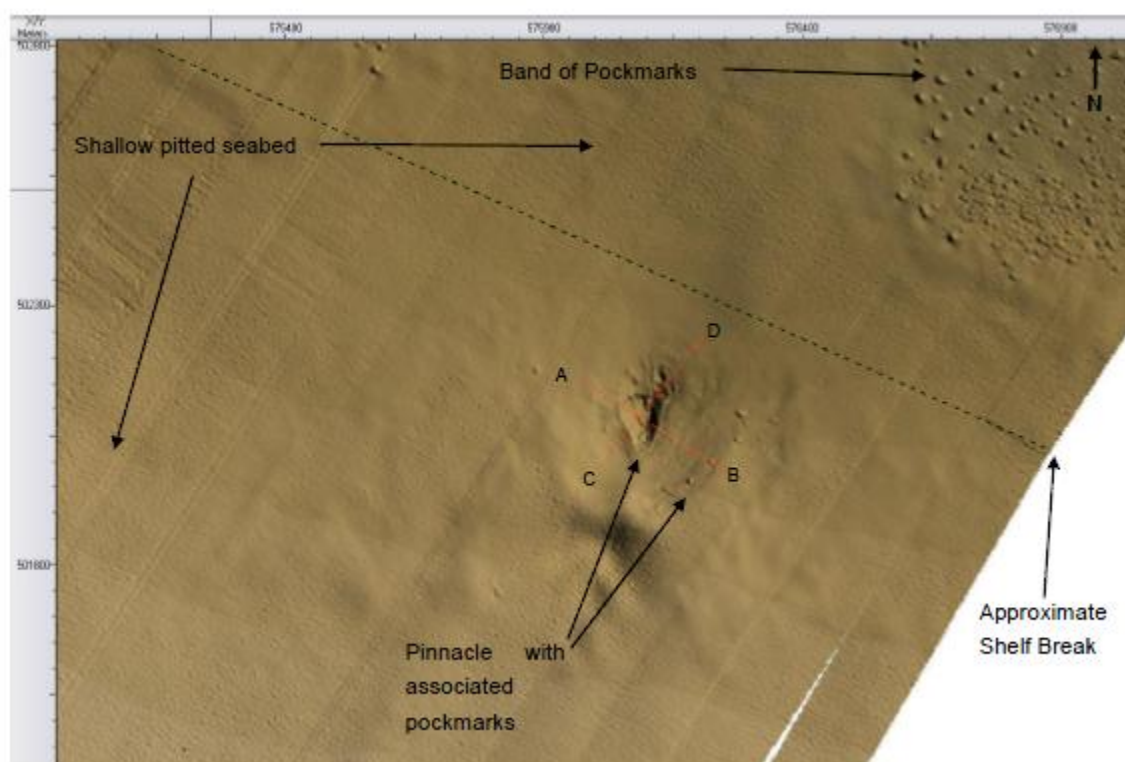
Figure 4-27 Shaded relief image of seabed, two westernmost knolls (3.3 km x 4.8 km area), sea depth between 375 – 500 m

From west to east the large knolls measure 1540 m x 230 m x 43 m, 1850 m x 1210 m x 95 m and 565 m x 362 m x 98 m.

The knolls are rough and likely to be hard; the steep dips that they maintain and high acoustic reflectivity support this interpretation. Dips reach at least 40° and probably exceed this figure over short slope sections.

The knolls occur in relatively low lying parts of the canyon heads; areas where older sediment is closer to seabed. This may contribute to their formation. The exact composition of these structures is unknown but they presumably comprise of some form of carbonate cement. The processes behind the structures may be geological or biological and could involve supply of hydrocarbons from depth.

A similar, but far smaller, pinnacle is located in 125 m of water close to the eastern margin of the data coverage. This feature measures 177 m x 87 m x 5 m (Figure 4-28 and Figure 4-29)



patterns of sediment distribution around the knolls are testament to the local disruption of bottom currents. The affected areas are labelled as sedimentary shadows on Figure 4-27. Numerous sonar contacts are identified over both the shelf and slope. These are generally interpreted to represent natural seabed variations such as accumulations of shell gravel or Methane Derived Authogenic Carbonate (MDAC). It is highly likely than some of these contacts relate to debris items

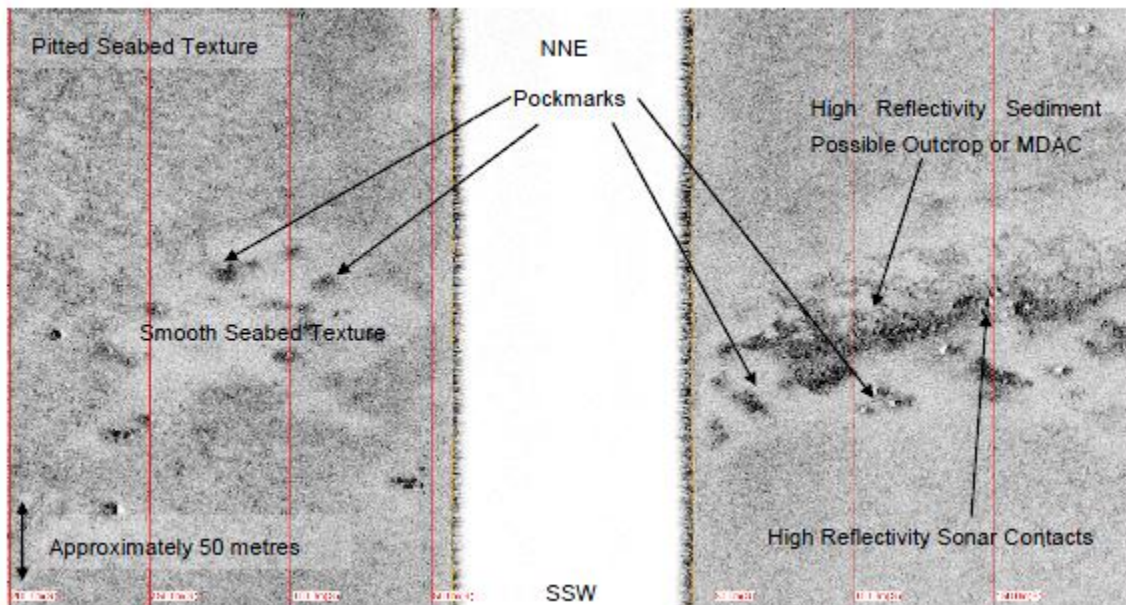


Figure 4-30 Image of Outcrop with Pockmarks and High Reflectivity Contacts

Man-made Seabed Features- Wells and associated features

The seabed shows some legacy of human activity, generally related to drilling operations and fishing.

Eight wells have been drilled in the study area (Table 4-6)

Table 4-6 Exploration Well Locations

Geodetic Datum WGS84, UTM Zone 30 North, 3°W				
Well	Operator	Water Depth [m]	Position [m]	
			Easting	Northing
Sankofa East-1X	ENI Ghana	825	551 401.0	493 702.0
Sankofa-2A&ST	ENI Ghana	862	549 396.5	496 616.0
Sankofa East-2A	ENI Ghana	988	544 567.3	493 152.9
Sankofa East-3A (proposed)	ENI Ghana	826	550 905.7	496 306.2
Sankofa-1A	Vitol	865	548 118.8	495 005.6
Gye Nyame-2A	ENI Ghana	388	570 834.8	496 924.5
Gye Nyame-1	ENI Ghana	519	565 340.8	494 894.3
WCTP-2X	Vitol	894	546 343.8	494 804.5
WCTP-3X	Vitol	779	554 559.6	491 947.9

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All of these wells have associated areas of drill spoil which tend to be elongated along the strike of the slope, representing also a strong evidence for active contour currents (Figure 4-31)

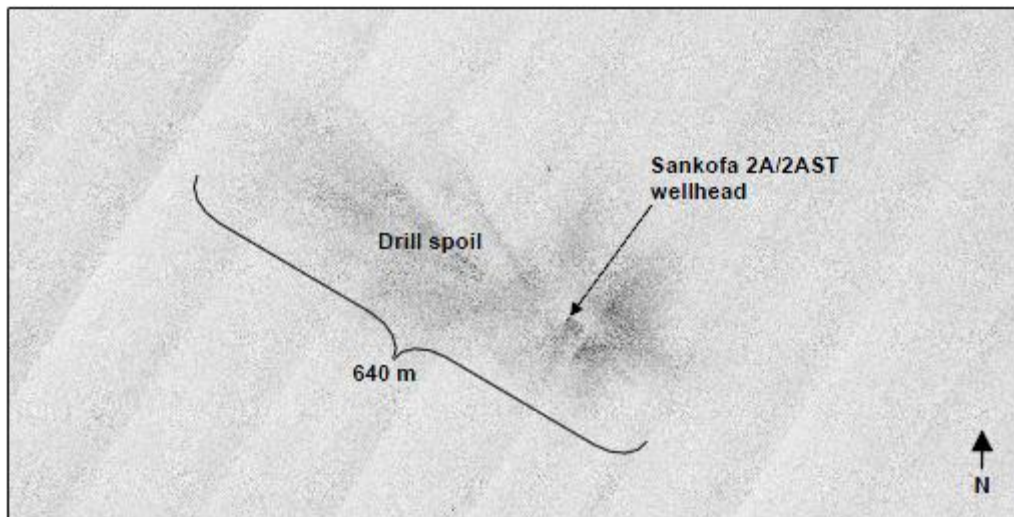


Figure 4-31 Side scan sonar mosaic, Sankofa 2A/2AST well (0.6 km x 1.4 km area)

Man-made Seabed Features- Fishing gear and associated features

There is evidence for two types of fishing within the study area. There are numerous seabed scars which are interpreted as potential trawl marks. These generally occur on the shelf in water depths of less than 130 m. It is possible that a high proportion of these seabed marks are due to current scour.

There are also three strings of contacts which are firmly interpreted to be related to some type of long line fishing. The most significant string of contacts is almost 11 km long and is positioned in the east of the area orientated along the strike of the slope in water depths of about 600 m (Figure 4-32). It is unknown whether these strings of gear are in active use or are lost in these positions.

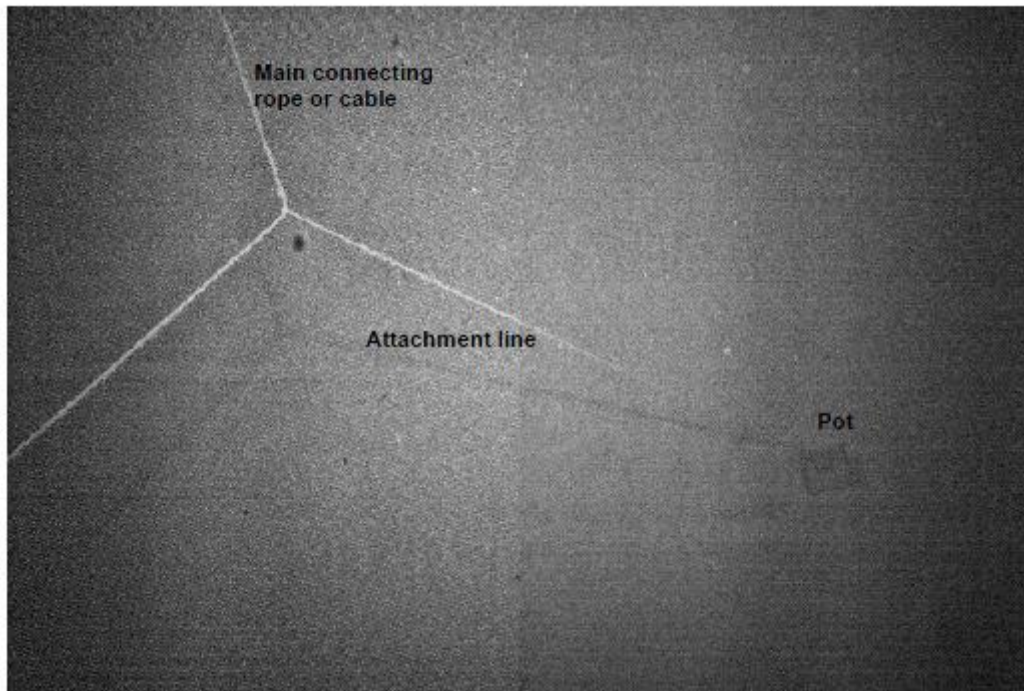


Figure 4-32 Photograph, longline fishing gear

Seabed Sediments

Seabed sediments consist of slightly silty SAND on the shelf to a water depth of approximately 125 m.

The shelf also features numerous large outcrops of CALCARENITE. In deeper water the seabed sediments comprise very soft slightly silty sandy CLAY. Exceptions to this general picture are the large carbonate knolls of the upper slope. Small areas of carbonate or exceptional seabed sediments may be mapped as sonar contacts.

4.4.3 Shallow Geology

The shallow sub-surface geology is important to describe and detail top few geological layers, to a maximum of 40 m depth below the seabed, that can influence surface sediments.

On the shelf, in water depths below 115 m, the shallow geology consists of truncated sequences of calcarenite which are typically covered by surficial sediments of silty sand 1 m to 3 m thick (Figure 4-33). However the calcarenite outcrops at the seabed in trending bands.

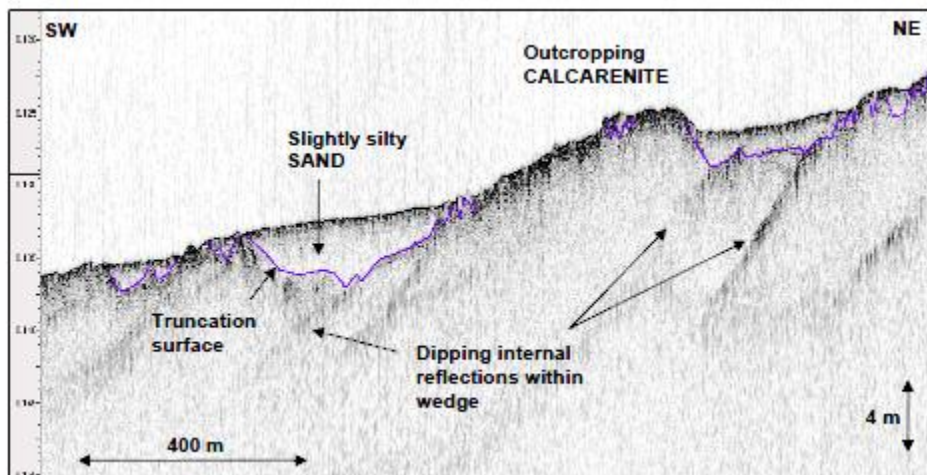


Figure 4-33 Line 048_1 profiler data showing shelf stratigraphy

The southern margin of this silty sand is difficult to map. This is probably due to the absence of the truncation surface which is mapped as the base of the sand on the shelf.

The shelf has not seen significant amounts of deposition over recent geological time.

On the slope the clay-prone deposits can be identified as well bedded with increased concentrations of sand and silt layers around the canyons where unusual depositional conditions have prevailed. In some areas, such as over the apex of the inter canyon banks, fractured units appear toward the limit of penetration (Figure 4-34 and Figure 4-35)

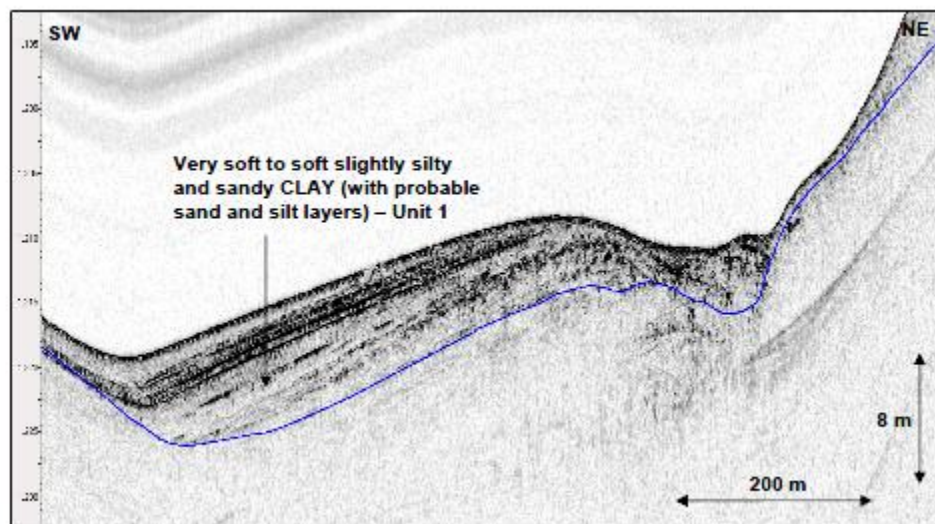


Figure 4-34 Line 60_1 profiler data showing slope stratigraphy, canyon

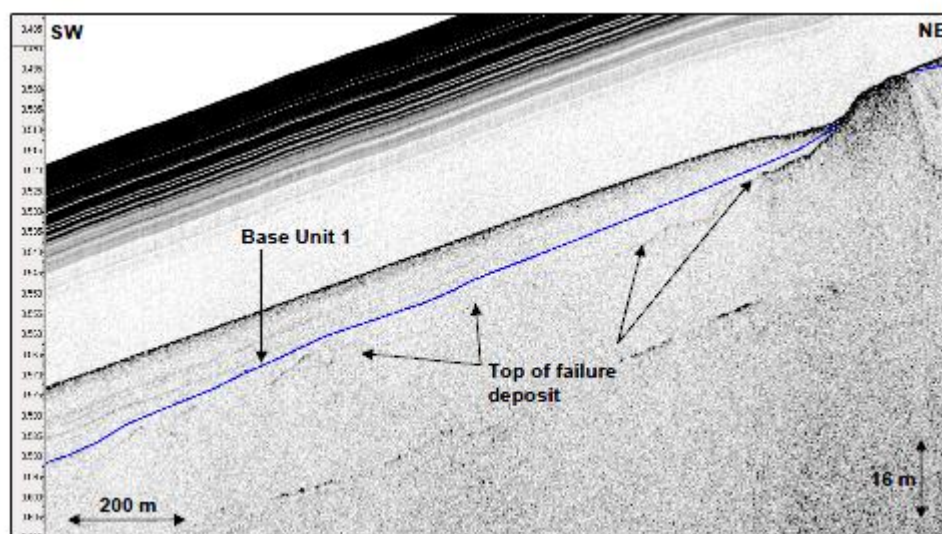


Figure 4-35 Line 054_2 profiler data showing failure deposit

4.5 SEDIMENT AND WATER QUALITY

4.5.1 Sediment quality

Sediment granulometry in the survey area is very poorly sorted and ranged from fine sand to fine silt. Silt is the dominant sediment component at the majority of stations. In general, the proportion of silt increases and the proportion of sand decreases with increasing water depth.

Considering chemistry there are some salient issues.

Total hydrocarbons are low at most stations but are considerably elevated at Station 41. Station 41 is located approximately 340 m west-northwest of the ENI Ghana Gye Nyame-1 well where new hydrocarbon resources were discovered in July 2011. Side scan sonar of drill spoil at the Sankofa 2A/2AST well, located approximately 16 km west-northwest of Gye Nyame-1, is observed to extend approximately 500 m west-northwest of the well. Thus it is likely that the high readings at Station 41 are related to local anthropogenic activities, and petrogenic contamination.

Total PAHs are low at all stations apart from Station 41. At Station 41 they are considerably elevated, with a dominance of NPD 2-3 ring PAHs. Elevated PAHs at station 41 support the assertion of drilling related sediment contamination from the nearby Gye Nyame-1 well.

CPI ratios at most stations suggest a dominance of biogenic/terrestrial n-alkanes. In contrast, the signature at Station 41 indicates that the n-alkanes within the sediments are probably of anthropogenic sources. Station 41 is dominated by short chain alkanes, indicating petrogenic contamination. The GC trace at Station 41 is indicative of well weathered low-toxicity based drilling muds. Pristane and phytane concentrations are also markedly elevated at Station 41.

Metal concentrations are generally low, although arsenic, chromium and nickel are found to exceed respective NOAA ERL values at Stations 41, 44 and 48. Barium, used as a weighting agent in drilling muds, has marginally elevated levels due to general drilling activities in the region, and higher level at station 41 that indicates direct drilling related contamination.

A detailed description of the Sediment Quality has been provided in Annex B1.

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4.5.2 Water quality

Water Profiles

Water profiles are acquired at three sampling stations within the survey area. An example water profile from Station 46 is presented in Figure 4-36. The complete set of water profiles are presented in B2.4 Water- Water Profiles.

Water Profiles - Temperature

Sea surface temperatures on the Ghanaian coast typically range between 27°C and 29°C with the Tropical Surface Water (TSW) surface layer extending down to approximately 45 m, depending on the season and position of the thermocline (ERM, 2009). Below the thermocline South Atlantic Central Water (SACW), which is cool and highly saline, extends down to approximately 700 m (ERM, 2009).

Sea surface temperatures in the current survey are approximately 29.6°C at all stations. A thermocline is recorded at all stations at approximately 25 m, with temperatures declining by ~10°C in the discontinuity layer which extended to 75 m deep. Temperatures continue to decrease with depth to approximately 4.5°C, 5.5°C and 7.6°C at the maximum depths surveyed at Stations 38, 46 and 50, respectively. The temperature profiles are observed to be similar to those recorded in the previous Jubilee Field survey (TDI Brooks, 2008; ERM, 2009), although a more gradual change in superficial temperatures are noted in the current survey.

Water Profiles - Salinity

Surface salinity from the current survey is approximately 35 practical salinity units (psu) at all three stations. Salinity increases to approximately 35.8 psu between 40 m and 70 m at all stations and remains constant to about 100 m before gradually declining to about 34.75 psu at Stations 46 and 50 at maximum recording depths of ~710 m and 520 m, respectively. At Station 38, salinity values decline to approximately 34.6 psu at 700 m before increasing slightly to about 34.8 psu at 1121 m, the maximum depth surveyed.

The salinity profiles in the current survey are broadly similar to those observed in the previous Jubilee Field survey (TDI Brooks, 2008; ERM, 2009), which shows surface salinity of around 35 psu, a slight increase in salinity sub-surface, and a subsequent uniform water column.

Water Profiles - pH

The pH of the water column ranges from approximately pH 7.85 to pH 8.3 at all three stations. Surface values range between pH 8.17 and pH 8.29. Values decrease with depth down to approximately pH 7.84 at 400 m to 450 m at all stations. As with the temperature and salinity profiles, the main variation in pH is in the depth range 50 m to 75 m (Figure 4-36). Slight fluctuations in the trend are also seen in all three profiles at around 100 m and 200 m.

These results are broadly comparable to those recorded in the previous Jubilee survey, where values range from pH 7.33 to pH 8.27 and also decrease with depth (TDI Brooks, 2008; ERM, 2009).

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Water Profiles - Dissolved Oxygen

Dissolved oxygen (DO) concentrations in surficial waters are at approximately 100% saturation (Sat) at all stations, although some readings of supersaturated concentrations of DO are recorded at the shallowest water depths surveyed indicating either oxygen production by phytoplankton or surface mixing.

Concentrations decrease relatively rapidly within the top 100 m of the water column to approximately 80% Sat, generally remaining at this concentration to the maximum depth surveyed at each station, although a very slight increase in deep water DO concentration is observed at Stations 38 and 46. The depth range of the DO discontinuity layer at all stations is relatively consistent with the discontinuity layer noted for all other variables (except turbidity), indicating water column stratification between approximately 25 m and 80 m depth.

Profiles at the Jubilee Field survey show a decreasing trend with depth. Profiles taken at deeper stations (greater than 1000 m) show that oxygen levels tend to increase again at depths greater than 200 m (ERM, 2009). This is broadly consistent with the results of the current study.

Water Profiles - Turbidity

The water profiles at all stations across the survey area show a non-turbid, clear water column that do not vary with depth. The turbidity averaged 1.5 NTU at all stations. There are no distinguishable differences in turbidity observed between the deeper and shallower stations in the survey area.

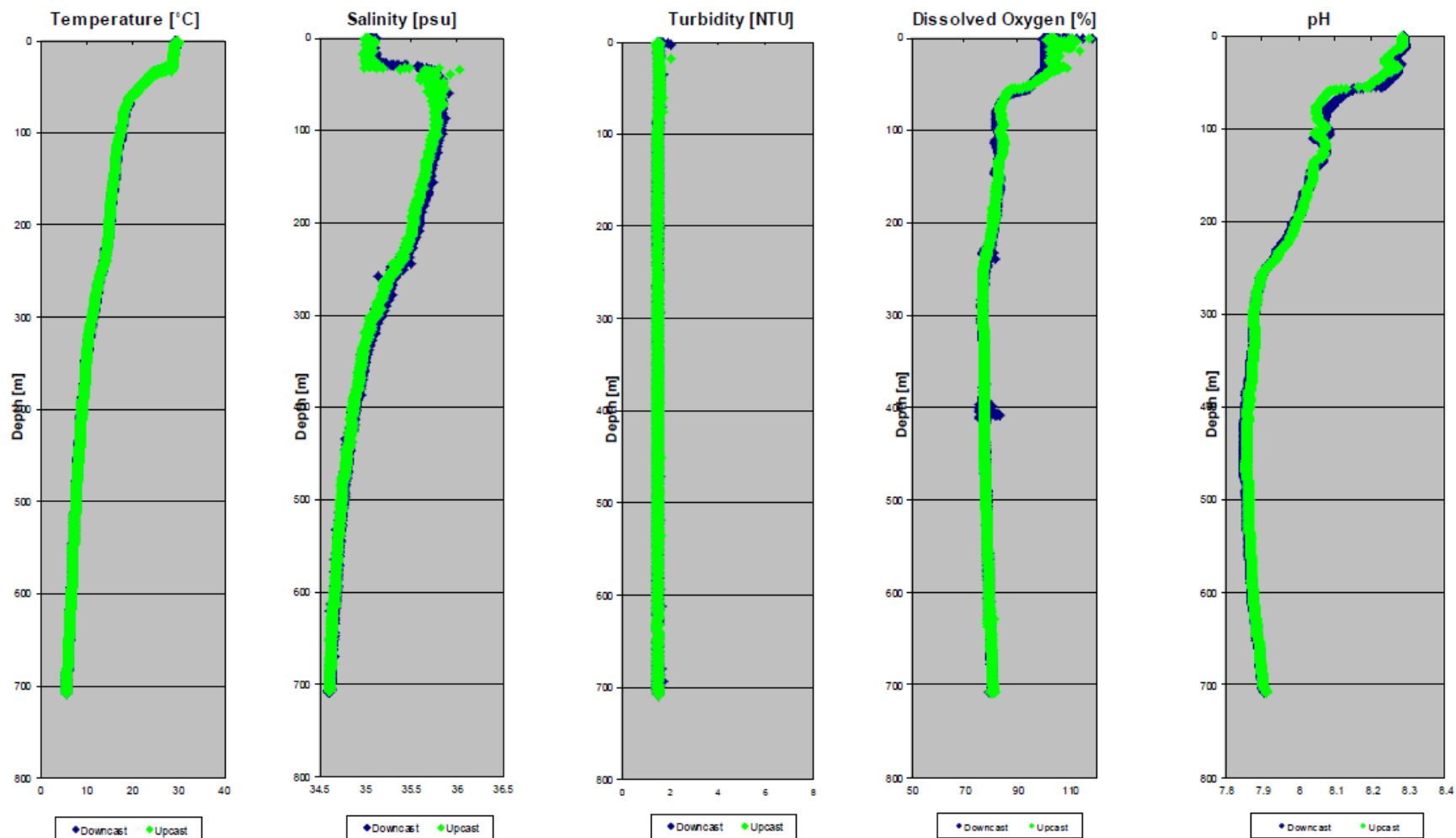


Figure 4-36 Water profile - Station 46

Water Samples

Discrete water samples are collected using a 30 litre Niskin bottle water sampler at three sampling stations. At each sampling station, water samples are taken from three depths: 1 m (superficial sample); 100 m; and 200 m.

Table 4-7 displays summary results for some parameters analyzed.

Table 4-7 Summary of Organic Matter, Nutrients, Total Dissolved Solids, Oxygen Demand, Phenol Index, Cyanide and Faecal Coliforms [mg.l-1], and Chlorophyll a [µg.l-1]

Station	Depth	Total Organic Carbon	Total Nitrogen	Nitrate	Ammoniacal N	Phosphate	Phosphorus	TDS	Chlorophyll a	COD	BOD	Phenol index	Cyanide (Free)	Cyanide (Total)	Faecal coliforms / 100 ml
38	1 m	<0.2	<1	<0.2	0.41	0.06	<0.1	39900	<0.40	840	<2.0	<0.05	<0.02	<0.02	<1
	100 m	<0.2	<1	0.2	0.6	0.08	<0.1	39400	0.44	510	<2.0	<0.05	<0.02	<0.02	<1
	200 m	<0.2	<1	0.3	0.6	0.09	<0.1	40000	<0.40	490	<2.0	<0.05	<0.02	<0.02	<1
46	1 m	<0.2	<1	<0.2	0.5	0.06	<0.1	39500	<0.40	530	<2.0	<0.05	<0.02	<0.02	<1
	100 m	<0.2	<1	0.2	0.6	0.08	<0.1	38900	<0.40	180	<2.0	0.13	<0.02	0.23	<1
	200 m	<0.2	<1	0.3	0.5	0.09	<0.1	39700	<0.40	<2	<2.0	<0.05	<0.02	<0.02	<1
50	1 m	<0.2	<1	<0.2	0.4	0.14	<0.1	39900	<0.40	640	<2.0	<0.05	<0.02	<0.02	<1
	100 m	<0.2	<1	0.3	0.5	0.08	<0.1	39900	<0.40	520	<2.0	<0.05	<0.02	<0.02	<1
	200 m	<0.2	<1	0.4	0.41	0.09	<0.1	39400	<0.40	480	<2.0	<0.05	<0.02	<0.02	<1

Note: TDS = total dissolved solids. BOD = biochemical oxygen demand. COD = chemical oxygen demand. Phenol index as C₆H₅OH.

Organic Matter and Nutrients

Total organic carbon, total nitrogen and phosphorus concentrations are all below their respective detection limits at all stations. The concentration of nitrate is also below detection limits but only in the surficial 1 m depth samples. At depths of 100 m and 200 m, nitrate concentrations range between 0.2 mg.l-1 to 0.4 mg.l-1, higher values being recorded at the deeper sampling depth at each station.

Ammoniacal nitrogen (nitrogen in ammonia) range from 0.4 mg.l-1 to 0.6 mg.l-1. Values are marginally higher at the deeper sampling locations. Nutrient ranges are similar to those recorded during the phase 2&4 survey.

Phosphate concentrations range two-fold from 0.06 mg.l-1 to 0.14 mg.l-1. A consistent pattern in the concentration at 100 m and 200 m at all stations is recorded, of 0.08 mg.l-1 and 0.09 mg.l-1, respectively. A surficial concentration of 0.06 mg.l-1 is also noted for Stations 38 and 46 at the 1 m sampling depth, increasing to 0.14 mg.l-1 at Station 50. Phosphate levels are similar albeit slightly lower to those recorded during the phase 2&4 survey (range of 0.02 to 0.58 mg.l-1).

Total Dissolved Solids

Total dissolved solids range from 38,900 mg.l-1 to 40,000 mg.l-1. No trend in depth distribution is evident. These results are comparable to those reported by TDI Brooks (2008) and are comparable to the results of the Phase 2&4 survey

Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) refers to the amount of oxygen that would be consumed if all the organics in one litre of water are oxidised by bacteria and protozoa (ReVelle and ReVelle, 1988).

Organic material contained in manure, slurries, silage effluents, waste milk, vegetable washings and other produce which enters a water course is broken down by micro-organisms. This process

removes oxygen from the water. In severe cases of contamination, aquatic life can be killed through oxygen starvation. BOD levels in the present study are below the limit of detection (<2 mg.l-1) at all stations, indicating that the biochemical demand for oxygen by bacteria and protozoa was minimal.

Chemical Oxygen Demand

Chemical oxygen demand (COD) refers to the quantity of oxygen used in biological and non-biological oxidation of materials in water and is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water, making COD a useful measure of water quality.

COD (settled) concentrations in the current survey ranged from <2 mg.l-1 (detection limits) at 200 m at Station 46, to 840 mg.l-1 at 1 m depth at Station 38. Concentrations at all stations are greatest in the surficial 1 m sample and lowest in the 200 m sample. COD levels are comparable to those of the Phase 2&4 survey (215 mg.l-1 to 460 mg.l-1)

Chlorophyll a

Chlorophyll a concentrations are below the detection limits (0.40 µg.l-1) at all stations and depths, apart from at 100 m at Station 38 where the concentration is 0.44 µg.l-1. These low values (lower than levels from the phase 2&4 survey) indicate production by photosynthetic plankton may be limited at the time of sampling.

Phenol Index, Cyanide and Faecal Coliforms

Faecal coliforms and Cyanide (free) are both below the detection limits at all stations. Phenol index (C6H5OH) and Cyanide (total) are both below the detection limits (0.05 mg.l-1 and 0.02 mg.l-1, respectively) at all stations apart from at 100 m at Station 46, where concentrations of 0.13 mg.l-1 and 0.23 mg.l-1 are recorded, respectively.

Hydrocarbons - Total Hydrocarbons and n-Alkanes

Hydrocarbon concentrations (total hydrocarbon concentrations, total n-alkanes and carbon preference index (CPI)) are summarised for each sample in Table 4-8, values for individual n-alkanes are given in Table 4-9. An example gas chromatography (GC) trace is given in Figure 4-37 and GC traces for all samples are provided in B2.5 Water-Gas Chromatography Trace.

Total hydrocarbon concentrations range over from 9.8 µg l-1 to 23.3 µg l-1 (Station 38 at 100 m and Station 50 at 200 m, respectively). Maximum values are approximately four times greater than recorded along the proposed pipeline corridor (2.9 µg l-1 to 5.9 µg) in the Phase 2&4 survey. No depth related trends are apparent. Total n-Alkanes (nC12-36) are less variable than THC concentrations, ranging from 0.69 µg l-1 to 0.86 µg l-1 (Station 50 at 200 m and Station 46 at 1 m, respectively). As with THC concentrations, no depth related trends are apparent.

GC traces at all sample depths and stations show low n-alkanes across the range, although peaks are higher in the shorter chain alkanes compared to the longer chained species (B2.5 Water-Gas Chromatography Trace).

Higher concentrations of the individual aliphatic compounds are recorded for the shorter chained nC12-20 alkanes at all sample depths and stations (Table 4-9). The nC12-36 CPI ratio is below 1 at each sampling location, indicating that the n-alkanes present are potentially from anthropogenic sources. The moderate levels of hydrocarbons recorded in the water samples may be attributed to shipping activities (i.e. minor spills from vessels) or other highly dispersed sources.

Table 4-8 Summary of Hydrocarbon Concentrations [$\mu\text{g.l}^{-1}$ water]

Station	Depth [m]	THC	n-Alkanes (nC ₁₂₋₃₆)	UCM	CPI			Pr	Ph
					nC ₁₂₋₂₀	nC ₂₁₋₃₆	nC ₁₂₋₃₆		
38	1	17.5	0.75	13.2	0.64	0.98	0.68	0.024	0.009
	100	9.8	0.75	6.4	0.57	0.91	0.63	0.021	0.020
	200	15.4	0.77	11.7	0.56	1.39	0.64	0.028	0.018
46	1	9.9	0.86	6.3	0.64	1.00	0.74	0.028	0.010
	100	14.4	0.70	10.8	0.62	1.98	0.84	0.023	0.008
	200	15.2	0.72	11.8	0.61	1.22	0.68	0.027	0.010
50	1	15.5	0.78	12.0	0.54	1.34	0.63	0.033	0.011
	100	13.4	0.69	10.6	0.59	0.91	0.66	0.022	0.013
	200	23.3	0.78	18.6	0.58	1.21	0.63	0.034	0.013
Current Survey	Min	9.80	0.69	6.30	0.54	0.91	0.63	0.021	0.008
	Mean	14.93	0.76	11.27	0.59	1.22	0.68	0.027	0.012
	Max	23.30	0.86	18.60	0.64	1.98	0.84	0.034	0.020
	SD	4.05	0.05	3.67	0.04	0.34	0.07	0.005	0.004

Note: THC = total hydrocarbon concentrations; UCM = unresolved complex mixture; CPI = carbon preference index (ratio of the sum of odd- to the sum of even-carbon alkanes); Pr = pristane; Ph = phytane; Min = minimum; Max = Maximum; SD = 1 standard deviation.

Table 4-9 Individual Aliphatic Concentrations [ng.l^{-1} water]

Station	38			46			50		
	1 m	100 m	200 m	1 m	100 m	200 m	1 m	100 m	200 m
nC12	239.0	246.0	278.0	224.0	209.0	226.0	283.0	208.0	287.0
nC13	123.0	118.0	145.0	119.0	101.0	136.0	143.0	114.0	141.0
nC14	50.0	47.8	55.7	48.4	40.4	59.4	55.6	46.9	59.0
nC15	61.8	49.1	41.9	56.4	51.7	46.9	35.7	34.7	51.5
nC16	37.1	25.0	36.8	36.0	20.9	32.6	30.6	27.6	33.0
nC17	32.7	21.3	26.6	31.4	23.0	26.8	29.6	24.1	37.9
nC18	33.3	33.2	30.7	26.5	27.5	35.2	36.3	29.0	34.0
nC19	27.1	23.9	24.7	21.9	21.0	25.1	24.5	24.2	24.9
nC20	25.5	23.3	24.2	20.7	19.1	30.9	23.5	21.2	27.0
nC21	7.7	5.4	8.6	7.4	7.7	7.4	9.6	2.4	7.8
nC22	6.7	6.8	5.3	5.4	6.0	5.5	6.3	6.5	5.7
nC23	6.9	8.0	6.7	8.5	10.5	5.9	7.4	6.0	7.3
nC24	5.9	7.7	6.1	7.9	7.0	5.4	7.7	6.1	7.7
nC25	7.3	9.5	8.6	8.3	13.4	6.7	10.1	6.3	7.1
nC26	7.8	10.9	7.4	9.2	6.3	6.1	9.2	6.1	4.9
nC27	8.6	8.9	9.4	12.9	24.6	13.8	8.4	10.8	7.1
nC28	7.7	10.6	5.1	13.4	9.7	6.2	8.4	6.2	5.5
nC29	9.1	7.8	8.1	20.2	25.7	5.9	7.4	7.8	5.5
nC30	10.5	6.8	6.7	28.9	11.1	8.3	3.6	9.9	4.7
nC31	9.9	12.6	10.5	30.5	25.7	6.2	12.6	9.9	4.2
nC32	12.2	17.4	7.7	33.3	7.2	6.2	6.3	12.5	4.5
nC33	5.6	12.4	5.4	29.7	8.4	3.7	6.6	14.8	3.4
nC34	5.9	13.0	4.7	27.6	2.8	3.4	5.1	16.3	1.0
nC35	5.7	14.0	3.5	20.7	4.6	4.9	4.7	18.7	1.6
nC36	4.8	12.9	0.8	11.9	10.9	3.3	3.4	21.0	2.4
Total Alk. ($\mu\text{g/l}$)	0.751	0.752	0.768	0.860	0.695	0.717	0.779	0.691	0.775
Pristane ($\mu\text{g/l}$)	23.9	20.7	28.4	28.1	22.6	27.2	33.2	22.5	33.6
Phytane ($\mu\text{g/l}$)	9.5	19.8	17.6	9.9	8.2	9.7	11.1	12.8	12.6

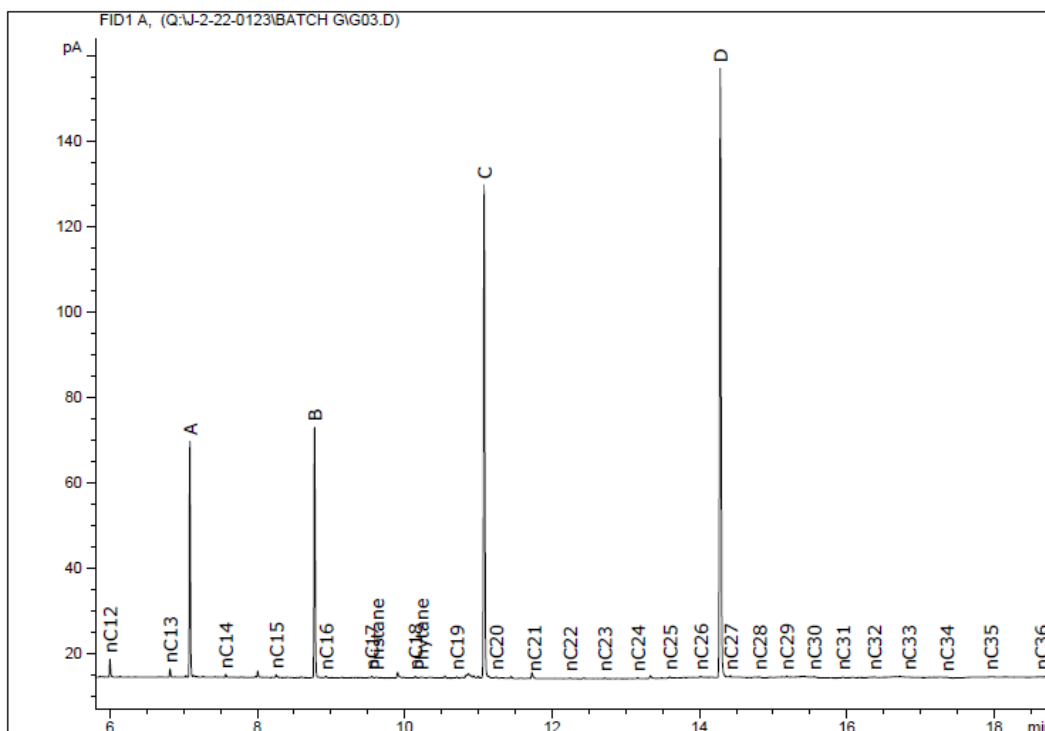


Figure 4-37 Example gas chromatography trace (Station 46 surface sample)

Hydrocarbons - Polycyclic Aromatic Hydrocarbons

A summary of PAH concentrations is displayed in Table 4-10, UK Department of Energy and Climate Change (DECC) specified concentrations are displayed in Table 4-10 and USEPA specified concentrations are shown in Table 4-11.

Total PAH (2-6 ring) concentrations range two-fold from 32 ng.l-1 (Station 46 at 1 m) to 61 ng.l-1 (both Station 38 and 50 at 200 m). NPD/4-6 ring ratios range approximately seven-fold from 1.18 (Station 38 at 200 m) to 8.20 (Station 46 at 200 m), with a strong preference for petrogenic NPD PAH over pyrolytic 4-6 ring PAH at all stations and depths. In sediments dominance of NPD can be indicative of petroleum contamination (see paragraph 4.5.1(Polycyclic Aromatic Hydrocarbons (PAHs))), however PAHs are generally insoluble in water and readily sorb to suspended particles, eventually being accumulated in bottom sediments.

Levels of PAHs would therefor typically be expected to be greater in sediments than in overlying waters in the absence of any water born contamination (e.g. oil spills or produced waters from vessels or oil and gas platforms). The solubility of PAHs decreases with increasing molecular weight (Moore and Ramamoorthy, 1984) and also decreases with alkyl substitution. Therefore, the overall dominance of lighter NPD PAHs observed in the current samples may be due to the greater solubility of these compounds compared to heavier 4-6 ring PAHs. Parent Alkyl graphs (Figure 4-38 and B2.6Water- Parent Alkyl PAH Graphs) show a similar trend between samples with an overall dominance of parent rather than alkyl groups, again suggesting the more soluble PAHs are present in the water samples.

USEPA specified PAH concentrations are generally low (less than 2.4 ng.l-1) at all stations and depths, with the exception of naphthalene concentrations which range from 6.8 ng.l-1 (Station 46 at 1 m) to 18.3 ng.l-1 (Station 50 at 200 m). Values are all within the approximate ranges of levels recorded from the Phase 2&4 survey.

Table 4-10 Summary of Polycyclic Aromatic Hydrocarbon Concentrations [ng.l-1 water]

Station	Depth [m]	Total 2-6 ring PAH	NPD	4-6 ring	NPD / 4-6 ring ratio
38	1	52	32	20	1.60
	100	47	29	18	1.61
	200	61	33	28	1.18
46	1	32	24	8	3.00
	100	35	29	6	4.83
	200	46	41	5	8.20
50	1	52	30	22	1.36
	100	40	27	13	2.08
	200	61	52	9	5.78
Current Survey	Min	32	24	5	1.18
	Mean	47	33	14	3.29
	Max	61	52	28	8.20
	SD	10	9	8	2.45

Note: Min = minimum; Max = Maximum; SD = 1 standard deviation.

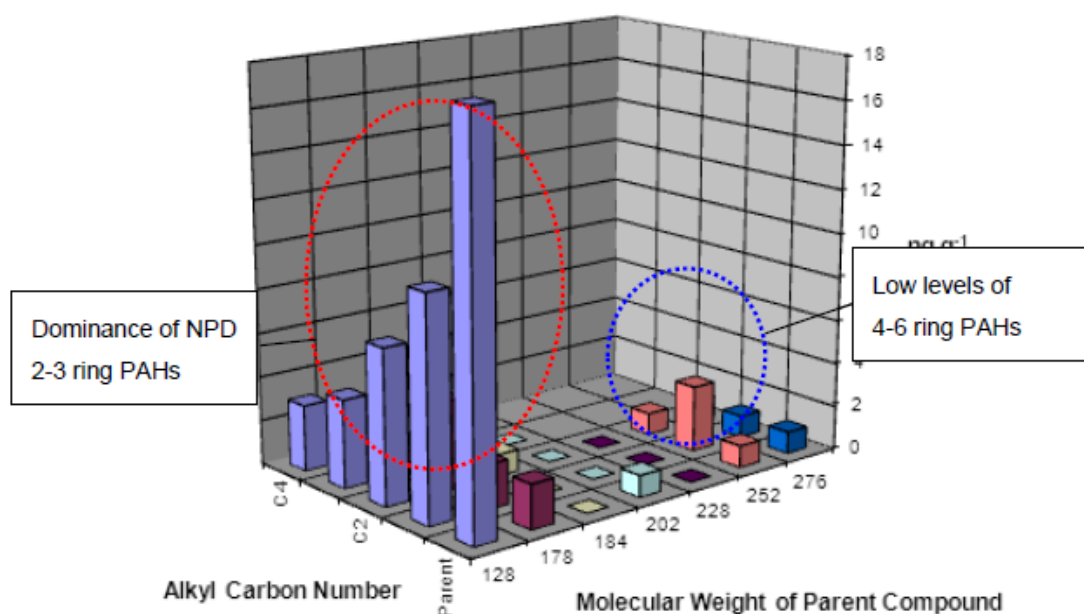


Figure 4-38 Petrogenic Dominated Parent/ Alkyl PAH Distribution – Station 50 at 200 m

Table 4-11 DECC Specified PAH Concentrations [ng.l-1 water]

Station	38			46			50		
Depth	1 m	100 m	200 m	1 m	100 m	200 m	1 m	100 m	200 m
Naphthalene (128)	8	8	10	7	10	14	8	7	18
C1 128	5	5	6	4	5	7	5	5	10
C2 128	5	4	5	3	4	7	5	4	7
C3 128	3	3	3	2	2	4	3	3	4
C4 128	2	2	2	2	1	2	2	2	3
TOTAL 128	23	22	26	18	22	34	23	21	42
Phenanthrene/Anthracene (178)	2	2	2	1	2	2	2	1	2
C1 178	2	1	1	1	1	1	1	1	2
C2 178	2	2	2	2	2	2	2	2	4
C3 178	1	1	1	1	1	1	1	1	1
TOTAL 178	7	6	6	5	6	6	6	5	9
Dibenzothiophene (DBT)	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 184	<1	<1	<1	<1	<1	<1	<1	<1	<1
C2 184	1	1	1	1	1	1	1	1	1
C3 184	1	<1	<1	<1	<1	<1	<1	<1	<1
TOTAL 184	2	1	1	1	1	1	1	1	1
Fluoranthene/Pyrene (202)	1	1	1	1	1	1	1	1	1
C1 202	<1	<1	<1	<1	<1	<1	<1	<1	<1
C2 202	<1	<1	<1	<1	<1	<1	<1	<1	<1
C3 202	1	1	<1	<1	<1	<1	1	<1	<1
TOTAL 202	2	2	1	1	1	1	2	1	1
Benzantracenes/Benzphenanthrene	1	1	1	<1	<1	<1	1	<1	<1
C1 228	<1	<1	<1	<1	<1	<1	<1	<1	<1
C2 228	<1	<1	1	1	1	<1	1	<1	<1
TOTAL 228	1	1	2	1	1	<1	2	<1	<1
m/z 252	5	3	5	1	1	1	4	2	1
C1 252	4	5	10	3	3	3	6	5	3
C2 252	1	2	4	1	<1	<1	3	2	1
TOTAL 252	10	10	19	5	4	4	13	9	5
m/z 276	5	3	4	1	<1	<1	2	1	1
C1 276	1	1	1	<1	<1	<1	1	1	1
C2 276	1	1	1	<1	<1	<1	2	1	1
TOTAL 276	7	5	6	1	<1	<1	5	3	3
NPD	32	29	33	24	29	41	30	27	52
% NPD	62	62	54	75	83	89	58	68	85
Total 2-6 ring PAH	52	47	61	32	35	46	52	40	61

Table 4-12 USEPA Specified PAH Concentrations [ng.l-1 water]

Station	38			46			50		
Depth	1 m	100 m	200 m	1 m	100 m	200 m	1 m	100 m	200 m
Naphthalene	8.1	7.9	9.6	6.8	10.5	13.6	8.0	6.8	18.3
Acenaphthylene	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1
Acenaphthene	0.5	0.4	0.4	0.3	0.3	0.5	0.4	0.4	0.7
Fluorene	1.0	0.8	0.9	0.7	0.7	1.1	0.9	<0.1	1.3
Phenanthrene	2.0	1.8	1.8	1.5	1.6	2.0	1.7	1.5	2.4
Anthracene	0.2	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1
Fluoranthene	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.4
Pyrene	0.9	1.0	1.0	0.7	0.9	1.4	0.9	0.8	1.1
Benzo(a)anthracene	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Chrysene	0.5	0.3	0.3	0.1	0.1	0.1	0.2	0.1	0.1
Benzo(b)fluoranthene	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Benzo(k)fluoranthene	<0.1	0.1	0.2	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Benzo(a)pyrene	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Indeno(123cd)pyrene	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Benzo(ghi)perylene	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(ah)anthracene	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Total EPA 16	14.3	13.5	15.5	10.8	14.9	19.6	13.4	10.7	24.8

Heavy and Trace Metal Analysis

All heavy and trace metals in all water samples are below detection limits or at very low levels (Table 4-13). There are no notable differences identified between the stations or within the water column.

Aluminium, barium, cadmium, cobalt, mercury and lead are all at or below their respective detection limits at all stations and depths. Chromium, nickel and vanadium concentrations range from the detection limit (<0.002 mg.l-1) to 0.003 mg.l-1. Zinc concentrations range from 0.011 mg.l-1 to 0.015 mg.l-1 and arsenic ranged from 0.025 mg.l-1 to 0.030 mg.l-1. Most samples detect iron at the detection limit (<0.01 mg.l-1) or 0.02 mg.l-1, with one sample (1 m at Station 38) recording 0.18 mg.l-1.

Selenium concentrations range from 0.037 mg.l-1 to 0.104 mg.l-1.

All heavy and trace metal concentrations are markedly below the chronic Ambient Water Quality Criteria (AWQC) (Table 4-13).

Table 4-13 Total Heavy and Trace Metal Concentrations [mg.l-1]

Station	Depth [m]	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	Ni	Pb	Se	V	Zn
38	1	<0.01	0.025	<0.01	<0.0001	0.001	<0.001	0.006	0.18	<0.0001	0.003	<0.001	0.037	0.002	0.011
	100	0.01	0.028	<0.01	<0.0001	0.001	0.002	0.006	0.02	<0.0001	0.003	<0.001	0.065	0.002	0.013
	200	0.01	0.028	<0.01	<0.0001	0.001	0.001	0.006	<0.01	<0.0001	0.003	<0.001	0.071	0.002	0.011
6	1	0.01	0.026	<0.01	<0.0001	0.001	0.001	0.006	<0.01	<0.0001	0.002	<0.001	0.072	0.002	0.011
	100	0.01	0.029	<0.01	<0.0001	0.001	0.001	0.006	<0.01	<0.0001	0.002	<0.001	0.087	0.002	0.011
	200	0.01	0.029	<0.01	<0.0001	0.001	<0.001	0.006	<0.01	<0.0001	0.002	<0.001	0.071	0.002	0.010
50	1	0.01	0.028	<0.01	<0.0001	0.001	0.002	0.006	<0.01	<0.0001	0.003	<0.001	0.078	0.002	0.015
	100	0.01	0.030	<0.01	<0.0001	<0.001	<0.001	0.006	<0.01	<0.0001	0.002	<0.001	0.052	0.002	0.013
	200	0.01	0.029	<0.01	<0.0001	<0.001	0.002	0.006	<0.01	<0.0001	0.002	<0.001	0.104	0.002	0.013
Current Survey	Mean	0.01	0.028	-	-	0.001	0.0015	0.006	0.10	-	0.002	-	0.071	0.002	0.012
	SD	-	0.002	-	-	-	0.0005	-	0.11	-	0.001	-	0.019	-	0.002
AWQC (Chronic)		-	2.300	200.00	8.8000	1.000	27.4000	3.100	50.00	0.94	8.2	8.100	71.000	50.000	81.000

4.6 ATMOSPHERIC AIR QUALITY AND NOISE

The OCTP Block Field is located approximately 60 km offshore and therefore away from any industries, urban areas or other onshore sources of air pollution.

The only offshore source of air pollution would be vessels travelling along shipping lanes approximately eight nautical miles south of the field as well as vessels involved in exploration and appraisal well drilling in the vicinity.

In term of exposure to fishermen and other users of the area the concentration of pollutants in the air in the location of the field from these and other sources are expected to be very low due to the high level of atmospheric dispersion in the offshore environment.

4.7 PLANKTON

4.7.1 Phytoplankton Analysis

Water samples are collected at three stations (Stations 38, 46 and 50) using a Niskin style water sampler (more commonly called "Niskin Bottle"). At each station separate samples are collected at depths of 1 m, 100 m and 200 m to identify any vertical zonation of plankton communities. For each sample, 100 ml of preserved water is analysed for phytoplankton, with planktonic taxa identified to the lowest possible taxonomic level, enumerated and expressed as density per litre.

Unidentified centric diatoms include a significant proportion of all individuals. Individuals in this group are not considered to include any of the families which are identified to a lower taxonomic level (APEM, Pers comm.). The quantification of centric diatom individuals in the different size ranges (i.e. <20 µm, 20-50 µm, and >50 µm) are, however, merged into a single 'centric diatom' taxon category; all further analyses and reporting relates to this single combined group. Raphiated pennate diatoms have also been treated in this way, i.e. the different size classes (<20 µm and 20-50 µm) have been merged into a single taxon. The full planktonic data set, indicating those taxa which are merged for analysis, is presented in the annex B2.7 Plankton-Phytoplankton Analysis.

Phytoplankton are photosynthetic planktonic life forms which typically comprise suspended or motile microscopic algae including diatoms and desmids, dinoflagellates (single celled protozoans), and cyanobacteria. As well as requiring light for photosynthesis, phytoplankton are also dependent on nutrients such as nitrogen, phosphate and silicic acid. While this analysis is primarily focused on photosynthetic plankton, some species of dinoflagellates are known to be mixotrophic or heterotrophic, for example *Protoperdinium* spp. (Jeong and Latz, 1994); such taxa have been included in the current analysis.

It should be noted that the constitution of the plankton is seasonably variable and the following analysis only represents the state of the community at the time of sampling. As phytoplankton have fast generation times and as growth and production is strongly determined by resource limitations, predominantly the availability of sunlight and vital nutrients (Miller, 2003), changes in the levels of these variables can rapidly affect community structure.

General Description and Diversity

A total of 27 phytoplankton taxa are identified (Table 4-14); this value includes single entries for centric diatoms and raphidiate pennate diatoms as discussed above. The majority of taxa (14 taxa, 51.9%) are diatoms (*Bacillariophyceae*), followed by dinoflagellates (*Dinophyceae*) (10 taxa, 37.0%). The remaining taxa are made up of microflagellates, cyanophytes (blue-green algae) and a single species of silicoflagellate, *Dictyocha fibula* (Table 4-14 and Figure 4-39).

Microflagellates are the most abundant taxon, containing ~77% of all individuals. Microflagellates consist of heterotrophic protists, not strictly phytoplankton, although many microflagellates can also photosynthesise. This taxon contains smaller individuals (<20 µm) which, like dinoflagellates, have flagella enabling them to move through the water column. Diatoms are the second most abundant group, comprising ~20% of all individuals. Dinoflagellates make up 2.3% of phytoplankton recorded, while the cyanophytes and silicoflagellates make up 0.7% and 0.1%, respectively.

Table 4-14 Number of Taxa and Density of Phytoplankton Groups

Group	Number of Taxa	Taxa [%]	Mean Density [ind. l ⁻¹]	Density [%]
Diatom	14	51.9	26.0	19.8
Dinoflagellate	10	37.0	4.2	2.3
Microflagellate	1	3.7	1416.0	77.1
Cyanophyta	1	3.7	12.2	0.7
Silicoflagellate	1	3.7	1.1	0.1
TOTAL	27	100.0	-	100.0

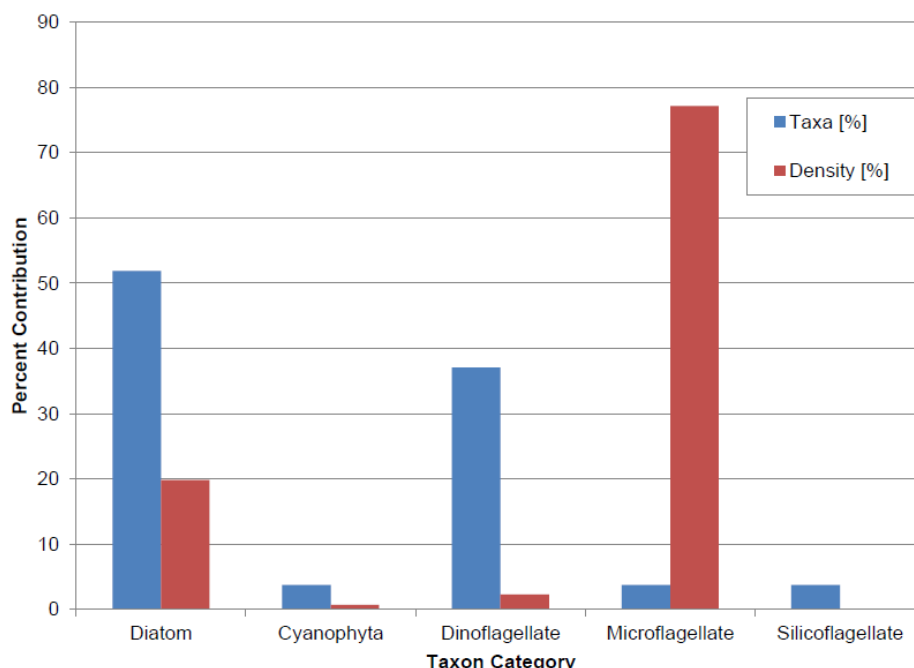


Figure 4-39 Number of Taxa and Density of Phytoplankton Taxonomic Groups

Six of the top ten most abundant taxa/groups are diatoms (Table 4-15), although microflagellates are ranked number 1 in density and in dominance. It is, however, likely that the microflagellates group comprise several different species.

Centric diatoms, consisting of several size ranges, are ranked second in density and dominance. Ranked third in density and dominance are the raphiated pennate diatoms. Highest densities of diatoms, including both centric and pennate species, are recorded at Station 56 at 1 m depth. No single taxa/group is found in more than four of the nine samples (44.4% frequency) obtained from the three stations by three depths sampling array. No phytoplankters are recorded at 200 m depth at Station 38 or 46.

Table 4-15 Dominant Phytoplankton Taxa by Density and Dominance Rank

Taxon/Group	Rank Density	Mean Density [ind. l ⁻¹] per sample (n=9)	Frequency [%]	Rank Dominance
Microflagellate	1	1416.00	44.4	1
CENTRIC DIATOM	2	257.78	44.4	2
Raphiated Pennate Diatom	3	46.67	44.4	3
<i>Pseudo-nitzschia pungens</i>	4	12.22	11.1	4
Cyanophyceae	4	12.22	11.1	4
<i>Pseudosolenia calcar-avis</i>	6	11.11	22.2	4
<i>Scrippsiella</i> sp.	7	8.89	11.1	7
<i>Nitzschia longissima</i>	7	8.89	11.1	14
<i>Oxytoxum</i> sp.	9	7.78	33.3	8
<i>Eucampia zodiacus</i>	9	7.78	11.1	8

Primary and Univariate Analysis

Primary variables (numbers of taxa and density) are calculated for the sample data using the PRIMER v6.0 DIVERSE procedure (Clarke and Gorley, 2006). Results are presented in Table 4-16.

The number of taxa, although limited, is most variable between stations in the surficial 1 m samples, ranging from 2 to 7 to 13 at Stations 38, 50 and 46, respectively. Eight taxa are recorded

at Stations 38 and 46 at 100 m depth; at the same depth only three taxa are recorded at Station 50. At Station 50, only one single taxon is recorded at 200 m, with no taxa recorded at this depth at Stations 38 and 46. The total number of taxa at each station is greatest at Station 46 (21 taxa) and roughly equal at Stations 38 (10 taxa) and 50 (11 taxa).

Variation in phytoplankton density is largely related to densities in the two numerically dominant groups, microflagellates and centric diatoms. Over all depths, total abundance is greatest at Station 50 (total cells.l-1 = 7776), with numbers declining at Station 46 (total cells.l-1 = 6008). Numbers are reduced at Station 38 (total cells.l-1 = 2739). Relatively high densities are recorded at 100 m at all three stations, highest densities being recorded at this depth at Station 50. Lowest densities are recorded at 200 m depth; at this depth only 10 cells.l-1 are recorded at Station 50 and no cells were observed at the other stations. Density values were generally low at 1 m depth, apart from at Station 46 where a total of 2399 cells.l-1 are recorded, due to relatively high densities of microflagellates and centric diatoms.

Shannon-Wiener (H') diversity vary between 0 and 1.7, and Pielou's evenness from 0 to 1. Diversity is highest at 1 m depth at Stations 46 and 50, and evenness highest at all three stations at the same depth.

Table 4-16 Phytoplankton Primary and Univariate Parameters [I-1]

Station		No of Taxa [S]	Density [N]	Equitability [J']	Shannon-Wiener [H']
38	1 m	2	20.0	1.0	0.69
	100 m	8	2719.3	0.6	1.17
	200 m	0	0.0		0.00
46	1 m	13	3609.3	0.6	1.43
	100 m	8	2398.9	0.2	0.34
	200 m	0	0.0		0.00
50	1 m	7	220.0	0.9	1.71
	100 m	3	7546.5	0.0	0.04
	200 m	1	10.0		0.00
Min		0	0.0	0.0	0.00
Mean		5	1836.0	0.5	0.60
Max		13	7546.5	1.0	1.70
SD		4	2569.9	0.4	0.70

Note: Min = minimum; Max = maximum; SD = 1 standard deviation.

Multivariate Analysis

Multivariate analysis is used to further examine the planktonic community structure and to determine whether subtle spatial patterns, not apparent in the univariate measures, can be detected. Analyses are conducted with PRIMER v6.1.15 (Clarke and Gorley, 2006) on fourth root transformed data (to indicate any variations in community structure potentially masked by the large variations in densities).

At 200 m depth, both Stations 38 and 46 are denuded of phytoplankton, and Station 50 is largely depauperate except for a single taxon (raphiated pennate diatoms) at low density. The lack of cells at this depth is likely to be for the same reason; to the lack of light and/or grazing effects, and therefore it makes biological sense to consider the samples similar to one another. For this reason, a dummy variable with a value of 1 is inserted into the data matrix before construction of Bray-Curtis similarity (see Clarke and Gorley, 2006; Clarke *et al.*, 2006).

Clustering with SIMPROF testing ($P < 0.05$) on fourth root transformed data result in two significant clusters. These clusters essentially separate differences in community structure between depths,

Cluster A containing samples obtained at 1 m and 100 m depth, and Cluster B containing depauperate samples obtained at 200 m. Note that the 1 m depth sample obtained from Station 38 is also grouped in Cluster B, due to only two taxa at limited densities being recorded from this sampling site.

Analysis of Similarity (ANOSIM) is used to test for variation with depth on fourth root transformed data. A significant difference between the communities at different depths is observed (Global $R = 0.539$, $P = 2.9\%$). Note that due to the number of samples obtained at each depth and the subsequent limited number of data permutations to construct the null distribution of the ANOSIM test statistic, the maximum significance of the statistic will never be less than 10%. Pairwise comparisons reveal that the greatest difference is between 100 m and 200 m depth ($R = 1$, $P = 10\%$). These results are consistent with the univariate analysis which also suggested zonation of phytoplankton within the water column.

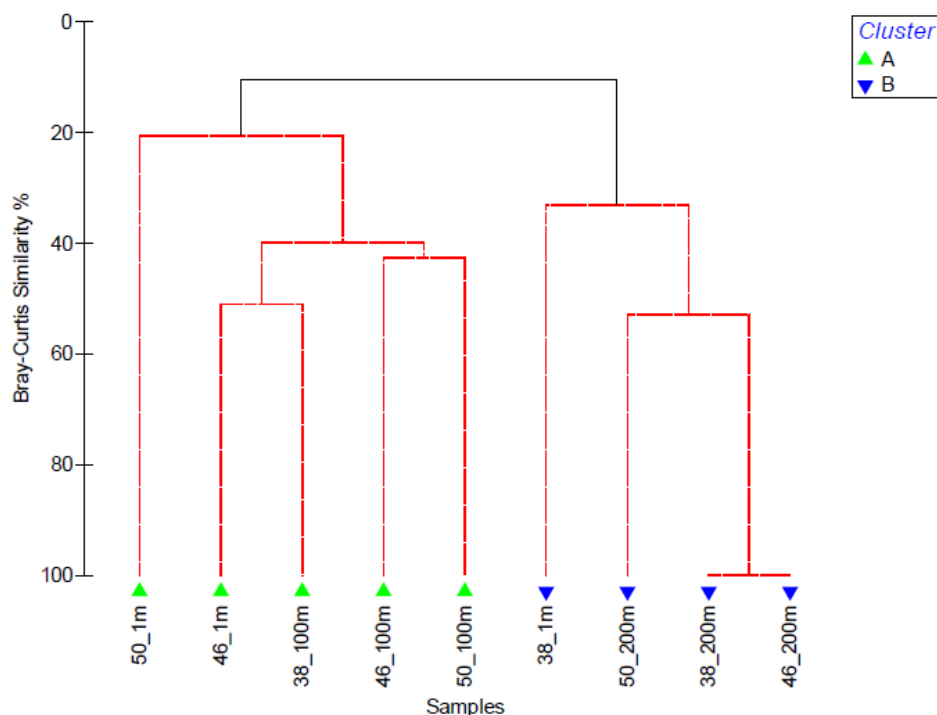


Figure 4-40 Dendrogram of Bray Curtis similarity of phytoplankton community structure

4.7.2 Zooplankton

Zooplankton samples are collected at three stations (Stations 38, 46, and 50) using a 120 μm cod-end plankton net. A single vertical trawl is completed at each station. Zooplankton data are derived from taxonomic analysis of the samples. Individuals of planktonic taxa are identified, enumerate and expressed as density per m^3 (ind.m^{-3}) by dividing the total number of individuals obtained in the samples by the volume of water that passes through the net. The full zooplankton dataset is presented in the annex B2.8 Plankton- Zooplankton Analysis.

To ensure zooplankton community data are suitable for the analysis, the data are standardised to remove extraneous data (i.e. taxa of little relevance to the analysis) and ensure that all taxa are mutually exclusive. Larvae of benthic invertebrates form a proportion of the zooplankton (termed meroplankton) and as such, unlike in the macrofaunal analysis, juvenile specimens are retained for the zooplankton data analyses. As with phytoplankton, zooplankton communities vary seasonally and, therefore, the current assessment represents the state of the zooplankton at the time of sampling only.

General Description and Diversity

Zooplankton communities can be split into: holoplankton, those organisms which are permanent residents in the water column; and meroplankton, organisms that reside in the plankton for part of their life cycle (i.e. larval and juvenile invertebrates and fish). In total, 132 discrete taxonomic groups are identified from the analysis, although this is likely to be an underestimation of the true diversity since many species are identified to a low level of taxonomic resolution.

The majority of species and individuals recorded in the samples are holoplankton, in particular Copepoda and other Crustacea (Table 4-17). In terms of density, the Copepoda dominate the holoplankton, containing 65.0% of all individuals. Other crustaceans (i.e. Crustacea with Copepoda removed) make up 16.2% of the total density and comprised 38 different identified taxa. In addition, 7 crustacean taxa are also included within the meroplankton 'other' grouping. A group comprising several 'other' holoplankton taxa contains the greatest number of taxa (40.2%), but only contributes 7.5% to total density; this group contained members of the *Annelida*, *Crustacea*, *Cephalorhyncha*, *Chordata*, *Cnidaria* and *Phoronida*.

Meroplankton are comparatively rare in the samples constituting 4.0% of the total density (Table 4-17 and Figure 4-41). Fish eggs (Ichthyoplankton) are also relatively scarce with a percentage density of 0.4%.

Results from this survey are broadly consistent with results from the previous Jubilee survey which also shows a dominance of copepods within the zooplankton trawls (ERM, 2009). Results are also comparable to the data from the Phase 2&4 survey.

Table 4-17 Number of Taxa and Density of Zooplankton Taxonomic Groups

Group		Number of Taxa	Total Taxa [%]	Average Density [ind. m ⁻³]	Density [%]
Holoplankton	Copepoda	11	8.3	2510	65.0
	Other crustacea	38	28.8	626	16.2
	Chordata	5	3.8	82	2.1
	Other*	53	40.2	288	7.5
Meroplankton	Echinodermata	2	1.5	1	0.0
	Mollusca	3	2.3	9	0.2
	Other**	18	13.6	331	8.6
Eggs	Ichthyoplankton	2	1.5	15	0.4
Holoplankton (total)		107	81.1	3505	90.8
Meroplankton (total)		23	17.4	341	8.8
Eggs (total)		2	1.5	15	0.4
Total		132	100.0	3861	100.0

Note: *Other Holoplankton include Annelida, Chaetognatha, Cnidaria, Ctenophora, Foraminifera, Mollusca, Myxozoa, Nemertea, Radiozoa, Sipuncula and Animalia. **Other Meroplankton include Annelida, Crustacea, Cephalorhyncha, Chordata, Cnidaria and Phoronida.

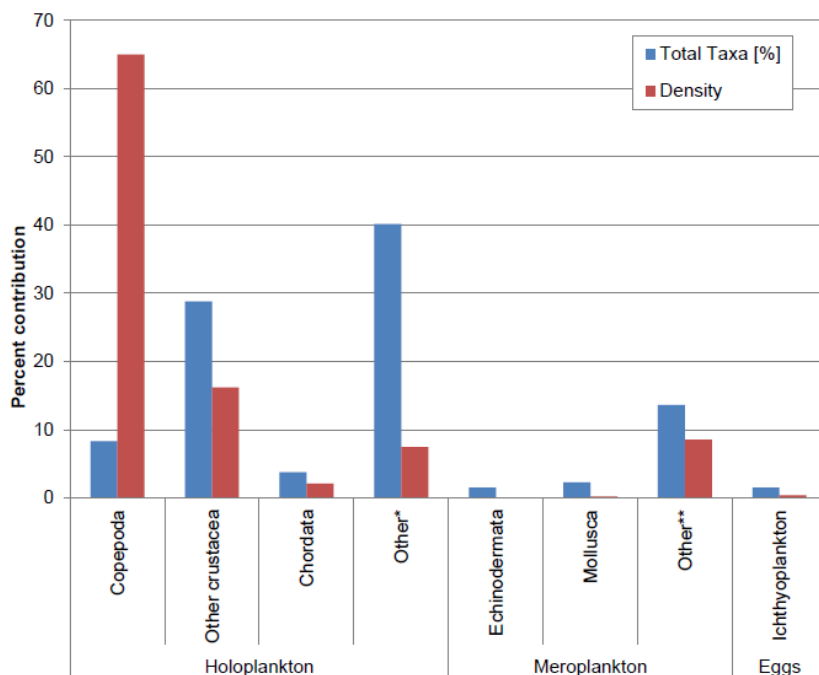


Figure 4-41 Number of Taxa and Density of Zooplankton Taxonomic Groups (Note: *Other Holoplankton include Annelida, Chaetognatha, Cnidaria, Ctenophora, Foraminifera, Mollusca, Myxozoa, Nemertea, Radiozoa, Sipuncula and Animalia. **Other Meroplankton include Annelida, Crustacea, Cephalorhyncha, Chordata, Cnidaria and Phoronida)

Primary variables

Due to the low level of samples (a total of three trawls) and the inconsistent taxonomic resolution, with many taxa being identified to phylum level, and some being identified further, statistical analysis (univariate/multivariate) is not deemed appropriate. Primary variables are given in Table 4-18 of the community observed at each station.

The number of discrete taxa identified in each sample is slightly higher at Station 46, at 96 taxa, relative to 62 and 65 taxa (Stations 38 and 50, respectively). The total zooplankton density is higher at the shallow stations (1892 ind.m⁻³ at Station 46 and 1758 ind.m⁻³ at Station 50) than at the deeper Station 38 (211 ind.m⁻³). Total density is lower than levels from the Phase 2&4 survey suggesting that zooplankton communities are richer in the shallower water, possibly due to increased nutrient supply from coastal upwells and terrestrial run-off.

The relative proportions of copepods and meroplankton in the samples appears to follow a similar trend to the total density with higher percentages at the two shallow sites (Table 4-18). Over 94% of the density of the deeper Station 38 is copepods and only 0.3% is meroplankton.

Table 4-18 Primary Variables of Zooplankton

Station	Number of Taxa	Total Density [m ⁻³]*	Copepod Density [%]	Meroplankton Density [%]
38	62	211	94.2	0.3
46	94	1892	59.0	7.6
50	65	1758	67.9	11.2

4.8 BENTHIC ORGANISMS

A detailed description of the Benthic Organisms has been provided in Annex B1.

The macrofauna are characterized by low abundance and low diversity assemblages, with numbers of individuals and species consistently low at all stations. At some stations no macrofauna are recorded.

As previously enlightened station 41 is characterized by contaminated sediment but considering the paucity of fauna and the general lack of abundance at all stations surveyed it is not possible to determine if the faunal composition has been affected. Furthermore, no increase in density of opportunistic or pollution tolerant fauna is observed at Station 41.

The same kind of conclusion can be done considering that all stations are found to contain sediments with concentrations of arsenic, chromium and/or nickel above their respective ERL level.

4.9 CORAL REEF

Coral reefs are underwater structures made from calcium carbonate secreted by corals. Coral reefs are colonies of tiny animals found in marine waters that contain few nutrients. Most coral reefs are built from stony corals, which in turn consist of polyps that cluster in groups. The polyps belong to a group of animals known as *Cnidaria*, which also includes sea anemones and jellyfish. Unlike sea anemones, coral polyps secrete hard carbonate exoskeletons which support and protect their bodies. Reefs grow best in warm, shallow, clear, sunny and agitated waters.

Coral reefs deliver ecosystem services to tourism, fisheries and shoreline protection. However, coral reefs are fragile ecosystems, partly because they are very sensitive to water temperature. They are under threat from climate change, oceanic acidification, blast fishing, cyanide fishing for aquarium fish, overuse of reef resources, and harmful land-use practices, including urban and agricultural runoff and water pollution, which can harm reefs by encouraging excess algal growth.

In the project area and the surrounding blocks there are some findings of both, deep corals (coldwater corals found in the nearby Tano Basin) and shallow corals in nearshore areas, identified at 28 m depth.

NOAA's Coral Reef Information System (CoRIS) and NOAA Coral Reef conservation Program websites give us an overview on coral threats and future scenarios.

Coral reefs formed by shallow water corals, face numerous hazards and threats. As human populations and coastal pressures increase, reef resources are more heavily exploited, and many coral habitats continue to decline. Current estimates note that 10 percent of all coral reefs are degraded beyond recovery. Thirty percent are in critical condition and may die within 10 to 20 years. Experts predict that if current pressures are allowed to continue unabated, 60 percent of the world's coral reefs may die completely by 2050 (CRTF, 2000). Reef degradation occurs in response to both natural and anthropogenic (human-caused) stresses. Threats to coral reefs can be also classified as either local or global: local threats include overfishing, destructive fishing practices, nutrient runoff, sedimentation, and coral disease while global threats include mass coral bleaching produced by rising sea surface temperature (worsened by climate change), and ocean acidification. Together, these represent some of the greatest threats to coral reefs. (<http://www.coris.noaa.gov/about/hazards/>)

Coral reef threats often do not occur in isolation, but together, having cumulative effects on the reefs and decreasing its overall resiliency. Following destructive natural events such as hurricanes, cyclones or disease outbreaks, reefs can be damaged or weakened, but healthy ones generally are resilient and eventually recover. In many cases, however, natural disturbances are exacerbated by anthropogenic stresses, such as pollution, sedimentation and overfishing, which can further weaken coral systems and compromise their ability to recover from disturbances. Conversely, a reef directly or indirectly affected by anthropogenic stresses may be too weak to withstand a natural event. In addition, many scientists believe that human activities intensify natural disturbances, subjecting coral reefs to stronger, more frequent storms, disease outbreaks and other natural events. (<http://www.coris.noaa.gov/about/hazards/>)

Furthermore, even if little is known about deep water coral (coldwater corals), during the annual meeting of the American Association for the Advancement of Science in Seattle, United States, in February 2004 was stated that documented and potential sources of threats to coldwater corals are:

- commercial bottom trawling and other bottom fishing
- hydrocarbon exploration and production
- cable and pipeline placement
- bioprospecting and destructive scientific sampling
- other pollution
- waste disposal and dumping
- coral exploitation and trade
- upcoming threats: sequestration of CO₂, other mineral exploration and increased atmospheric CO₂.

A full description of the Coral Reefs has been provided in Annex B1.

4.10 CHEMOSYNTHETIC ORGANISMS

Chemosynthesis is the biological conversion of one or more carbon molecules and nutrients into organic matter using the oxidation of inorganic molecules (eg hydrogen sulphide) or methane as a source of energy, rather than sunlight, as used in photosynthesis. In water depths where there is no light penetration and where seepage of hydrocarbons, venting of hydrothermal fluids or other geological processes supply abundant reduced compounds, microorganisms can use chemosynthesis to produce biomass and can become the dominant component of the ecosystem. Chemosynthetic communities can have unusually high biomass (MacDonald, 2002).

The three main sources of energy and nutrients for deep sea communities are marine snow, whale falls, and chemosynthesis at hydrothermal vents and cold seeps.

The first type of organism to take advantage of this deep-sea energy source is bacteria that metabolize methane and hydrogen sulfide. Other organisms that rely with this type of bacteria are bivalves, mussels and tubeworms.

Recently seep communities have been discovered in the eastern Atlantic, on a giant pockmark cluster in the Gulf of Guinea near the Congo deep channel, also on other pockmarks of the Congo margin, Gabon margin and Nigeria margin (Olu K., Cordes E. E., Fisher C. R., Brooks J. M., Sibuet M. & Desbruyères D. (2010). "Biogeography and Potential Exchanges Among the Atlantic Equatorial Belt Cold-Seep Faunas". PLoS ONE 5(8): e11967. doi:10.1371/journal.pone.0011967). These cold seeps are within the Atlantic Equatorial Belt (AEB), that extends from the Gulf of Mexico to the Gulf of Guinea, that was one focus of the Census of Marine Life ChEss (Chemosynthetic Ecosystems) program to study biogeography of seep and vent fauna (Figure 4-42).

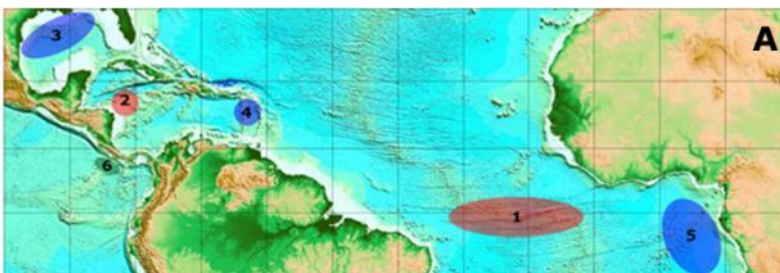


Figure 4-42 Atlantic Equatorial Belt- Priority field program area. A) AEB: (1) Equatorial MAR and fracture zones; (2) Mid-Cayman Rise; (3) Gulf of Mexico; (4) Barbados Accretionary Prism; (5) NW African margin; (6), Costa Rica margin

The Figure 4-43, and the Table 4-19 show the sampling sites and the list for deep-sea Bathymodiolus mussels evidencing the presence of these species in the proximity of the project area.

(Jun-Ichi Miyazaki, Leonardo de Oliveira Martins, Yuko Fujita, Hiroto Matsumoto, Yoshihiro Fujiwara (2010) "Evolutionary Process of Deep-Sea Bathymodiolus Mussels"
<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0010363>)

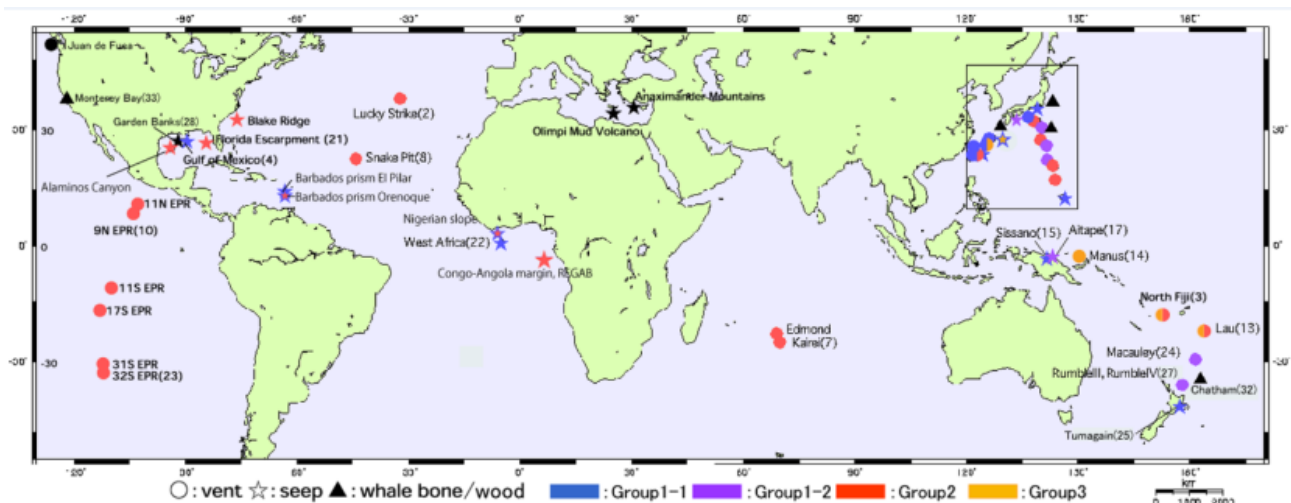


Figure 4-43 Sampling sites for deep-sea Bathymodiolus mussels

Table 4-19 Sample list for deep-sea Bathymodiulus mussels

Species	Sample abbreviation	Sampling site (locality number in Fig. 1)	Depth (m)	Habitat type
Bathymodiolinae				
<i>Bathymodiulus adaloides</i>	AK1	Off Kikajima Island (1)	1 451	Seep
<i>B. azoricus</i>	AZL1	Lucky Strike, Mid-Atlantic Ridge (2)	Unknown	Vent
<i>B. brevior</i> NF	BN	Muscle Valley, North Fiji Basin (3)	Unknown	Vent
<i>B. childressi</i>	CHG1	Gulf of Mexico (4)	1 859	Seep
<i>B. hirtus</i>	HK1	Kuroshima Knoll, Off Yaeyama Islands (5)	637	Seep
<i>B. japonicus</i>	JH1	Off Hatsushima, Sagami Bay (6)	1 170–1 180	Seep
<i>B. marindicus</i>	MK1	Kairei Field, Southern Central Indian Ridge (7)	2 443–2 454	Vent
<i>B. platifrons</i>	PH1	Off Hatsushima, Sagami Bay (6)	1 170–1 180	Seep
<i>B. puteoserpentis</i>	PUS1	Snake Pit, Mid-Atlantic Ridge (8)	3 023–3 510	Vent
<i>B. securiformis</i>	LK1	Kuroshima Knoll, Off Yaeyama Islands (5)	641	Seep
<i>B. septemferum</i>	SM1	Myojin Knoll, Izu-Ogasawara Island-arc (9)	1 288–1 290	Vent
<i>B. thermophilus</i>	TH1	9N East Pacific Rise (10)	2 524	Vent
Chamorro <i>B. sp.</i>	C1	South Chamorro Seamount, Mariana (11)	2 899	Seep
Eifuku <i>B. sp.</i>	EF1	Northwest Eifuku Seamount (12)	1 625	Vent
Kikajima <i>B. sp.</i>	Kikajima	Off Kikajima Island (1)	1 430	Seep
Lau <i>B. sp. 1</i>	Lau1	Hine Hina, Lau Basin (13)	1 818	vent
Lau <i>B. sp. 2</i>	BR1	Hine Hina, Lau Basin (13)	1 818	Vent
<i>B. manusensis</i>	BE1	PACKMANUS Field E, Manus Basin (14)	1 627–1 629	Vent
NZ <i>B. sp.</i>	Ne1	Off New Zea land (unknown)	Unknown	Vent
Sissano <i>B. sp. 1</i>	SI2-1	Sissano, Papua New Guinea (15)	1 646	Seep
Sissano <i>B. sp. 2</i>	SI1-1	Sissano, Papua New Guinea (15)	1 881	Seep
Sissano <i>B. sp. 3</i>	SI3-3	Sissano, Papua New Guinea (15)	1 881	Seep
<i>Gigantides horikoshii</i>	Kaikata	Kaikata Seamount (16)	486	Vent
Altape <i>G. sp.</i>	Altape1	Altape, Papua New Guinea (17)	470	Seep
Ashizuri <i>G. sp.</i>	Ashizuri	Off Ashizuri Cape (18)	575	Seep
Nikko <i>G. sp.</i>	NK1	Nikko Seamount (19)	485	Vent
Sumisu <i>G. sp.</i>	Su1	Sumisu Caldera (20)	676–686	Vent
Database				
<i>B. brooksi</i>	<i>B. brooksi</i> WFE(DB)	West Florida Escarpment (21)	3 314	Seep
<i>B. heckerae</i>	<i>B. heckerae</i> WFE(DB)	West Florida Escarpment (21)	3 314	Seep
<i>B. mauritanicus</i>	<i>B. mauritanicus</i> (DB)	West Africa (22)	1 000–1 267	Seep
<i>B. sp. East Pacific</i>	<i>B. off. thermophilus</i> (DB)	325 East Pacific Rise (23)	2 331	Vent
<i>B. sp. NZ3</i>	<i>B. sp. NZ3</i> (DB)	Macaulley Cone (24)	200	Vent
<i>B. tangaroa</i>	<i>B. tangaroa</i> (DB)	Off Turnagain Cape, New Zea land (25)	920–1 205	Seep
<i>B. brevior</i> MT	<i>B. brevior</i> MT(DB)	Mariana Trough (26)	3 589	Vent
<i>Gigantides gladius</i>	<i>Gigantides gladius</i> (DB)	Rumble III (27)	300–460	Vent
Tamu fisher	Tamu fisher(DB)	Garden Banks (28)	546–650	Seep
Modiolinae & Mytilinae				
<i>Adipicola crypta</i>	ACN1	Off Noma Cape, Kagoshima (29)	225–229	Whale bone
<i>Adipicola iwataki</i>	AIH1	Off Nakaminato, Ibaraki (30)	490	Wood
<i>Adipicola pacifica</i>	APN1	Off Noma Cape, Kagoshima (29)	225–229	Whale bone
<i>Idasota japonica</i>	UNI1	Off Noma Cape, Kagoshima (29)	400–425	Wood
<i>Benthomodiulus geikotsucola</i>	Tori1-1	Torishima Seamount (31)	4 051	Whale bone
<i>Modiolus nipponicus</i>	<i>Modiolus nipponicus</i>	Off Oura Harbor, Shizuoka	-	Shallow
Database				
<i>Benthomodiulus lignicola</i>	<i>Benthomodiulus lignicola</i> (DB)	Chatham Rise (32)	826–1 174	Whale bone, Wood
<i>Idas macdonaldi</i>	<i>Idas macdonaldi</i> (DB)	Garden Banks (28)	650	Seep
<i>Idas washingtonia</i>	<i>Idas washingtonia</i> (DB)	Monterey Bay (33)	960–1 910	Whale bone, Wood, Vent

Other research program and studies put in evidence results that could confirm the presence of chemosynthetic communities in the proximity of the project area.

The Environmental Baseline Survey explained in GHANA JUBILEE FIELD PHASE 1 DEVELOPMENT reports two examples of research with some findings:

-Brooks and Bernard (2006) found two sites with chemosynthetic communities using coring samplers over small mounds associated with presumed deeper faulting in water depths of between 1,600 and 2,200 m offshore Nigeria. The communities comprised a high density of mussels and associated tubeworms, clams, shrimps, limpets, crabs, brittle stars, heart urchins and sponges.

-Nibbelink and Huggard (2002) in a study of submarine canyons offshore the Volta River Delta in Ghana, noted evidence of gas seeps on seismic data and oil slicks on radar images. They interpreted the flat floors of the canyons as carbonate formed by chemosynthetic communities that feed on hydrocarbons seeping from the depleted free gas zones below the canyons.

Regarding the results and the research programs cited above in the project area potentially exist chemosynthetic communities but neither Fugro survey nor The Environmental Baseline Survey of

GHANA JUBILEE FIELD PHASE 1 DEVELOPMENT, indicate the presence of any chemosynthetic communities in their survey area

4.11 MARINE MAMMALS

The following paragraphs provide a summary of the desktop studies about the populations of marine mammals which pass through or live permanently/seasonally in the area of the project. A full description can be found in Annex B1.

Considering the physiological and ecological characteristics of these animals, data for distribution of the mammals and their use of habitats has not always been available. Many aspects of their life are still relatively undocumented and our knowledge of their geographical distribution, behaviour and other characteristics is constantly evolving. Descriptions of marine mammals derive almost exclusively from dead specimens, beached or killed by whalers and fishermen.

Towards the end of the century Jefferson *et al.* have already undertaken a census of sightings of odontoceti (toothed whales) and pinnipeds (seals and sea-lions) in the area between the Straits of Gibraltar and the mouth of the river Congo. Since the year 2000 studies have been carried out on the presence and distribution of marine mammals in the Gulf of Guinea area.

The ecological significance of Ghana's coastal waters for dolphins and whales has only recently become the subject of scientific studies, which partially explains the lack of population abundance estimates and why their natural history remains largely unknown. The conditions created by the seasonal upwelling in the northern Gulf of Guinea is likely to create conditions favourable for marine mammals as well as for fisheries.

Small cetaceans of Ghana are documented to suffer considerable pressure from frequent by-catches in mostly drift gillnet fisheries and perhaps also in industrial purse-seine fisheries although the latter remain largely unmonitored. While total mortality is unknown, it is significant and potentially increasing with intensifying fishing effort. Monitoring of landings over a few years has shown the presence of at least 17 different species of dolphins and small whales and all are affected to varying degrees.

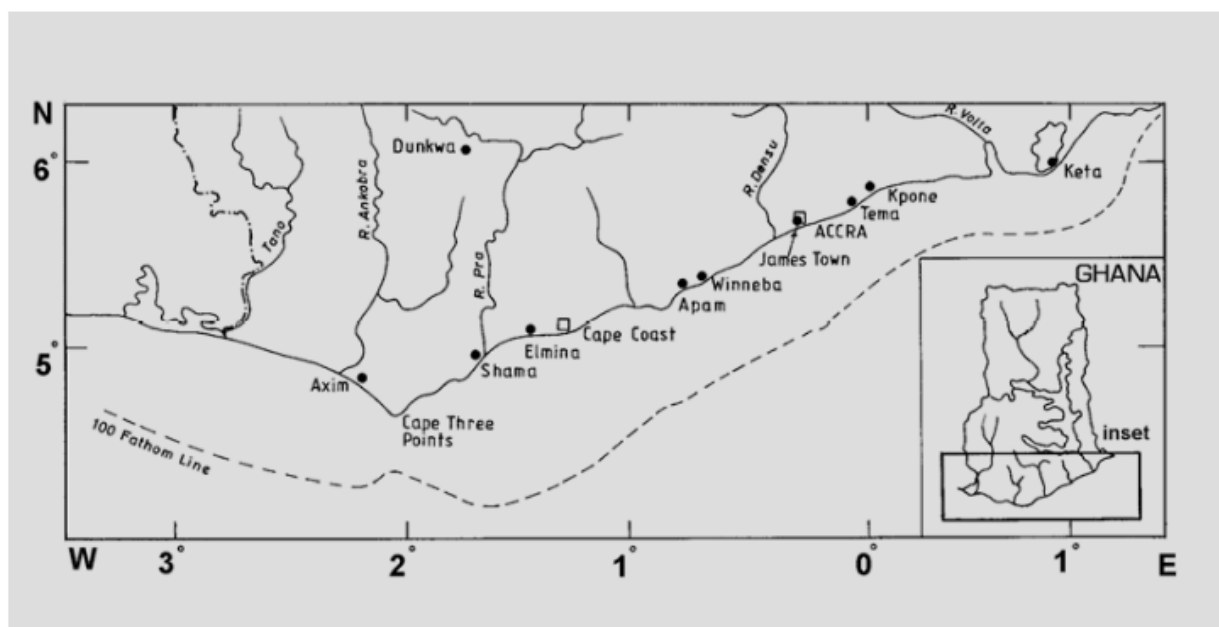
Researchers at the University of Ghana at Legon and the Wildlife Department have pressed for the adoption of conservation strategies for marine mammals offshore Ghana.

In 2008, the Conference of the Parties of the Convention for the Conservation of Migratory Species (CMS/UNEP) included the West African population of *Clymene dolphin* (*Stenella clymene*) (Ghana's principal dolphin species) on its Appendix II (http://www.cms.int/bodies/COP/cop9/Proposals/Appendix_I_II_Proposals.pdf), thus formally recognising its vulnerable status. The Atlantic humpback dolphin, a species endemic to West Africa, has not yet been found in Ghana even though good habitat exists. Rudimentary knowledge of the presence of large whales in Ghana waters may result equally problematic as potential conservation issues may also go unrecognised. For instance, the Gulf of Guinea humpback whale population occupies Ghana's shelf zone as a calving and breeding area, i.e. during a period when they are most vulnerable to disturbance. The global threat of large ships colliding with whales and killing or injuring them is well-documented. Shipping is known to affect at least humpback whales and Bryde's whales worldwide but also in West Africa and especially near large ports. In West Africa, a number of unexplained whale deaths are suspected to be due to ship strikes.

Together with these deaths is important to consider the washing ashore of whales carcass. A total of 20 dead whales have been discovered along Ghana's coastline in the last four years (starting from 2009) including at least eight since September 2013.

Current knowledge of the distribution, natural history, population structure and ecology of dolphins and whales in the Gulf of Guinea is rudimentary and fragmentary in the scientific literature. All

information on cetaceans in Ghana is the result of land-based field research, mainly monitoring of fishing port for landings of small cetacean by-catches as well as the study of stranded animals. Capture locations and thus habitat (neritic, slope, pelagic) are unknown, as fishermen may operate both shorewards and offshore of Ghana's continental shelf and operate at considerable distances to the east or west of the ports where they landed catches. No shipboard surveys for marine mammals have been implemented so far, therefore it is not presently possible to provide distribution maps for Ghana or adjacent states. Scientists who study aquatic mammals are based at the University of Ghana at Legon and the Faculty of Sciences at the University of Cape Coast. Figure 4-44 shows artisanal fishing ports and fish landing beaches where cetaceans have been landed (Van Waerebeek *et al*, 2009). Specimens derived from by-catches and stranding shows that the cetacean fauna of Ghana is moderately diverse, essentially tropical and predominantly pelagic. It comprises 18 species belonging to 5 families: 14 species of *Delphinidae* (dolphins) and one species each of families *Ziphiidae* (beaked whales), *Physeteridae* (sperm whales), *Kogiidae* (pygmy sperm whales) and *Balaenopteridae* (rorquals).



Source: Van Waerebeek *et al*, 2009

Figure 4-44 Fishing Ports on the Ghanaian Coast

References to cetaceans in West Africa include Wilson *et al* (1987) for a striped dolphin *Stenella coeruleoalba* record from Côte d'Ivoire, but no voucher material is identifiable. However, striped dolphins are not uncommon offshore Angola (Weir, 2007) and this delphinid and the short-snouted common dolphin *Delphinus delphis* are expected to occur in the Gulf in deep waters. Among beaked whales, the Gervais' beaked whale *Mesoplodon europaeus* has been documented from Ascension and Guinea-Bissau (Rice, 1998), so may also be present offshore, as well as Blainville's beaked whale *Mesoplodon densirostris* which is a pantropical cetacean. Another widely distributed (sub)tropical cetacean that may be present within the survey area is the pygmy sperm whale *Kogia breviceps*. All these species have a pelagic distribution in common and may be present in the Gulf. The presence of long-snouted common dolphin in Ghana, Côte d'Ivoire (Cadenat, 1959) and Gabon (Van Waerebeek, 1997) puts in evidence a wide distribution in the Gulf, perhaps partly related to the seasonal upwelling over the continental shelf (Adamec and O'Brien, 1978). The listing of *D. delphis* in Ofori-Danson *et al* (2003) was premature, but the species may be present offshore. The skull of a confirmed *D. delphis* was collected in Mayoumba, Gabon (van Bree and Purves, 1972; Van Waerebeek, 1997).

Among baleen whales, pictures of Bryde's whales *Balaenoptera brydei/edeni* were taken as far north as Gabon (Ruud, 1952) and it is likely that Bryde's whale occurs in Ghana's Exclusive Economic Zone (EEZ) waters. *B. brydei* was originally described from South Africa (Olsen 1913) and is the most likely species involved. Other rorquals (*Balaenoptera spp.*) could also occur. No Atlantic humpback dolphins (*Sousa teuszii*) have so far been confirmed in Côte d'Ivoire, Ghana, Togo, Benin or Nigeria (Debrah, 2000; Ofori-Danson *et al*, 2003; Van Waerebeek *et al*, 2004, 2009; Perrin and Van Waerebeek, 2007), despite suitable coastal habitat. Also, since the holotype was collected in the port of Douala (Kükenthal, 1892), it has not been reported again from Cameroon. Possible explanations may include local extirpation through intense pressure from coastal fisheries (by-catch), disturbance and other habitat encroachment or insufficient research effort.

There are unconfirmed fishermen's reports that humpback dolphins may occasionally be seen between the Volta River delta and Lomé, Togo. In recent years, Atlantic humpback dolphins have been encountered with some regularity in Gabon (Schepers and Marteijn, 1993; Collins *et al*, 2004; Van Waerebeek *et al*, 2004). In 2008, the species was listed on Appendix I of CMS reflecting mounting international concern about its population status. Other rorquals such as minke whales (*Balaenoptera acutorostrata*), sei whales (*Balaenoptera borealis*), blue whales (*Balaenoptera musculus*) and fin whales (*Balaenoptera physalus*) have very wide distributions globally. Of these, the blue, fin and sei whales are classified as Endangered on the IUCN's Red Data List. The primary and secondary ranges of blue whales and the secondary ranges of fin whales potentially extend into the Gulf of Guinea, although there are no records of blue whales in Ghanaian waters. Sei whales are not generally found in equatorial waters as they occupy areas northern and southern oceans (Jefferson *et al*, 2008).

Regular landings in several Ghana ports of Clymene dolphin, pantropical spotted dolphin, common bottlenose dolphin and, to a lesser degree, short-finned pilot whale, Risso's dolphin, Atlantic spotted dolphin, rough-toothed dolphin and melon-headed whale suggest that these species are not rare in the northern Gulf of Guinea, although any estimate of population abundance is lacking. Rarely captured species may be characterised by a lower abundance in the areas that are near the continental shelf and slope. Landed cetaceans are often used as 'marine bush meat' (Clapham and Van Waerebeek 2007), which is defined as meat and other edible parts derived from wild-caught marine mammals, sea turtles and seabirds.

The knowledge about distribution, natural history, population structure and ecology of dolphins and whales in the Gulf of Guinea is rudimentary and fragmentary in the scientific literature. The most important remarks about marine mammals concern the threats.

The main threats are:

- Collision with ships
- pressure from frequent by-catches in mostly drift gillnet fisheries and perhaps also in industrial purse-seine fisheries
- water pollution
- seismic activity related to hydrocarbon exploitation activities

Among the causes of the beaching of cetaceans the seismic activity and the use of sonar are surely recognized, while the events of washing ashore of whales carcass remain without a definite explanation.

It is important to underline that in some opinions, the washing ashore of whales carcass along western Ghana's coastline has been associated with the offshore activity for oil production. The discovering of the 20 dead whales along Ghana's coastline started in 2009 when oil exploitation activities intensified offshore Cape Three Points and continued with the production of oil. However,

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this association is not shared by all researchers belonging to this field of studies. Indeed, so far, there is no scientific evidence of direct correlation between activities of the extractive sector in Ghana and whale beaching events. This was also mentioned by researchers of the University of Ghana.

4.12 SEA BIRDS

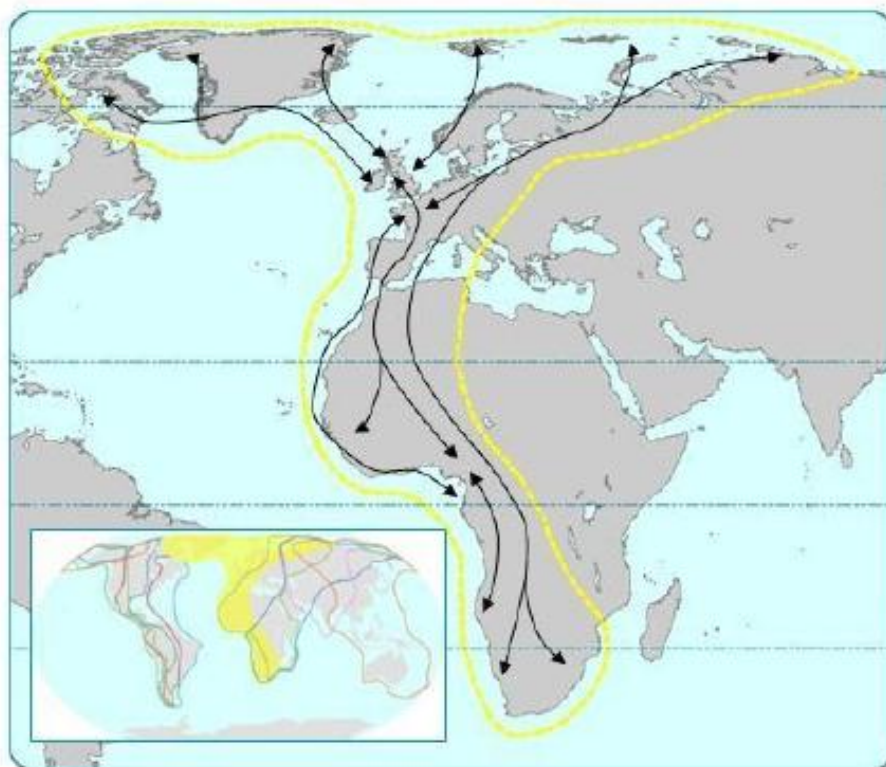
The west coast of Africa forms an important section of the East Atlantic Flyway (Figure 4-45), an internationally-important migration route for a range of bird species, especially shore birds and seabirds (Boere *et al*, 2006, Flegg 2004). A number of species breed in higher northern latitudes winter along the West African coast and many fly along the coast on migration. Seabirds known to follow this migration route include a number of tern species (*Sterna sp.*), skuas (*Stercorarius* and *Catharacta spp.*) and petrels (*Hydrobatidae*).

The distance of the migration routes of these species from the shore depends on prey distribution and availability (eg the abundance and distribution of shoals of anchovies or sardines) (Flegg 2004). Species of waders known to migrate along the flyway include sanderling (*Calidris alba*) and knott (*Calidris canuta*). The highest concentrations of seabirds are experienced during the spring and autumn migrations, around March and April, and September and October. Waders are present during the winter months between October and March. The marine birds of Ghana include storm petrels (*Oceanodroma castro*) and Ascension frigatebirds (*Fregata aquila*). Records dating back to the 1960s reveal only limited sightings of a few species (Elgood *et al*, 1994). The rarity of oceanic birds may be attributable to the absence of suitable breeding sites (eg remote islands and rocky cliffs) off the Ghana coast and in the Gulf of Guinea.

During the environmental baseline studies for the West African Gas Pipeline (WAGP, 2004) in 2002/2003, the survey crew recorded several sightings of black tern (*Chlidonias niger*), White winged black tern (*Chlidonias leucopterus*), royal tern (*Sterna maxima*), common tern (*Sterna hirundo*), sandwich tern (*Sterna sandvicensis*), great black-back gull (*Larus marinus*), lesser black-back gull (*Larus fuscus*), pomarine skua (*Stercorarius pomarinus*) and great skua (*Catharacta skua*). The two species of skua are predominant in the Western offshore environment. Black terns were mainly recorded at nearshore locations close to estuaries and/or lagoons. These species leave the onshore areas to feed at sea during the afternoon. The general low diversity of marine birds may be ascribed to lack of suitable habitats and availability of food resources in the offshore area. There are 40 Important Bird Areas (IBAs) designated by Birdlife International within Ghana (BirdLife International (2013) Country profile: Ghana. Available from: <http://www.birdlife.org/datazone/country/ghana> accessed on 20 November 2013). Six IBAs are located along the coastline of Ghana, namely:

- Amansuri wetland;
- Densu Delta Ramsar Site;
- Keta Lagoon Complex Ramsar Site;
- Muni-Pomadze Ramsar Site;
- Sakumo Ramsar Site; and
- Songor Ramsar Site.

According to BirdLife International (2013) in Ghana there are a total of 676 species of birds divided in Landbirds (555 species), Migratory (211 species), Seabirds (15 species) and Waterbirds (120 species).



Flyways



Figure 4-45 Representation of East Atlantic Flyway (Boere *et al*, 2006, Flegg 2004)

Overall the IUCN red List Status of bird species in Ghana is shown in Figure 4-46 while the list of seabirds species is shown in Table 4-20.

 EX Extinct	<u>0</u>
 EW Extinct in the Wild	<u>0</u>
   Globally Threatened	<u>17</u> (61 st)
   %threatened	3% (151 st)
 CR Critically Endangered	<u>0</u>
 EN Endangered	<u>4</u>
 VU Vulnerable	<u>13</u>
 NT Near Threatened	<u>21</u>
 LC Least Concern	<u>636</u>
 DD Data Deficient	<u>2</u>

The numbers in brackets refer to the country's rank when compared to other countries and territories globally.

Figure 4-46 Overall IUCN Red List Status of bird species in Ghana (BirdLife International (2013) Country profile: Ghana. Available from: <http://www.birdlife.org/datazone/country/ghana> accessed on 20 November 2013)

Table 4-20 Seabirds Species List in Ghana (BirdLife International (2013) Country profile: Ghana. Available from: <http://www.birdlife.org/datazone/country/ghana> accessed on 20 November 2013) (IUCN Red List Status CR=Critically Endangered; EN=Endangered; DD=Data deficient; LC=Least Concern; NT=Near Threatened; VU=Vulnerable)

Species	CommonName	IUCN Category
<i>Sterna balaenarum</i>	Damara Tern	NT
<i>Phalacrocorax carbo</i>	Great Cormorant	LC
<i>Pelecanus onocrotalus</i>	Great White Pelican	LC
<i>Stercorarius pomarinus</i>	Pomarine Jaeger	LC
<i>Larus fuscus</i>	Lesser Black-backed Gull	LC
<i>Larus ridibundus</i>	Black-headed Gull	LC
<i>Sterna nilotica</i>	Gull-billed Tern	LC
<i>Sterna caspia</i>	Caspian Tern	LC
<i>Sterna maxima</i>	Royal Tern	LC
<i>Sterna sandvicensis</i>	Sandwich Tern	LC
<i>Sterna hirundo</i>	Common Tern	LC
<i>Sterna paradisaea</i>	Arctic Tern	LC
<i>Sterna albifrons</i>	Little Tern	LC
<i>Chlidonias niger</i>	Black Tern	LC
<i>Sterna dougallii</i>	Roseate Tern	LC

4.13 FISH ECOLOGY

The composition and distribution of fish species found in Ghanaian waters, and the wider Gulf of Guinea, is influenced by the seasonal upwelling that occurs between Nigeria and the Ivory Coast mainly in July to September and to a lesser extent in December to February. The rising of colder, dense and nutrient-rich deep waters stimulate high levels of primary production (phytoplankton) and consequently this will increase the production of zooplankton and fish.

The fish species found in Ghanaian waters belong to four groups:

- small pelagic species;
- large pelagic species (tuna and billfish);
- demersal (bottom dwelling) species; and
- deep sea species

4.13.1 Small pelagic species

The pelagic fish assemblage consists of a number of species that are exploited commercially but are also important members of the pelagic ecosystem, providing food for a number of large predators, particularly large pelagic fish such as tuna, billfish and sharks. The most important pelagic fish species found in the coastal and offshore waters of Ghana are:

- round sardinella (*Sardinella aurita*);
- flat sardinella (*S. maderensis*);
- European anchovy (*Engraulis encrasicolus*); and
- chub mackerel (*Scomber japonicus*).

These species are important commercially as they represent approximately 80 percent of the total catch landed in the country.

Acoustic surveys have shown that the two sardinella species and the European anchovy represent almost 60 percent of the total biomass in Ghanaian waters (FAO & UNDP, 2006).

Further detail on the above listed species can be found in Annex B1.

4.13.2 Large Pelagic Species

Large pelagic fish stocks off the coast of Ghana include tuna and billfish. These species are highly migratory and occupy the surface waters of the entire tropical and sub-tropical Atlantic Ocean. They are important species in the ecosystem as both predators and prey for sharks, other tuna and cetaceans as well as providing an important commercial resource for industrial fisheries.

The tuna species are:

- skipjack tuna (*Katsuwonus pelamis*);
- yellowfin tuna (*Thunnus albacares*); and
- bigeye tuna (*Thunnus obesus*).

Billfish species occur in much lower numbers and comprise:

- swordfish (*Xiphias gladius*);
- Atlantic blue marlin (*Makaira nigricans*); and
- Atlantic sailfish (*Istiophorus albicans*).

Further detail on the above listed species can be found in Annex B1.

4.13.3 Demersal Species

Demersal fish are widespread on the continental shelf along the entire length of the Ghanaian coastline. Species composition is a typical tropical assemblage including the following families:

- Three Porgies or seabreams (*Sparidae*), eg *Pagellus bellottii*, *Pagrus caeruleostictus*, *Dentex canariensis*, *Dentex gibbosus*, *Dentex angolensis* and *Dentex congoensis*;
- Two Grunts (*Haemulidae*), eg *Pomadasys incisus*, *P. jubelini* and *Brachydeuterus auritus*;
- One Croakers or drums (*Sciaenidae*), eg *Pseudotolithus senegalensis*;
- Goatfishes (*Mullidae*), eg *Pseudupeneus prayensis*;
- Snappers (*Lutjanidae*), eg *Lutjanus fulgens* and *L. goreensis*;
- Groupers (*Serranidae*), eg *Epinephelus aeneus*;
- Threadfins (*Polynemidae*), eg *Galeoides decadactylus*; and
- Emperors (*Lethrinidae*), eg *Lethrinus atlanticus*.

The seasonal upwelling of cold and saline waters over the Ghanaian shelf provokes changes in the geographical distribution of many of the demersal fish species. During the upwelling season, the bathymetric extension of the croakers is reduced to a minimum, while the deep water porgies are found nearer the coast than at other times of the year.

The demersal species that are most important commercially are cassava croaker (*Pseudotolithus senegalensis*), bigeye grunt (*Brachydeuterus auritus*), red pandora (*Pellagus bellottii*), Angola dentex (*Dentex angolensis*), Congo dentex (*Dentex congoensis*) and West African Goatfish (*Pseudupeneus prayensis*).

Further detail on the above listed species can be found in Annex B1.

4.13.4 Deep Sea Species

Froese and Pauly (2009) lists over 180 species of deep-sea fish, including 51 bathydemersal species that are associated with the bottom and a further 106 are listed as bathypelagic (1000 to 4000 m). The remaining species are generally considered to occupy depths to 1000 m (ie epipelagic or mesopelagic) but may venture into deeper water during part of their lifecycle.

Froese and Pauly (2009) lists 89 species from 28 families that are likely to be found in Ghanaian waters within the depth range 1,100 and 1,700 m.

Table 4-21 provides a list of the families and representative species that potentially occur on the seabed in the project area.

Table 4-21 Deep Water Fish Families Potentially Present in the Project Area

Family	Species
Alepocephalidae	<i>Asquamiceps caeruleus</i> , <i>Bathytroctes microlepis</i> , <i>Xenodermichthys copei</i> , <i>Herwigia kreffti</i> , <i>Einara macrolepis</i> , <i>Alepocephalus rostratus</i> , <i>Talismania antillarum</i> , <i>Leptoderma macrops</i> , <i>Talismania homoptera</i> , <i>Talismania mekistonema</i> , <i>Talismania longifilis</i>
Bathysauridae	<i>Bathysaurus mollis</i>
Carapidae	<i>Snyderidia canina</i>
Centrophoridae	<i>Centrophorus lusitanicus</i>
Congridae	<i>Bathyrcongus vicinus</i>
Dalatidae	<i>Dalatias licha</i>
Gempylidae	<i>Lepidocybium flavobrunneum</i> , <i>Nesiarchus nasutus</i> , <i>Nealotus tripes</i>
Gonostomatidae	<i>Diplophos taenia</i> , <i>Cyclothone braueri</i> , <i>Bonapartia pedaliota</i> , <i>Cyclothone pallida</i> , <i>Cyclothone microdon</i> , <i>Cyclothone alba</i> , <i>Cyclothone livida</i> , <i>Gonostoma atlanticum</i> , <i>Sigmops bathyphilus</i> , <i>Cyclothone obscura</i>
Halosauridae	<i>Halosaurus ovenii</i>
Ipnopidae	<i>Bathymicrops regis</i> , <i>Bathytrophops sewelli</i> , <i>Bathypterois atricolor</i> , <i>Bathypterois quadrifilis</i> , <i>Bathypterois grallator</i>
Macrouridae	<i>Malacocephalus occidentalis</i> , <i>Malacocephalus laevis</i> , <i>Nezumia aequalis</i> , <i>Nezumia duodecim</i> , <i>Nezumia micronechodon</i> , <i>Bathygadus melanobranchus</i>
Myctophidae	<i>Diaplys perspicillatus</i> , <i>Ceratoscopelus warmingii</i> , <i>Notoscopelus resplendens</i> , <i>Diaplys lucidus</i> , <i>Lobianchia dofleini</i> , <i>Diaplys splendidus</i> , <i>Lampadena anomala</i> , <i>Lampanyctus alatus</i> , <i>Benthosema suborbitale</i>
Nemichthyidae	<i>Nemichthys scolopaceus</i> , <i>Nemichthys curvirostris</i>
Neoscopelidae	<i>Scopelogadus tristis</i>
Nettastomatidae	<i>Nettastoma melanurum</i> , <i>Venefica proboscidea</i>
Notosudidae	<i>Ahliesaurus berryi</i>
Ogcocephalidae	<i>Dibranchius atlanticus</i>
Ophidiidae	<i>Monomitopus metriostoma</i>
Opisthoproctidae	<i>Dolichopteryx binocularis</i> , <i>Winteria telescopa</i>
Paralepididae	<i>Dolichosudis fuliginosa</i>
Phosichthyidae	<i>Vinciguerra nimbaria</i>
Platytrichtidae	<i>Barbantus curvifrons</i> , <i>Holtbyrnia innesi</i> , <i>Sagamichthys schmakenbecki</i> , <i>Platytrichtes apus</i> , <i>Maulisia mauli</i> , <i>Searsia koefoedi</i>
Rajidae	<i>Bathyraja hesperaficana</i> , <i>Rajella barnardi</i> , <i>Dipturus doutrei</i>
Serrivomeridae	<i>Serrivomer beanie</i>
Squalidae	<i>Squalus uyato</i>
Sternoptychidae	<i>Sternoptyx pseudobscura</i> , <i>Argyropelecus hemigymnus</i> , <i>Argyropelecus sladeni</i> , <i>Argyropelecus affinis</i> , <i>Sternoptyx diaphana</i>
Stomiidae	<i>Astronesthes macropogon</i> , <i>Flagellostomias boureei</i> , <i>Stomias affinis</i> , <i>Stomias longibarbus</i> , <i>Borostomias cluensis</i> , <i>Malacosteus niger</i> , <i>Pachystomias microdon</i> , <i>Bathophilus brevis</i> , <i>Heterophotus ophistoma</i>

Source: Froese and Pauly (2009)

Maintenance of deep-sea fish communities depends on the presence of large fish to break up the bulk of the carrion falls, allowing the majority of fish species to access a vital food source and the presence of small amphipods (small crustaceans) at the basis of the food chain that support many of the larger fish.

4.13.5 Protected or Endangered Species

The sensitive species in Ghanaian waters according to the IUCN red list (IUCN, 2013) are presented in Annex B1. Of these only the tuna and swordfish species are likely to occur in the water depths found in the project field area.

A number of these species are commercially important and are subjected to heavy exploitation, particularly Albacore tuna and swordfish. It should be noted that Albacore catches in Ghanaian waters are not currently recorded (ICCAT Fishstat data). Of the listed species, bigeye tuna, yellowfin tuna and swordfish are recorded as being present in the project area. These species are all found within the surface waters of the area (the first 100 m below the surface). Swordfish and bigeye may also be found at depths up to 250 m.

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In the global context there is concern about the bigeye tuna stocks. The International Commission for the Conservation of Atlantic Tunas (ICCAT) has listed it as the species of greatest concern, after the bluefin, in terms of its population status and the unsustainable levels of exploitation exacted on this species.

4.14 MARINE HABITATS AND PROTECTED AREAS

In the marine area affected by the project operations no protected or restricted areas have been highlighted by the desktop study. Ghana has not declared any marine protected area with the exception of Ramsar sites that are all located onshore.

5 SOCIO-CULTURAL BASELINE

There are 10 administrative regions in Ghana, same as in 1984. The coast and the sea are very important for the people of Ghana and for the Country's economy. The main economic activities practiced in the coastal zone are fishing, farming, manufacturing, salt production, oil and gas extraction and tourism.

The Western region covers an area of approximately 23,921 square kilometres, which is about 10 per cent of Ghana's total land area and some 75% of its vegetation is classifiable as high forest area. It lies in the equatorial climatic zone that is characterized by moderate temperatures and is also the wettest part of Ghana with an average rainfall of 1,600mm per annum. The southernmost part of Ghana lies in this region, at Cape Three Points near Busua, in the Ahanta West District.

Table 5-1 Districts in the study area coastal zone with relative population, surface area and shoreline length

Region	District	Population	Area (sq. km)	Coastline (km)
Western	Jomoro	150,107	1,350	55
	Nzema East	90,915	982	30
	Ellembelle	87,501	1,468	28
	Ahanta West	106,215	568	57
	STM	559,548	50	
	Shama	81,966	215	

5.1 SOURCE CENSUS 2010, USAID 2010 ADMINISTRATIVE STRUCTURE

The government structure in Ghana is made up of ten administrative regions subdivided into 170 metropolitan, municipal and districts areas, each with an administrative assembly comprised of a combination of appointed (a third) and elected (two-thirds) officials. Ghana changed from the local authorities system of administration to the district assembly system in 1988. The country was demarcated into 138 districts out of the existing 140 local authorities. The boundaries of the districts do not necessarily conform to the boundaries of the local authorities but are coterminous with regional boundaries.

The Western Region was once a single vast province covering the present Western and Central Regions, and known as the Western Province, with its capital in Cape Coast, until the country achieved republican status in 1960. The Region, as presently constituted, became a separate administration in July 1960, with Sekondi as its capital, when the Central Region was carved out of the erstwhile province. Present day urbanised settings have made Sekondi and Takoradi one big metropolis.

The Western Region (the Region closest to the project) currently comprises 17 Districts, two Municipalities, and one Metropolis, the latter being STM. The Districts and their District capitals are presented in Table 5-2. Six of the 17 districts constitute the coastal districts of the Western Region; Jomoro, Nzema East, Ellembelle, Ahanta West, Shama and Sekondi-Takoradi.

The **Nzema East** Municipal was once somewhat larger but after the creation in its more westerly area of first Jomoro and then Ellembelle, now covers a distinctly smaller surface area. Its capital is Axim. The **Jomoro** District (which used to be part of the then Nzema East Municipal) was created by Legislative Instrument 1394 in 1988, and lies on the Country's border with Cote d'Ivoire, to the West. The District's capital is Half Assini. The **Ellembelle** District was carved out of the then Nzema East District in December 2007 by (LI) 1918 and inaugurated in February 2008, with Nkroful as the District Administrative seat or Capital. Shama District was created in 2005.

There is very little published data available for these newly created Districts; much information still refers to the previous administrative subdivision of the Region and most of the information presented here for the new Districts is derived from the interviews with District officials.

Table 5-2 Districts and Capitals of the Western Region

Districts	Administration Type	Capitals
Jomoro	District	Half Assini
Nzema East	Municipality	Axim
Shama	District	Shama
Sekondi-Takoradi	Metropolis	Sekondi
Ellembele	District	Nkroful
Ahanta West	District	Agona Nkwanta
Tarkwa Nsuaem (Wassa West)	Municipality	Tarkwa
Wassa Amenfi West	District	Asankragua
Aowin-Suaman	District	Enchi
Juabeso	District	Juabeso
Sefwi-Wiawso	District	Sefwi-Wiawso
Bibiani-Anhwiaso-Bekwai	District	Bibiani
Bia	District	Essam
Wassa-Amenfi East	District	Wassa Akropong
Pristea Huni Valley	District	Bogoso
Sefwi Akontombra	District	Sefwi Akontombra
Mpohor-Wassa-East	District	Daboase

The Regional Coordinating Council (RCC), which is the highest decision-making body, comprises the Regional Minister who is also its Chairperson, District Chief Executives, Presiding Members of the various District Assemblies and two Paramount Chiefs nominated by the Regional House of Chiefs. There is also a Regional Coordinating Director, who is the Secretary to the RCC and the head of the civil administration of the region.

Each District has a District Chief Executive (DCE) who heads the local assembly. The DCE is nominated by the President of the country and is confirmed by the assembly through balloting. The local government is made up of the Regional Coordinating Council (RCC), four-tier Metropolitan and three-tier Municipal/District Assemblies with Urban/ Town/ Area/ Zonal Councils. Each Electoral Area (EA) is represented at the assembly by an elected assembly member and has a Unit Committee.

The District Assemblies constitute:

- the pivot of administrative and developmental decision-making in the district and the basic unit of government administration.
- the Administrative entity assigned with deliberative, legislative as well as executive functions.
- The monolithic structure assigned the responsibility of the totality of government to bring about integration of political, administrative and development support needed to achieve a more equitable allocation of power, wealth, and geographically dispersed development in Ghana.
- the Planning Authority for the District.

Meanwhile, Paramountcies constitute the expression of traditional authorities and hierarchical structures of Ghana, and carry great influence. This monarchical authority ensures the maintenance of law and order among the traditional hierarchies and the people, handles all affairs pertaining to stools, and mediates in chieftaincy disputes.

In Jomoro District there is just one Paramountcy, the Western Nzema Traditional Council, with its capital at Beyin. Ellembelle District too has only one Paramountcy, the Eastern Nzema Traditional Council, situated at Atuabo. While Nzema East Municipal, though largely reduced in size over the years, has five Paramountcies, which are:

- Lower Axim Traditional Council -Axim
- Upper Axim Traditional Council - Axim
- Nsein Traditional Council - Nsein
- Ajomoro Traditional Council - Apataim
- Gwira Traditional Council - Bamiankor

All the Traditional Councils, in the three Districts of Nzema East, Ellembelle and Jomoro, constitute the Nzema Manle Council (District House of Chiefs), with headquarters at Esiam. Finally, there are three Paramountcies in Ahanta West, namely Busua, Upper Dixcove and Lower Dixcove with the Ahantahene (Omanhene) at Busua.

5.2 HISTORY AND CULTURE

The Western Region comprises five **major indigenous ethnic groups**. These groupings exhibit a high degree of cultural homogeneity, especially in the areas of lineage, inheritance and succession, marriage and religion. The location occupied by the five major ethnic groups in the region cannot be clearly and unambiguously defined, as their boundaries overlap.

The Ahantas, who form about 6%, and the Nzemas (including the Evalues) 11% of Ghanaians by birth in the region, occupy the entire coastline from Shama on the east to the western border of Ghana.

The Wassa people, who form about 12 per cent of Ghanaians by birth in the region, can be found further inland off the coast towards the interior. However, the people of Essiam in the Ellembelle district also trace their lineage to the Wassa people who first settled along the coast.

The Sefwis who represent about 11% and the Aowins who constitute about 3% of Ghanaians by birth in the region are in the northern part of the region.

There yet other indigenous minorities present in the region, among these the Pepesa.

Although not indigenous to the Region, about 18% of Ghanaians by birth in the region are Fantes; settlers who migrated several years ago from the Central Region, and have since then fully integrated themselves into the indigenous populations. Apart from the Fantes, **other ethnic groups who have migrated into the region** are the Asantes (7.3%), Ewes (5.9%), Brongs (3.4%) and Kusasis (2.9%). Most of the region's inhabitants are either Ghanaians by birth (92.2%) or by naturalisation (4.1%), with a few immigrants from other neighbouring West African countries.

The **languages/dialects** of the Sefwis and Aowins are very similar to each other, as well as to the Ahanta and Nzema languages. The four groups can converse with each other in their own peculiar dialects or languages and still understand one another.

It is worth noting that although Ahanta, Nzema, Wassa, Sefwi and Brossa (Aowin) are the languages spoken by the indigenes of this region, Fante is widely spoken as a second language in the southern part of the region. It is in fact the school language and medium of instruction in lower primary classes in many of the basic schools. Twi is more widely spoken in the Sefwi and Bibiani areas even though Fante is also widely spoken in the same areas. The only other language used as a school language/medium of instruction is Nzema, even though Ahanta has now also become a written language.

There is complete freedom of religious belief in the region, however the major **religious denominations** are Christian (81%) (Pentecostals (21.6%), Protestants (19.5%), Methodists,

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Catholics (19.4%), Christ's Church) and other Charismatic churches. Muslims (8.5%) and traditionalists (1.5%) follow suit.

Though Western Christian religions are widely embraced, most of the local communities tend to adapt their Christian faith to the practice of local traditions. In fact the local populations are in practice largely traditionalists with a high commitment to **traditional beliefs and practices**. Most communities have their own 'fetish priest or priestess'. Most rituals or 'fetishes' nowadays consist in animal sacrifices to the chief god and other smaller gods. The essence of most rituals is to seek for peace and unity as well as development of the community. Given this manifest attachment to traditional practices the Western Region is naturally littered with cemeteries and royal cemeteries (mausoleums), sacred spots, shrines and other **cultural sites**. Moreover, there are diverse **taboo practices** in place; in many of the coastal fishing communities any activity in the lagoon is prohibited on Wednesdays, fishing is not undertaken on the seas on Tuesdays and Thursdays are taboo days for farming.

The major **festival** among the Ahanta and the Nzema people of the Western Region of Ghana is the Kundum festival, and is held in all the major traditional chiefdoms/paramountcies of the study area. The festival is celebrated between September and October, more or less coinciding with the harvest period, and constitutes an important expression of culture, social cohesion and politics of the Ahanta and Nzema people. During Kundum 'food' is offered to the gods and is an occasion for:

- Thanks giving and paying of homage;
- Honouring ancestors;
- Socialization;
- Unity and peace (rekindling the sense of community);
- Reconciliation;
- Calibration of life of existing citizens;
- Pour of libation for protection and long life;
- Settlement of disputes among citizens and family members;
- Instilling of moral values (humility and fairness) among the youth;
- Food security.

Other festivals of cultural importance to the local populations are the Odwira (Yam Festival) celebrated by the Gwira Traditional Area (in Nzema East), the new Clan Festival – a colourful and educative socio-economic development festival – which takes place from December 26th to January 1st, as well as several other town-based festivals.

5.3 MACRO-ECONOMIC CONTEXT

Similarly to other African countries, Ghana has endured a number of economic challenges throughout the 70s, 80s and 90s. In response to the "African economic crisis" during the 1980s, the Government of Ghana agreed to implement the International Monetary Fund's (IMF) Economic Recovery Programme (ERP), which focused on stabilisation, rehabilitation and liberalisation. This structural adjustment plan resulted in the changing of many economic policies. Nevertheless, Ghana continued to struggle with the accumulation of large foreign debt and was classified as a "poor" nation by the World Bank (1) .

The recent discovery of oil and gas off the coast of Ghana and resultant extraction and production activities, however, has contributed to an increasing GDP. In 2012, Ghana had a GDP growth rate of 7.9 percent, ranking 13th in the world (CIA World Factbook, n.d).

Development policies exist at a national, regional and district level that have been formulated in response to key political and development milestones in Ghana's history and are summarised in Table 5-3 below.

(1) Defined as countries with a per capita income of less than 1 USD per day.

Table 5-3 Development Policies Relevant to the Project

Policy	Key Aspects
National Level Policies	
The Coordinated Programme of Economic and Social Development Policies, 2010 – 2016 (Agenda for Shared Growth and Accelerated Development for a Better Ghana) (Adopted June 2011)	- Designed to address historical economic and social challenges that are seen to have hampered national development. - Driven by a medium-term vision of shared growth through accelerated job creation, integrated industrial development and agricultural modernisation, via policy measures that the government plans to pursue in order to “transform the economy from its over-dependence on primary raw materials to a diversified economy”. - Priority interventions include: - Economic Development; - Social Development; - Science, Technology & Innovation; - Infrastructure Development; - Spatial Development Zones; - Natural Resource Management; - Environmental Governance; and - Transparent and Accountable Governance.
Land Commission Guidelines for Considering Large-Scale Land Transactions for Agricultural and other Purposes (Approved February 2012)	- Provides guidelines for acquisitions of tracts of land larger than 50 acres. - Highlights that most of the land users in rural areas (where the majority of large scale land acquisitions are occurring in Ghana) are smallholder farmers without registered title deeds or interests on those lands. - Emphasises that most of these farmers have only use rights to the land and are thus vulnerable to negotiations undertaken by a higher interest holder (like a chief or family head) over the release of the land. - Emphasises the participation of all stakeholders in the process of such transaction.
Regional Level Policies	
Western Region Spatial Development Framework 2013--33 (WRSDF) (Draft April 2012)	- Presents a spatial plan for the integration of social, economic and environmental development for the Region. - Zones the Region into three spatial zones. - Identifies the Project Area within Zone 3: Coastal - Industrial Districts. - Recognizes the discovery of oil and gas as a key driver of development in the Region and the DAoI. - Takes account of a specialist oil and gas harbour with associated supply facilities at Atuabo (Ellembelle). - Recognises that to maximise employment opportunities requires long term strategic planning for training as well as wide access to business procurement in institutional, structural and future land use and infrastructure terms.
District Level Policies	
Ellembelle District Assembly Medium-Term Development Plan 2014-2017 (Prepared November 2014)	- The overarching goal of the plan is to: - co-ordinate social services and environmental sustainability; - improve security and develop accessibility to production areas; and - strengthen local institutions to support equitable growth and sustainable development. - Priority focus areas include - ensuring and sustaining macroeconomic stability, - enhancing competitiveness of Ghana's private sector, - accelerated agriculture modernization and sustainable natural resource management, - oil and gas development, - infrastructure and human settlements, - human development, productivity and employment, and - transparent and accountable governance.

Policy	Key Aspects
Atuabo Structural Plan	This plan incorporates the objects of the District Medium Term Development Plan (MTDP) into the Structure Planning Process and makes spatial meaning of the social, economic and environmental proposals in the area. The objectives of the plan include: - To take into account the impacts from the developing gas and oil industry activities and ensure the functional integration of these activities into the local development; - To provide a physical development plan to guide the long term development of Ellembelle within the context of the current WRSDF and Ellembelle Spatial Development Framework (ESDF) with key consideration for the gas processing plant at Atuabo; - To provide the legal and institutional basis for designated land uses, infrastructure networks, permissible developments and densities through an integrated and participatory structure planning process; - To provide the basis for the District's Town and Country Planning Department (TCPD) Office and other institutions to prepare Local plans that would conform to the Structure Plan and WRSDF
Local Plan for Atuabo Petrochemical Enclave in the Ellembelle District	This plan has been prepared under the Western Region Spatial Development Framework Project, The objectives of the plan are: - To provide a physical development plan that will attract and promote investment and guide development within and around the designated Atuabo petro-chemical enclave. - To ensure that reasonable amount of land within the vicinity of the existing Atuabo and Asemndasuazo communities is reserved and planned for future housing and infrastructure development whilst ensuring that land suitable for agricultural use is preserved to protect livelihoods; - To define development guidelines and regulations that will provide the basis for effective development control process towards orderly and harmonious physical development within and around the petro-chemical enclave; and - To contribute to mitigation measures needed to protect the environment and public health from the potential impacts of the industrial activities.
Local Plan for Shama Industrial Park	This plan translates broad policy proposals made for the area at the structure plan level into action and to provide a system for the day to day management of the area, specifically the plan: - Specifies the level of utility services requirement and their distribution plans; - Explains the procedure for land acquisition and the tenurial arrangement systems that pertains to the area; - Outlines the required and permissible land uses, heights, densities and ancillary services that must be provided on each site of the local plan area; - Defines the permissible built area to non-built area per plot; - Provides regulations for building designs, construction materials and colour schemes; - Points out the rights and responsibilities of investors in the local plan area; and - Lists the other approval permits in addition to development and building permits - developers must obtain for developing land.
Shama Structural Plan 2013 - 2033	This plan was deisned to promote growth and manage development over the short, medium and long term. Specific objectives of the plan are; To provide a physical development pattern to guide the long term

Policy	Key Aspects
	development of Shama within the context of the current WRSDF - To provide the legal and institutional basis for the designation of land use, infrastructure, permissible developments and densities through an integrated and participatory structure planning process - To provide the basis for the District's Town and Country Planning Department (TCPD) Office and other institutions to prepare Local plans that will not only conform to the Structure Plan but also to the WRSDF and the DSDF that will guide the future development of the entire district - To incorporate development proposals made in the Medium Term Development Plan (MTDP) into the Structure Plan and to make spatial meaning of the social, economic and environmental proposals made in the MTDP. - To identify areas within the demarcated structure plan area - with prospects of redevelopment and regeneration; - that are environmentally sensitive to some proposed interventions; - that are suitable for intensive development of certain activities; and - with prospects for coordinated development between existing uses and proposed interventions within the DSDF.

5.4 DEMOGRAPHICS AND GEOPOLITICS

The population of Ghana is approximately 24 658 823 million according to the 2010 Population and Housing census, with the Western Region having approximately 2.5 million people (Government of Ghana 2010). The Western Region comprises nine percent of the total population (2.3 million people) and has a population density of 97 people per km² making it the fifth most densely populated region in the country (Ghana Statistical Service, 2012), and has experienced accelerated population growth over the years. Between 1960 and 1970, the population grew by 23 percent, between 1970 and 1984 it more than doubled, while between 1984 and 2000, it increased by 66 percent.

The rapid population growth registered between 1970 and 1984 (high in comparison with the national average) may be attributable to several factors, including an increase in the birth rate and a decrease in the mortality rate over the period. The growth would also have been linked to in-migration resulting from increased economic activity, particularly between 1984 and 2000, when the region experienced a boom in both the mining and the cocoa industries (Population and Housing Census, 2000). The current growth rate in the Western Region mirrors the national growth rate at 2 percent (Ghana Statistical Service, 2012). Population growth in the Western Region are from the 2010 Population and Housing Census, and therefore, pre-date the recent oil and gas developments industry in the region. No more up to date national population statistics are available at the time of writing. The Region is expected to experience population growth in the future as people migrate to the area in search of employment opportunities.

Migration (both in and out) in the region has been affected by geographical and economic factors over the years. The region has the highest rainfall in the country, with the Axim area and the Ankobra and lower Tano river basins having the highest rainfall in the whole country. The high rainfall makes the region suitable for the cultivation of rain-fed forest area cash crops such as cocoa, coconut palm, oil palm, rubber, and a small amount of coffee. The region has the highest production figures for all these four economic crops. This might have attracted people from other regions, notably Brong Ahafo and Ashanti, to the farming areas. In 1970, 35% of the inhabitants of the region were born outside the region. This figure declined to 29.3 per cent in 2000.

Nowadays, migration by the large takes place in the fishing industry. Very large proportions of fishermen in the Region emigrate from the northern parts, moving towards the coastal area during the major fishing season, which is normally between July and September. During this period, fishing-related migration also occurs within and between the shorefront communities all along the coast. The fishing migrants are hosted by the resident coastal communities in their homes, free of charge or at most for token fees.

Another form of migration present in the Region is that associated to **refugees**, currently mainly originating from Ivory Coast. In Ghana, as of October 2011, there were about 18,000 Ivorian refugees.

The **Krisan Refugee Camp** situated in the study area is a melting-pot of cultures, religion, and languages; it is home to **1,700 refugees** from several African nations; Burundi, Democratic Republic of the Congo, Côte d'Ivoire, Liberia, Republic of Congo, Rwanda, Sierra Leone, Somalia, Sudan and Togo. The camp is well planned in terms of structures and the people though from different countries seem at peace with one another. Nevertheless, the camp's population are in need of improved livelihood resources and livelihood stability.

Population density (standing at 104 persons/km² in Jomoro, 80 persons/km² in Ellembelle and 62 persons/km² Nzema East, and 167 persons/km² in Ahanta West) would indicate no great pressure of population on the land tout-court. However, the same cannot be said of pressure on resources and existing infrastructure. For example, settlements or growth points such as Esiam and Aiyinasi in Ellembelle District, though urbanised areas, have been experiencing relatively higher population densities with corresponding pressure being exerted on existing and limited infrastructural facilities.

The head of the household is the one who is identified as the head by members of the household and not necessarily the one who maintains the household. The Region is characterised by 72% male-headed households against 28% female-headed households. Other relatives and grandchildren, who are an extension of the nuclear family, make up 26% of the household structure. According to the 2010 Census, there are 553,635 **households** in the region, occupying 380,104 **housing units**, which give an average of 1.5households per house. Comparable past averages are 2.2 for 1970 and 2.0 for 1984. This may be the result of increases in supply of houses.or a slow-down in the formation of new households.

The average **household size**, that is, the average number of persons in a household, has been on the increase since 1960, when 3.8 was recorded. This increased to 4.0 in 1970 and to 4.4 in 1984. The average number of persons per household for 2010 is 4.2. Notwithstanding the constant increase over the years, the household size in the region is still below the national average of 4.4. The observed large household sizes over the years may be the result of the high fertility rate (3.9 per woman) prevailing in the region and the practice of adult children with offspring, staying with their parents.

The number of houses in the region increased from 61,103 in 1960 to 127,427 in 1984, and further to 259,874 in 2000, and to 380,104 in 2010. While this constitutes an increase in housing stock, the increase in housing stock has lagged behind population growth as reflected in the number of people per house in the region, which is still considered too high, notwithstanding its steady decline from 10.2 in 1970 to 9.0 in 1984, and further to 6.3 in 2010. Household members or relatives own more than half of the houses in the region; and generally make them available to other relatives either for a token rent or free of charge. Most of the houses, particularly in the rural areas, are constructed with sun-dried mud bricks with cemented floors and corrugated metal roofing materials.

42.4 % of the Western Region is urbanised and the remaining 57.6% is rural (the rural/urban classification of localities is population based, with a population size of 5,000 or more being urban and less than 5,000 being rural).

The population of the Western Region is relatively young, with approximately 45 percent of the population falling between the ages of 0 and 15 years while 3% of the population are more than 64 years old . A summary of the **age characteristics** by District is provided in Table 5-4. The new Districts of STM and Shama have reported separate data. Jomoro has the lowest proportion of people between 0 and 15 years (41 percent) compared with the other Districts with between 42 percent and 44 percent. Only three percent of the population in the Region are older than 64 years. The age structure follows the known trend of a developing economy with a broad base (many young people) that gradually tapers off with increasing age. Jomoro has the largest proportion of the population (53 percent) in the working age group (15-64 years) in the Region. Ahanta West (52 percent) also has a significant proportion of the population in this age group. These figures may be due to migration of young adults to the commercial and mining towns in these Districts.

Table 5-4 Age Characteristic by District

District	0 -14 years	15 – 64 years	Over 65 years
Shama	41.2	54.1	4.7
STMA	32.6	63.2	4.1
Ahanta West	41.4	54.2	3.8
Nzema East	41.0	55.2	2.8
Ellembelle	39.4	55.7	4.9
Jomoro	40.0	55.6	4.4
Western Region	39	57.2	3.8

Source: Regional Analytical Report-Western Region Ghana Statistical Services,2010 Census.

There is a relatively high dependency ratio in the Region. This is attributable to the high proportion of the population who are not economically active; primarily due to age (younger than 15 years or older than 64 years) and high levels of unemployment. This dependency places a heavy burden on the economically active sector of the population in the District and can lead to low standards of living.

Gender distribution within the populations of each District are illustrated in Table 5-5.

Table 5-5 Population by District and Gender

Geographical Area	Sex		
	Total	Male	Female
Ghana	24,658,823	12024845	12633978
Western Region	2,376,021	1187774	1188247
Jomoro	150,107	73561	76546
Ellembelle	87,501	42317	45184
Nzema East	60,828	29947	30881
Ahanta West	106,215	50999	55216
STM	559,548	273436	286112
Shama	81,966	38704	43262

Source: Ghana Statistical Service, 2010

An overview of the population characteristics for the six coastal Districts that form part of the study is hereby provided.

Jomoro District. The District has a total population of 150,107 and a population growth rate of 3.2 percent. The District is mainly rural (29.6percent urban) with only four settlements having

populations in excess of 5,000. The major settlements with larger populations are Bonyere, Elubo, Half Assini and Tikobo No.1. Population density has increased over recent years with 2010 figures being 103.7 persons per km². Almost 15.8 percent of the population are immigrants, mainly settled in the northern part of the District. About 53 percent of immigrants are male and 58 percent are in the age group of 18 - 35 years.

Nzema East Municipality. The District has a total population of 60,828. The population density was 62 per km². The area is largely rural (26.6 percent urban) with most communities having a population of less than 5,000. However, a steady rural to urban migration has seen an increase in the urban populations in recent years. According to the municipal planning office, migrations tend to be seasonal with persons migrating to farming areas during the farming season and to the coast during the fishing season. There is, however, no data to indicate whether there has been an increased migration into the District recently.

Ellembelle District. The District has a total population of 87,507. The population density of the District is 80.1 persons per km². The District is mainly rural with only 26 percent of the population living in urban centres.

Ahanta West District. A population of 106,215 was reported for this District in 2010.. The District is characterised by a high population density of 198 persons per km² in 2010 compared with regional population density of 51 per km². The high population density of the District indicates population pressure on land and other limited facilities and services within various settlements. Approximately 80 percent of the population lives in rural settlements making Ahanta West a rural District.

Sekondi-Takoradi Metropolis (STM). The population of STM was 559,548 in 2010. It is the most populated area in the Western Region and comprised about 23.5 percent of the regions total population in 2010. Population density is 2,712.3 people per km². The STM has 49 communities and approximately 14 of these settlements have a population exceeding 7,000. The major settlements are Takoradi, Effia-Kwesimintsim, Effiakuma, and Sekondi. Built up areas in the Metropolis can be classified into urban and rural settings. The urban portions constitute about 32 percent of the land area and accommodate close to 70 percent of the population. Sekondi-Takoradi, serves as a destination as well as transit point for approximately 80,000 migrants mostly from rural portions of the country that commute to the area in for work. This has resulted in the increased development of slums in the city.

Shama District. The population of the District was reported as 81,966 in the 2010 census. Population density is 549 people per km². The population growth rate of 3.5 percent in 2000 was higher than the regional and national averages of 3.2 percent and 2.7 percent respectively. The District experiences emigration of economically active people in search of employment in major urban centres.

5.5 LOCAL ECONOMY AND LIVELIHOOD RESOURCES

Ghana's domestic economy currently revolves around agriculture (which includes fishing). This accounts for about 45 to 50 percent of GDP and employs about 55 percent of the work force, mainly small landholders and fishers. Other major sources of employment include mining and quarrying (employing approximately 15 percent of the population), and manufacturing, employing approximately 11 percent of the population.

Ghana also has a wide range of natural, cultural and historical attractions, which provides the basis for the growing tourism industry. Indeed, according to the Ghana Investment Promotion Centre (2010), Ghana's tourism sector is expected to grow at an average rate of 4.1 percent per annum over the next two decades. Since the late 1980s tourism has received considerable attention in the economic development strategy of Ghana. The number of tourist arrivals and amount of tourists'

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expenditure has steadily increased, while both public and private investment activity in various tourism subsectors have expanded (GIPC, 2010).

5.5.1 Regional Economic Activities

The **Western Region** is endowed with considerable natural resources, which give it a significant economic importance within the context of national development potential. It is in fact one of the largest producers of **cocoa**, rubber and coconut, and one of the major producers of **vegetable oils** as a result of the extensive oil palm and coconut plantations. The Benso Oil Palm Plantation, owned by Unilever Ghana Limited, is one of the largest in the country. The region also has the largest and only economically viable **rubber plantation** in the country, stretching from Agona Junction to Bonsa on the Tarkwa road, from Agona Junction to Dadwen on the Axim road, and Baamiangor in the Dwira traditional area on the Esaaman to Dominase/Enibil road. The plantations used to support the erstwhile but still potentially viable Firestone tyre factory at Bonsa, but now support only the **rubber-processing factory** at Agona Junction, which processes rubber into a semi-finished product for export. Moreover, the rich tropical forest makes the Region one of the largest producers of **raw and sawn timber** as well as processed **wood products**, while a wide variety of minerals, including gold, bauxite, iron, diamonds and manganese are either being exploited or are potentially exploitable. The region's total geological profile and mineral potential are yet to be fully determined. Large potential deposits of **gas and crude oil** that are nearest to possible economic exploitation can be found in the Tano Basin and offshore in the Jomoro (Western Nzema) District. The same district has high quality limestone and fine sand deposits upon which the country's cement and glass industries can rely. Finally, some **salt production** is practiced in the coastal Districts of the Western Region.

The major **industrial activities** in the region are consequentially agriculture, excluding fishing but including forestry and hunting (58.1%), mining and quarrying (2.4%), manufacturing (10.2%) and wholesale and retail trade (10.3%), while the four major **employment sectors** in the region are agriculture including fishing, animal husbandry and hunting (58.1%), production and transport work (14.5%), sales work (10.2%) and professional and technical work (5.4%).

The **economically active population** in all the districts (except the Shama-Ahanta East metropolitan area) exceeds 70%. However, more than two-thirds of the economically active population in all the districts of the region are made up of self-employed persons with no employees, i.e. involved in **mainly subsistence activities**.

Subsistence farming, including fishing, is in fact the most widely practiced economic activity by the Region's population. Food crops produced are mainly cassava, maize, rice, cocoyam, plantain, pepper and tomatoes; rice is grown in some low-lying areas. Fishing shall be dealt with in greater detail further on in the Report.

The **tourism potential** in the Western Region is related to the number and extent of pristine tropical beaches as well as wildlife parks and forest and game reserves featuring tropical rainforests, inland lakes and rivers. Some of the most popular recreational beaches along the western coastline are located at Biriwa, Brenu Akyinim, Busua, Butre, Cape Coast, Egyembra, Elmina, Komeda, Sekondi and Takoradi (Ghana Tourism Bureau, 2010). Hotels are generally located at popular beach destinations and at commercial centres. There are a total of only 28 waterfront hotels (approximately 1000 beds) along the whole Ghanaian coast officially registered at the Tourist Board of Ghana.

5.5.2 Economic Activities at Coastal Districts

Similarly to the Region at large, **economic activities within the study area** include small-scale agriculture, processing of coconut oil, fishing, trading and petty-trading, coastal salt production, some forestry, as well as more formal sources of employment (teaching, health care, etc.). Fisheries, small-holder farming and tourism are the three most important activities in relation to the study area.

The **agricultural activities** within the coastal districts of the Western Region reflect those typical of the Western Region overall. There is evidence of agricultural activities throughout the coastal area, including small plots where coconuts, cassava, palm-nut, plantain, corn and vegetables are grown. Some **livestock herding** is also practiced along the coastal road. According to an assessment of critical coastal habitats of the Western Region of Ghana, implemented by the Coastal Resources Center - University of Rhode Island in 2010-2011, the following crops can be found in the referral coastal districts (see Table 5-6). It is evident that most resources are used both for subsistence and sale; in fact the general rule among subsistence farming and fishing communities is that in presence of surplus, resources are taken to the nearest market place for sale. Table 5-6 also highlights community participation in resource use by gender and age group.

Table 5-6 Agricultural Resources Use in the coastal districts of Western Region (source: "Assessment of Critical Coastal Habitats of the Western Region, Ghana, University of Rhode island & USAID, July 2011)

Resource	Use	Amansuri (macroareas 1-4)			Ankobra			Cape Three Points (macroareas 6-7)			Princetown (macroareas 5-6)		
		m	w	c	m	w	c	m	w	c	m	w	c
Cassava	d	x	x	x	x	x	x		x		x	x	x
	s	x	x	x	x	x	x		x		x	x	x
Cocoyam	d				x	x	x						
	s				x	x	x						
Mushroom	d							x	x	x			
	s							x	x	x			
Pepper	d												
	s												
Plantain	d	x	x	x	x	x	x						
	s	x	x	x	x	x	x						
Tomatoes	d												
	s												
Vegetables	d				x	x	x						
	s				x	x	x						
Yam	d				x	x	x						
	s				x	x	x						
Medicinal herbs	d	x	x	x									
	s	x	x	x									
Coconut	d	x	x	x	x	x	x				x		
	s	x	x	x	x	x	x				x		
Palm nuts	d												
	s												

d=domestic, s=sale, m=men, w=women, c=children.

Tourism in the region has been described as the country's sleeping giant. Even though the Central Region often comes to mind when tourism is discussed, the sheer mass of the tourism potential of the Western Region is yet to be properly assessed and exploited. The region has the second largest concentration of forts and castles in the country, accounting for seven out of the country's fifteen selected tourist forts under the Museums and Monuments Board. Fort St. Anthony in Axim is the second oldest Fort and European settlement in Ghana. Others are Fort Apollonia in Beyin, Fort Gross-Friedrichsburg at Princetown, and Fort Metal Cross at Dixcove.

Table 5-7 Historical Monuments situated along the Ghana Western Coastline

Town/Location	Monuments
Beyin	Fort Appolonia built in 1770 by Britain
Sawoma	Monument
Axim	Fort Antonio built in 1515 by the Portuguese
Princess Town	Fort Gross Fredericksburg built in 1683 by Brandenburg-Prussians
Akoda	Ruins of and old Fort Dorothea
Dixcove	Fort Metal Cross built in 1692 by the British
Butre	Fort Batenstein built in 1656 by the Dutch
Sekondi	Fort of Orange built in 1656 by the Dutch
Shama	Fort St. Sebastian built in 1523 by the Portuguese
Komeda	Ruins of Fort Vredenburg built by the Dutch in 1682
	Fort English built by the Dutch in 1687
Elmina	Elmina Castle (St. George's Castle) built in 1482 by the Dutch
	Fort St. Jago built in 1665 by the Portuguese
Cape Coast	Cape Coast Castle built in 1653 by the Dutch
Moree	Fort Nassau built in 1612 by the Dutch
Anamabo	Fort Charles built in 1630 by the Dutch
Abandze	Fort Amsterdam built in 1631 by the British

Source: *Environmental Sensitivity Map for the Coastal Areas of Ghana, 2004*

The area has a substantial **eco-tourism potential** which is yet to be fully exploited. There is the southernmost part of Ghana at Cape Three Points near Busua in Ahanta West, a part of which is already a classified forest reserve, which is destined to be enlarged extending down towards the coastline. Wildlife and nature reserves in the Western Region include ANKasa Conservation Area including Nini-Suhein Natinal Park, Amansuri Conservatin Area (the wetlands which include the internationally recognised bird sanctuary, located in Nzema East), and Bia National Park. There can also be found the famous Nzulezo village built on stilts on water in Jomoro, as well as the sea turtle conservation area at Krisan near Eikwe, in the same district.

Moreover, there are clean and still unspoilt coconut palm-lined beaches, well-preserved wildlife parks and forest and game reserves. Some of the more popular recreational beaches along the western coastline are located at Biriwa, Brenu Akyinim, Busua, Butre, Cape Coast, Egyembra, Elmina, Komeda, Sekondi and Takoradi.

With regards to tourism infrastructure the area still requires great investment. The region has some good, moderately priced hotels and eco-tourism hotels dotted around the beaches and nearby areas. In fact, hotels are generally located at the popular beach destinations and at commercial centres.

In recent years, tourism in Ghana has become a major socio-economic activity and one of the most important and fastest growing sectors of the Ghanaian economy. The number of tourist arrivals and amount of tourists' expenditure has steadily increased, while both public and private investment activity in various tourism sub-sectors have expanded. In 2004, the sector attracted more than 500,000 foreign tourists with the corresponding tourist receipts of US\$640 million. No wonder economists have predicted that the economic survival of Ghana will depend on what Governments will do to treat and manage the tourism sector. In the meantime the Government of Ghana has expressed its intentions to use tourism as an alternative development strategy to help address broad national issues. Indeed, discussions on tourism during eni site selection field survey meetings with the District Assemblies of Jomoro, Ellembele, Nzema East and Ahanta West (June 2012), all revealed clear plans to invest in the districts' tourism development.

5.5.3 Economic Activities by District

Jomoro District

The economy of Jomoro District consists of a large traditional agricultural sector made up of mostly small-scale farmers, a growing sector of small informal traders, artisans and technicians, and a small processing and manufacturing sector. Approximately 54 percent of the population is engaged in the agricultural sector, comprised of 39 percent farming and 15 percent fishing. Major crops grown are cassava (40.5%), coconut (16 %), maize (15%), cocoa (9.4%), and plantain (9.4%). The use of traditional farming methods, which include slash and burn and the extraction of wood fuel, is resulting in deforestation. Both inland and sea fishing is another major economic activity and is characterised by the use of canoes with out-board motors and dragnets. The District has extensive rainforest and wood harvesting takes place around Mpataba, Nuba, Ankasa, Tikobo No.1, Ellenda and Anwiafutu area. There are, however, no established timber processing companies in the District. Larger industries in the District include the Wienco factory which manufactures erosion control mats from coconut husks. There is also the Effasu Power Plant which is due to be recommissioned in the near future.

Nzema East Municipality and Ellembelle District

Information on economic activities in the area is only available for the former Nzema East District which included both Nzema East Municipality and Ellembelle District. Sixty percent of the population in this area is involved in agriculture and agro-processing. The major tree crops grown are coconut, oil palm, rubber and cocoa with cassava and plantain being the major food crops. Vegetables are also cultivated among other crops and rice is grown in some low-lying areas like Asanta, Kikam, Esiana and Kamgbunli. Food crops such as cassava, maize, rice, cocoyam and plantain are grown extensively both for subsistence and for cash. Coconut is grown extensively in the District especially in the southern part while cocoa is grown commercially in the northern parts of the area. In recent years, Cape St. Paul's Wilt Disease has devastated about half of the coconut plantations in this area. This has seriously affected the economic livelihoods of people in these areas, leading to low incomes and increased unemployment. Fishing is a key economic activity in the area. The District has the second highest marine fish production in Ghana and approximately nine percent of the population is involved in the fishing sector. According to the Ellembelle District planning officer, the area also has economic minerals such as kaolin, silica and gold; the latter which is currently being exploited by the Adamus Resources Limited.

Ahanta West District

Approximately 65 percent of the active population in Ahanta West is directly involved in agricultural production. Farming is the major economic activity in the District. Other economic activities include informal trading, processing of agricultural produce mainly oil palm, cassava, rubber and other trades like hairdressing, dressmaking, carpentry, block-making, auto-electricians, fitting, car-body spraying, refrigeration mechanics or repairers and others. Oil palm and rubber are the major cash crops, however, farming is mainly subsistence in nature. Apart from rubber and oil palm, food crops such as cassava, maize, plantain, vegetables are also cultivated in the District. Significant timber and sawmills in the Western Region are located in the District. These companies are the major sources of employment and economic activity in the District. NORPALM and Ghana Rubber Estates Limited (GREL) are the two major companies with extensive oil palm and rubber plantations respectively. These companies employ considerable numbers of people in the District. Fishing is an important economic activity for the people of the coastal areas. Dixcove is noted all over the Western Region for its sharks, tuna and lobsters catches. Other important fishing communities include Funkoe, Butre, Aketekyi, Akwidaa, Adjua, Egyambra and Cape Three Points.

Sekondi-Takoradi Metropolis (STM)

The major economic activities in STM are related to the port. The area is the third largest industrialised centre in the country and there are significant industrial and commercial activities in the manufacturing sector (food processing, spirits production, textiles, metal fabrication) and resources sector (timber, clay). STM has a large food and goods market which is a centre for small and medium sized trading. The manufacturing industry includes cement, household utilities, cocoa processing and wood processing. The major food items processed are fish, cassava and palm

kernel. Fish is mostly smoked at areas like New Takoradi and Amanful. In STM, 19 percent of the population is employed in the agricultural sector. Crop production is practiced at a small scale. Fishing is the predominant occupation category of the agriculture sector, with up to 1,800 people engaged in fishing along the coastline from Takoradi to Ngyeresia. Commercial livestock and poultry farming is largely non-existent in the Metropolis, however, many urban dwellers keep sheep, goats and poultry on free range and household level.

Shama District

Farming and fishing are the main economic activities in the District, employing about 78 percent of the population. Main crops include cassava, plantain, cocoyam, maze rice, oil palm and vegetables. According to the District planning officer, coconut palm was extensively grown in the District until the 1990s when Wilt Disease exterminated most of the trees. The main fishing communities in the District are Abuesi, Shama and Aboadze. These occupy about seventy percent of the coastline of the District. The three communities have about 1,500 registered seaworthy canoes and a catch of about 30,000 t is recovered annually. Large quantities of Birimian rock deposits have been revealed in the District. Small and medium scale quarry firms have started mining the rock reserves. There are no major industries in Shama except for the 550 MW Takoradi Thermal Power Station at Aboadze.

5.6 LAND TENURE

Ghana maintains a dual land tenure system, comprised of customary and statutory land tenure. Customary tenure is based on local practices and norms, which are flexible and vary according to location. Such tenure is typically unwritten and is managed by a traditional ruler (the paramount chief or local chiefs); a council of elders; or family or lineage heads. The principles stem from rights established through first clearance of land, conquest or settlement.

The National statutory land tenure system is based on officially documented statutes and regulations, formalised in a legal system that is rooted in the colonial law. These laws define processes, acceptable behaviours and consequences for noncompliance. Administration of this legal system sits with government structures and individuals delegated with relevant authority. The state-recognised land rights are allocated and confirmed through the issue of titles or other forms of registration of ownership. The customary owners - stools, clans, families, and tendamba own about 78 percent of the total land area in Ghana. Of the remaining 22 percent, the state owns outright about 20 percent while the remaining 2 percent is held in dual ownership: the legal estate in the government and the beneficiary/equitable interest in the community (FAO, 2003). In addition, There are no comprehensive data on land ownership and defined boundaries for the 78 percent of the land held by the customary sector (FAO, 2003)..

Under the 1992 Constitution, three distinct land tenure systems are recognised: public lands, stool or customary lands and private freehold lands. Public lands are owned by the government and are for public use. Customary lands are communal and are held by traditional communities or groups thereof and are characterised by various land tenure. Finally, Private Freehold land is not owned by government or a traditional authority, but rather an individual or entity and includes the building and the land it is built on. The land acquisition area falls under the classification of customary land.

Under customary lands, there are three forms of right to land, and due to the nature of the land tenure system, an individual can hold multiple rights to one piece of land. The land use rights are described below:

- **Use Rights:** the right to use the land (conferred either to “natives” or “settlers”).
- **Control rights:** the right to make decisions on how the land should be used and to benefit financially from the sale of the crops etc.
- **Transfer rights:** the right to sell or mortgage the land; to convey the land to others through intra-community re-allocations or to heirs; and to reallocate use and control rights.

Under the traditional system, any person who wants to buy or lease land has to request permission from the chief and follow the correct traditional protocols. Family land can be bought or leased, and if leased, the family and the lessee have to agree on the rent before the transaction is regarded as complete. The same applies if the person wants to buy the land and a selling price must be agreed upon. Once this transaction is completed the buyer becomes the legal owner of the land.

Land ownership is also determined by the systems of matrilineal (maternal) and patrilineal (paternal) inheritance. In the Ellembele District matrilineality is the dominant form of inheritance and family land may be handed down through the female line from mother to child but not from father to child. If a man owns family land he is only able to pass the land on to his sisters' heirs thereby keeping the property within the family through the female line. Chiefs remain the custodians of traditional lands but do not have absolute control as land acquisition registration and revenue collection is done through the Office of the Administrator of Stool Lands. In addition, there is a legal obligation to distribute revenues from Stool Land (Article 267 of the Constitution and Section eight of the Stool Lands Act 1994) as follows:

- The first ten percent of the revenue accruing from Stool Lands shall be paid to the Administrator of Stool Lands to cover administrative expenses.
- The remaining revenue shall be disbursed in the following proportions by the Administrator;
 - 25 percent to the Stool through the traditional authority for the maintenance of the Stool in keeping with its status;
 - 20 percent to the traditional authority; and
 - 55 percent to the District Assembly within the area of authority in which the Stool Land is situated.

The land in the DAol is in the “customary ownership” of chiefs, who dispense and allocate it on behalf of their people. This land access category is usufruct rights to stool land. Under the customary system, the land is viewed as a common heritage from God to the indigenes, through their ancestors and must be preserved and handed to their successive descendants.

5.7 WELFARE

5.7.1 Poverty

Table 5-8 illustrates the poverty profile in Ghana. The poverty incidence in the Western Region of Ghana contributed about 6.8% to the national poverty level. The levels of unemployment in the Western Region are also considered to be high.

Table 5-8 Poverty Profile in Ghana

	Poverty incidence	Contri-bution to total poverty	Poverty gap	Contri-bution to total poverty gap
Western	20.9	7.9	5.7	6.8
Central	18.8	6.9	5.6	6.4
Greater Accra	5.6	3.8	1.6	3.5
Volta	33.8	12.1	9.8	11.0
Eastern	21.7	9.3	5.8	7.8
Ashanti	14.8	12.0	3.5	9.0
Brong Ahafo	27.9	11.4	7.4	9.4
Northern	50.4	20.8	19.3	24.9
Upper East	44.4	7.4	17.2	9.0
Upper West	70.7	8.4	33.2	12.3
All Ghana	24.2	100.0	7.8	100.0

Ghana Statistical Service, 2014

5.7.2 Education

Ghana has a free basic education system that is compulsory up to age 15. There are six years of primary education, three years junior secondary school education, three years of secondary education and four years of tertiary level education.

The level of **literacy** in the Western region is 58.2% (population of Ghana above 15 years of age literate in either English or a major Ghanaian language), compared to a national average of 57.9%. The level of literacy for females (47.9%) in the region is low compared to males (68.0%). Moreover, the highest educational attainment level by females (42.4%) in the region is primary, while for males (42.4%) it is middle/junior secondary school (JSS). This low literacy level for females could be linked to the low level of **educational attainment** in the region. In fact, nearly two-thirds (64.3%) of those currently in school are at the primary level, while only 21.3% are in junior secondary school. There is therefore a very high attrition rate between primary and junior secondary school levels. Several reasons account for the **high dropout** during the transition from primary to junior secondary. These include the unavailability of junior secondary schools within many rural localities, resulting in pupils having to travel 10 kilometres or more to the nearest junior secondary school. Other important factors are affordability and poor infra-structural facilities. In recent years, however, there have been efforts to improve both quality and quantity of infrastructural facilities of primary and junior secondary schools. At any rate these figures depict low educational and literacy levels and distinct gender disparity in access to education and basic school enrolment.

In the Western Region, Shama Ahanta East has the highest number of teaching staff. Approximately, 15 percent of teaching staff is based in this District because of the high number of schools and pupils. The lowest number of primary teaching staff was recorded in Ahanta West District and the lowest numbers for secondary teaching staff occur in Juaboso.

There are a broad range of **educational facilities** in all of the Districts, including pre-schools, primary schools, junior high schools, senior high schools and tertiary institutions. These facilities fall into public and private categories that are run by the government, individuals or religious organisations. There are 1,320 primary schools in the Region, 1,240 of these are public and 80 are private schools. There are half as many junior secondary schools as there are primary schools, which indicates that access to these schools would be more difficult for some children in the Region. Consequently, as aforementioned, children living in localities where junior secondary schools are not within reasonable distances are likely to drop out of school after primary school (Ghana Districts, 2009). Access to senior secondary school in the Region is poor compared to access to primary schools and junior secondary schools. There are 42 senior secondary schools in the Region, with most concentrated in the Sekondi-Takoradi area. An overview of educational facilities for the Districts is provided below.

Jomoro District

The District has 68 primary schools, 53 junior secondary schools and two senior secondary schools. The District has focused on the provision of infrastructure such as classroom blocks and provision of furniture; however, many school blocks are in poor condition and need major rehabilitation.

Nzema East Municipality and Ellembele District

Educational infrastructure in the area is in fairly good condition. However, some facilities require renovation. Numbers of educational facilities are only available for the former Nzema East District. The following facilities were available: 132 pre-schools, 138 primary schools, 67 junior secondary schools, four senior secondary schools and three tertiary level institutions, namely Kikam Technical Institute, Esiam Public Health Nursing School and Asanta Teacher Training.

Ahanta West District

The District has private and public educational facilities including 90 pre-schools, 86 primary schools, 54 junior secondary schools, three senior secondary schools and a vocational/technical school.

Sekondi-Takoradi Metropolis and Shama District

There are 177 pre-schools in STM, 161 primary schools, 144 junior high schools, 19 secondary high schools, four technical/vocational schools and nursing and teacher training colleges under public management. School facilities within the area are evenly distributed, so there is easy access to these facilities and children travel short distances to attend school.

5.8 SOCIAL INFRASTRUCTURE AND SERVICES

5.8.1 Water

There are three major sources of drinking water namely, piped (inside, outside, tanker supply), well (well, borehole) and natural (spring, river, stream, lakes, rainwater, dugout). In the western region only 32 percent of houses have access to treated piped water with 8.5 percent having this available within their dwelling places. The highly urbanised Districts have almost 100 percent availability of, or accessibility to piped water. This is in contrast to rural Districts where over 60 percent of households rely mainly on surface waters such as rivers, streams, dugouts, shallow hand-dug wells, spring or rain water as their main source of water, with only approximately 9 percent having access to processed piped water. A few have access to deep boreholes and relatively shallow but clean water wells. An overview of the water sources is presented in Table 5-9.

Table 5-9 Overview of Water Resources

Water Type	Access	All Districts	Jomoro	Nzema East	Ahanta West	Shama - Ahanta East
Total Households		409,282	22,137	29,591	23,064	86,511
Piped Outside		23.2%	15.5%	10.6%	14.4%	59.7%
Piped Inside		8.5%	1.3%	2.2%	2.9%	27.3%
Tanker Supply		0.7%	0.5%	0.3%	2.2%	0.7%
Well		23.2%	32.9%	23.1%	28.5%	7.8%
Borehole		14.2%	14.8%	14.5%	28.6%	1.2%
River / Stream		24.1%	31.2%	36.3%	16.0%	1.3%
Spring / Rain		4.4%	3.1%	3.4%	5.7%	1.4%
Dugout		1.5%	0.7%	0.6%	1.5%	0.3%
Other		0.2%	0.0%	0.0%	0.1%	0.3%

Source: Population and Housing Census, 2000

Note: Statistics unavailable for newly created Districts

Potable water is in fact gradually being made available to rural communities through the sinking of deeper boreholes. Table 5-10 lists the sampling results of some of the wells encountered during the field survey, June 2012. Results reveal that water tends to be somewhat salty when wells are located close to the coast and only lightly mineralized once wells are located further inland (behind the coast road); none of the wells sampled contain oligomineral water.

Table 5-10 Sampling of a few wells in Study Area (eni site selection survey, June 2012)

Town/Location	pH	Conductivity (Microsiemens /cm)	Photo
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Metika (Macroarea 1)	6.8	1.650	
ESIAMA 1 (Macroarea 5) 	7.3 5	2.400	
ESIAMA - Chief Fisherman's private well (Macroarea 5)	7.4 5	1.870	
ASAMKO aqueduct	6.3	473	

Egyan inland well (Macroarea 6)	6.4	860	
			
Egyan town well (Macroarea 6)	6.4	557	No photo (raining heavily)
AKONU (Macroarea 6)	6.5	840	
			

ASANTA (Macroarea 5)

6.7
5

1.885



5.8.2 Electricity

Electricity and kerosene lamps are used as the main sources of **lighting** in the Western Region, providing about 99 percent of the lighting needs of households. In the urban areas, the majority of households use electricity while in the rural Districts, kerosene lamps are the main source of lighting. Rural households are also gradually gaining access to electricity through a rural electrification programme, even though this programme has as yet only touched a few communities located fairly close to urban centres. An overview of access to electricity for the Districts is provided below.

Jomoro District

A large portion of the population in Jomoro (55%) does not have electricity. The large towns in the District such as Half Assini, Elubo, Tikobo 1, Jaway Wharf and Mpataba have all been connected to the national grid; however, settlements on the south western part of the District such as Newtown, Nzimtianu and other parts in the north, have no power. Those with power experience voltage fluctuations and frequent power interruptions.

Nzema East Municipality and Ellembelle District

Households in the urban areas have access to electricity, while a large number of peri-urban and rural households are also gradually gaining access to electricity through the rural electrification programme, even though this programme has a very long way to go and benefited only a few communities which are fairly close to urban centres.

Ahanta West District

Electricity services have been expanded to include communities such as Media, Boakrom, Aboadi, Kubekor, Aboagyekrom, Enmokanwo, Boekrom, Ellobankanta and others under Self Help Electrification Project (SHEP). Most people have access to electricity, however, regular power outages are common due to inadequate infrastructure such as transformers.

Sekondi-Takoradi Metropolis and Shama District

Almost 90% of the Metropolis has been connected to the electricity grid through the SHEP. Street lighting is, however, a problem in the Metro. A number of communities in the metropolis are without electricity, these include newly schemed areas. The Metro, as a whole, experiences frequent power outages. In Shama, almost the entire (95 %) District is connected to the national electricity grid.

Fuel for **cooking** is instead principally charcoal and firewood in the Region, even for quite a sizeable number of urban dwellers. Coconut husks are also used. Liquid petroleum gas is used for cooking in some homes, particularly in the big cities and towns. The use of electricity for cooking is minimal, being limited to Sekondi-Takoradi with its highly urbanised status and access to electricity.

The Takoradi Thermal Power Plant lies on the coast approximately 17 km east of Sekondi-Takoradi, and relies on marine water for cooling purposes. The Thermal Plant started operation in 1997, and was initiated by the Volta River Authority to complement the existing Hydro Plant at Akosombo and Kpong. The Takoradi Thermal Power Plant is therefore a facility of strategic importance for meeting Ghana's energy needs (Volta River Authority, 2006). The plant has historically been fuelled by crude or fuel oil but conversion to use of natural gas from the West Africa Gas Pipeline (WAGP) occurred in 2008 though initial flows have been intermittent.

There are two existing bulk fuel storage facilities in STM, namely the Shell and GOIL depots located between Poasi and New Takoradi. According to the STMA planning officer, a third bulk fuel facility is planned by Cirrus in the same area. Takoradi Port also has dedicated oil berthing facilities. Fuel is distributed via road tanker to filling stations in the coastal District either from Tema or Takoradi. Other than the effects of intermittent national fuel shortages, none of the Districts experience problems with fuel availability.

5.8.3 Telecommunications

Two main types of telephone systems are in operation in the country. These are the fixed line telephones and the mobile telephone systems. Other systems being operated are wireless, radio telephone and satellite communication systems. Vodafone Ghana Telecom Company operates over 95 percent of the fixed line telephones in the country. Teledensity of fixed line telephones in the Western Region is 0.3 telephones per 100 persons, which is below the national average of 0.7. Of the 12,985 fixed lines the Region recorded in the year 2000, 11,046 or 86 percent served the Sekondi Takoradi metropolis. The Western Region is extensively covered by the following mobile telephone operators: MTN, Vodafone, Ghana operators of Vodafone, Tigo, Kasapa and Zain. The Region has the second highest locality coverage by MTN, which is the largest mobile telephone system in the country. Mobile telephone coverage is poor in the northern part of Nzema East Municipality and in Jomoro District.

5.8.4 Police Services

Police services in the Region are those offered by the Ghana Police Service. Most communities have a Police Station and every District capital has a District Police Headquarter with a Regional Police Headquarter in the regional capital. The Western Region Command of the Ghana Police Service is located in Takoradi. Apart from the Police Service, chiefs and elders in the communities are responsible for settling disputes.

5.8.5 Fire Services

Fire response capability in Takoradi exists through the National Fire Service and the Ghana Ports and Harbours Authority Fire Service Department. There are reportedly a total of five fire tenders at the National Fire Station's disposal in case of emergencies. The port has two fire tenders and the airport, one.

5.9 TRANSPORT INFRASTRUCTURE

5.9.1 Roads

The Ghana Private Road Transport Union (GPRTU) and other transport organisations provide transport services within the Districts in the Region. The most common means of transport is by road where there are privately owned or state owned buses. The state owned buses usually operate within the urban areas. In the villages, private taxis and small buses owned by private individuals are operational. The road network in the Western Region is limited and the conditions of the roads can be very poor, particularly in the rainy season. Goods such as bauxite, manganese, timber and timber products and cocoa are transported by rail on the Western Line which runs from Takoradi to Kumasi and Awaso.

An overview of transport and road infrastructure present in the relevant Districts is hereby provided.

Jomoro District

Thirty-six percent of roads in Jomoro are trunk roads while the remaining 64 percent are feeder roads. The roads tend to be generally muddy and slippery during the wet season and sometimes become inaccessible. An exception is the trunk road which traverses the District in an east-west direction to Takoradi and which forms part of the Trans- West African Highway. In 2007 and 2008 there were major improvements in road rehabilitation. Boats are an important mode of transport for goods and passengers in Jomoro District. There are communities along the Juan Lagoon and other river bodies which can only be accessed by boat.

Nzema East Municipality and Ellembele District

The former Nzema East District has a total of 154 km of trunk roads, of which 64 km are metalled. The metalled trunk roads form part of the Trans-West Africa Highway. The rest of the trunk roads are gravel or earth-surfaced. Apart from the trunk roads, the District has a total of 253 km of feeder roads, of which 40 percent are in poor condition. Over 70 percent of these feeder roads are in the southern half of the District.

Ahanta West District

The road networks (mostly feeder roads) have been improved by 10%. This has opened up the District for easy access to farming communities and market centres. In 2006, for example, 14 feeder roads underwent maintenance. Due to the poor condition of some of the feeder roads, some parts of the District are not easily accessible, especially during the rainy season.

Sekondi-Takoradi Metropolis and Shama District

Most of the roads in the STM, particularly those within the urban centers have been over stretched. There is rapid development taking place in the hinterland and a significant proportion of these areas is without access roads. The condition of the road network in the Metropolis stands at 51.6% good, 28.2% fair and 19.6% poor. The total length of all-weather roads in the Metropolis has been extended from 330 km in 1996 to over 400 km in 2006.

5.9.2 Ports and Harbours

The Port of Takoradi was built as the first commercial port of Ghana in 1928 to handle imports and exports to and from the country. The port currently has a covered storage area of 140,000 m² and has an open storage area of 250,000m². It has a wide range of vessels supporting its operations

including tugboats, lighter tugs, a water barge and a patrol boat. The Port handles both domestic and transit cargoes and currently handles about 600 vessels annually, which is 37 percent of the total national seaborne traffic, 62 percent of total national export and 20 percent of total national imports annually. Almost 160,000 tonnes of cargo are handled annually at the port. The Port of Takoradi also has a fishing harbour located at Sekondi, which has an ice plant that can accommodate vessels with up to 3 m draft. Other ship traffic in the area is associated with ports such as Abidjan (Côte d'Ivoire) and Lagos (Nigeria).

5.9.3 Airports

The Takoradi Airport is the only civilian airport in the Western Region. The airport has one runway. Ghana Air Force also has a base at the airport. At least one scheduled domestic flight lands and takes off from this airport daily.

5.10 WASTE AND SANITATION

The indiscriminate disposal of solid waste in gutters, open spaces and the sea has led to unsanitary conditions in some Districts. Added to this is the unavailability of toilet facilities with over 40 percent of dwellings in the Western Region having either no toilet facilities or having to use a public toilet. The environs of these public toilets are being turned into solid waste dumps with serious health hazards in many of the urban and peri-urban localities (Population and Housing Census, 2000). Where facilities do exist in the region, the most common types are Kumasi Ventilated-Improved Pit (KVIP), pit latrine or a bucket/pan system. Where no facilities exist, people are forced to make use of the beaches, outlying bushes and gutters.

Waste management is a serious issue in the Western Region like many others in Ghana. The predominant means of waste disposal is either by dumping; this may be at specified sites; or indiscriminately burning or burying. Approximately 60 percent of all households in all the Districts use a specified public dump while an additional 29 percent use unauthorised dump sites to dispose of waste. The waste from these open dumps washes into streams and rivers which often serve as sources of water for local communities. Collection and disposal of waste by the local authorities accounts for only about 2 percent of all households. Households in Sekondi Takoradi, more than any other District, use collection agencies and public dumping sites. A site visit of the existing waste handling facilities was undertaken in May 2009 to determine the suitability of these facilities for the wastes from the Jubilee Project.

5.11 COOPERATION AND DEVELOPMENT

In Ghana, ODA (Official Development Assistance) is channelled through technical assistance projects and through a budget support mechanism, named Multi-Donor Budgetary Support which serves as the main framework for poverty-reduction interventions, financed by both domestic and external resources. The scheme is said to have reduced competing demands on the Government of Ghana. It has also wiped out any reference to external interventions in the districts with the exception of international NGOs. Non-governmental organizations that can be found in the coastal districts are depicted in Table 5-11.

Table 5-11 NGOs operating in the coastal districts of the study area

District	NGO	Intervention Areas
Jomoro	COSPE (co-operation for the development of emerging countries)	Developing of small scale and income generating activities.
	SNV	Land tenure issues, ownership of resources on land, sustainable management of resources
	Ghana wildlife Society	Conservation of biodiversity, wildlife, migratory birds.
	COLANDEF	Land governance, natural resource management, gender,

		local governance
Ellembele	COLANDEF	Land governance, natural resource management, gender, local governance
Nzema East	Care International	Land tenure issues, ownership of resources on land, sustainable management of resources
	Friends of the Nation	Environmental conservation
	SNV	Sanitation improvement programme for Axim
	COLANDEF	Land governance, natural resource management, gender, local governance
	COSPE	Income generating activities
Ahanta West	Conservation Foundation	Environment, gender equity, water and sanitation, health
	Ricerca e Co-operazione	Conservation of biodiversity
	World Vision International	Water and Sanitation, education, health, child protection
Sekondi-Takoradi	Friends of the Nation	Natural Resources Management, Community Development, Enterprise Development
	Eagle's Eye Charity Foundation	Basic Education, Vocational Training, Youth and Women Empowerment, Advocacy, Health Relief, Community Development, Human Rights
	Friends of Women	Women and girls empowerment
	Jomelos Save Life Organisation	Food, education and health services for orphans, long-distance adoption
	Mehran Foundation	Health and education
	Safe Blood Ghana	Youth Health Awareness on HIV/AIDS, Child Support Programme through micro-credit loans

Local NGOs/CBO are active in STMA and the District of Shama; that is outside the 4 districts of the study area but within Western Region, and should therefore still be considered for stakeholder identification and consultation.

6 HEALTH BASELINE

In 2011 eni Ghana undertook to conduct an Environmental, Social and Health (ESH) Baseline Study in order to provide a broad preliminary analysis of the sensitive aspects and areas existing throughout the country in general, and secondly and in particular regard to those specific areas potentially affected by current and future company operations (defined as the six fringe coastal districts of Ahanta West, Sekondi-Takoradi, Shama, Nzema East, Ellembele and Jomoro, in the Western Region of Ghana). The regional and district level health data collected through the survey carried out is here-in used to provide an overview of the health status in the Region and in the six referral coastal districts.

The health baseline information in this section has been updated to reflect recent data.

6.1 REGIONAL HEALTH STATUS

6.1.1 Morbidity

The ten top causes of morbidity in the Western Region is presented in Table 6-1. Malaria is the number one cause of morbidity, contributing to the 37.50% to all new reported cases in 2013. The other main causes of morbidity were respiratory infections, skin diseases and diarrhoea.

Table 6-1 Top ten Causes of Morbidity in Western Region, 2011-2013

2011			2012			2013		
Disease Condition	No. of Cases	%	Disease Condition	No. of Cases	%	Disease Condition	No. of Cases	%
Malaria	1,206,510	40.7	Malaria	1,208,370	49.3	Malaria	1,384,255	37.50
Acute Respiratory Infection (ARI)	347,020	11.7	Acute Respiratory Infection (ARI)	337,019	13.8	Upper Respiratory Tract Infection	410,093	11.11
Skin Diseases & Ulcers	144,320	4.9	Skin Diseases & Ulcers	139,610	5.7	Diarrhoea	185,200	5.02
Diarrhoea	142,715	4.8	Diarrhoea	137,356	5.6	Skin Disease	163,347	4.43
Rheumatism and Joint	112,242	3.8	Rheumatism & Other Joint Pains	107,116	4.4	Rheumatism & Other Join Pains	157,780	4.27
Intestinal worms	59,698	2.0	Intestinal Worms	57,161	2.3	Intestinal worm	123,973	3.36
Acute Eye infection	57,972	2.0	Acute Eye Infection	57,014	2.3	Anaemia	109,533	2.97
Anaemia	56,727	1.9	Anaemia	54,565	2.2	Acute Eye Infection	55,460	1.50
Hypertension	41,548	1.4	Hypertension	39,994	1.6	Hypertension	50,656	1.37
Pregnancy and Related	35,918	1.2	Vaginal Discharge	39,406	1.6	Acute Urinary Tract Infection	46,804	1.27
All Other Diseases	756,505	25.5	All Other Diseases	271,379	11.1	All Others	1,004,196	27.20
TOTAL	2,961,175	100	Total	2,448,990	100	Total	3,691,297	100.00

Source: Ghana health service, Western Region, 2013

The top ten causes of hospital admissions in the Western Region for the period 2011-2013 reflects the morbidity data as shown in Table 6-2. In 2013, the top ten causes of admissions accounted for 63.9% of all admissions with malaria and gastroenteritis being the most common causes. Malaria contributed 39.3% which showed a decrease from 2012 (43.7%) but an increase from the 2011 (21.2%). According to the District Health Director, at Nkroful, the most recent bed nets distribution in Ellembelle district took place in 2012. However, it is worthy to note that possession does not necessarily translate into use.

Table 6-2 Top ten Causes of Admissions in Western Region, 2011-2013

2011			2012			2013		
Disease Condition	No. of Cases	%	Disease Condition	No. of Cases	%	Disease Condition	No. of Cases	%
Malaria	29,534	21.2	Malaria	16,355	43.7	Malaria	16,355	43.7
Diarrhoeal Disease	3,667	2.6	Gastroenteritis	2,145	5.7	Gastroenteritis	2,907	5.79
Anaemia	2,997	2.1	Hypertension	1,214	3.2	Anemia	2,269	4.52
Hypertension	1,815	1.3	Anaemia	1,203	3.2	Hypertension	1,902	3.79
Hernia	1,486	1.1	Abortion	1,02	2.7	Abortion	1,257	2.50
Abortion	1,464	1.0	False labour	783	2.1	Sepsis	1,128	2.25
Enteric Fever	1,263	0.9	Pneumonia	718	1.9	Pneumonia	841	1.67
Malaria Pregnancy	868	0.6	Typhoid fever	600	1.6	Hernia	774	1.54
Pneumonia	842	0.6	Cellulitis	409	1.1	Cellulitis	638	1.27
Fibroid	841	0.6	Sepsis	411	1.1	Typhoid Fever	635	1.26
All other Disease	94,67	67.9	All Other Disease	12,672	33.9	All Others	18,141	36.12
Total	139,447	100	Total	37,423	100	Total	50,231	100.00

Source: Ghana health service, Western Region, 2013

6.1.2 Mortality

Regional level

The top ten causes of hospital recorded deaths in the Western Region are shown in Table 6-3. During the period 2011-2013, the top ten causes of reported deaths accounted for between 42.3% in 2013 and 56.9% in 2012 of all causes of deaths. Malaria was the most common cause of death in 2013 and 2012 and the second most common cause in 2011. Anaemia was the main cause of death in 2011. The other main causes of deaths during this period were septicaemia, hypertension and sepsis.

Table 6-3 Causes of Deaths in the Western Region, 2011-2013

2011			2012			2013		
Condition	No. of Cases	%	Condition	No. of Cases	%	Condition	No. of Cases	%
Anaemia	336	10.2	Malaria	87	13.2	Malaria	65	8.21

2011			2012			2013		
Condition	No. of Cases	%	Condition	No. of Cases	%	Condition	No. of Cases	%
Malaria	269	8.1	Hypertension	46	7.0	Septicemia	61	7.70
Sepsis	261	8.1	Sepsis	42	6.4	Cerebrovascular Accident	43	5.43
Cerebrovascular Accident	241	7.3	Anaemia	41	6.2	Anemia	39	4.92
HIV/AIDS	167	5.1	Stroke	37	5.6	Pneumonia	27	3.41
Pneumonia	158	4.8	Cardiovascular disease	30	4.5	HIV/AIDS	26	3.28
Hypertension	106	3.2	HIV/AIDS	30	4.5	Diabetes Mellitus	20	2.53
Gastroenteritis	98	3	Pneumonia	29	4.4	Hypertension	20	2.53
Cirrhosis of Liver	81	2.5	Gastroenteritis	19	2.9	Cardiovascular Accident	17	2.15
Cerebrovascular Accident	78	2.4	Meningitis	15	2.3	Hypoglycemia	17	2.15
All Other Disease	1,503	45.6	All Others	285	43.1	All Others	457	57.70
Total	3,298	100	Total	661*	100	Total	792*	100.00

* According to the Annual Health Report for the Western Region dated 2013, the number of admission cases recorded in the in-patient mortality were not entered in DHIMS at the time of writing the report (18/02/2014). This would explain the difference in the total number of deaths registered in 2011 and the subsequent years (i.e 2012 and 2013). Annex 21 Sectorwide Indicators of the same report indicates a total number of deaths for 2012 and 2013 of 3,276 and 3,579 respectively, numbers aligned with the trend of the previous years.
Source: Ghana health service, Western Region, 2013

6.2 HEALTH STATUS IAT THE DISTRICT AND LOCAL LEVEL

This section discusses the health profile of Ellembelle District and at the local level.

6.2.1 Morbidity

Similarly as for the regional level, malaria was the leading cause of ill health 2013 within the Ellembelle District, contributing 37% to all new reported cases in 2013. The second most common disease for the same period was acute respiratory tract infections.

Table 6-4 Top ten Causes of Morbidity in Ellembelle District, 2013

No.	Disease Condition	No. of cases	%
1	Malaria	132,984	37
2	Acute Respiratory Tract Infection	45,085	12
3	Rheumatism. & other Joint Pains	22,831	6
4	Skin Diseases & Ulcers	22,444	6
5	Diarrhoea Diseases	19,222	5
6	Intestinal Worms	12,710	4
7	Gynaecological conditions	10,735	3
8	Anaemia	6,220	2
9	Urinary Tract Infection	4,714	1
10	Acute Eye Infection	3,873	1
Others		79,903	22
Total		360,721	100

Source: Ghana health service, annual District health report, Ellembelle, 2013

The top ten causes of hospital admission in St Martin de Porres hospital in Eikwe sub-District (where people within the Area of Influence mostly seek medical attention) for 2013 are shown in Table 6-5. The data presents a similar health profile to the morbidity data and regional hospital admissions.

Table 6-5 Top ten Causes of Admissions in St Martin de Porres Hospital, 2013

No.	Disease Condition	No. of cases	% of total cases
1	Malaria	1,793	15.1
2	Anaemia	1,037	8.7
3	Diarrhoeal diseases	798	6.7
4	Abortion	636	5.4
5	Pregnancy and related Complication	396	3.3
6	Hernia	376	3.2
7	Hypertension	339	2.9
8	Neonatal Sepsis	254	2.1
9	Pneumonia	194	1.6
10	Enteric Fever	150	1.3
Total		5,973	50.4
Others		5,885	49.6
Grand Total		11,858	100

Source: St Martin de Porres hospital annual report, 2013

The main cause of disease in Ellembelle District is Malaria. Malaria is also the main cause of outpatient attendance in all the health facilities among all age groups. It also accounts for most of the admissions and deaths especially among children at the only hospital in the District, St Martin de Porres at Eikwe.

Tuberculosis (TB) and HIV are also commonly detected at the hospital. However, cases of Eikwe hospital are reported to be mainly attributable to patients from neighbouring districts and the Ivory Coast. Other diseases like yaws and schistosomiasis are found to be common among school children (Ellembelle Development Plan, 2009).

Local Level

As shown in Table 6-6 and similar to the Western Region, the main causes of morbidity at the two CHPS Compounds in the Area of Influence are malaria, respiratory diseases and diarrhoea. However, malaria represented the 63.8% of the total cases while at regional and district levels this rate was significantly lower, 37.50 and 37% respectively. This can be explained because of the limited facilities available within the CHPS compared with the health centres and hospital at the District and regional levels. Within the CHPS, some specific conditions (ie. Hypertension, diabetes, cerebrovascular accidents, septicaemia, asthma, etc.), cannot be managed and are referred to the higher levels.

Table 6-6 Top five Causes of Outpatient Morbidity, Atuabo and Sanzule CHPS Compound, 2013

No.	Disease Condition	Atuabo CHPS		Sanzule CHPS	
		No. of cases	% of total cases	No. of cases	% of total cases
1	Malaria	831	63.8	831	63.8
2	Acute Respiratory Infection / Chest Infection	181	13.9	181	13.9
3	Diarrhoea	112	8.6	112	8.6
4	Musculoskeletal Disorders	95	7.3	95	7.3
5	Skin infection	83	6.4	83	6.4
Total		1,302	100	1,302	100

Source: Atuabo and Sanzule CHPS compounds, 2013. Fieldwork ERM-SRC, 2014

6.2.2 Mortality

At district level, the only updated information publicly available regarding mortality are the figures recorded at St Martin de Porres hospital (2013). The top ten causes of mortality in St Martin de Porres hospital for 2013 are shown in Table 6-7 and reflect the data for the Western Region, with the main causes of mortality being asphyxia, malaria and septicaemia. According to the medical Director of the hospital, the major contribution factor to the number of deaths due to asphyxia is the lack of a paediatrician to manage perinatal and neonatal conditions effectively.

Table 6-7 Top ten Causes of Mortality in St Martin de Porres Hospital, 2013

No.	Disease Condition	No. of cases	% of total cases
1	Asphyxia	28	6.5
2	Malaria	27	6.3
3	Septicemia	26	6.1
4	Diarrhoeal Diseases	25	5.8
5	Cerebrovascular Accident (CVA)	21	4.9
6	Pneumonia	21	4.9
7	Anaemia	20	4.7
8	Neonatal Sepsis	20	4.7
9	Premature baby	16	3.7
10	Congestive Cardiac Failure (CCF)	14	3.3
	Total	218	50.9
	Others	210	49.1

No.	Disease Condition	No. of cases	% of total cases
Grand Total		428	100.0

Source: St Martin de Porres hospital annual report, 2013

6.2.3 HIV/AIDS and Tuberculosis

Tuberculosis

Tuberculosis (TB) diagnosis and treatment are offered to clients free of charge under the National tuberculosis control program (NTP). This program is responsible for designing and implementing policies, programs and interventions for the effective and efficient detection management and prevention of TB in the country. It operates in almost all public and private health facilities involved with the management of TB.

The St Martin de Porres hospital at Eikwe, implemented a policy to register only TB patients in the catchment of the hospital (ie. the Eikwe sub-District where the Area of Influence is located), for whom treatment is also initiated, has effectively reduced the registered TB patient numbers from over 100 to 31, in the last 5 years. Other confirmed cases in the hospital are referred to health units closer to patients address. In 2013, of the 31 total registered patients, 11 were positive. This policy aims to improve the effectiveness and efficiency of follow-up and monitoring of patients on TB treatment by the DOTS¹ strategy.

These numbers translate into a case notification rate of 278/100,000 population. This is much higher than the overall case notification rate in Ghana (63/100,000 population) for all forms of TB (National tuberculosis control program, 2011).

Table 6-8 presents tuberculosis cases in St Martin de Porres hospital in the period 2009-2013.

Table 6-8 Tuberculosis Cases, 2009-2013

Year			2009	2010	2011	2012	2013
PULMONARY TB	Smear Positive	Total Pulm	90	67	75	29	29
		Total Smear +ve	63	41	34	15	14
		New Cases	54	34	33	13	11
		Relapse	9	7	1	2	3
	Smear Negative		27	46	41	14	14
	Extra Pulm.		12	12	13	0	3
Total TB			102	99	88	29	31

Source: St Martin de Porres hospital annual report, 2013

HIV/AIDS

According to the 2013 HIV sentinel survey report in Ghana, the national HIV prevalence in 2013 is 1.3%. An estimated 224,488 Persons made up of 189,931 adults and 34,557 Children (15%) are living with HIV in Ghana. HIV prevalence amongst pregnant women attending Antenatal clinic for 2013 is 1.9% a drop from 2.1% in 2012. It is the first recording below 2% in two decades.

Regarding the HIV prevalence by age group at national level, the higher prevalence was recorded within the 45-49 group at 3.3%, followed by 35-39 at 3.2% and with 15-19 being the lowest at 0.8%. There has been a decrease from the previous year in all age groups except for

(1) ¹ DOTS stands for *Directly observed treatment, short-course*, is the name given to the tuberculosis control strategy recommended by the World Health Organization (WHO).

15-19 and 45-49. In general, HIV prevalence is higher in urban areas while Syphilis is higher in rural areas.

The prevalence in the Western Region in 2013 was 2.4% whilst the higher HIV prevalence rate was registered in the Eastern Region with 3.7% and the lowest prevalence in the Northern and Upper West Regions with 0.8% in both.

Table 6-9 presents the HIV Screening and Outcome in 2013 recorded at St Martin de Porres Hospital.

Table 6-9 HIV Screening and Outcome, 2013

Source	Sex	Screening Outcome &	0-11 months	1-4 yrs	5-9 yrs	10-14 yrs	15-19 yrs	20-34 yrs	35-44 yrs	45-59 yrs	60+ yrs	Grand total
Blood Donors	Male	Total	0	0	0	0	47	1538	395	47	13	2040
		+ve	0	0	0	0	2	90	22	1	0	115
	Female	Total	0	0	0	0	0	3	0	0	0	3
		+ve	0	0	0	0	0	0	0	0	0	0
	Subtotal	Total	0	0	0	0	0	1541	395	47	13	2043
	+ve	+ve	0	0	0	0	0	90	22	1	0	115
Patients	Male	Total	0	6	26	14	14	234	182	188	34	698
		+ve	0	0	3	2	0	40	45	42	6	138
	Female	Total	0	2	30	19	59	606	313	205	33	1267
		+ve	0	1	2	4	6	160	88	57	7	325
	Subtotal	Total	0	8	56	33	73	840	495	393	67	1965
	+ve	+ve	0	1	5	6	6	200	133	99	13	463
[V]CT*	Male	Total	0	0	1	0	0	1	1	0	0	3
		+ve	0	0	0	0	0	0	0	0	0	3
	Female	Total	0	2	0	2	0	3	0	2	0	9
		+ve	0	0	0	0	0	0	0	0	0	0
	Subtotal	Total	0	0	1	2	0	4	1	2	0	12
	+ve	+ve	0	0	0	0	0	0	0	0	0	0
PMTCT	Female	Total	0	0	0	8	202	1403	428	28	2	2071
		+ve	0	0	0	0	4	33	17	1	0	55
Grand Total	Total	Screening	0	10	57	43	322	3788	1319	470	82	6091
	Total	Positive	0	1	5	6	12	323	172	101	13	633

Source: St Martin de Porres hospital annual report, 2013

Note*: [V]CT* = Voluntary testing and counselling, also known as; HIV counselling and testing (HCT)

6.3 HEALTH FACILITIES

6.3.1 Health Care Facilities

The public health service is offered through a hierarchy of hospitals, health centres, maternity homes and clinics including community-based health planning and services (CHPS) compounds. Services are run on a three-tier system of care, from primary through secondary to tertiary services organized at five levels: community, sub-district, district, regional and national. Community and sub-District levels provide primary care with district and regional hospitals providing secondary health care (see Figure 6-1). The teaching hospitals provide tertiary services and are the most specialised.

The public sector is complemented by the private health sector, which provides about 42 per cent of Ghana's health care services (Arhinful, 2009).

Traditional healing centres and traditional healers including herbalists, spiritualists, homeopaths and other nonconventional health service providers form part of the primary health care services available as shown in Figure 6-1.

Figure 6-1 Health Care System in Ghana



Source: ERM, 2014

6.3.2 Traditional Medicine

The use of traditional healers is common in Ghana and is also recognized by the GHS as part of the CHPS. The Department of health offers basic training to interested traditional healers such as

first aid, safe delivery of babies, identifying signs of anaemia and good hygiene practices for the mother and midwife (Traditional Healer, April 2012).

The usefulness of the traditional birth attendants (TBA) is also recognized and as such the GHS has incorporated TBAs into maternal health delivery outlets when uncomplicated deliveries are expected. Training programmes are freely arranged for registered TBAs on a regular basis. Training areas normally focus on identification of likely complications, first aid and other relevant services. Approximately the 6.1% of births in Ellembelle District are supervised by trained TBAs in 2009.

Traditional medicine in the Area of Influence is mainly practiced by spiritualist (also known as faith healers) and Herbalist. Healers use non-timber forest products as medicine to cure various ailments, including malaria, typhoid, fever, diarrhoea, arthritis, rheumatism, and snake bites. The dominant faith healers operate under the 12 apostle Church locally called “Nakaba”. These operate prayer camps where healing is sought from.

From the key informant interviews performed with health professionals and focus groups it emerged that the use of traditional medicine is high in the Area of Influence as there is a high tendency for people to associate certain illnesses to spirits. Thus, at the initial stage, people resort to traditional remedies from spiritualists and herbalists before seeking medical care at the CHPS or hospitals. Cases may therefore present late with potentially avoidable complications.

6.4 HEALTH INFRASTRUCTURE

For the purpose of effective and efficient delivery of health services, the District health administration has divided the District into 5 sub-Districts: Aiyinase, Esiam, Eikwe, Nkroful and New Aiyinase. The Area of Influence is mainly located within the Eikwe sub-district.

Health infrastructure in the Ellembelle District consists mainly of:

1. one mission hospital;
2. four (4) health centres;
3. seven (7) clinics, and
4. fourteen (14) CHPS compounds.

The highest referral facility in the region is Effia Nkwanta regional hospital which provides secondary health care. There are no tertiary health facilities in the Western Region.

Tables below present the breakdown of primary and secondary health facilities at National level, in the Western region and in Ellembelle District.

Table 6-10 Distribution of Health Facilities in Ghana (2014)

Ownership	Hospital	Health centre	Clinic	CHPS	Maternity home	Total
Public	352	785	918	1,710	-	3,765
Private*	119	-	474	-	241	834
Total	471	785	1,392	1,710	241	4,599

* Accredited private health facilities in Ghana by 12th May 2014. Information provided by the Health Facility Regulatory Agency.

Source: MOH-Ghana, 2014 extracted from Health and Life Sciences in Ghana, March 2014 (Embassy of the Kingdom of the Netherlands in Ghana).

Table 6-11 Health Facilities in the Western Region by Ownership and Type (2013)

Ownership	Hospital	Health centre	Clinic	CHPS	Maternity home	Total
Government	15	56	42	181	0	294

Ownership	Hospital	Health centre	Clinic	CHPS	Maternity home	Total
Mission	4	2	18	0	1	25
Quasi-gov't	3	0	2	0	0	5
Private	7	1	47	0	40	95
Industrial	2	0	0	0	0	2
Total	31	59	109	181	41	421

Source: Ghana health service, Western Region, 2013

Table 6-12 Health Facilities in Ellembele District by Ownership and Type (2014)

Ownership	Hospital	Health centre	Clinic	CHPS	Maternity home	Total
Government	0	4	2	14	-	20
Mission	1	0	0	0	0	1
Quasi-gov't	0	0	1	0	0	1
Private	0	0	3	0	0	3
Industrial	0	0	1	0	0	1
Total	1	4	7	14	0	26

Source: Ghana health service, Ellembele District profile, 2014

As shown in Table 6-12 currently there are not maternity homes within the Ellembele District, and most of the existing maternity homes available within the Western Region are private (Table 6-11). A maternity home is a privately owned health facility (often manned by a midwife) that primarily offers antenatal and delivery services.

6.4.1 Health facilities in the Area of Influence

The health facilities within the Area of Influence include:

- one hospital at Eikwe (St Martin de Porres hospital);
- one CHPS compound located at Atuabo serving Atuabo and Asemde-Suazo⁶ communities; and
- one CHPS compound located at Sanzule serving Sanzule, Anwolakrom (also known as Ewe) and Bakanta communities.

In addition, Krisan Refugee Camp has a clinic which provides basic primary health care to the 1,700 refugees living in the camp.

There are six (6) active TBAs in the sub-district (Annual Health Service Report 2013 of St Martin de Porres hospital, Eikwe), they have been trained and work as maternal and child health volunteers assisting the communities (family planning, maternal and new-born, etc.).

In general, people within the Area of Influence go to St. Martin de Porres catholic hospital in Eikwe to seek medical attention. In Atuabo, participants in focus groups report that they also go to Kabaku Health Centre in nearby Jomoro District hospital, which is 2 km west and 6 km of Atuabo.

St. Martin de Porres Hospital, Eikwe

St. Martin de Porres Hospital, Eikwe is a catholic health facility which was established in 1959, and currently serves as the District hospital. The hospital serves a wide catchment area that extends beyond Ellembele District, covering a population of over 100,000. Patients outside the Eikwe sub-district come to the Eikwe hospital mainly for maternity care.

(2) ⁶ Neighboring community to the Area of Influence.

The hospital is an obstetrics and gynaecology specialist hospital but also offers the following services:

- general outpatient services;
- general surgery and orthopaedics;
- reproductive and child health (RCH) services;
- HIV testing and counselling (HTC), prevention of mother-to-child transmission (PMTCT) and antiretroviral therapy (ART); and
- home –based care.

Other services include:

- diagnostic services (laboratory, blood bank, ultrasonography and X-ray);
- pharmacy: about 97% of essential drugs are stocked by the hospital and adequate medical supplies are also maintained for most part of the year. The hospital gets its supplies from the catholic medicine centre, the Western Regional medical stores and private suppliers (accredited companies); and
- a stand-by ambulance for transporting emergency cases to and from the hospital.

The hospital has 200 beds with an overall bed occupancy rate of 94% in 2013. The outpatient clinic has an average daily attendance of about 270 and average monthly admissions of about 1,230. The St. Martin de Porres Hospital contributes about 40% of the total outpatient department (OPD) attendance in the District. The number of OPD attendance and hospital admissions increased significantly with the introduction of the NHIS. On the average, insured clients form about 85% of all in and out patients. The hospital has a free treatment list for those patients not insured and that cannot afford consultations and medication. Health care is also free for all pregnant women and new borns up to 6 weeks post-partum.

The total number of staff is 218 with medical staff constituting about 40% of all staff (human resources strategic plan, St. Martin de Porres Hospital, 2013-2015). Currently the hospital has only 3 doctors in the hospital made up of one medical officer, one general surgeon and one obstetrician gynaecologist.

The two main sources of income for the hospital are the Government of Ghana through subventions and income generated as fees from patients. The largest spending areas are salaries, drugs and medicines and medical supplies.

In addition, donations of assorted equipment and medicines are received from organisations and individuals. For instance, in 2013 eni Foundation reconstructed the antenatal block for the hospital, provided a 4x4 vehicle for outreach programs and funds for various trainings and procurement of equipment for maternal and child health programs in the sub-district.

According to the key informant interviews with health professionals at the hospital conducted in December 2014, the main challenges faced by are:

- inadequate medical staff particularly doctors and midwives;
- lack of mortuary services;
- broken X-ray machine;
- fluctuations and interruptions in power supply; and
- delays in reimbursement from the NHIS.

Figure 6-2 shows some photographs of the St Martin de Porres hospital at Eikwe.

Figure 6-2 St Martin de Porres Hospital at Eikwe



Source: ERM-SRC, 2014

Atuabo CHPS Compound

The Atuabo CHPS Compound was established in November 2012 by the Ghana health service in collaboration with Atuabo and Asemda–Suazo communities which the CHPS serves. The estimated population of these communities are 15,484 and 689 respectively. The CHPS is manned by two community health officers and a healthcare assistant and has an average daily outpatient department (OPD) attendance of three.

Services offered by the CHPS Compound include:

- treatment of minor ailments;
- reproductive and child health services mainly;

- family planning;
- postnatal care; and
- child welfare clinic consisting of immunisation, growth monitoring and Vitamin A Supplementation.
- school health services;
- health promotion; and
- integrated disease surveillance and response (IDSR).

Antenatal and delivery services are not offered as there is no midwife or labour ward.

The Atuabo CHPS Compound has basic medical equipment and supplies including Sphygmomanometer (BP Apparatus), thermometers, weighing scale, vaccine carriers, Malaria rapid diagnostic kits, needle, syringes and basic drugs. The facility gets its supply of drugs and equipment from the District health administration at Nkroful while the vaccines are obtained from Eikwe. The facility has no ambulance.

The health facility has electricity and regular supply of water. However, it does not have a refrigerator for vaccines. It therefore gets its supply of vaccines from St. Martin de Porres hospital at Eikwe.

The main source of revenue is from outpatient services, sale of drugs and family planning commodities. Most of the patients are insured and do not pay in cash for services rendered.

Figure 6-3 shows the CHPS in Atuabo community.

Figure 6-3 Atuabo CHPS Compound, 2014



Source: ERM-SRC, 2014

Sanzule CHPS Compound

The Sanzule CHPS Compound was established by the Ghana health service in collaboration with the Sanzule, Bakanta and Anwolakrom communities which the CHPS serves. The three communities in the CHPS zone have an estimated population of 1,295 and 760 and 600 respectively. The CHPS compound is manned by three Community Health Officers.

Services, equipment, supplies and funding sources at the the Sanzule CHPS Compound are the same as for Atuabo CHPS Compound outlined above. Antenatal and delivery services are not offered as there is no midwife or labour ward. The facility has no ambulance. Referred patients from the facility go by commercial vehicles.

Office accommodation for its operations is a rented privately owned apartment at Sanzule. eni foundation is funding the construction of a new building at the permanent site. Figure 6-4 shows the CHPS in Sanzule.

Figure 6-4 Sanzule CHPS Compound, 2014



Source: ERM-SRC, 2014

7 IMPACT IDENTIFICATION AND ASSESSMENT

7.1 ASSESSMENT METHODOLOGY

The present chapter analyses the associated and potential impacts that the proposed Ghana OCTP Block Phase 1 Development Project activities could have on the biophysical and anthropic environment. As described in Chapters 2 (Project Description), the project essentially involves installation of the drilling rig, drilling, production testing and well completion. The salient features involve the well drilling operations, to be performed using a “Semisubmersible Drilling Unit”, Installation, operation and removal of well heads; Laying and operation of Transport Systems (flowlines); and Installation and operation of FPSO and mooring systems.

The chapter describes the impact identification and assessment methodology, identifies the potential impacts and assesses the significance of the identified potential impacts on the various environmental, social and health components. The assessment approach generally involves matching the various activities of the proposed project (as described in this report) with the components of the existing biophysical and anthropic environment (Baseline Analyses chapters 4-6).

7.1.1 Potential Impacts Identification and Characterisation

The environmental, social and health impacts potentially generated by the development of the project were identified via the elaboration of impact pathways. An impact pathway is substantially a process tool which allows for the identification of the main impacts on the surrounding physical environment and the host communities’ society, economy and health, induced during the execution of the project, from the initial phase, through to Operation and Production, and ultimately Decommissioning.

The process begins with an impact identification matrix, which involves the listing of the main project activities carried out during the various project phase on one side and the baseline biophysical and anthropic profile components (i.e. environmental, socio-economic and health components) on the other, so as to highlight the relationships between project activities and potential direct impacts. In some cases the components are expressible by means of specific *indicator parameters* (see next paragraph).

Characterisation refers to the *types* of impact generated by the Project; i.e. any project can generate a wide range of potential impacts, some of which will be direct, whilst others will be more complex and difficult to identify (see box below).

Types of impact:	
Direct (or primary)	Impacts that result from a direct interaction between a planned project activity and the receiving natural or socio-economic environment.
Indirect	Impacts that follow on from the primary interactions between the project and its natural and socio-economic environment as a result of subsequent interactions.
Cumulative	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the project.
Perceived	Changes that may be unconnected to, but blamed on, the project. These are usually identified and assessed through stakeholder engagement and consultation.

Therefore, once the direct impacts are established, the next step is to complete the impact pathway by determining the indirect impacts of these direct changes to the environmental, social and health components, as well as any subsequent cumulative and perceived impacts.

7.1.2 Potential Impacts Indicator Parameters

The next step in the impact assessment methodology consists in selecting the parameters/indicators of each ESH component that are “sensitive” to the changes triggered by the potential impacts identified. Their sensitivity renders them capable of describing and/or quantifying the potential impacts caused by project activities, as well as providing a clear picture of the potential impacts’ boundaries and characteristics.

The identification of indicator parameters therefore serves the purpose of translating the identified potential impacts into measurable (qualitatively and/or quantitatively) terms, in order to proceed to their evaluation via the qualitative assessment method hereby described and/or specific *ad hoc* modelling/simulation techniques

7.1.3 Impacts Evaluation

Once identified, the significance of the potential impacts must be assessed in order to determine requirements for impact mitigation (or enhancement of benefits) and management measures to be implemented during the project.

Where feasible, in relation to certain components the potential impacts identified were assessed quantitatively via modelling techniques. These modelling techniques put into correlation the values of the single indicator parameters of each component before and after the project’s activities, thus allowing to quantify their relative potential disturbing effect.

In the case of other components the assessment is solely qualitative and is limited to a series of considerations on the possible natural and/or anthropic sources of disturbance, their status within the marine environment and their effects on the biophysical and/or anthropic ecosystems. Here, in assessing the significance of each potential impact (positive or negative), the following criteria of consequence were applied:

- **Duration:** The temporal scale of the effect, ranging from 1 year or less to 10 years or more (potentially irreversible);
- **Extent:** The geographical scope of the impact, ranging from local scale (the proposed operating area and immediate environs) through to international transboundary scale effects;
- **Magnitude:** This is composed of three elements, namely:
 - extent of the change induced with respect to the baseline,
 - sensitivity/resilience of the receptor, i.e. its ability to recover or adapt to the change induced (1 implies good adaptability/resilience or low sensitivity while 4 means poor adaptability/capacity to recover or high sensitivity),
 - importance/persistence of cumulative effects derived from the impact;
- **No. of Elements:** includes individuals, households, enterprises, species and habitats that could be affected by the impact.

Each criterion is assigned a rating, and the consequence (severity) score is the sum total of the criteria ratings (ranging from 4 to 16) (see Table 7-1)

Table 7-1 Ranking of evaluation criteria.

Ranking	Evaluation Criteria			
	Duration	Extent	Importance / resilience of receptor / resource	No. of elements involved

Ranking	Evaluation Criteria			
	Duration	Extent	Importance / resilience of receptor / resource	No. of elements involved
Low 1	Less than 1 year / Temporary	Local scale: the proposed operating site and its immediate environs	Low value/sensitivity of receptors or resources, able to recover or adapt to the change without interventions	Affecting small no. of individuals, households, individual enterprises and/or small no. of species
Medium 2	Between 1 and 5 years	Regional scale: as determined by country's administrative boundaries	Moderate value/sensitivity of receptors or resources, able to adapt with some difficulty and which may require interventions	Affecting small number of individuals, communities or administrative and/or higher no. of species and habitats
High 3	Between 5 and 10 years	National scale: Entire country	High value/sensitivity of receptors or resources, poorly able to adapt to changes with strong interventions	Affecting great no. of individuals, households and/or medium/large enterprises and/or habitats and ecosystems
Critical 4	Over 10 years / Irreversible	International scale: trans-boundary	Extreme value/sensitivity of receptors or resources, resulting in permanent changes	Affecting huge no. of individuals, households and/or large enterprises and/or habitats structure and ecosystems functions
Score	1 – 4	1 – 4	1 – 4	1 – 4

Alongside impact consequence, it is necessary to establish the impact's probability of occurrence. Probability is divided into four, almost equally weighted, categories:

- **Unlikely:** Unlikely to occur in normal operating conditions but may occur in exceptional circumstances;
- **Possible:** May occur under normal operating conditions, but not likely;
- **Probable:** Likely to occur under normal operating conditions; and
- **Definite:** Will occur under normal operating conditions.

Once consequence and probability have been established, the significance (Low, Medium or High) can be determined (see Table 7-2). Consequence and probability can be established quantitatively or qualitatively, on the basis of an analysis of the information contained in the baseline data report, project data and other relevant (international) literature.

Table 7-2 Significance ratings

Consequence Score	Probability			
	Unlikely	Possible	Probable	Definite
4 – 6	Low	Low	Low	Low
7 – 9	Low	Low	Medium	Medium
10 – 12	Low	Medium	Medium	High
13 – 16	Low	Medium	High	Critical

Discussion relating to the Identification and Characterisation of Potential Impacts, and Potential Impact Indicator Parameters can be found in Annex G.

7.2 EVALUATION OF IMPACTS ON THE BIOPHYSICAL ENVIRONMENT

Environmental Effects of Potential Impacts Identified

Each environmental component may be affected by a synergy of potential impacts, which stem one from the other. For example, the component Seabed and Marine Subsoil is potentially affected by 5 different types of impact, and these impacts in turn may be generated by one or more project actions. Moving towards the impact evaluation it is therefore necessary to first provide a description of the environmental effects of each potential impact, as well as which project actions give rise to the same potential impact. This is discussed in detail in Annex G.

7.2.1 Impact on Air Quality

During the proposed project execution, modest levels of emissions will be generated from different sources such as helicopter movement, sea going and supply vessels and generators. The effects of the emissions are expected to be low as their effects will be mitigated in addition to atmospheric dynamics observed in the study area. Under most offshore meteorological (winds, gales, etc.) conditions, concentration of air quality pollutants would be well below their maximum predicted values due to the effect of dispersion / dilution leading to very negligible effect.

During well drilling, installation of FPSO, laying of flowlines and well heads installation activities, atmospheric emissions are essentially linked to exhaust gases from the engines. Other emissions are related to gas flaring in production tests. Considering that the activities in question are short-lived and that the weather conditions in the open sea present such features as the nearly constant wind of varying direction and intensity, it is clear that the pollutants in question are disposed of quite rapidly.

The position of the rig and other facilities allow a greater spread of the plume formed in the atmosphere, permitting the dispersion due to the higher probability of winds; previous studies of atmospheric dispersion, show a complete diffusion of pollutant emitted from the fuel combustion. As regards the atmospheric component, the results reported above indicate that emissions cannot in any way modify the pre-existing air quality in the offshore area involved in the operations. Moreover, the project area is located quite far from the coast; so its impact on the shoreline will be minimal. Therefore, it is possible to underline that the project impacts on the atmosphere due to emissions produced by the project is totally negligible.

The engineering design approach shall be to minimize emissions to the atmosphere where practical and economically possible and to apply good engineering practice in the choice of materials and equipment to minimize fugitive emissions. Where emissions are unavoidable, the approach shall be for point sources, to provide stacks of adequate height to ensure good dispersion.

The following sources of atmospheric emissions are considered:

- discharge of exhaust gases from the engines of the drilling unit
- discharge of exhaust gases from the engines of the supply vessels
- emissions of gas burning during production tests.
- Installation of FPSO and mooring system
- FPSO operation

The fuel considered for the project activities is diesel, with a sulphur content below 0.2% by weight.

In Table 7-3 data about greenhouse gases (GHG) emissions is reported, calculating the Global Warming Potentials (GWP) according to IPCC (2007) characterization factor.

Table 7-3 Global Warming Potential of project activities

POLLUTANT	CO2 Kg	CH4 kg	GWP Kg CO2 eq.
Drilling unit	51.601.204,34	2.794,47	51.671.066,19
Supply vessel	26.182.154,20	1699,25	26.224.635,45
Gas flared in production tests	2.175.119,15	222,6285	2.180.684,86
Oil burned in production tests	8.393.647,50	290,19	8.400.902,25
TOTAL	88.352.125,19	5.006,54	88.477.288,75

Summary Evaluation

The effects of the emissions are expected to be low as their effects will be mitigated in addition to atmospheric dynamics observed in the study area. Under most offshore meteorological conditions (winds, gales, etc.), concentration of air quality pollutants would be well below their maximum predicted values due to the effect of dispersion / dilution leading to very negligible effect.

During FPSO operation, and well heads activities, atmospheric emissions are essentially linked to exhaust gases from the engines. Considering that the activities in question produce modest level of emissions and that the weather conditions in the open sea present such features as the nearly constant wind of varying direction and intensity, it is clear that the pollutants in question are dispersed quite rapidly.

The position of the FPSO facilities allow a greater spread of the plume formed in the atmosphere, permitting the dispersion due to the higher probability of winds; previous studies of atmospheric dispersion, show a complete diffusion of pollutant emitted from the fuel combustion. Moreover, the project area is located quite far from the coast; so its impact on the shoreline will be absent.

The potential impact of air emissions on air quality is therefore assessed to be of low significance.

Table 7-4 Significance of impact of air emissions.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. elements of involved	Score		
Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -

7.2.2 Impact on Water Quality

During project execution, there will be temporary re-suspension of sediment particles including organic matter within the water column. This will be low in magnitude and short term hence not envisaged to have pronounced significant effect on water quality. The following project activities are likely to contribute to the quality of seawater:

The project's activities require the presence of some vessels in the surrounding waters to support the various phases of the work. All vessels have mechanical seals which prevent any leaking of oily bilge water and thus the physiological hydrocarbon leaks can be deemed negligible. During the drilling phase, vessels are envisaged to transport personnel and a supply-vessel (for ordinary maintenance and for loading and unloading other materials).

The presence of naval vessels and the FPSO operation means the emission of hot water as the engine cooling water is discharged with a local increase in temperature, and possible consequences for primary production; this water may contain hydrocarbon residues, biocides / antifouling and trace metals.

The presence of the drilling structure, submerged well-heads, flowlines and FPSO mooring system may lead to some level of distortion in the current field. However, the results of hydrodynamic models applied to similar structures have revealed that the variation only affects a very small volume of water around the infrastructure and, therefore, its effect can be considered insignificant as compared to waves and currents motion.

During the drilling and completion phases, the FPSO and well heads installation, and FPSO operations, effluents from the crew quarters and service areas of the drilling unit, the FPSO and the vessels, are discharged into the sea after adequate treatment. These discharges contain nitrogen and phosphorous compounds and organic substances in general, substances which can raise the BOD level, the level of water trophism and reduce transparency.

The presence of vessels can lead to increases in the lead concentration in the water when leaded fuels are used. On the other hand, the drilling system and well head are not expected to release lead into the sea.

The presence of materials suspended in the water column directly reduces transparency (and thus light penetration) and this can interfere with the variation in euphotic zones and, in turn, photosynthesis of the plant organisms present, both in the water column and on the sea bed. Generally, fine materials are a direct result of the increase in particulate substances present in the sea. However, reduced transparency is often the result of increased numbers of phytoplanktonic organisms or organic substances present as a result of the increased availability of nutrients.

The use of sacrificial anodes to protect the submerged structures against corrosion has negligible effects on the water column. The anodes (which contain no mercury) **shed metals**, especially Al, causing a slight increase in the concentration of these elements in the water column.

The project envisages the total reinjection of production water, thus in the present document potential impacts deriving from discharge of the these waters into the sea are described. The produced water will be discharged into the sea, after treatment the reduce the oil content in compliance with local legislation and international standards, only in case of unavailability of the water injection system.

Oily and accidentally oily waters are stored in special drums to be transferred to land to be properly disposed/treated.

Civil wastes (sewage, water from washbasins, showers, the caboose) are treated, as to achieve legal concentration limit, with approved systems before being discharged into the sea.

Definition of the Indicator Parameters

- Transparency
- Temperature
- Nutrients
- Organic substances, TOC
- Chlorophyll "a"
- Total Hydrocarbons
- Oxygen concentration
- Heavy metals.

Potential impacts due to Sewage Waste Discharge

The concentration in the water of a series of characteristic indicators is considered, all of which are linked to the treated sewage discharged. These indicators are the nitrogen and phosphorous compounds detected in the water — i.e. ammoniacal nitrogen $N-NH_3$, nitric nitrogen $N-NO_3$, nitrous nitrogen $N-NO_2$ and phosphorous from orthophosphates $P-PO_4$.

The presence of nutrients directly affects the level of water trophism, making a substrate available to the primary producers for the synthesis of organic molecules. The phosphates are considered the limiting factor in the development of phytoplankton and any significant increase in the water phosphate concentration can, in some cases, lead to extensive algal bloom. The presence of organic substances in the sea can indirectly affect the level of trophism since it stimulates heterotrophic micro-organisms, mineralizing and placing inorganic ions into circulation.

These parameters are linked solely to the sewage discharged from the vessels and platform and are thus related to the installation and drilling operations. The sewage is treated and it is not possible to determine the individual nutrient concentrations. An overall estimate of the impact can be made considering the BOD, the reference parameter for controlling sewage treatment. The sewage discharges are, in fact, treated so as to achieve a BOD within the 40 mg/l limit.

Evaluation of the dispersion of the treated sewage is performed using the DISP3D model that can determine the primary dispersion of pollutants and the secondary dispersion due to currents. The model is a two-stage process: primary dispersion is evaluated using a jet formation while secondary dispersion is calculated using a 3-D dispersion model that takes the initial concentration from the primary dispersion model and operates over a rectangular domain; in other words it applies the approximation that the sea bed is flat and that there are no impediments in the domain calculation - i.e. structures, coast, etc. The current values must be supplied by the user as input for the model.

The extent of sewage discharged from the vessels and systems during installation and drilling is approximately 12 m³/day (100 l x 30 days x 120 pers = 36000 lt/month) which means approximately 13.9×10^{-5} m³/s.

During FPSOs operation activities and throughout the entire life cycle of the projected activities it is estimated that about 60 operatives will be present on the FPSO; on the basis of the data available in the literature for sites similar to the one under consideration, we can provide an estimate of civil waste water produced: 100 l x 30 days x 60 pers = 180000 lt/month (6000 l/day)

In subsequent simulations, the emission value of the installation and drilling phase (the higher value compared with the operation phase), was considered the average emission value but, to verify the process, a dispersion simulation was also performed considering peak emissions arbitrarily set at 10 times the average value.

For simulation purposes, current speed was set at 5, 10 and 20 cm/s; low current speeds correspond to lower pollutant dispersion and thus the concentration will be higher.

The digital simulations were performed over an 800 x 400 m domain, horizontal resolution 20 m, vertical resolution variable. Since discharges are made near the surface and, in the sea, vertical exchange is reduced, a rather tight resolution was adopted near sea level – variable from 1 to 4 m – and was progressively eased toward the bottom.

Figure 7-1 shows the BOD iso-concentration curve calculated with average sewage emissions and an environmental current of 5 cm/s. The calculation assumed a sewage BOD concentration of 40

mg/l and emission levels were set at approximately 4 m below sea level. The figure refers to the calculation level falling between 3 and 7 m below the surface, the zone where maximum concentration was recorded. Digital simulation showed a concentration peak of 1.9×10^{-3} ppm which was reduced by one order of magnitude at just 100 m from the emission point. Therefore the values obtained were 2000- 20,000 times lower than the BOD concentration limit of 4 ppm, set as acceptable.

Similar considerations can be made regarding the results obtained with stationary current levels of 0.10 m/s (Figure 7-2) and 0.20 m/s (Figure 7-3).

It is worth noting that even assuming peak emission values an order of magnitude higher than the average emissions (Figure 7-4), the peak concentration — 7.0×10^{-3} mg/l — is more than 500 times lower than the above-mentioned limit and it drops to more than 3000 times lower at a distance of around 200 m from the point of emission.

Therefore we can conclude that the increase in nutrient concentration is negligible, even in the immediate vicinity of the point of emission.

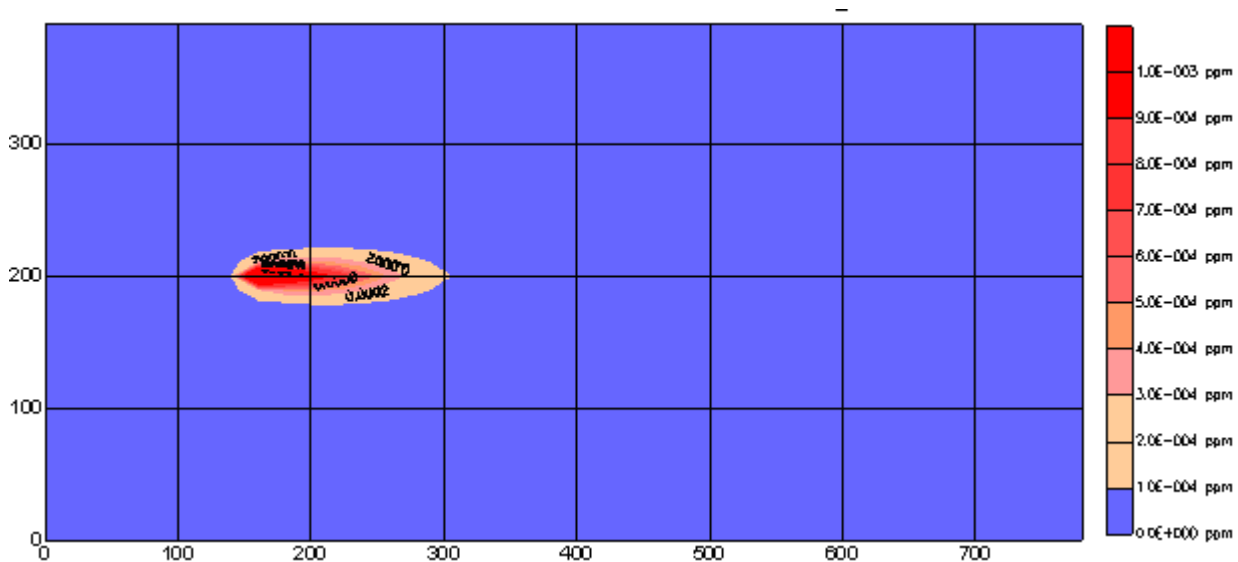


Figure 7-1 Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.05 m/s – Average emission capacity: $6.94 \times 10^{-5} \text{ m}^3/\text{s}$

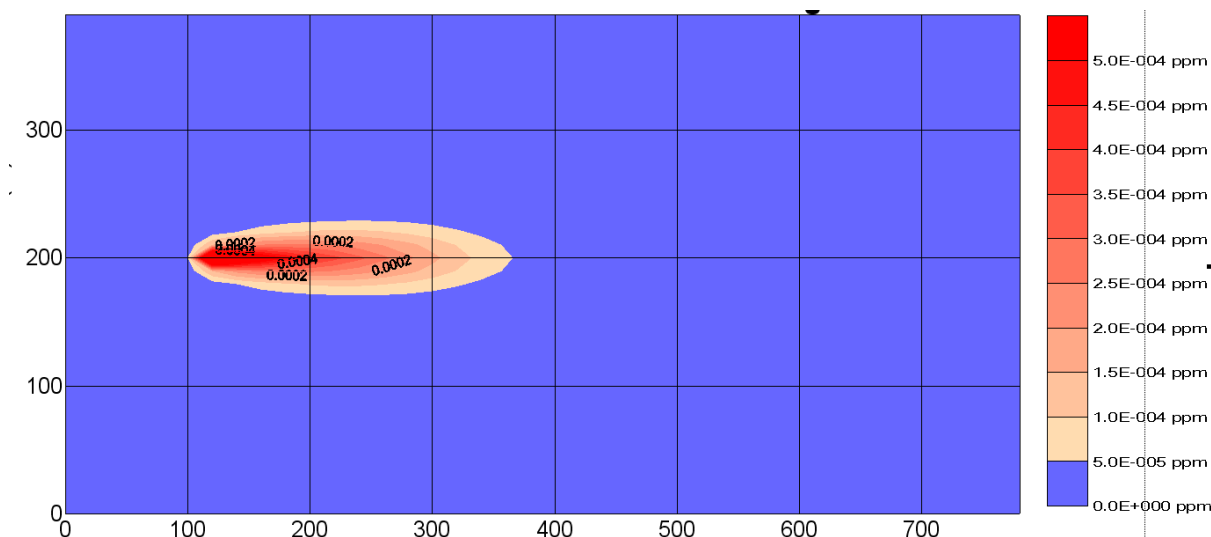


Figure 7-2 Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.10 m/s – Average emission capacity: $6.94 \times 10^{-5} \text{ m}^3/\text{s}$

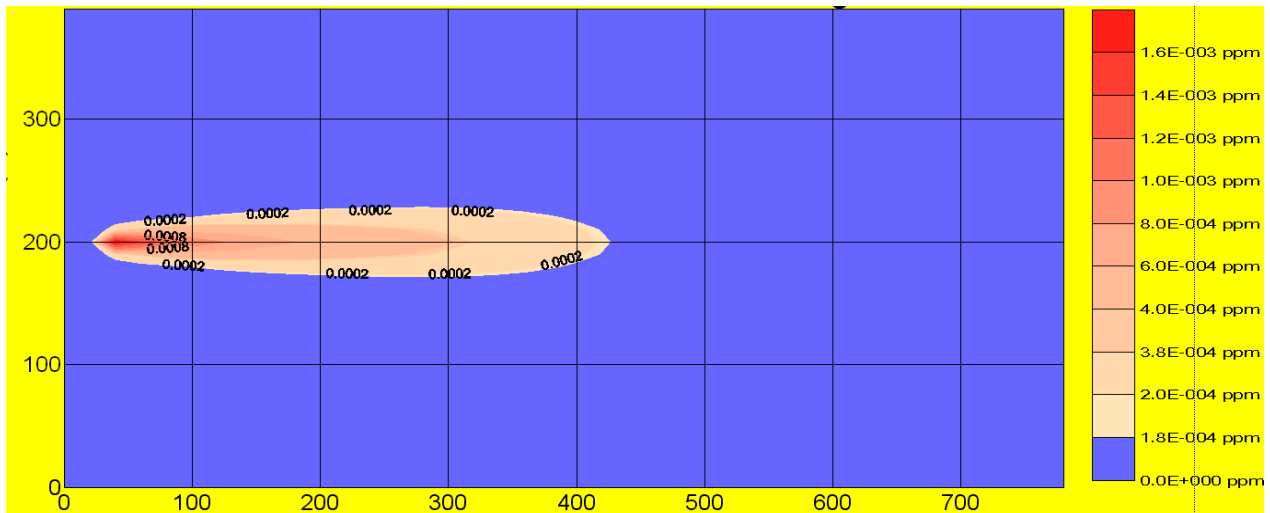


Figure 7-3 Analysis of the water dispersion of sewage showing expected BOD concentrations (ppm) – V=0.20 m/s – Average emission capacity: $6.94 \times 10^{-5} \text{ m}^3/\text{s}$

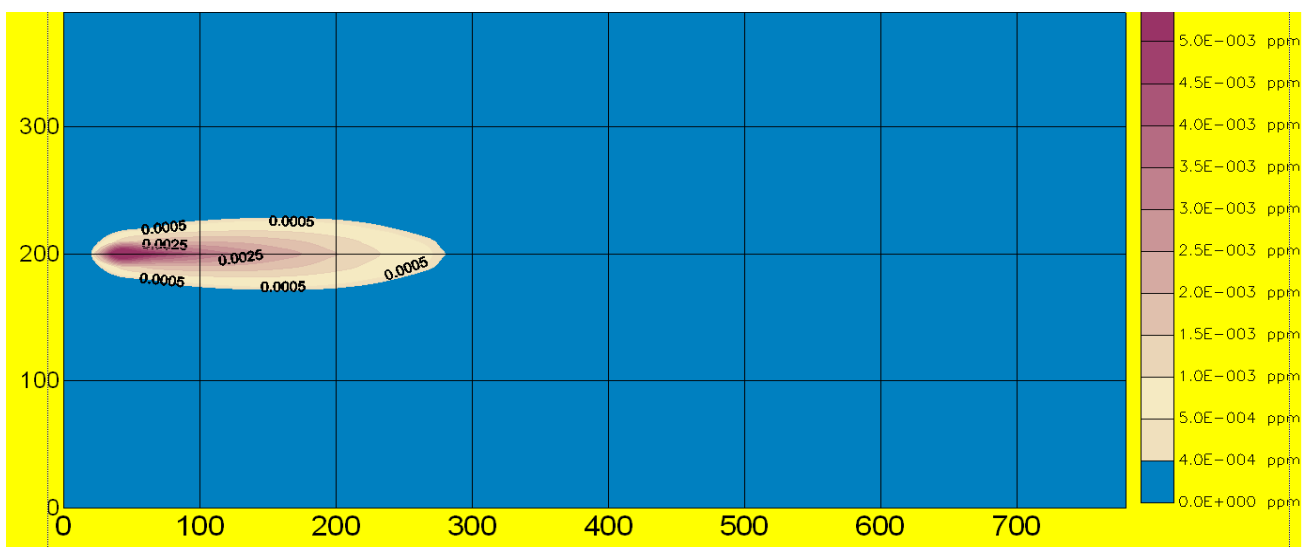


Figure 7-4 Analysis of the water dispersion of sewage showing expected BOD concentrations (ppm) – V=0.20 m/s – Average emission capacity: $6.94 \times 10^{-4} \text{ m}^3/\text{s}$

In light of the foregoing considerations and the modelling results it is possible to observe that the impact of wastewater discharge on the quality of the receiving body and on parameter indicators related to the increased availability of organic matter, will be limited to a restricted area of the water column, in proximity of the discharge point.

Potential impacts due to Production/Hot Water Discharge

Associated with oil and gas deposits, production waters are brought to the surface along with the hydrocarbons produced. The quantity and quality of the production water generated during cultivation activities depends on the type of well, the nature of the geological formation and the extent to which the well is exploited.

In some cases chemical compounds can be added to the production waters. The amounts of such additives — e.g. corrosion inhibitors, biocides, de-emulsifiers, etc. — found in production water does not generally exceed a few parts per million (ppm).

The production waters typically contain i) an inorganic component — essentially composed of chlorides, bicarbonates and ions of sodium, potassium, calcium, barium and strontium, with concentrations increasing as depth increases — and ii) an organic component — alkanes from C7 to C31, aromatic compounds and polycyclic hydrocarbons.

The volatile hydrocarbon liquids (VHLs) — including light aromatics and, in particular, compounds ranging from benzene to naphthalene of ecotoxicological interest since they are most highly soluble in water — are those most commonly found in the production water.

The fraction of petroleum insoluble in water is, above all, composed of high molecular weight aliphatic hydrocarbons (HMW-HC) and cyclical and aromatic hydrocarbons, again with high molecular weight: only small amounts of polycyclic aromatic hydrocarbons, PAH, are present in the production waters.

The temperature of the production water increases as the production zone deepens (in shallow wells the temperature ranges from 30 to 50°C while it can even reach 250°C in the deepest wells).

The solid content suspended in the production water can vary quite significantly; the presence of major amounts of suspended solids can lead to a significant decrease in the transparency of the discharge water column.

Regarding the temperature trend, the discharge enters the receptor body with a difference with respect to the ambient temperature of 3°C, however, already in the first few meters, thanks to the primary dilution, a thermal variance of 2 °C is recorded 50 -60 m from the point of entry.

The effects of the discharge primary and secondary dispersion determine a rapid attenuation of the thermal delta between that of the discharge and the receiving environment.

Beyond a 100 m distance, temperature increase settles below + 0.5°C.

Near the entry point temperature delta is greater at the surface, rather than in the rest of the water column, consistent with the lower density of efflux linked to its higher temperature.

However, that it could have repercussions on the community on the sea floor is ruled out because of its great depth; thus can be assumed that the consequence for phytoplankton would be negligible.

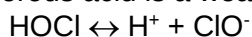
Potential impacts due to biocides/antifouling (Chlorine) Discharge

Chlorine compounds are the most commonly used and economical biocides. Sodium Hypochlorite (NaOCl) can be used.

When added to water the reactions of NaOCl produce HOCl:



Hypochlorous acid is a weak acid, only partially dissociating into hydrogen and hypochlorite ions:



The degree of dissociation of hypochlorous acid is significantly affected by pH and temperature.

With decreasing pH, the degree of dissociation of hypochlorous acid decreases. Below a pH of 5.0, the dissociation of hypochlorous acid is virtually 0%, regardless of temperature. As temperature increases or decreases, the dissociation curve shifts along the pH axis, as shown on figure below. The sum of hypochlorous acid and hypochlorite ion in solution is called “free available chlorine”.

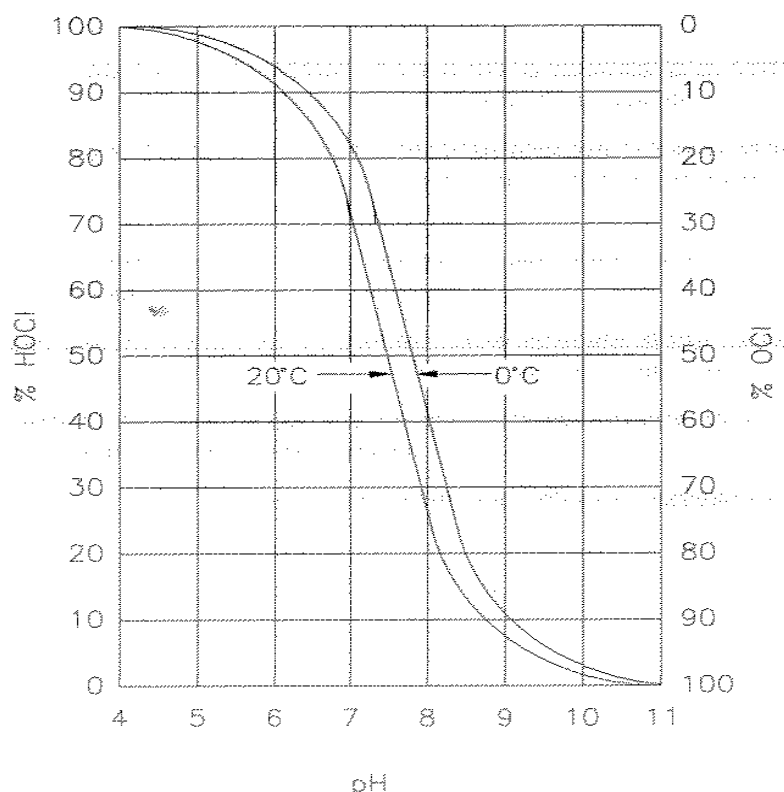
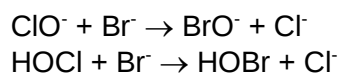


Figure 7-5 Dissociation curve of hypochlorous acid as a function of temperature and pH

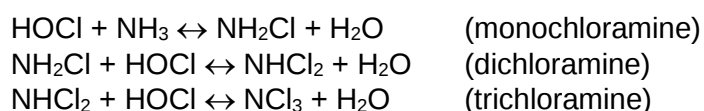
The effectiveness of chlorine depends on which of these species is present and is therefore a function of pH. For instance, the killing power of HOCl is much greater than that of ClO^- , possibly because the charged ClO^- ion has a more difficult penetrating the cell wall. At typical seawater pH values (8.1 – 8.2) the chlorine is only 20% active.

However, in waters containing bromide ions, such as seawater that contains nearly 65 g/l of bromides, chlorine oxidizes the bromide ions to form HOBr, which is still an effective biocide at pH 8-9.

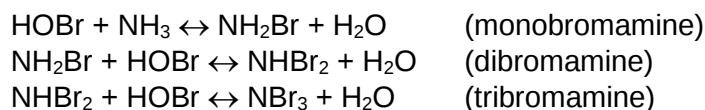
The bromides present in seawater (nearly 65 mg/l) are oxidized into hypobromite and hypobromous acid according to the reactions:



Ammonia-nitrogen is present in seawater as amino groups in amino acids. Further reactions occur between ammonia-nitrogen and hypochlorous acid to form chloro-amine compounds:



and between ammonia-nitrogen and hypobromous acid to form bromo-amines:



All these reactions can occur simultaneously, and it is the physicochemical parameters of the seawater and the amounts of added oxidizing agent that will determine the prevailing reactions. Most of the compounds that are formed oxidize the organic matter in the medium at varying rates and efficiencies depending on the species and nature of the compounds:

- Hypochlorous acid is some 80 times more effective than hypochlorite ion
- Dissociation of HOBr occurs at a higher pH than HOCl, which makes it more effective in alkaline environments. As figure below shows, at seawater pH, hypochlorous acid is 80% dissociated while hypobromous acid is 20% dissociated.
- Chloramines are less effective as biocide and no longer react with organic matter
- Bromamines are still effective as biocide and react with organic matter

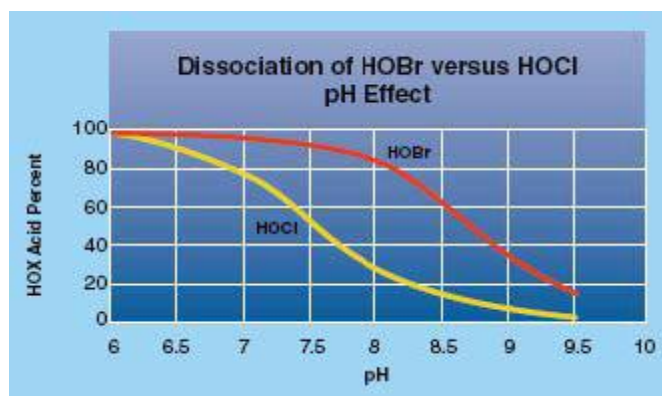


Figure 7-6 Dissociation of HOBr vs. HOCl – pH effect

The main products present in the medium are hypobromous acid, mono-chloramine, and di- and tri-bromamine.

The toxicity induced by the presence of chlorinated or brominated products in the medium may modify the parameters of the local ecosystem (bioaccumulation of toxic products, destruction of organic matter, etc.)

The degree of toxicity of the different compounds that are formed in seawater depends on a number of physicochemical parameters and on the compound's lifetime.

Chloramines are persistent and their effect is detrimental for receiving bodies.

Bromamines are not persistent. Their lifetime is far shorter than that of chloramines as shown on figure below.

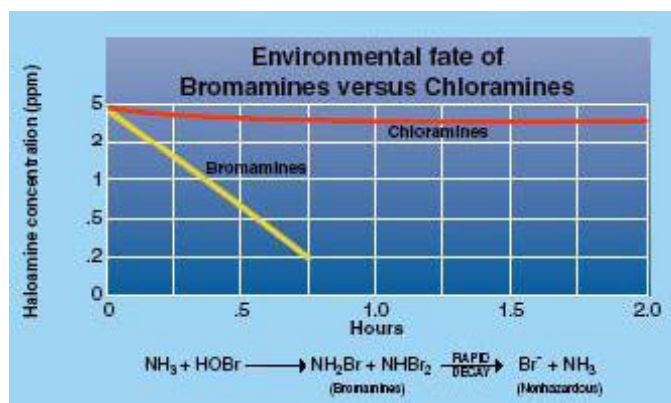


Figure 7-7 Environmental fate of Bromamines vs. Chloramines

Chlorinated or brominated organic compounds are usually more stable than inorganic compounds. While chlorine compounds are effective in controlling fouling, used in waters with high organic substances like seawater, they lead to the formation of halogenated organics (in particular, trihalomethanes) which are released in the environment.

Sometimes to comply with the limits imposed by legislation for chlorine compound and keep the system clean it is possible to use a reducing chemical in order to lower the residual chlorine at the discharge.

Different environmental scenarios can be considered possible depending on the hydrodynamic conditions present, whether there is a thermocline with stratification of the temperature gradient and variation in density at different depths, whether a vertical/horizontal flow is established, etc. The behaviour of discharged waters, with their temperature and content of antifouling and biocides, after their release into the water column is similar to that of wastewater containing nutrients and organic matter considered in previous modellings.

In this context, it is also important to consider the limited size of the discharges compared to the volume of the receptor body, the low concentration of biocides / antifouling and the system and procedures by which the water is discharged along the water column, in order to ensure a good level of mixing.

The **discharge of volumes of hot water and water containing pollutants, biocides and anti-corrosion substances** from the FPSO production process and supply vessels engine cooling into a large and deep basin like the one under consideration may trigger environmental interferences of negligible intensity.

In light of the foregoing considerations and the modeling results it is possible to observe that the impact of the discharge of production and cooling water on (i) the temperature of the receiving body (ii) on indicator parameters relative to temperature and (iii) on those indicator parameters relative to the presence of biocides and antifouling in the production and cooling water, will be limited to a restricted area of the water column in the proximity of the discharge point.

Organic substances, TOC

In this case, the organic substance is expressed as the concentration of organic carbon (TOC). The Total Organic Carbon is the sum of the carbon dissolved (DOC) and the particulate carbon (POC). The concentration is linked to the natural processes inherent to the biogeochemical cycle of this element and to any allochthonous sources (transport of solids from rivers, algae and discharge bloom, sewage).

It is more commonly interpreted as a BOD indicator that quantifies the oxygen demand and thus provides an indirect measurement of the concentration of organic substances present in the water directly relating them to the real site conditions. Also see dissolved Oxygen and BOD.

Chlorophyll “a”

This is an indicator of the trophic state of the offshore environment since it is directly linked to the amount of phytoplankton which, in turn, may increase as a result of sewage discharges.

Total hydrocarbons

The presence of hydrocarbons in the aromatic and aliphatic fractions leads directly to an increase in their concentration and indirectly to an accumulation in organisms at various points along the food chain. The aromatic component (PAH — benzene, toluene, xylene, naphthalene, phenanthrene, etc. general formula: C_nH_{2n-6} with $n > 6$) plays an important environmental role since it also includes the light aromatic hydrocarbons considered among the most highly toxic compounds for the environment (the acute effects and toxicity of PAHs with 2- and 3-rings have been demonstrated while the effects of those with greater numbers of rings has yet to be clarified). In general, sediments containing the highest concentrations of Polycyclical Aromatic Hydrocarbons (in particular those with high molecular weight) are relatively more stable in water.

The sediment PAH level is related to human activities while the concentration of PAHs with a low number of rings quickly drops in the sediments (since they are highly water soluble).

In general, the presence of consistent levels of 3- and 4-ring compounds indicates that the source is spent oils, lubricants and crude oil while 4 or more rings indicate that the input is combustion. The increase in the seaborne hydrocarbon concentration is generally related to shipping traffic, and this is more intense during installation of the well drilling structures.

The higher molecular weight aliphatic and aromatic hydrocarbons are characterized by low volatility and low solubility in water and thus tend to accumulate selectively in the biota and marine sediments. ☒

Considering that the vessel traffic is more intense during the reduced installation and drilling phase and reduced during the prolonged operation phase, and that in any case the quantities released are negligible, it is possible to observe that the impact of the activities in their entirety on the parameter in question is rather negligible.

Water column depth and the volume of the receiving body, distance from the coast and the fact that the supply vessels are in motion all contribute towards rendering little significant their impact.

Dissolved Oxygen

The amount of oxygen dissolved in the water depends on the solubility of this gas in the aqueous medium at a given salinity and temperature. It varies on the basis of a complex series of factors, including in particular, such biotic processes as algal photosynthesis (oxygen production) and bacterial organic substance mineralization (oxygen consumption). This parameter is affected by the input of nutrients through sewage discharge, even if the area of influence in open sea is very narrow.

The variability of this parameter is an indicator of the trophic state of the water and thus depends mainly on the increase in the autotrophic biomass in suspension. In fact, there is a clear-cut relationship between the chlorophyll “a” concentration and the fluctuation in dissolved oxygen.

The fluctuations around the value of physical saturation are mainly the result of oxygen derived from photosynthesis; subsaturation values are seen when the microalgal concentrations increase.

The dissolved oxygen value varies greatly from zone to zone and between surface and deep waters.

Potential impacts due to Sacrificial anodes on metals content

Alterations in the concentration of heavy metals in the water column are related to their release from sacrificial anodes and the transiting naval support vessels. Metals considered indicative to environmental conditions of the area are aluminium and lead. The former, in as much as it is the main constituent of the sacrificial anodes, the latter given its being the principal substance present in naval vessel fuel.

Modelling was used to evaluate of the effects of heavy metal dispersion in water, released by the sacrificial anodes.

The sacrificial anodes are composed of an aluminium-based alloy, which constitutes 95% of the total composition, as well as of Magnesium, Manganese, Zinc, Indium and Copper.

Considering that the rate of the anodes' dissolution can be estimated at c. 3kg/Amp/yr. and that residual current variability can be estimated in an interval of 80-300 mAmp, the release of metals should result between c. 250g/yr. and 900g/yr.

Nevertheless in the dispersion simulations a notably more conservative approach was opted for, assuming a release accrual equalling 5kg/yr.

Notwithstanding the notably conservative assumptions, the values calculated for metal release concentration in the marine environment surrounding the pipeline, prove very low, with a maximal in immediate proximity of the pipeline of 4 µg/m³.

Furthermore, concentration levels decrease to almost negligible amounts at a 1 metre distance from the structure; also considering the spacing of the anodes along the structure it is possible to exclude the juxtaposition of adjoining anodes.

Figure 7-8 and Figure 7-9 respectively represent the calculation domain and grid adopted for simulations. The calculation domain is 20 m in length, 3m high and 1m deep, i.e. roughly the estimated dimension of the anodes. It should be observed that this domain description leads to the disregard of longitudinal dispersion phenomena, introducing an ulterior element of conservativeness in the evaluation of metals concentration in the marine environment.

The computational grid's meshes are subjected to densification in proximity of the seabed so as to obtain a better description of phenomena associated with the turbulent boundary layer.

Simulations were carried out considering 3 possible scenarios for marine current velocity in proximity of the seafloor, all assumed to flow perpendicularly to the structure:

- 5cm/s current
- 10cm/s current
- 40cm/s current

The first two cases correspond to climatic conditions with weak currents and therefore reduced dispersive effects, while the third scenario corresponds to an estimate of expected currents in case of storms of medium intensity (return period of c. 1 year), and therefore describes a situation characterised by a greater efficiency of released metals' dispersion.

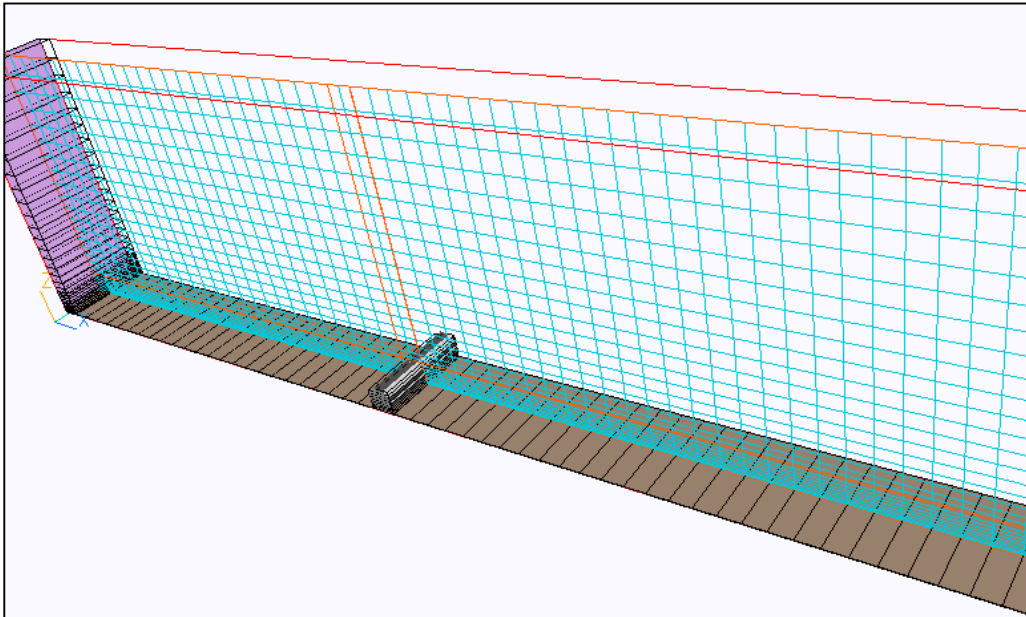


Figure 7-8 Calculation domain and grid on both sides of the pipeline

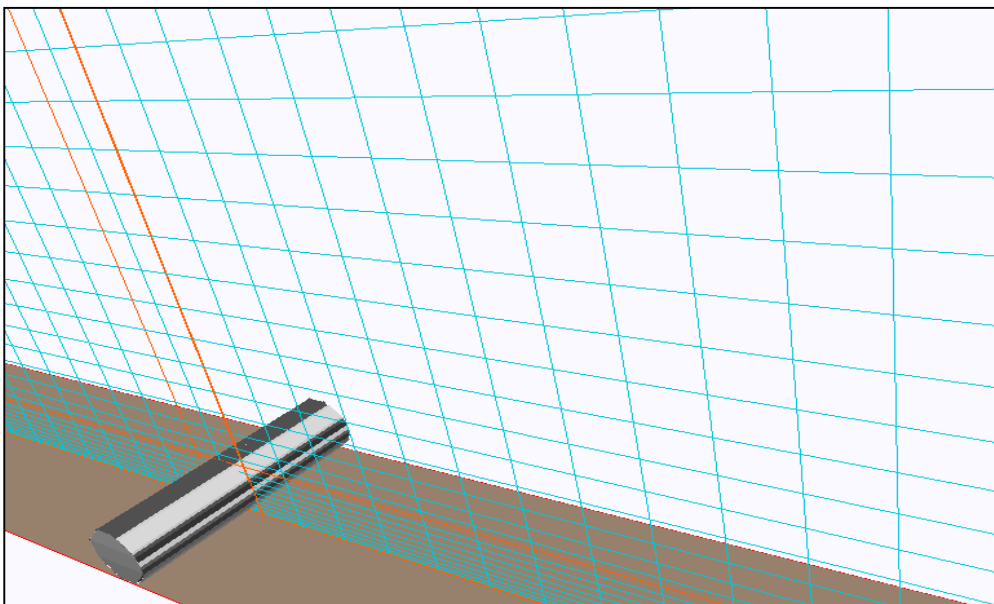


Figure 7-9 Calculation domain and grid – Detail in proximity of the pipeline

Results

Figure 7-10 illustrates the current velocity calculated around the structure for the undisturbed current scenario equal to 5cm/s. As foreseeable on the basis of hydrodynamic considerations, the iso-speed lines substantially highlight 3 regions: a region of flux amplification in correspondence of the pipeline's top-side, a limited region of stagnation upstream and a wider region of stagnation and recirculation downstream. Flux amplification is nevertheless rather contained: maximum current velocity calculated is only 30% greater to the undisturbed value. Moreover, the effects caused by the pipeline's presence in the hydrodynamic field disappear over brief enough distances; at only 1.5m downstream from the pipeline, the flux resumes its undisturbed conditions.

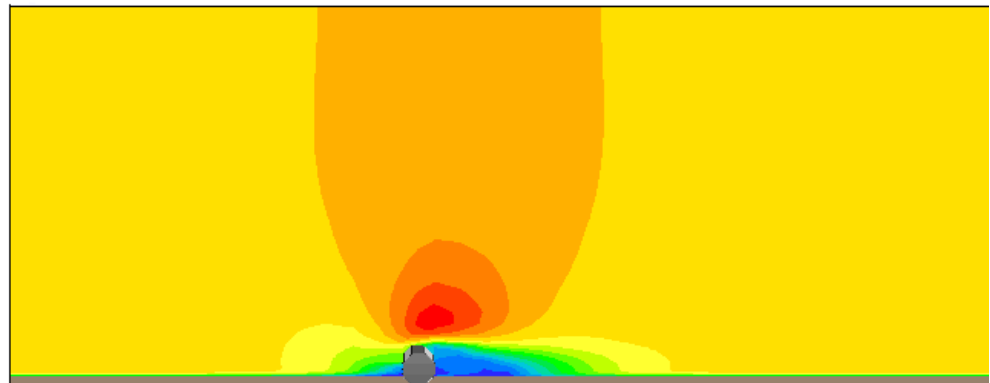
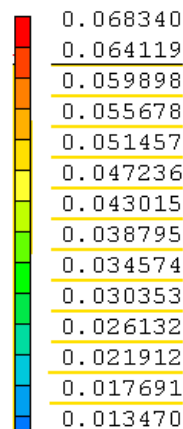


Figure 7-10 Hydrodynamic field around the pipeline – V=0.05 m/s & velocity scale (m/s)

The iso-concentration curves of released metals (Figure 7-11) indicate rather low values: in proximity of the pipeline it is possible to observe maximum concentrations of $4\mu\text{g}/\text{m}^3$, while at only 0.5m from the pipeline values decrease to $1\mu\text{g}/\text{m}^3$ and records completely negligible values at distances beyond 1m. in order to obtain a metric comparison, the structure + anode system is represented, for a total diameter of c. 25cm. To this regard it is also possible to observe that anodes are spaced at roughly 100-120m intervals along the linear structures. Therefore, considering that metals release concentration is in fact negligible within a few metres of the pipeline, phenomena regarding adjoining anodes' emissions juxtaposition may be ruled out.

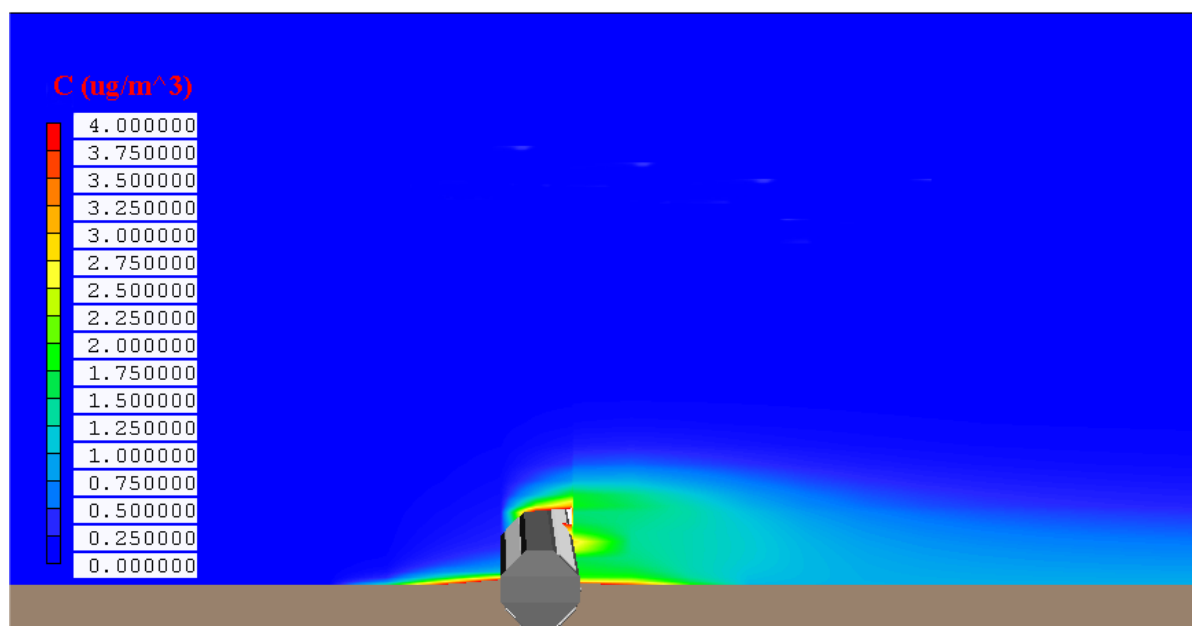


Figure 7-11 Metals concentration around the pipeline ($\mu\text{g}/\text{m}^3$) – V=0.05 m/s

Calculations carried out for undisturbed currents equal to 10 cm/s (Figure 7-12) indicate notably more extensive downstream phenomena, while again the maximum flux amplification on the top-side of the pipeline stands at 30%. A detailed view of the hydrodynamics in proximity of the pipeline is represented in Figure 7-13. The iso-concentration curves of released metals (Figure 7-14) indicate a greater extension of appreciable concentration zones, even though for extremely low values as well as lower maximums with respect to the 5cm/s scenario. Indeed, in proximity of the pipeline maximum values stand at $2\mu\text{g}/\text{m}^3$ with respect to the $4\mu\text{g}/\text{m}^3$ of the previous scenario, while concentrations decrease to values below $1\mu\text{g}/\text{m}^3$ for distances at 50-60cm from the pipeline.

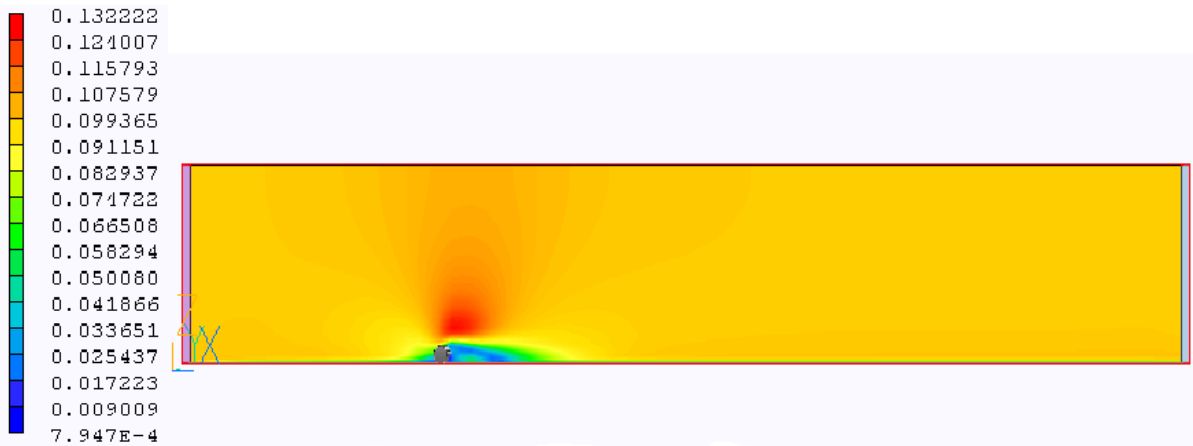


Figure 7-12 Hydrodynamic field around the pipeline – V=0.10 m/s

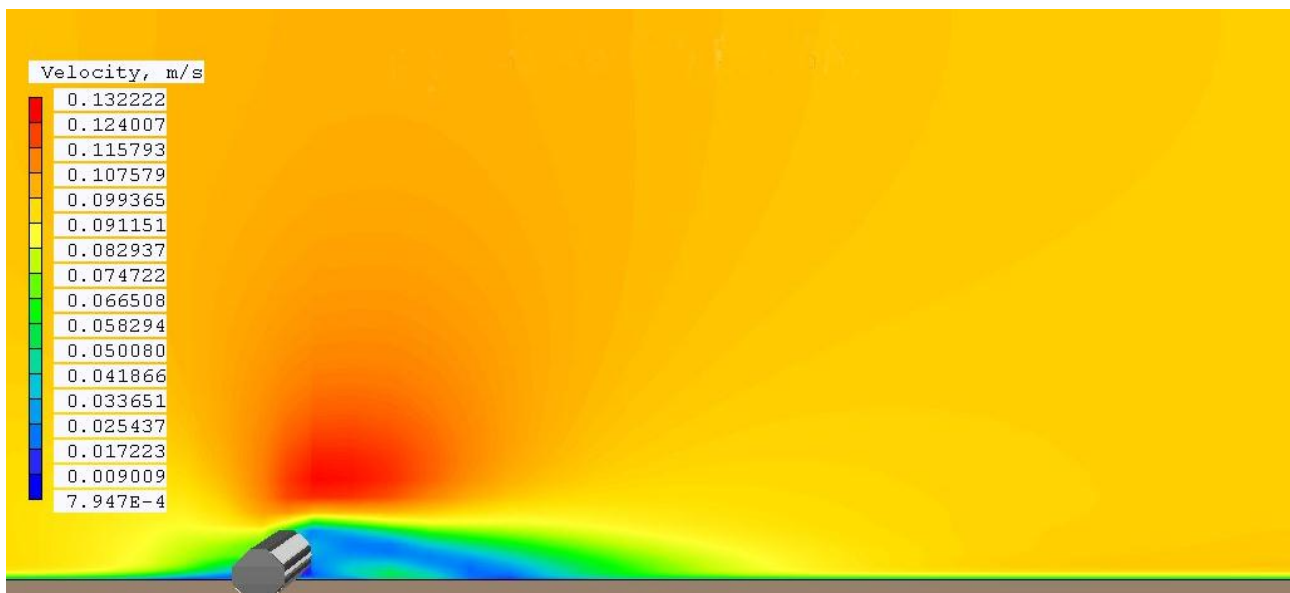


Figure 7-13 Hydrodynamic field around the pipeline – V=0.10 m/s - Detail

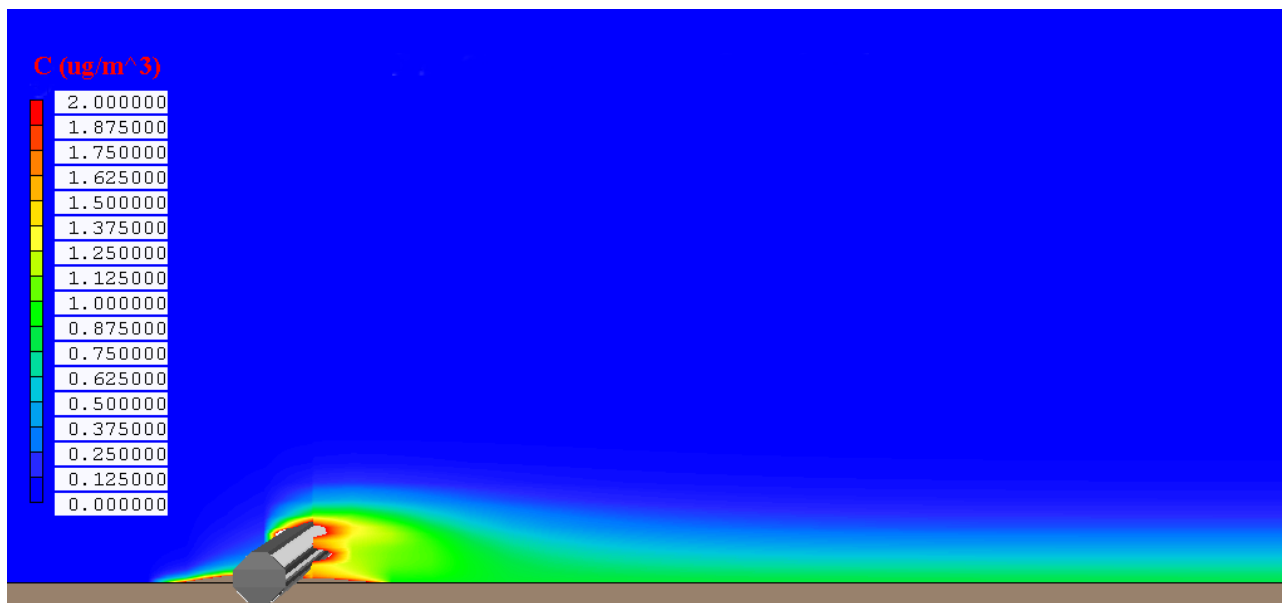


Figure 7-14 Metals concentrations around the pipeline ($\mu\text{g}/\text{m}^3$) – $V=0.10$ m/s

The 40cm/s current velocity scenario indicates a greater extension of the area manifesting conditions of flux disturbance and ulterior amplification of downstream phenomena (Figure 7-15), which are perceivable up to at least 3.5m from the pipeline. Nevertheless, the greater flux velocity also entails a greater efficiency in the phenomena of contaminants' dispersion. Coherently, the iso-concentration curves of released metals indicate extremely low levels of concentration, with maximums in proximity of the pipeline well below $1\mu\text{g}/\text{m}^3$ (Figure 7-16), and concentration levels below $0.3\mu\text{g}/\text{m}^3$ at a 0.5m distance from the pipeline.

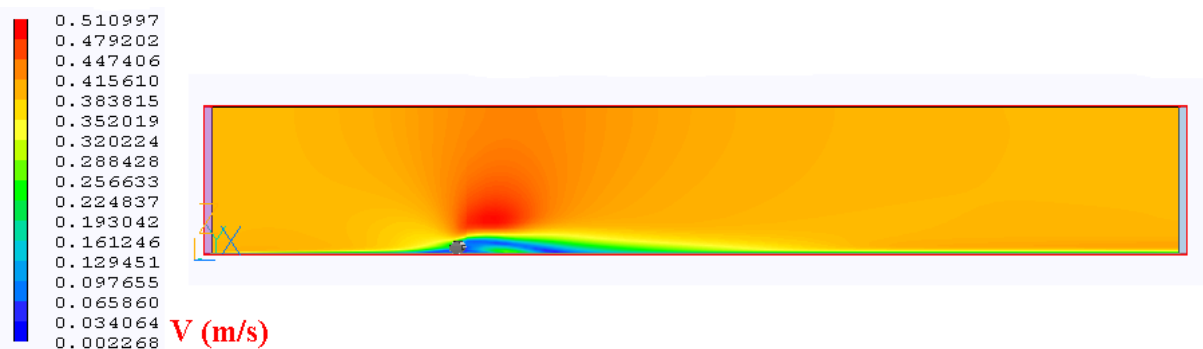


Figure 7-15 Hydrodynamic field around the pipeline – $V=0.40$ m/s

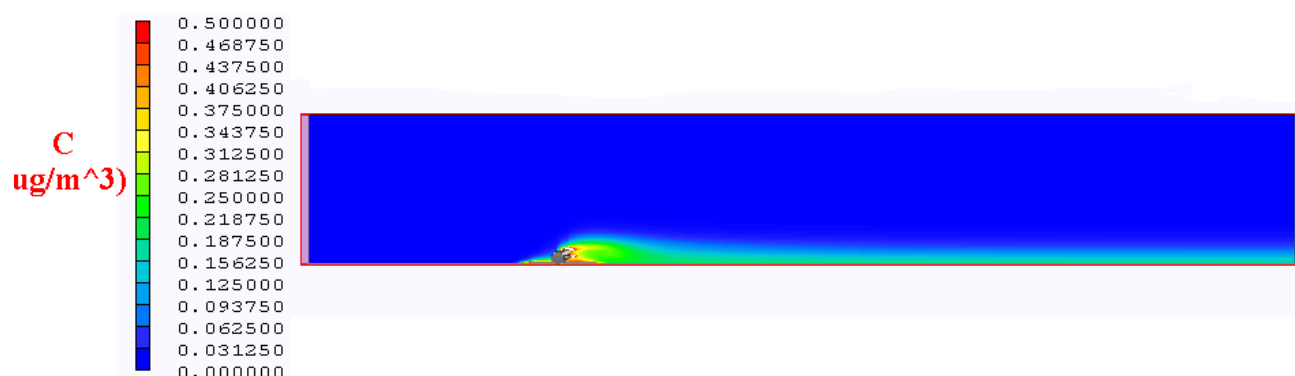


Figure 7-16 Metals concentrations around the pipeline ($\mu\text{g}/\text{m}^3$) – $V=0.40$ m/s

In synthesis the numerical simulations of metals dispersion, consequential to the corrosion of the submerged structures' sacrificial anodes, were carried out for 3 scenarios typical of hydrodynamic conditions. With regards to fractioning of the anodes' dissolution, notably conservative assumptions were adopted for the calculations. Nevertheless, values calculated for concentration levels of metals released into the surrounding marine environment proved to be distinctly low, with maximums in immediate proximity of the pipeline standing at $4 \mu\text{g}/\text{m}^3$.

Furthermore, concentration levels decrease to almost negligible amounts at distances just over 1m from the pipeline. Hence, considering the effective spacing of the anodes it is possible to exclude the effect of emissions juxtaposition between adjoining anodes.

With regards to lead content, given that vessel traffic is more intense during the brief installation and drilling phase and reduced during the prolonged operation phase, and that the quantities released into the environment are negligible, it is possible to observe that the impact of the supply vessels' overall activities on lead concentration will be fairly negligible.

Water column depth and volume of the receiving body, distance from the coast and the fact that the supply vessels are in motion all contribute to rendering little significant their impact.

Summary Evaluation

Changes in sea water quality as a result of installation of the various permanent sub-sea structures (well-heads, pipelines, flowlines, etc.) and routine operational discharges from the vessels, drilling unit and FPSO will be small and limited to the immediate vicinity of the discharge points. The dynamic nature of the water column environment as a result of waves and currents means that any pollution resulting from these activities would rapidly disperse in the environment. The potential impact of changes in sea water quality is therefore assessed to be of **low significance** (see Table 7-5).

Table 7-5 Significance of impact on sea water quality.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -

7.2.3 Impact on Seabed and Marine Subsoil

Most of the impacts on the seabed caused by the project are related to the relatively short construction phase with the activities related to drilling, installation of the mooring system and the laying of pipelines.

The impacts resulting from the discharge of production water, civil waste containing organic matter and nutrients, the release of cooling water containing biocides and antifouling from supply vessels during the construction phase and during the longer operations phase are not capable of causing effects on the seabed given the notable water depths and the hydrodynamic conditions which prevent contaminants from leaving significant traces on the sea floor itself.

The drilling unit has a dynamic positioning system, so the interference between the drilling structure and the sea bed are limited to the riser. The physical presence of the structures and the shifting and re-depositing of the sediments caused by the operations, may lead to habitat loss and changes in the type of the sediment and thus in the number and type of the macro-benthic species which depend to a large extent on the characteristics of the sea bed sediments.

Over the long term, the flowlines and the sub-sea structures of the well heads and mooring system may encourage colonisation by sessile organisms, leading to habitat conditions different from those in the surrounding area. There is also the possibility of species enrichment or the appearance of new species, especially since the surrounding sea beds are mobile and not hard.

These effects could be qualitatively similar to that of the permanent production structures, but widely quantitatively lower. Since the sub-sea structures cause a localized variation in the current field, they indirectly affect the sedimentation process which, in turn, modifies the sea bed morphology. Nevertheless, this only occurs in a limited area on the sea bed in the immediate vicinity of the risers.

Likewise emission of the fine material resulting from sewage discharged during drilling can produce imperceptible variations in the characteristics of the sediments on the sea bed. Discharging sewage directly emits nutrients and organic substances that can settle on the sea bed. This occurs during the installation and drilling phases when personnel are present at the site. Of course, this effect is very displaced because of the water depth.

The effects arising from the presence of sacrificial anodes along the flowlines laid on the sea bottom and other underwater structures will be limited to the immediate environs of the structures, affecting a very small volume of the water column and an even smaller volume of sediments.

Definition of the Indicator Parameters

The following parameters were used to define the quality and assess the impact the activities have on the sediments.

- Variation in particle size distribution
- Organic substances - TOC
- Total Hydrocarbons - PAH
- Heavy metals

Variation in particle size distribution

In the absence of any outside disturbance, the particle size characteristics of the site are generally an index of the hydrodynamics typical of the zone and source of the sediments. Alteration in the main particle size classes in a limited area can therefore be due to external disturbance.

Interferences present during Project realisation are limited the riser during drilling and the areas interested by the installation of wellheads, flowlines and FPSO mooring system; these interferences affecting only small areas (some thousands of square metres) and the potential

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alterations of the parameter in question due to Project activities, can therefore be considered negligible.

Organic substances - TOC

The percentage of organic carbon in the overall weight of the sample is an index of the organic content of the sediments. Organic substances are a major source of nutrients for the benthic fauna and can be decomposed by the bacterial flora present in the sediment. However, the presence of large amounts of organic carbon per unit of surface and the resulting bacterial oxidation leads to high consumption of oxygen and this, in turn, generally results in hypoxia or oxygen depletion of the substrate.

The concentrations of organic substances and organic carbon are linked to the particle size composition of the sediment. In general, the higher the percentage of sand, the lower the carbon content and thus it is difficult to compare TOC concentrations in sediments with different particle size distributions.

During the implementation of the project and its operational phase the source of organic matter is formed by the introduction of civil sewage and the increased productivity of the upper layers of the column for all the factors aforementioned (release of cooling water, FAD effect, etc.).

In light of modelling results and the above considerations it is possible to observe that the impact of Project activities on sediment quality and relative indicator parameters, will be limited; the considerable depth of the water column and the resulting dilution contribute to mitigating the effects of alterations that occur in marine sediments at their surface.

Total hydrocarbons

The increase in the concentration of hydrocarbons in the water, and thus in the sediments, is generally related to shipping traffic.

Considering that vessel traffic is more intense during the brief installation and drilling phase and reduced during the prolonged operation phase, and that in any case the quantities released are negligible, it is possible to observe that the impact of the activities in their entirety on the parameter in question is rather negligible.

The considerable depth of the water column and the resulting dilution help to limit the effects of the alterations that occur in marine sediments at their surface.

Metals

As previously discussed for the sea environment, lead is deemed most meaningful indicator of alterations because it is linked to shipping traffic.

Considering that vessel traffic is more intense during the brief installation and drilling phase and reduced during the prolonged operation phase, and that in any case the quantities released are negligible, it is possible to observe that the impact of the supply vessels activities in their entirety on the lead concentration will be rather negligible.

The considerable depth of the water column and volume of the receiving body, distance from coast and the fact that supply vessels are in constant movement all contribute to rendering little significant the impact.

The simulations on impact from dissolution of the sacrificial anodes show that the level of heavy metals introduced into the marine environment is negligible and already at just a few meters from the anode the metal concentration returns to concentration levels existing in nature.

A small increase of Aluminium in sediments can thus derive from the re-deposit on the seabed of the metals released from sacrificial anodes but the envisaged impact will be negligible.

Summary Evaluation

Changes in sea bed morphology and sediments as a result of installation of the various units and routine operational discharges from the vessels, drilling unit and FPSO will therefore be small and limited to the immediate vicinity of the discharge points. The potential impact of changes in seabed and marine subsoil is therefore assessed to be of **low significance** (see Table 7-6).

Table 7-6 Significance of impact on sea bed and marine subsoil.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Local 1	Low 1	Very small 1	6	Definite	LOW -

7.2.4 Impacts on vegetation, flora, fauna and ecosystems

The project activities trigger different types of disturbances in the biological environment and they affect the biological components differently.

The disturbances affect all levels — planktonic, nektonic and benthic — since the systems are mutually dependent.

The presence of the support vessels necessary for the operations, the drilling operations, subsea installation and operation activities leads to an **increase of the low frequency underwater noise level** which may drive fish species away, although only temporarily and within the small area where the noise is heard, and may also interfere with the normal physiological functions and behaviour of some species of mammals and reptiles.

The movement of vessels and the presence of the FPSO implies also a **risk of collision with cetaceans or turtles**. The consequence of a vessel collision with a marine animal may range from minor disturbance or injury to a worst case of fatality to an individual. Collisions have been known to occur worldwide and also in West Africa (Félix and Van Waerebeek 2005; Van Waerebeek et al 2007) and increased marine vessel traffic during the drilling and construction/ installation phase of the project will increase the risk of collisions. The increased risk of collision is considered to be low given the relatively low volume of Project related traffic and the speed that these vessels move at (typically less than 12 knots). In anycase, should the presence of large cetaceans be detected, all possible measures will be taken to avoid collision.

The transportation of the Project vessels, from other marine areas at the beginning of the Project, if these are not local, could lead to the introduction of “invasive” or “alien” species into Ghanaian waters through **ballast water exchange**. These species have the potential to disturb or alter the ecosystem of a local environment, which may contribute to the extinction of native species, presenting a threat to biodiversity, altering the native food web, and impacting human health due to consumption of contaminated seafood.

These risks are also generally much lower in deep offshore waters than in coastal areas, estuaries and ports. Considering that most of the construction activities will take place in deepwater areas this will contribute to reducing any effect due to such potential introduction.

The main effect of the **discharge of engine cooling water and production water** containing **biocides and anti-corrosion substances** is a possible local increase in temperature, with possible consequences for primary production and a local contamination of the water column.

The **discharge of treated sewage** containing nutrients easily assimilated into the primary production cycle and **suspended matter** causes an increase in turbidity and the consumption of oxygen to degrade the matter through the column of water and also an increase in primary production. In the event that this discharged material reaches the sea bed (this might not occur in the zone where the water is very deep) there is an **increase in organic matter** and thus a reduction in the amount of oxygen at the interface.

Changes in the trophism (increase in organic matter) may modify the concentration of chlorophyll a, linked in turn to the algal biomass.

The operations for installation, of the flowlines and anchoring of the lay barge and mooring system may cause small, localised morphological changes, sediments resuspension and risedimentation which may lead to **interference with structures** formed by biological processes and **benthic biocenoses** with potentially damages depending on the vulnerability of involved ecosystems.

The **mobilisation and resuspension of sediments** from the sea bed leads to a temporary increase in the turbidity of the water over a small area and may leads to a reduction in the level of light penetration. If this reduction in light levels continues for some time, there may be a decrease in the amount of oxygen in the water due to a reduction in the rate of photosynthesis and the activation of degradation/oxidation processes only; primary production is thus directly affected.

The positioning of the drilling and production structures and their presence leads to burying of the organisms and benthic biocenoses, and the removal of a small area of habitat; this removal is temporary in the case of the drilling system and restricted to drilling period and much longer in the case of well heads and sealines laying activities.

The temporary physical presence on the sea bottom of the project structures may produces local changes to the typical percentage of sand, clay and silt, and consequent negligible variations in the numbers and types of macrobenthic species (especially polychaetes and molluscs), which depend to a considerable extent on the types of sediment found on the sea bed.

The depth of the water column in the study area and the absence of light at the seabottom do not allow for the formation of a rich benthic community which, in the area affected by the Project activities presents itself as poor in species and sparse specimens; for these reasons disturbances affecting the seabed have negligible effects on benthic biocenoses.

The increase in the availability of the organic matter in the area both in suspension and on the sea bed, may produce direct effects on the area's biology, as a result of the physical presence of the sub-sea structures thanks to the F.A.D. (Fish Aggregating Device) effect, creating a new community of fauna different from that typically found in the waters around the well heads.

In zones with mobile sea beds, artificial sub-sea structures attract numerous pelagic and demersal species. The physical presence of the submerged structures in the open sea for relatively long periods of time (average operation: approx. 20 years) serves to aggregate numerous sea species, some of which are characteristic of hard substrates which, under normal conditions, would be absent or poorly represented in the area. These changes could cause an increase in the availability of organic matter in the water column, promoting the phyto- and zooplankton in the immediate vicinity of the structures.

During the drilling and installation phases, to ensure operations and safety, the area is lit all night. Such lighting can attract marine organisms in the surface-most portion of the water column.

The whole process interesting all levels, planktonic, nektonic and benthic, will also have beneficial effects on fishing in the zones close to these sub-sea structures.

This aggregation ability of submerged structures is lower at great depths where the species abundance and richness are lower because of the severity of environmental conditions.

There will be a de facto **reduction in the area available for commercial fishing** due to the presence of the production structures and the flowlines, or operations related to them. The operations may also temporarily chase the fish stock available for commercial fishing away from the involved areas and could partially modify the migratory routes for the young of some species.

However, this will not in any way compromise survival or create any significant impact on commercial fishing conducted in the vast area.

The fishing performed by coastal communities will not be affected in any way because such fishing does not involve the area covered by the proposed project which is at a quite some distance from the coast.

The sacrificial anodes (which contain no mercury) **shed metals**, especially Al, causing a slight increase in the concentration of these elements in the water column and in the sediment, to which they are confined, unable to significantly affect the biocenoses.

The bibliography on the effects of the presence of Al in marine sediments or the water column is very limited. However, there are no reports of cases in which this element has been toxic to marine organisms, and apparently sea-dwelling filtering organisms are not capable of bioaccumulating Al.

The metal ions (Pb) emitted into the water column by supply vessels can be lightly bioaccumulated by filter feeding organisms.

The **discharge of volumes of hot water, water containing pollutants, nutrients, biocides and anti-corrosion substances** from FPSO operation, supply vessels and offloading activities into a large and deep basin like the one under consideration may trigger environmental interferences of negligible intensity.

The type and gravity of the consequences of these discharges on the biological community, depend to a large degree on the size of the area affected to varying extents by these discharges. Different environmental scenarios can be considered possible depending on the hydrodynamic conditions present, whether there is a thermocline with stratification of the temperature gradient and variation in density at different depths, whether a vertical/horizontal flow is established, etc. In this context, it is important to consider the limited size of the discharges compared to the volume of the receptor body and the system and procedures by which the water is discharged along the water column, in order to ensure a good level of mixing.

Definition of the Indicator Parameters

- Interference with benthic populations
 - Average number of species present
 - Specific diversity index
- Metal bioaccumulation
- Bioaccumulation of hydrocarbons (PAH)

The biological world is a complex, dynamic system sensitive to even minimal changes in the environment. Even under normal conditions, the marine environment is subject to significant variations linked to the water mass dynamics, the contribution of continental waters, seasonal variations, etc. Thus it is difficult to establish what parameters are indicators of the disturbance created and, above all, to identify what contribution each individual form of disturbance makes to changes in these parameters.

Interference with the benthic populations

The composition of the benthic communities plays a role as biological indicators, understood as providing indication of the complex environmental conditions ensuing from the interaction of a multitude of biotic and abiotic parameters that are difficult to measure individually. This type of approach is based on the concept of biotic community (the series of populations that live in a given area or physical habitat and which make up an organized unit the characteristics of which go above and beyond those of the component individuals and populations) and thus assumes a series of interactions between organisms and between the organisms and the environment.

Each community presents the so-called homeostasis — i.e. the ability to maintain a steady state by using feedback control processes to respond to various stimuli. When these stimuli exceed the homeostasis capacity of the individual organisms, the community is no longer able to return to a state of equilibrium and its structure undergoes both qualitative and quantitative modifications. Thus the role of indicator attributed to the community as a whole given its ability to adapt to overall environmental situations.

Among the zoobenthic communities, the macroinvertebrates (organisms that can be trapped in a 1 mm mesh sieve) have, for various practical reasons, proved to be the best suited to this type of survey. In the marine benthic communities, the systematic groups (Taxa) most highly represented, both in terms of number of species and number of individuals, are the Annelids, Molluscs, Crustacea and Echinoderms. In particular, it has been shown that, since polychaetes occupy significantly diversified niches in the food chain and are found at various trophic levels in the macrobenthic communities, they are effective indicators, both functional and structural. Molluscs have been found to be effective indicators of the overall ecological conditions in coastal marine ecosystems. On the other hands, the Crustaceans, amphipods particular, have proved to be an important component of the mobile fauna in various environments.

The average number of species present and the specific diversity index reveal changes in the population because:

- they reflect both the reduction and survival of the most representative or most resistant species and
- they show the increase in some species as a result of the variation in environmental conditions or through repopulation.

The modelling discussed above shows that the interference related to the discharge of nutrients particulates and contaminants in vicinity of the surface, are not able to affect the seabed given the considerable depth of the water column.

The same can be said for the discharge of cooling water capable of causing alterations only to a restricted portion of the water column, without interfering with the seabed.

The release of Al ions will affect a limited portion of the water column and sediments in vicinity of the submerged structures and flowlines laid on the seabottom.

The potential introduction of invasive species from the ballast water exchange could however, derive in changes in the composition and diversity of benthic communities with the associated cascade effects through the trophic chain. The offshore location of the Project, as well as the depths in the area, are considered to limit any potential effect of invasive species, if any, as its establishment in the area would result more difficult.

Finally, it should be remembered that the depth of the water column in the study area and the absence of light at the seabottom do not allow for the formation of a rich benthic community which, in the area affected by the Project activities presents itself as poor in species and with sparse specimens.

For these reasons it is possible to observe that disturbances affecting the seabed have negligible effects on benthic biocenoses and are not capable of altering the parameter indicators under examination.

Potential impacts due to biocides/antifouling (Chlorine) Discharge

Several scientific papers regarding impact of chlorinated Cooling Waters CW (Taylor, 2006; Nebot *et al.*, 2006) indicate the presence of “confounding effects” between the use of hypochlorite as antifouling and ΔT of wastewaters, making it difficult to discriminate between the effects caused by the presence of chlorine and CBPs (compounds produced by the reaction of chlorine with substances present in seawater are called Chlorination By-Products - CBP's) and those generated by the difference in temperatures of wastewater. Also important is the different effects that ΔT could have on the species (it was found that the juvenile stages of various species of amphipods can be favoured by increases in temperature, whereas adult populations do not tolerate high temperatures; Taylor, 2006).

Studies conducted in the 80s and 90s did not identify impacts that can be attributed to residual chlorine alone; in a dispersive environment such as a non-enclosed sea, where there is a rapid water discharge, it seems impossible to identify significant impacts in terms of variations in the distribution, of species, abundance or biomass. Generally, sites in high energy open seas have a high capacity to dilute and spread chlorinated wastewaters (Lattemann & Höpner, 2008).

Preliminary studies regarding the effects of CW on benthic fauna were conducted by Lewis (1984), who determined a toxicity limit for *Mytilus edulis* (L.) for the concentration of total residual chlorine, under which the chlorination process does not cause the death of this species, but only delays its growth.

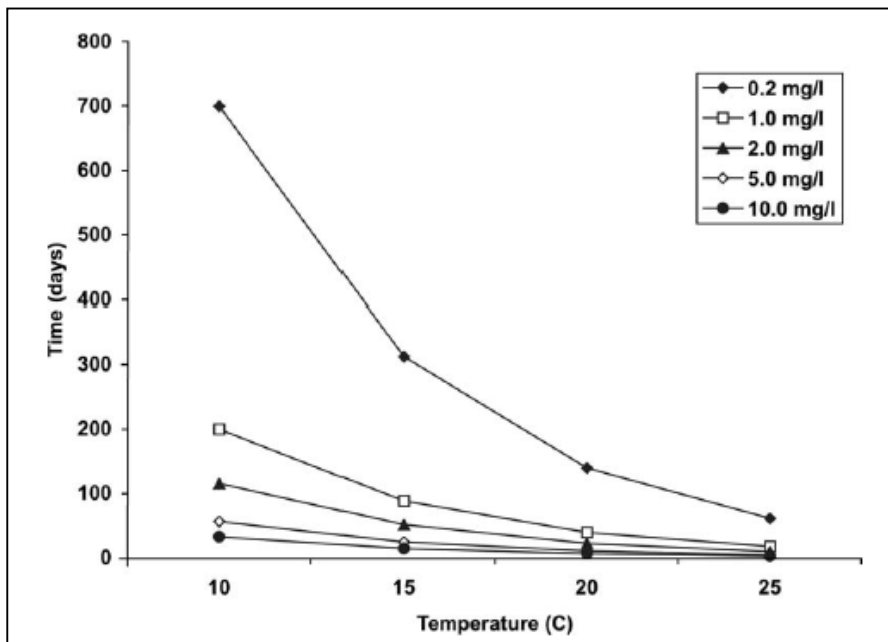


Figure 7-17 Acute toxicity of *Mytilus edulis*, expressed as forecasted time of death, as a function of various levels of chlorination, expressed as mg/l of total residual chlorine and various temperatures of the cooling water circuit (Taylor, 2006).

As shown in Figure 7-17, a concentration of 0.2 mg/l total residual chlorine involves a forecasted time of death ranging from a little under 100 to 700 days, in a range of temperature of wastewater from 10 to 25 °C. For lower levels of concentration the mortality is practically null.

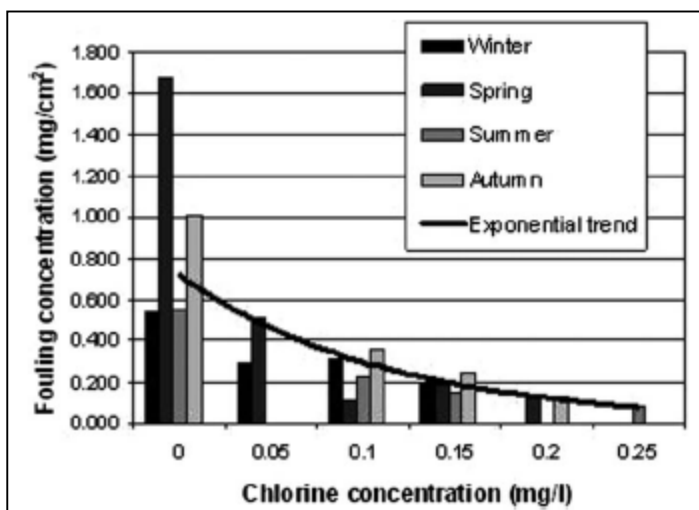


Figure 7-18 Effect of chlorine vs biofouling concentrations expressed as biomass (Nebot *et al.*, 2006).

Roberts and colleagues (Roberts Jr. *et al.*, 1990) examined the effects of oxidants produced by chlorination on the settlement of a species of oysters and barnacles, and on the influence of the settlement's distance from the water discharge point. No substantial difference was observed in the number of settled individuals for the mussels and barnacles tested. The growth and larvae survival experiments performed in the field showed no inhibition for concentrations higher than those that involved total inhibition to settlement in experiments conducted in the laboratory.

Elliot and colleagues (1993) and Davis (1993) conducted studies on biomarker organisms such as *Dicentrarchus labrax* (L., branzino) and on bioindicator organisms such as *Mytilus edulis*. They

observed the absence of damages to the fish's liver that could be attributed to exposure to CBPs, a bioconcentration of bromoforms in the fat of the examined fish species (70-160 times the levels of concentration in CW) that rapidly disappear when the chlorination process ceases, absence of ecotoxicological stress in the sea bass exposed to CBPs for long periods of time, absence of THMs in the mussel's tissues, generation of stress proteins.

Contrarily, other studies (Jenner, 1997) show different CBP toxicity data, indicating greater concentrations and their effects.

Table 7-7 Summary table of available data on CBP Toxicity
Summary of Available Data on CBP Toxicity

<i>Species</i>	<i>Exposure period</i>	<i>Effect concentration mg/litre</i>		<i>Ref.</i>
Bromoform				
Marine algae: diatoms / flagellates	7 d	EC ₅₀	> 32	1
Marine molluscs	96 h	LC ₅₀	40–140	2
Marine crustacea	96 h	LC ₅₀	26	2
Marine fish	96 h	LC ₅₀	12	2
Bromodichloromethane				
Protozoa: ciliate	24 h	EC ₅₀	240	3
Chloroform				
Marine algae: diatoms / flagellates	7 d	EC ₅₀	> 32	1
Marine molluscs	48 h	LC ₅₀	0.15–1	4
Marine crustacea	24 h	LC ₁₀₀	464–800	5
Marine fish	96 h	LC ₅₀	28	6
2,4,6-Tribromophenol, no marine data available				
Freshwater fish	96 h	LC ₅₀	1.1–6.8	7,8,9

For dibromoacetonitrile, dibromochloromethane and 2,4-dibromophenol there is no data available.
References: 1. Erikson & Freeman, 1978; 2. Gibson *et al.*, 1979; 3. Yoshioka *et al.*, 1985; 4. Stewart *et al.*, 1979; 5. Okubo & Okubo, 1962; 6. Madeley, 1973; 7. Blum & Speece, 1991; 8. Alexander *et al.*, 1983; 9. Geiger *et al.*, 1984–1985.

Effects: LC₅₀: concentration lethal to 50% of organisms; EC₅₀: Concentration producing an effect in 50% of population or causing a 50% effect compared to controls.

Metal bioaccumulation

A part of the metal ions released into the water are bioaccumulated in filter feeding organisms. Lead is considered the prime indicator because it is linked to shipping and installation activities. Given their reactivity and the various processes involved in their removal, heavy metals do not remain in the water column for a long time; they tend to accumulate in the fine sediments and, in some cases, in the tissues of marine organisms. In this case, they can be detrimental to the growth, reproduction and species composition of the animal and plant communities (UNESCO, 1980).

Al is not considered harmful or pollutant, and it must also be underlined that Al is not bioaccumulated by organisms but rather tends to be eliminated by clearance. A slight increase in the level of the element in filtering organisms may be due to the presence of Al in the intravalvular liquids.

The bodies tolerate Pb toxicity not only at low concentrations normally found in sea water but also at higher concentrations; an accumulation in tissues may therefore occur.

If the processes of excretion are not sufficient, the toxic elements can be transformed into non-toxic compounds and stored in the liver and kidneys or in other parts of the body, protecting from excessive concentration the more sensitive organs.

It is difficult to generalize on Pb toxicity of organisms, since there are considerable differences in resistance to this pollutant; *Mytilus*, for example, has a mechanism of purification which allows it to accumulate Pb in the form of metallic granules that are isolated from its organism.

In the project under review, the volume of the receiving body (water depth is about 1000m) allows for a rapid dilution of the Pb metal ions released as a result of the activities of supply vessels, thus limiting their accumulation in benthic organisms as well as those found in the water column.

The simulations presented above allow for the affirmation that the effect of sacrificial anodes on Al concentration is zero at just a few meters from the anode itself; alteration of the parameter in question can thus be excluded.

Hydrocarbon bioaccumulation

The increase in the concentration of hydrocarbons in the water, and thus in the sediments, is generally related to shipping traffic, and this is particularly intense while the well drilling structures are being installed. The presence of hydrocarbons and the increase in hydrocarbon concentrations in the water indirectly leads to bioaccumulation in filter feeding organisms which are highly sensitive to Polycyclical Aromatic hydrocarbons (PAH - benzene, toluene, xylene, naphthalene, phenanthrene, etc.), undoubtedly the most highly toxic hydrocarbons.

Many invertebrates tend to concentrate PAH drawn from the water, generally the result of the lipid-water separation balance, thus establishing a direct correlation with the surrounding waters. The damage to marine organisms can be acute, sub-lethal or chronic since many organisms are able to concentrate petroleum-based products.

In the project under review, the volume of the receiving body (water depth is about 1000m) allows for a rapid dilution of hydrocarbons released as a result of the activities of supply vessels, thus limiting their accumulation in benthic and water column organisms.

Summary evaluation

Changes in the marine biota and ecosystems as a result of the installation and presence of the subsea structures, drilling unit, well heads and support vessels, as well as normal operation discharges will be limited to the immediate vicinity of these activities. The potential impact is assessed to be of **low significance** and may even be positive if the subsea structures and exclusion zones attract and provide shelter to a wide variety of species (see Table 7-8).

Table 7-8 Significance of impact on vegetation, flora, fauna and ecosystems.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -/+

7.2.5 Underwater noise-generated impacts

Underwater sound allows marine animals to gather information and communicate at great distances and from all directions. The speed of sound determines the delay between when a sound is made and when it is heard. The speed of underwater sound is five times faster than sounds travelling in air, thus marine animals can perceive sound coming from much further distances than terrestrial animals. Because the sound travels faster, they also receive the sounds after much shorter delays (for the same distance). It is not a surprise that marine mammals have evolved many different uses for sounds.

Marine animals rely on sound to acoustically sense their surroundings, communicate, locate food, and protect themselves underwater. Marine mammals, such as whales, use sound to identify

objects such as food, obstacles, and other whales. By emitting clicks, or short pulses of sound, marine mammals can listen for echoes and detect prey items, or navigate around objects. This animal sense functions just like the sonar systems on navy ships. It is clear that producing and hearing sound is vital to marine mammal survival. Sound is also important to fishes. They produce various sounds, including grunts, croaks, clicks, and snaps, that are used to attract mates as well as ward off predators. Marine invertebrates also rely on sound for mating and protection. Little research has been done on marine invertebrates that produce sounds, but for those that do, like shrimp and lobsters, sound is very important for survival against predators.

Sound propagation

Sound is essentially generated when a vibrating object sets molecules in a medium adjacent to that object into motion. Sound amplitude or what is perceived as loudness is directly related to the amount of pressure generated by the vibrating object. In a compressible medium, the motion of molecules produces positive pressure where there is condensation and negative pressure where there is rarefaction of molecules. The intervals of condensation and rarefaction typically occur in a cyclical fashion. In a plane progressive wave of sound (when the acoustic pressure is the same in all planes perpendicular to the direction of propagation), the instantaneous pressure, p , generated in a compressible fluid can be described by:

$$p = \rho c u$$

where ρ equals the fluid density, c equals the speed of sound, and u equals the particle velocity. Acoustic pressure is typically measured as the root-mean-square (RMS) pressure average over the duration of the sound. For impulsive sound such as pile driving strikes or biosonar clicks, peak sound pressure (the range from zero to the greatest pressure of the signal) or peak-to-peak sound pressure (the range of the most positive to the most negative pressure of the signal) are often reported instead, since it is difficult to define an appropriate duration over which to average the signal's pressure (Madsen, 2005). Pressure is typically reported in units of pascals (Pa) or micropascals (μPa). In a plane progressive wave, sound intensity is described by the sound power per unit area and is a product of the sound pressure and particle velocity by

$$I = p u$$

and substituting u from first equation, intensity of the sound, I , is related to p by

$$I = p(p/\rho c) = p^2/\rho c$$

where p is the RMS pressure average over the duration of the sound. Intensity is typically reported in units of watts per square meter. Sound levels are most often described in units of decibel (dB), which is traditionally defined as a power or intensity ratio. Sound intensity level in decibels is as follows:

$$\text{dB} = 10 \log_{10} (I_1/I_2)$$

where I is the intensity of the sound of interest and I_2 is a reference intensity. In the case of a plane wave, sound pressure which is typically what is measured by a microphone or hydrophone may also be used to measure the sound's magnitude in dB. Because sound intensity is proportional to pressure squared, sound pressure level (SPL) in dB is given by

$$\text{dB} = 10 \log_{10} (p_1^2/p_2^2) = 20 \log_{10} (p_1/p_2)$$

where p_1 is the pressure of the sound of interest and p_2 is typically the standard reference pressure for a given medium. In water the reference is usually $1 \mu\text{Pa}$. SPLs in this document are referenced to the underwater convention (re $1 \mu\text{Pa}$) based on RMS measurements unless otherwise noted. This reference pressure is different from the standard used to measure sound pressure levels in

air. Thus a dB (re 1 μ Pa) underwater is not equivalent to a dB (re 20 μ Pa) measured in air. Pulsed sounds such as explosions, seismic air gun pulses, or pile driving impacts are often measured in terms of their energy and not just pressure or intensity. Energy measures include time as a dimension and are also used to quantify sound exposure when both amplitude and duration of exposure is important. Energy is proportional to the time integral of the pressure squared and in dB sound exposure levels (SELs) has the units of dB re 1 μ Pa²s.

Comparison of sound intensities measured in air and water

Direct comparisons of sound intensity levels measured in air and water cannot be made, unless levels are adjusted to take into account:

- the differences in acoustic impedance between air and water ($C_{\text{water}} = 1.5 \times 10^6$ and $C_{\text{air}} = 4.15 \times 10^2$) and
- the differences in reference pressures used for air and water ($p_{\text{ref water}} = 1 \mu\text{Pa}$ and $p_{\text{ref air}} = 20 \mu\text{Pa}$).

However, although the physics behind these adjustments is correct it may not reflect the complexities of marine mammal hearing.

The difference between a Sound Intensity Level measured in water and in air is:
 $26\text{dB} + 36\text{dB} = 62\text{dB}$

Therefore if a SIL is measured in air it has been proposed that its equivalent SIL underwater might be achieved by adding 62 dB, and, conversely if a SIL is measured in water, subtract 62dB from its value to get its equivalent value in air.

However, this may be a risky comparison because the mechanisms leading to damage in the ear underwater may be significantly different to those in the air.

Model description

The acoustic modelling approach is based on the equations of propagation of underwater noise and the simplistic model published by WDSC in *Oceans of noise*. The model is called Source Math Receiver Model.

The basic parameters of this model are:

- Source: the noise source, e.g. ship, sonar etc. Parameter of interest = source level (SL)
- Path or medium: the water column. Parameters of interest include transmission loss (TL), and ambient noise level (NL)
- Receiver: e.g. whale, hydrophone etc. Parameters of interest include signal to noise ratio (SNR), received sound intensity level (RL) and detection threshold (DT). A simple model of sound propagation is:

$$RL = SL - TL$$

Where RL is the received level, SL is the source level and TL is the transmission loss.

Model parameters

Transmission Loss (TL)

Transmission loss is the decrease in intensity of a sound as it propagates through a medium, and is the result of spreading, absorption, scattering, reflection and rarefaction. Transmission loss can

also be estimated by adding the effects of geometrical spreading (TLsp), absorption (TLa) and the transmission loss anomaly (A). The transmission loss anomaly includes scattering loss and losses due to reflection and refraction at boundary interfaces.

$$TL = TL_{spreading} + TL_{absorption} + A$$

For simplicity we'll only deal with spreading (TLsp) and absorption loss (TLa):

$$TL = TL_{spreading} + TL_{absorption}$$

$TL_{spreading}$ is a major component of transmission loss and is range (distance) dependent. Two forms of spreading loss are common underwater:

- Spherical or Geometrical spreading loss (TLg), and
- Cylindrical spreading loss (TLcy).

Spherical or Geometrical spreading loss (TLg)

Spherical spreading loss assumes a uniform or homogenous environment that is typical of deep waters (>2000m). Sound from a point source will spread outward as spherical waves, and intensity varies inversely with the square of the distance from the source:

$$TL_g = 20 \log \left(\frac{R}{R_o} \right)$$

$$R < R_1$$

Where R is the range in metres of the receiver from the source and R0 is a reference range, usually 1m.

With spherical spreading, sound levels decrease by 6dB if distance is doubled and by 20dB when distance increases by a factor of 10. R_1 is the range in metres at which spherical spreading stops and cylindrical spreading begins.

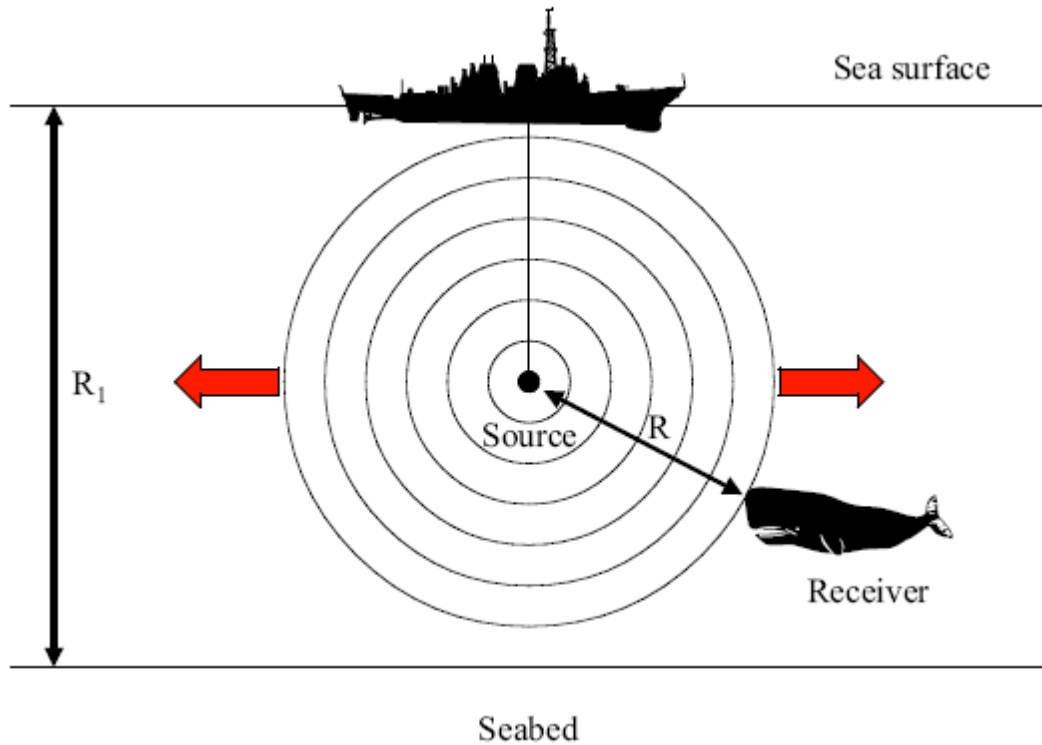


Figure 7-19 Spherical spreading of underwater noise

Note that for spherical spreading to occur, $R_1 > R$ (from Oceans of Noise, WDSCS 2004)

Cylindrical spreading loss

Cylindrical spreading is appropriate when the medium is non-homogenous. Non-homogenous mediums are typical of stratified or shallow coastal waters (<200m), where sound is reflected or refracted off the sea surface and seabed or off different density layers according to Snell's law.

At a given distance from the source, which is long in comparison to the water depth, various reflected waves combine constructively to form a cylindrical wave front. Where cylindrical spreading occurs, sound intensity varies inversely with distance from the source:

$$TL_{cy} = 20 \log R_1 + 10 \log \left(\frac{R}{R_0} \right) \quad R > R_1$$

Cylindrical spreading is applicable where the range of the receiver from the source is greater than the depth of the water column or density layer, i.e. for $R > R_1$. Where R_1 is the range in metres at which spherical spreading stops and cylindrical spreading begins. For ranges $R < R_1$, TL is spherical. Spreading loss for cylindrical spreading ($R > R_1$) is less than for spherical spreading ($R < R_1$), and sound intensity decreases by 3dB if distance doubles and by 10dB when distance increases by a factor of 10. Therefore, a sound source generated in shallow coastal waters or estuaries travels twice the distance of an equal sound source in the open ocean.

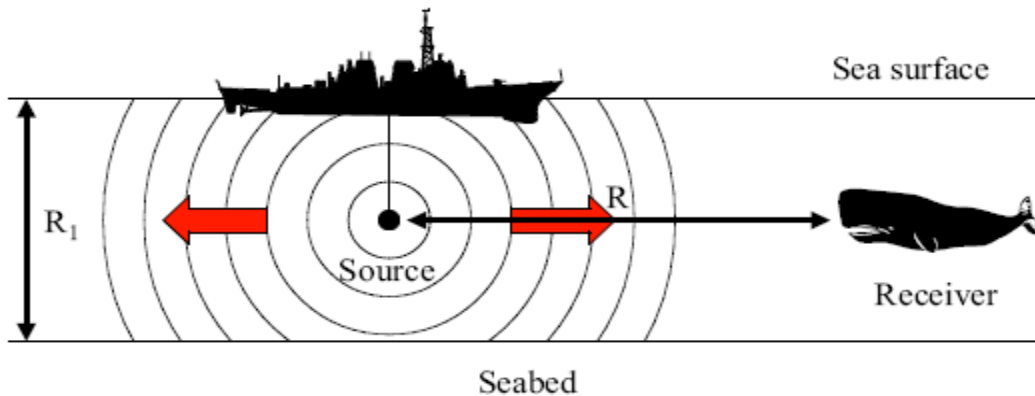


Figure 7-20 Cylindrical spreading of underwater noise

Note that for cylindrical spreading to occur, $R_1 < R$ (from Oceans of Noise, WDSCS 2004).

Absorption loss

The model applied considers the following equation for $TL_{absorption}$ (Richardson *et al.* 1995):

$$TL_{absorption} = \alpha R$$

where α is the absorption coefficient
 R is the distance from the source.

α is the result of a complex function of frequency of sound and of salinity, temperature, depth and pH of water. The following chart shows the trend of the absorption coefficient (in dB/km) as a function of frequency in typical sea water (Ainslie & McColm 1998).

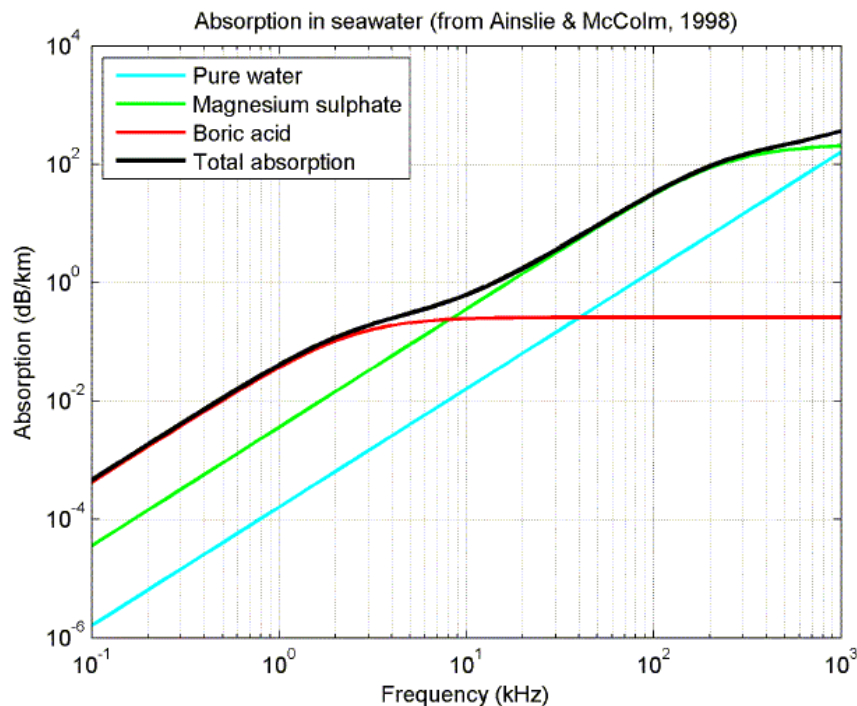


Figure 7-21 Absorption coefficient in sea water depending on frequency

It is clear that the contribution of absorption is negligible at lower frequencies, especially when compared with spreading loss. Absorption coefficient becomes significant at about 10 kHz, reaching 1 dB/km, and becomes predominant above 100 kHz, when it reaches 100 dB/km.

Sources definition

The design of the drilling rig and local oceanographic conditions will affect both the path of the sound into the water column and how much sound is transmitted.

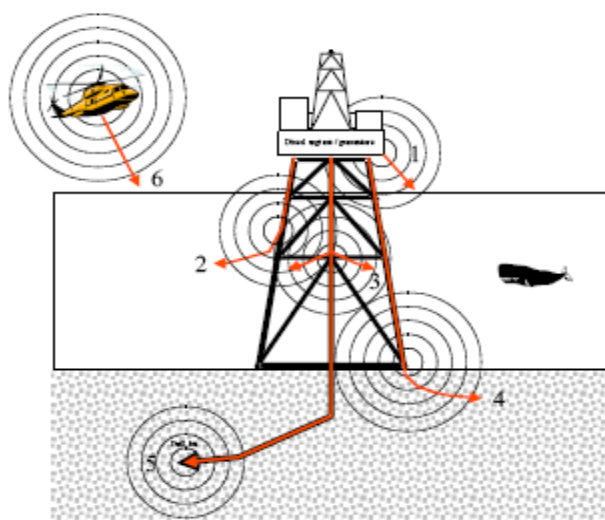


Figure 7-22 Sound transmission pathways associated with a fixed platform

Note: (1) Diesel engine/generator exhaust port, (2) Vibration through legs into the water, (3) Vibration through drill string and casing, (4) Vibration into the seabed, (5) Vibration of drill bit, (6) Noise from helicopters and vessels (Oceans of noise, WDCS 2004).

The following sources of underwater noise have been identified as potentially important:

- 2 support vessel
- 1 semisubmersible drilling rig

The present study will simulate noise emissions during the drilling activities considering the ones generating higher emissions for a defined time period. Data on noise emissions are based on typical examples of semisubmersible drilling rig (during drilling) and support vessel as described by P. D. Ward, 2013.

Table 7-9 Construction activities noise sources

	LeqA dB re 1 µPa-m											
	broadband	1/3 octave band centre frequencies (kHz)										
	0.1-10	0.05	0.1	0.2	0.5	1	2	4	8	16	32	64
Supply ship	172	140	158	158	160	157	158	157	155	152	150	146
Semisubmersible drilling rig (drilling)	170	120	115	105	100	90	85	80	75	70	65	55

Noise source have been considered in deep waters (1000 meters). These assumptions allow the use of spherical propagation described above for assessing impacts on receptors located at distances smaller than the depth of the sea floor (1000 meters from the source), at $R < R_1$. The spherical model is a better and cautionary approximation also at greater distances, whereas the cylindrical model is not appropriate at this depth and underestimates impacts when compared with

the spherical one. The spreading loss assumes the trend showed in the following chart (Spence 2006).

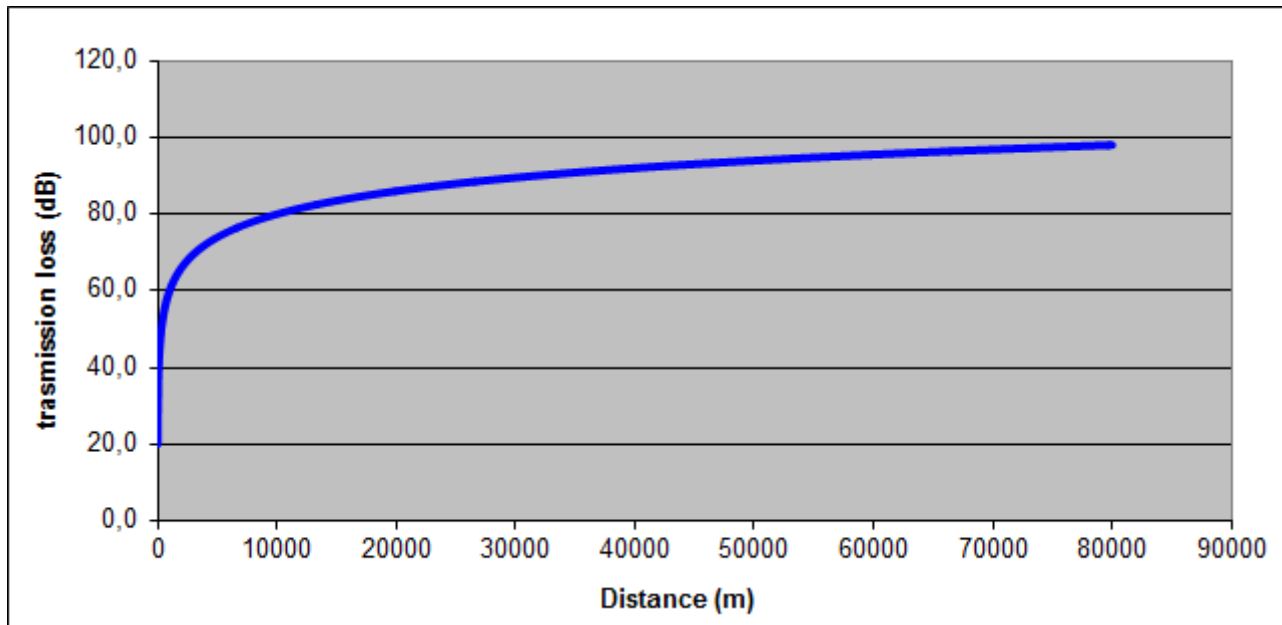


Figure 7-23 Spreading loss depending on source distance

Noise sources have been represented like a unique point source that emits the sum of the single emissions of the 2 supply ships and the submersible rig during drilling. Table 7-10 shows the level of the emission sources, and the level assumed for the calculation (logarithmic sum of the levels).

Table 7-10 Level of the noise emission assumed for calculation

	broadband	0.05	0.1	0.2	0.5	1	2	4	8	16	32	64
Semisubmersible	170	120	115	105	100	90	85	80	75	70	65	55
Supply ship (x2)	172	140	158	158	160	157	158	157	155	152	150	146
Model source	176.2	143	161	161	163	160	161	160	158	155	153	149

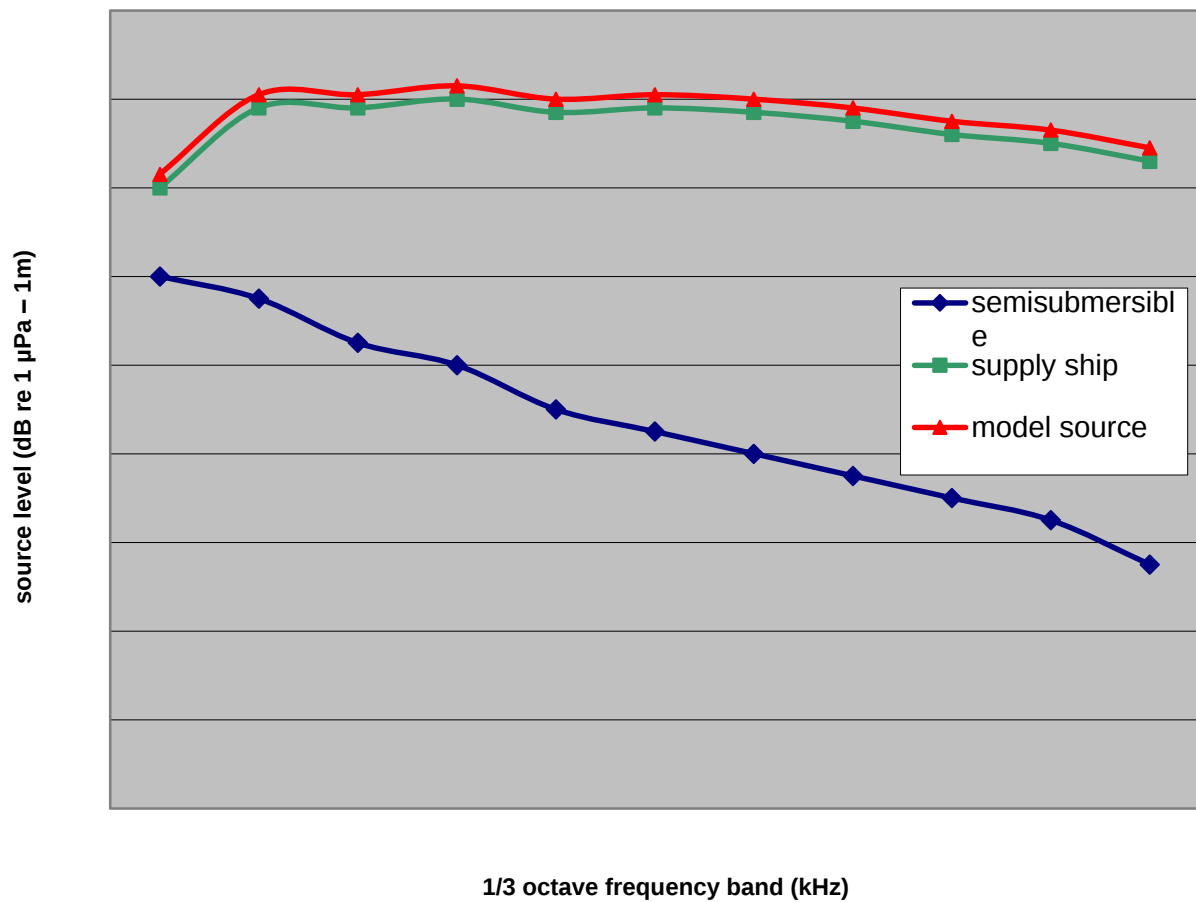


Figure 7-24 Sources as defined for the simulation

It is clear that the contribution of the semisubmersible rig to the total noise is negligible.

Simulation results

Model results are represented in Figure 7-25 below.

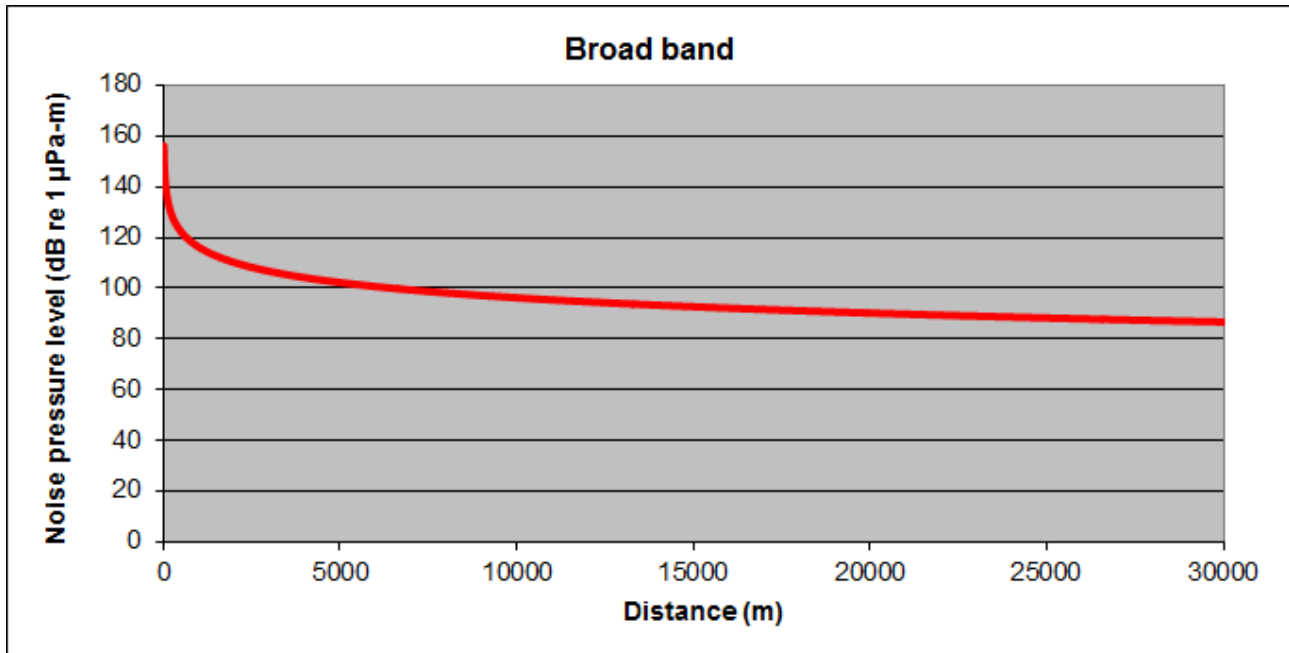


Figure 7-25 Pressure levels versus distance from the source in terms of emissions, for broad band frequencies, considering spreading loss

Considering broad band emission equal to 176.2 dB re 1 μ Pa, pressure levels fall below the 100 dB re 1 μ Pa at about 6 km from the source. This issue, however, is the sum of the contributions of each frequency over the entire frequency band, and does not take into account the effects of absorption, which is strongly dependent on frequency. In order to evaluate the impacts on marine life it is necessary to study the levels of pressure in the frequency range of hearing of the species analysed.

Figure 7-26 shows the pressure levels versus distance from the source, in terms of emissions for different frequencies in the band of 1 / 3 octave, considering the attenuation due to absorption.

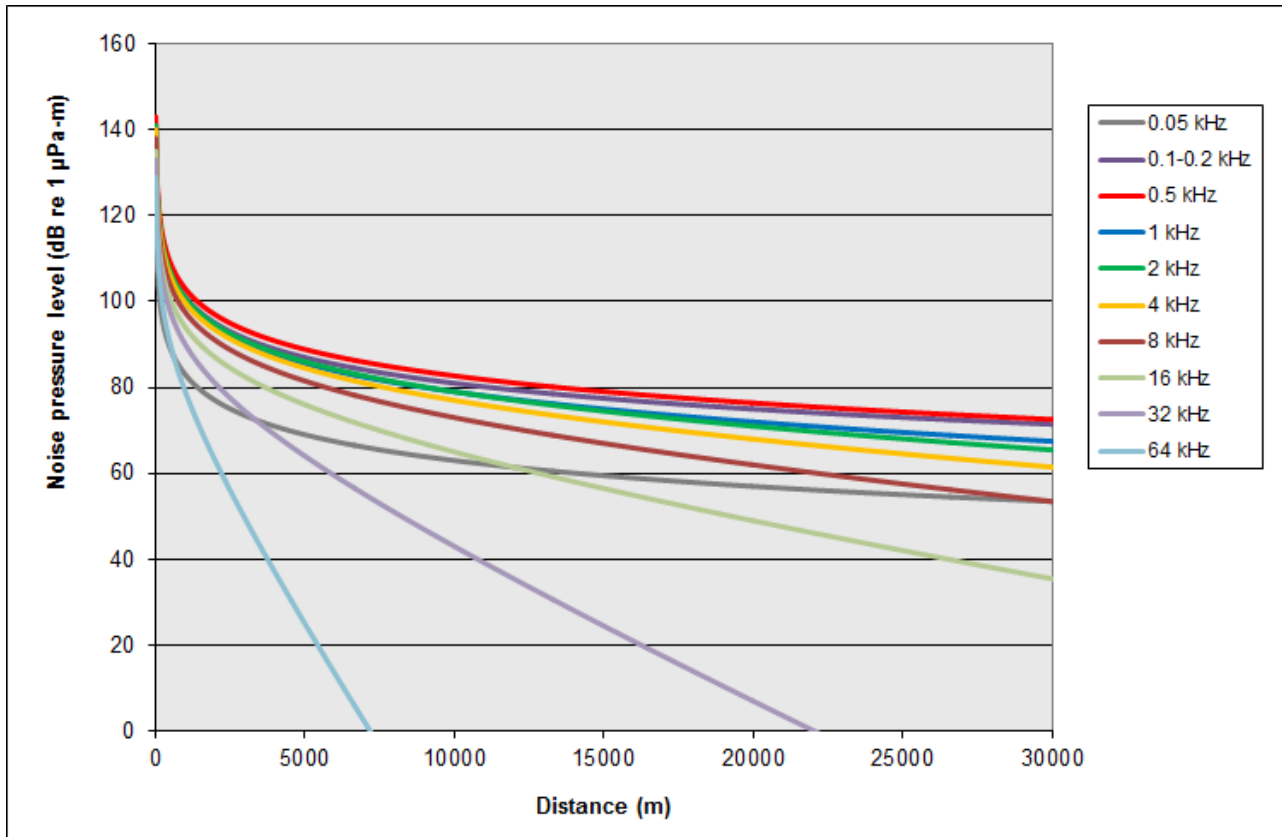


Figure 7-26 Pressure levels versus distance from the source in terms of emissions, for each 1/3 octave frequency band, considering spreading loss and absorption loss

An analysis of the chart shows that the decay of pressure over distance from the source is much faster for higher frequencies. Differences in plots at lower frequencies are mainly due to differences in starting level of emission from source, but absorption plays an important role at high frequencies. Levels of 80 dB re 1 µPa are achieved at less than 4000 meters for frequencies above 16 kHz. In parachart estimation of the impacts, will be addressed further the contribution of each frequency on the disorder of the main marine species present in the study.

Marine mammal use of and responses to sound

Marine mammals produce a variety of sounds and use hearing for communication, individual recognition, predator avoidance, prey detection and capture, orientation, navigation, mate selection, and mother-offspring bonding. At most frequencies, the ear is the most sensitive detector of acoustic energy although some evidence indicates that humans are affected by low-frequency sounds below their hearing threshold. In most marine mammals that have been tested, the best hearing sensitivity appears to correspond to the presumed primordial ocean background noise at any given frequency. This seems a reasonable limit because greater sensitivity may not convey an additional advantage. Beluga whales can detect the return of their echolocation signals when they are only 1 dB above background and grey whales can detect the calls of predatory killer whales at 0 dB above background. Whether anthropogenic sounds are detected at the low levels associated with detection of prey and predators is not known and likely varies with factors such as species and habitat. Marine mammals have adapted to varying levels of natural sound, and the adaptive mechanisms may allow them to function normally in the presence of many anthropogenic sounds. The key question is when; because of its level, frequency, duration, location, or some other characteristic introduced sound exceeds the adaptive capacity of marine mammals, causing

physical injury or eliciting physiological reactions, behavioural responses, masking, or other effects, and thereby posing a threat to individual animals or their populations.

Richardson *et al.* (1995) define four zones of noise influences, depending on the distance between source and receiver. The zone of audibility is defined as the area within which the animal is able to detect the sound. The zone of responsiveness is the region in which the animal reacts behaviourally or physiologically. This zone is usually smaller than the zone of audibility. The zone of masking is highly variable, usually somewhere between audibility and responsiveness and defines the region within which noise is strong enough to interfere with detection of other sounds, such as communication signals or echolocation clicks. The zone of hearing loss is the area near the noise source where the received sound level is high enough to cause tissue damage resulting in either temporary threshold shift (TTS) or permanent threshold shift (PTS) or even more severe damage. The different zones are illustrated in Figure 7-27 below:

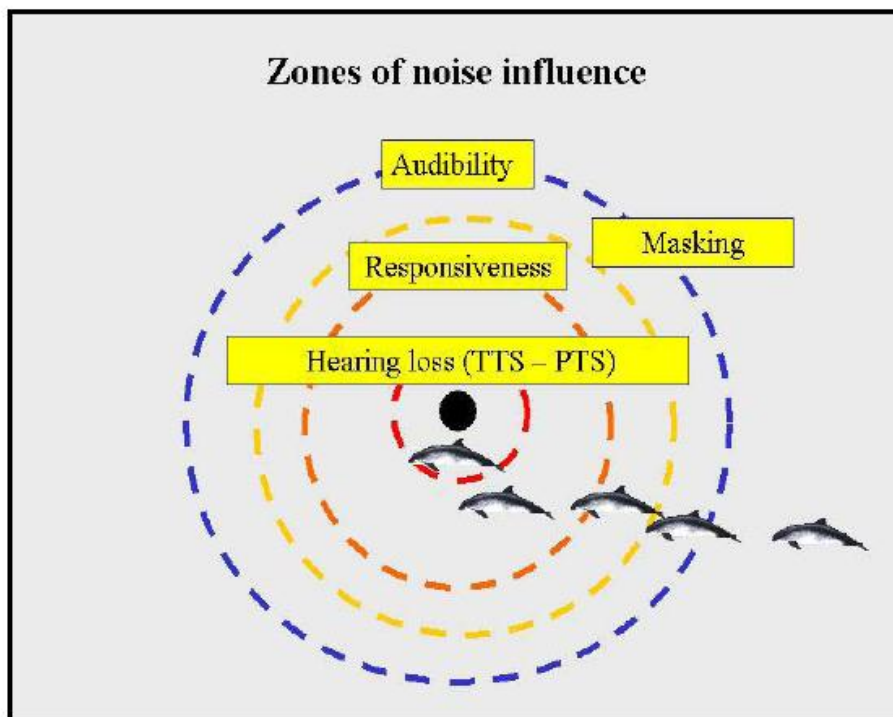


Figure 7-27 Zones of noise influence (Richardson *et al.* 1995)

Behavioural responses—At the detection threshold, or at some level above that, sound may evoke a behavioural response. Examples of behavioural responses include changes in habitat use to avoid areas of higher sound levels; diving and surfacing patterns or direction of movement; and vocalization intensity, frequency, repetition and duration (Richardson *et al.* 1995). Some of these behavioural responses may affect vital functions (for example, reproduction, feeding). It is often not clear whether such changes are significant (where significance is defined as having a measurable impact on either an animal's reproduction or survival or a population's status).

Masking—Masking occurs when a sound is more difficult to heard because of added noise (Southall *et al.* 2000). In this case, an animal's behaviour may be affected because it is not able to detect, interpret, and respond to biologically relevant sounds. Masking may occur at received levels less than those required to stimulate observable responses and therefore may affect marine mammals at greater distances from the sound source than those at which the animal shows a behavioural response.

Physiological reactions—Exposure to sound energy may result in a range of physiological effects in marine mammals. The auditory system is thought to be the most sensitive to sound exposure, but sound exposure also may cause non-auditory physiological effects such as stress and tissue injury.

Exposure of marine mammals to high intensity sound may cause a temporary threshold shift, or a temporary loss of hearing sensitivity. A reduction in sensitivity is the usual response of a mammalian sensor exposed to an intense or prolonged stimulus and, within limits, is reversible. Nonetheless, because of the importance of sound in the daily lives of marine mammals, even temporary threshold shifts have the potential to increase an animal's vulnerability to predation, reduce its foraging efficiency, or impede its communication.

Physical injury—Permanent threshold shifts—or permanent loss of hearing sensitivity—can result when animals are exposed even briefly to very intense sounds, over a longer duration to moderately intense sounds, or intermittently but repeatedly to sounds sufficient to cause temporary threshold shifts. Permanent threshold shifts result in the loss of sensory cells and nerve fibers. In terrestrial animals, temporary reductions in sensitivity of about 40 dB have been required to cause permanent threshold shifts. To date, temporary shifts of only about 20 dB have been induced experimentally in marine mammals, which is much less than required for a permanent shift if marine mammals respond similarly to terrestrial animals.

Ecological effects—Ecological (indirect) effects may occur if ecologically related species are affected by anthropogenic sound, thereby changing the nature of their relationship with marine mammals or the structure of the affected ecosystem. The best-studied indirect effects suggest that, in some cases, seismic activity may cause a decrease in the number of fish in the survey region. If and when such effects occur, they may reduce the foraging efficiency of marine mammals, potentially compromising their growth, condition, reproduction, and survival.

Population effects—The effects of sound on marine mammal populations are uncertain. Sound has not been considered a factor in several major declines over the past few decades involving pinnipeds and sea otters, species more easily monitored than cetaceans. Abundance and trends of cetacean populations often are poorly known and difficult to monitor; many populations could decline by half without such loss being detected.

Cumulative effects—Effects that are individually insignificant may become significant when repeated over time or combined with the effects of other sound sources. Baleen whales, for example, use low-frequency sound for communication and therefore may be affected by both seismic airguns and shipping noise. Similarly, the effects of sound may interact additively or synergistically with the effects of other risk factors. Beluga whales, for example, may be compromised in their ability to survive and reproduce if climate change has altered the distribution and availability of their prey, persistent organochlorine contaminants have altered their immune function and made them susceptible to disease and parasites, and noise from oil and gas operations, icebreakers, or commercial vessels has caused them to abandon important habitat.

Effect of the identified sound sources on marine mammals

Odontocetes produce rapid series of whistles and high-frequency clicks. Clicks individuals are generally used for echolocation, while groups of clicks and whistles are used for communication. The sounds are produced by passing air through a structure present in the head, similar to the human nasal cavity, called the phonic lips. When air passes through this narrow passage, the membranes of the phonic lips are sucked together, causing the vibration of the surrounding tissues

These vibrations can, like those in the human larynx, be unconsciously controlled with great sensitivity. The vibrations pass through the fabric of the head to the melon, which shapes and directs the sound into a ray of sound used for echolocation. All toothed whales except the sperm whale have two sets of phonic lips and are therefore able to produce two sounds independently. Once the air is passed through the phonic lips, enters the buccal pouch. Hence the air can be recycled at the bottom of the complex nasal, ready to be used to produce other sounds, or expelled through the blowhole (Nedwell *et al.*, 2003). The mysticetes have instead a larynx that appears to play a major role in the production of sound, but lacking the vocal cords. Scientists therefore remain uncertain about the exact functioning of the mechanism. The process however, cannot be completely comparable to that of man, as the baleen whales do not have to breathe out to produce sounds. It is likely that they recycle the air in the body for this purpose. Even the cranial sinuses can be used to create the sounds, but again, the researchers cannot explain how.

Odontocetes have a valid biosonar or system of echolocation by which they intercept the prey, mates and any obstacles in total darkness with the sound being able to feel the presence, distance, shape, size, texture and direction of movement. Some species can produce sounds of frequencies up to 300,000 Hz. Mysticetes do not have biosonars but produce signals which are very intense but with low frequency around 20-100 Hz, similar to the "bellows". The signals keep individuals in touch with each other even at a distance of tens or hundreds of kilometres.

The threshold of hearing is represented through the audiograms, the track that shows the weakest sound that can be perceived with varying frequency. Figure 7-28 shows the audiograms of some species of odontocetes.

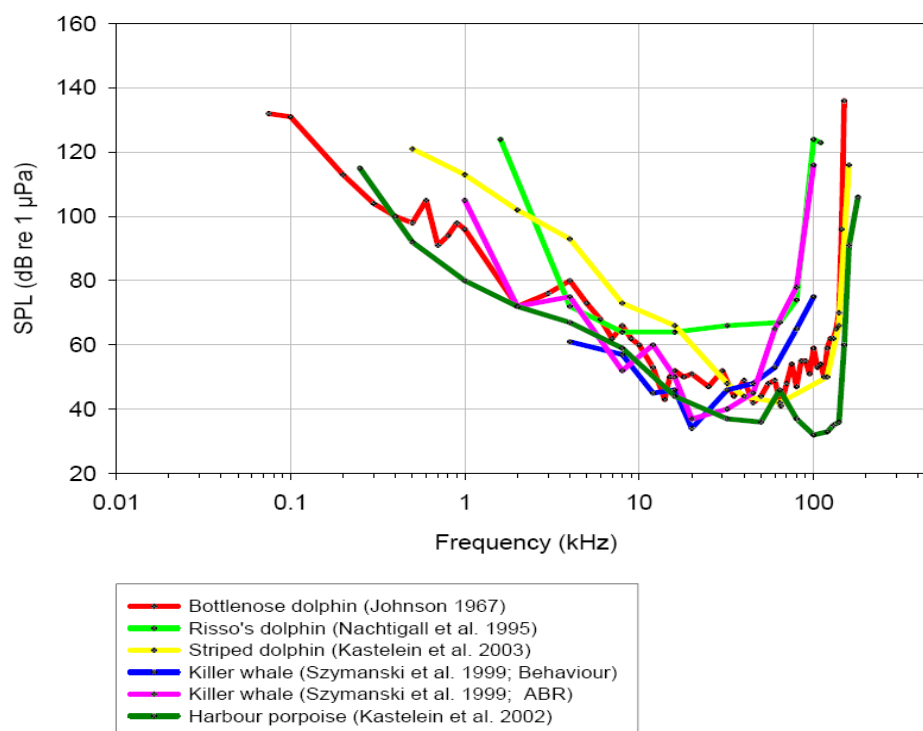


Figure 7-28 Audiograms of odontocetes species

All audiograms exhibit the characteristic U-shape form with relatively high threshold above 1 kHz and with the area of better perception of ultrasound in the frequency > 20kHz.

Comparing the audiogram values with the emission levels at known distances from the source it is possible to identify the area of audibility of the source. Table 7-11 shows the results of the model adopted as the SPL at 1 / 3 octave set at distances from the source.

Table 7-11 Results of the model adopted as the SPL at 1/3 octave set at distances from the source

Distance (m)	Frequency (kHz)											
	Broadband	0.05	0.1	0.2	0.5	1	2	4	8	16	32	64
1	176	143	161	161	163	160	161	160	158	155	153	149
100	136	103	121	121	123	120	121	120	118	115	113	108
400	124	91	109	109	111	108	109	108	106	103	100	93
1000	116	83	101	101	103	100	101	100	98	94	90	79
10000	96	63	81	81	83	79	79	77	73	65	43	-
30000	87	53	71	71	73	67	65	61	53	35	-	-
80000	78	45	63	62	63	54	47	38	20	-	-	-

The chart below (Figure 7-29) shows the attenuated values of noise produced by sources at different distances compared with an odontocete audiogram produced from the previous figure (Figure 7-28).

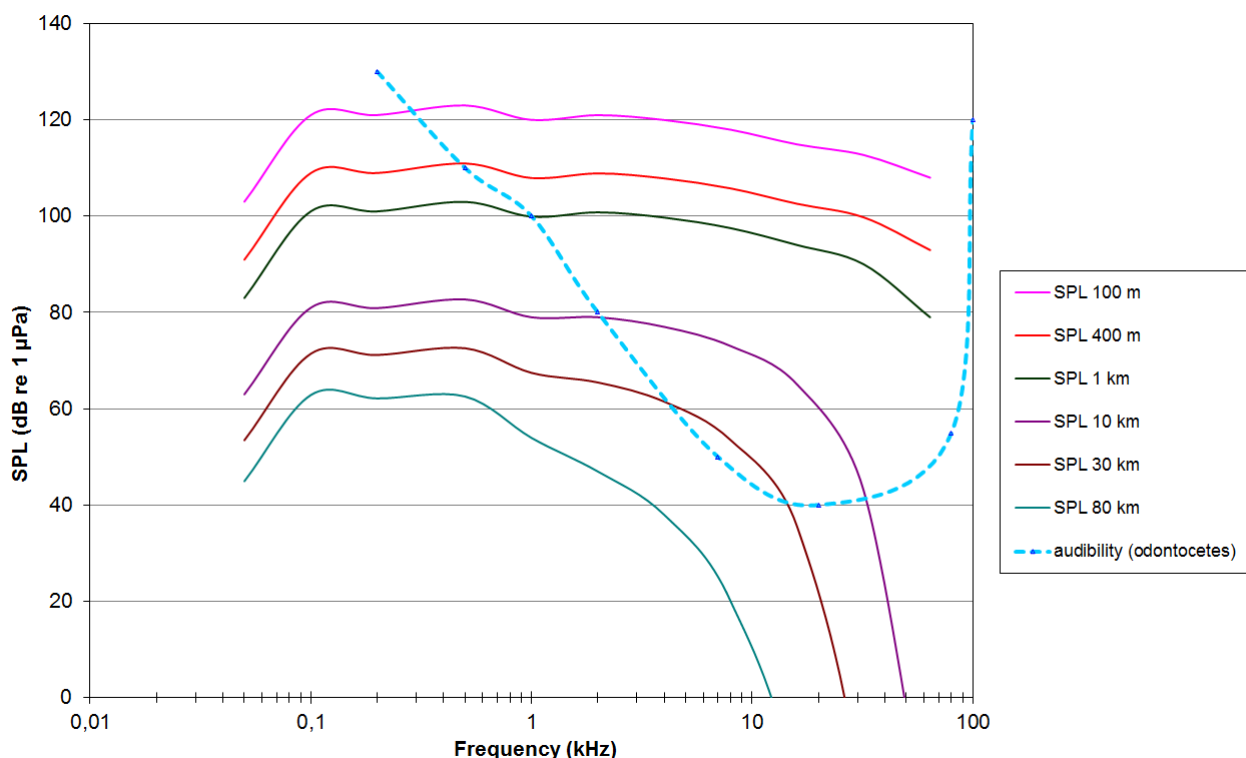


Figure 7-29 Attenuated values of the noise produced by the noise sources at different distances compared with an odontocete audiogram

SPL on the source simulated at various distances from the source has been compared with the odontocete species audiogram. Comparing simulation results and odontocetes audiogram, it is gathered that the noise emitted from the source may have an impact on the species because the levels inputted into the environment are above their threshold of hearing for frequencies of reference.

From these considerations, we also need to identify the levels at which noise becomes a cause of disturbance (area response) or even damage (TTS). Several studies describe levels of SPL-related behavioural responses of different species of cetaceans. In particular Nedwell *et al.* (2003) define the threshold of hearing dBht, the value for which are made of behavioural responses in cetaceans are at a higher level of the threshold of hearing of 75 dB for small responses and 90 for strong reactions.

Referring to these considerations parameter, you can locate the area of response by adding 75 dB, and the area of damage by adding 90 dB at the audiogram previously estimated. It should be emphasized that this analysis is completely deterministic because the threshold for listening dBht was postulated from studies on humans and fish, and on which the authors have declared a need for further assessment and analysis, supported by empirical evidence that the time of the study were not available.

Figure 7-30 shows an indication threshold levels of listening to low noise and high noise according to the criterion defined by Nedwell *et al.* (2003) to get the results of the model based on an evaluation criterion.

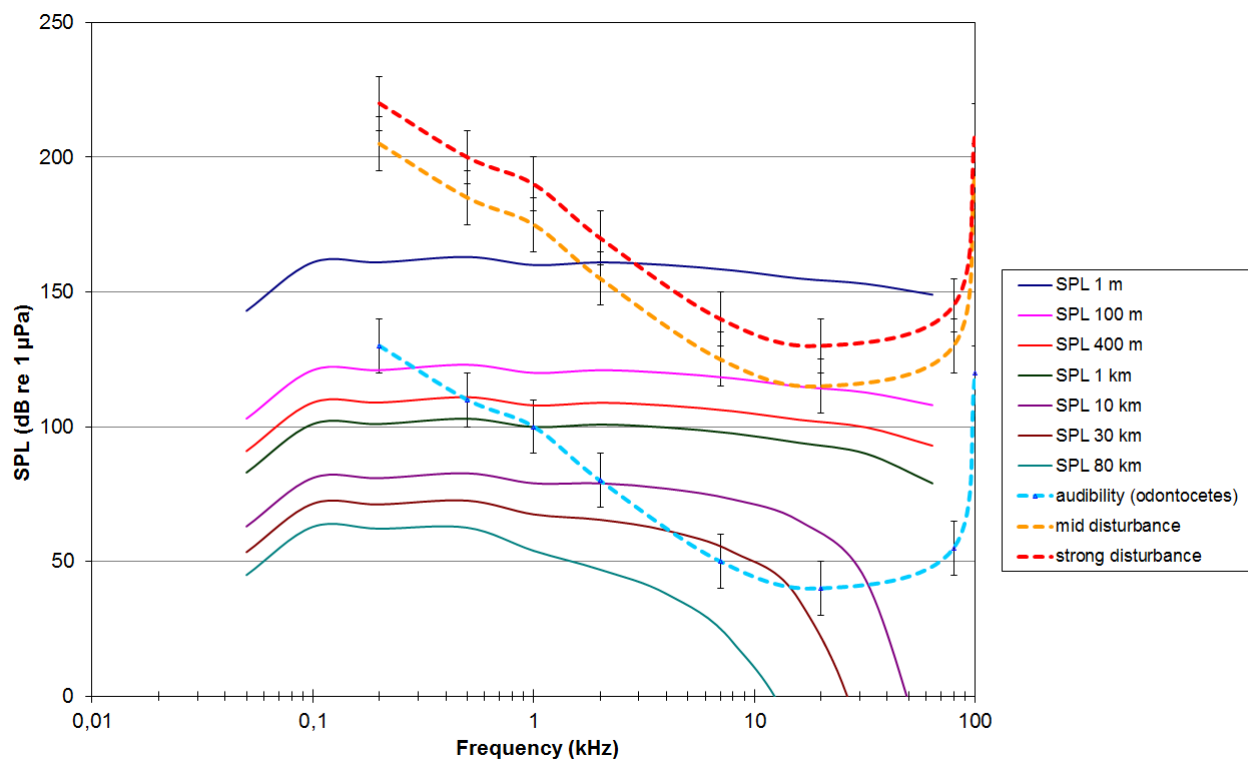


Figure 7-30 SPL generated at various distances from sources, compared with threshold levels of hearing of odontocetes, depending on frequency

An analysis of the figure shows that following the criterion of dBht, 1/3 octave band levels fall below the mid disturbance threshold of odontocetes outside a radius of 100 m from the source; at reasonably low distances the hypothesis of damage is therefore skirt.

More information can be deduced by analysing in detail the single species such as bottlenose truncatus, wide-spread in the Gulf of Guinea. Truncatus bottlenose dolphins, whose audiogram is shown below, has the ability, typical of dolphins, to perceive the signals covered by a background noise. The ability of dolphins to detect signals embedded in noise is measured using two parameters: masking band (MB) and critical ratio (CR).

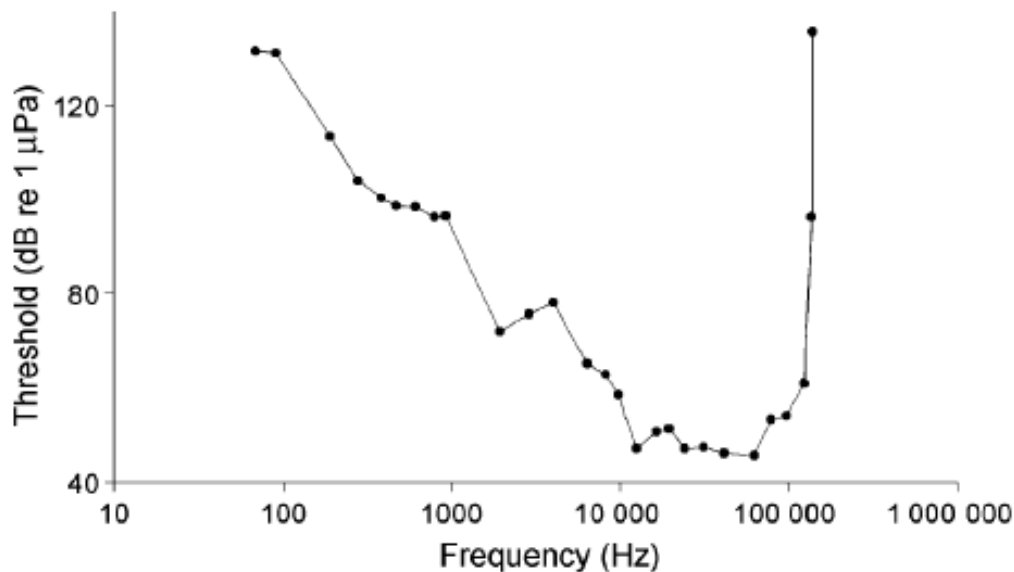


Figure 7-31 Audiogram of *Tursiops truncatus* (Johnson, 1967)

MB defines the frequency range able to mask a pure tone. Noise at frequencies outside the MB will have little effect on the detection of the tone.

The frequencies of communication of bottlenose dolphin (*Tursiops truncatus*) are shown in Table 7-12 below:

Table 7-12 Dolphin vocalisations (MCIWEM 2006)

Sound type	Frequency range (kHz)	Dominant Frequencies (kHz)	Source level (dB re 1 µPa at 1m)
Barks	0.20-16.0		
Whistles	0.80-24.0	3.5-14.5	125-173
Clicks	0.10-300	15.0-130	218-228

CR is a comparison of the signal power required for target detection versus noise power. MBs tend to be a constant function of the CR throughout an animal's functional hearing range.

Based on CR and masking bandwidth data, odontocetes, including bottlenose dolphins, are better than most mammals at detecting signals in noise. Johnson (1968) estimated masking bandwidths from the CRs of bottlenose dolphins. Between 5 and 100 kHz, MBs appeared to be less than 1/6-octave width and rose to approximately 1/3-octave width at 150 kHz. Source noise has the potential to mask dolphin vocalizations over a significant distance. Both these sounds will attenuate over distance, and masking will be determined by their levels relative to each other.

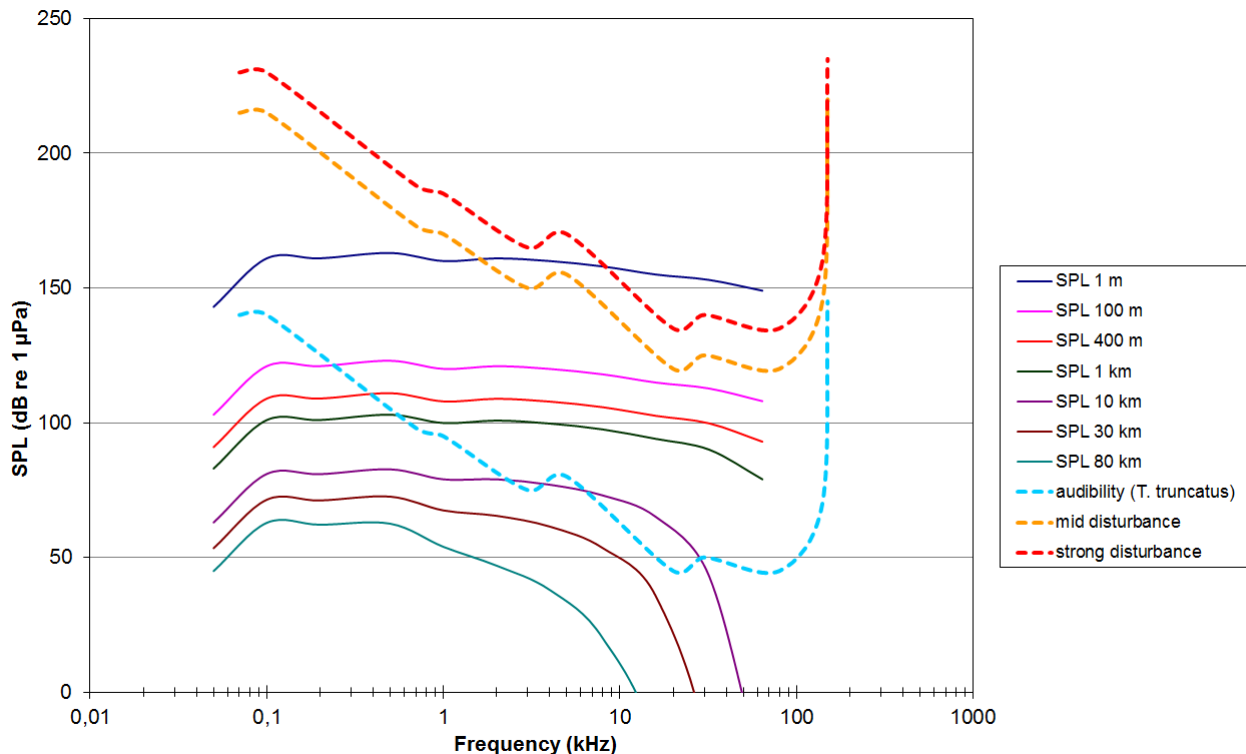


Figure 7-32 SPL in function of distance compared with Bottlenose dolphin audiogram

Fewer studies have been conducted on the ability of mysticetes to hear sounds than on that of the odontocetes (Richardson *et al.*, 1991), and therefore there are no reliable audiograms available in the scientific literature. Erbe (2002) did, in any case, extrapolate information on the hearing sensitivity of some mysticetes from the available literature. There is evidence of the presence of mysticetes in waters interested by the project, mainly Bryde's whale (*Balaenoptera brydei*) and humpback whale (*Megaptera novaeangliae*). Erbe reported an optimal hearing sensitivity frequency range of 0.07-0.9 kHz for Bryde's whales and a general sensitivity range of 0.02-10 kHz (with optimal in range 2-6 kHz) for humpback whales. Similar values apply to other species; clearly, mysticetes are sensible to much lower frequencies when compared with odontocetes, though precise audibility and disturbance thresholds are not available.

Malme *et al.* (1985) showed that individuals of *Megaptera novaeangliae* exposed to a simulation of the noise produced by platforms and semi-submersible drilling systems do not show avoidance. In another study about bowhead whale (*Balaena mysticetus*), Richardson & Malme (1993) showed how the noise produced by a drilling platform can be heard from a distance no greater than 2km from the source, close to the edge of the platform and under typical conditions of low frequency ambient noise. A later study clarified that the spatial extent of the area avoided by the marine mammals is between 500 m and 1 km and that once the noise source is removed, the marine mammals return to the area they had previously abandoned. This makes us think that the effects on their behaviour are reversible (Davis *et al.*, 1987).

Though we lack the data needed to conduct an in-depth study of perceived sound level over frequencies and distances, by examining case studies we can roughly assume that the disturbance threshold of mysticetes will not be reached outside a radius of 1 km from the source; at reasonably low distances the hypothesis of damage is therefore skirt.

Summary

It is difficult to predict which species will be most vulnerable to man-made noise because of the wide range of individual and population sensitivities as well as differences in wariness or motivation. Currently, it may only be possible to make generalizations about the vulnerability of species groups based on behavioural observations of responses to manmade sounds, habits and what is known about a species' auditory sensitivity or vocal range.

The potential impact of underwater noise as a result of the proposed drilling activities on marine mammals is therefore assessed to be of **medium significance** (see Table 7-13).

Table 7-13 Significance of impact of underwater noise on marine mammals.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Medium 2	Small 2	7	Definite	MEDIUM

7.3 IMPACTS ON THE SOCIO-ECONOMIC ENVIRONMENT

Given the offshore nature and activities of the Project the main potential social impacts that may be identified are increased marine traffic, disturbance to fishing activities and the macroeconomic impact of Government revenue generation. Another likely impact is that local communities develop perceptions and expectations on the project's potential to generate economic opportunities; these are generally far greater than actual opportunities created.

This qualitative identification of potential impacts is based on secondary sources (not directly commissioned fieldwork), including those data provided in previous environmental, social and health studies, bibliographic sources, computer databases, GIS data and satellite imagery, etc.

Scope of Assessment and Limitations Encountered

In defining the scope of the impact assessment, there are a few considerations to be made which influence the elaboration of the assessment of impacts on socio-economic and anthropic activities. These considerations and limitations are hereby outlined.

- Socio-economic and health impacts are not easily objectively measured and therefore often need to be inferred rather than measured. A combination of insight into social processes in general and a thorough knowledge of the affected communities are important in order to draw valid inferences;
- Communities are dynamic and often in a continual process of change. The proposed OCTP Block development project is one factor contributing to this change, but it is often difficult to identify when an impact is solely attributable to the Project or to other factors (or a combination thereof);
- Human beings are naturally continuously adapting to changes in their environment, including project impacts. As such, over time these impacts change in significance for those affected;
- Project operations are located offshore and will therefore imply few direct interactions with other human activities, exception made for limited numbers of other marine users operating in the area; among these commercial vessels

- Majority of the deepwater offshore infrastructure will be transported to the field by sea from international locations, and the shore base operations in Ghana will be limited to routine project support, supply runs, equipment and materials storage, and treated waste handling;
- Information on how the government would use the revenue that would accrue to them is not defined and is outside the control of the project so the direct socioeconomic benefits cannot be fully determined in this E(SH)IA;
- Finally, social impacts may often prove unavoidable for a given project design or approach, and as such, mitigation strategies should be regarded as strategies to manage change rather than as a means to avoid an impact.

7.3.1 Disruption of Economic Livelihood Activities

The presence of exclusions zones in effect around the drilling unit, FPSO, as well as the movements of supply and support vessels, may impede access to fishing areas and disrupt navigation by fishing vessels utilising the offshore region in the vicinity of the offshore development.

Any impacts on the ability of fishing and other vessels to operate normally may lead to a loss of income or indirect financial costs (in the case of damaged gear) and, for artisanal fisherman in particular, decreased food security, which is of concern in the region where coastal communities are reliant on subsistence fishing. Moreover, past interviews with local stakeholders, including fishing cooperatives, revealed that people have developed the belief that dredging and oil industry activities already existing in the region lead to decrease in fish catches.

However, considering that local fishing activities are practiced closer to shore with respect to the FPSO's offshore position, disturbance to artisanal fishing activities may be considered negligible. Disturbance is more likely to occur in respect to larger fishing vessels (e.g. Tuna fishing activity). However, here too the impact may be considered of moderate significance as the safety exclusion zone around the Project structures constitutes a minor reduction in the available fishing ground within the Ghanaian EEZ.

The assessment of the impact of disturbance to fishing activities and the consequent disruption of livelihood resources is further and fully developed in the annexed Fisheries Impact Assessment. With regards to the other marine related livelihood resource in the AOI, namely tourism, considering the distance of the OCTP Block from shore and coastal tourism infrastructure, impact on tourism may be considerable negligible in relation to Phase 1 activities of the project.

Table 7-14 Significance Assessment of disruption of fishing activities

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Local 1	Medium 2	Small 2	8	Possible	LOW -

7.3.2 Increased Government Revenue

Oil and gas production from the proposed OCTP Block Phase 1 project will contribute to Ghana's economy through taxes, royalties and other fees that eni Ghana and all other members of the Joint Venture would have to pay to the government of Ghana. In addition the Government will receive further revenues through other taxation such as personal income tax and withholding duties on imported services paid by employees, contractors and supporting services to the Project. This

would all contribute to Ghana's oil and gas revenue, increase Gross Domestic Product (GDP) and generally benefit the economy at a national scale.

In turn, these revenues generated by the Project increase finance availability of the Government and could contribute to the Ghanaian economy directly through reducing the balance of payments with respect to energy imports as well as facilitate the Government's investment in the Country's socioeconomic development, example the development of much-needed infrastructure such as road network, power grid water network, and waste management facilities, as well as the provision of social, education and health services, which would be of great benefit to the local communities. Revenue from oil and gas depend on the on side on world market prices, on the other on good fiscal discipline in managing these revenues. Consequently, the benefits of oil and gas revenue will depend on the policies and actions adopted by the Government of Ghana; the use of revenue received as a result of projects such as the proposed OCTP Block development is the responsibility of the Government.

To this regard, the level of revenues from the oil and gas industry and transparency on how it is used was in fact identified as a key issue during stakeholder consultations.

The **positive** impact of a contribution to Ghana's economy as a result of the project is assessed to be of **medium significance**.

Table 7-15 Significance assessment of Increased Government Revenue

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Small 2	9	Probable	MEDIUM +

7.3.3 Employment Opportunities Generation

An increase in local (Ghanaian) employment, either through direct employment in the project or in secondary businesses (contractors, suppliers and services providers), has the potential to improve the socio-economic well-being of employees, their families and their local communities from wages and other benefits. There will also be minor benefits to the wider economy through income taxes paid by employees and spending of earnings. In general, the oil industry is not a large employer, especially after the project installation phase, in relation to the revenues it can generate, therefore, the spread of money through wages into the wider local economy is less than that experienced for similar sized industries such as manufacturing or service-based industries. Therefore, although there are expectations amongst the local communities (as per stakeholder consultations outcomes) with regards to employment opportunities as a result of the project, it is not anticipated that the project will result in a significant number of opportunities.

In addition, it is expected that most of the jobs created by the project (in particular direct employment opportunities) will most probably be skilled/professional level jobs and it is highly unlikely that these skills will be available in the local community. Despite the fact that the creation of any employment opportunities in the Western region was stated as highly desirable, the OCTP Block project in its offshore phase is not expected to create many new employment opportunities (direct, indirect or induced) in the Ghana economy.

Therefore, while employment is generally a positive benefit there is the possible negative effect that due to lack of certain specific skilled labour to meet the particular staff requirements of offshore development projects and the relatively low numbers of staff required, the Project is unlikely to meet the high community expectations of employment opportunities (as expressed during Stakeholder consultations).

Nevertheless, there are other associated positive impacts. The skills developed through training received and experience gained when employed in the oil and gas sector will be transferred to other sectors of the economy and will provide positive benefits. It will also make Ghanaians more competitive in the international market place, facilitating increased opportunities and skills transfer. Moreover, formal employment is generally speaking more lucrative than many of the economic activities on which the local communities (particularly in the Soyo region) currently relies and a reliable regular income would increase financial security and material wealth, and improve the ability of the employees to better their standards of living, invest in their future and access better health care and education.

Overall the impacts from direct and indirect employment will be long term, localised and relatively small scale and therefore assessed as being of Low significance

Table 7-16 Significance assessment of employment opportunities generation

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +/-

7.3.4 Procurement of Goods and Services

The majority of the fabrication work for the FPSO will be undertaken with material sourced from international markets. Installation offshore will be carried out using specialist contractors and vessels also from sources outside Ghana. During the project lifetime there will, however, be local procurement of goods and equipment (i.e. food, fuel, chemicals and other consumables), logistics support (i.e. drivers, supply vessel crew, and plane and helicopter support, pilots and cabin crew), and services (i.e. onshore administrative support, accommodation staff, security, catering, cleaning).

Impacts from procurement of goods and services are likely to be positive through stimulating small and medium sized business development with investments in people (jobs and training) and generation of profits. Business investment in new and existing enterprises that provide goods and services can provide the basis for their longer term sustainable growth as they diversify to provide goods and services to other industries. Secondary wealth generation from the development and use of local providers of goods and services can be reasonably expected to have a positive impact through the generation of revenue able to flow into the local economy.

Positive impacts will be long term, but relatively small scale and localised and are assessed as of **Low** significance.

Table 7-17 Significance assessment of Procurement of goods and services

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +

7.3.5 Increase in Marine Traffic

Figure 7-33 and Figure 7-34 present data on current commercial vessel movements (showing general shipping lanes) and fishing vessel distribution off West Africa and the Ghanaian coast respectively.

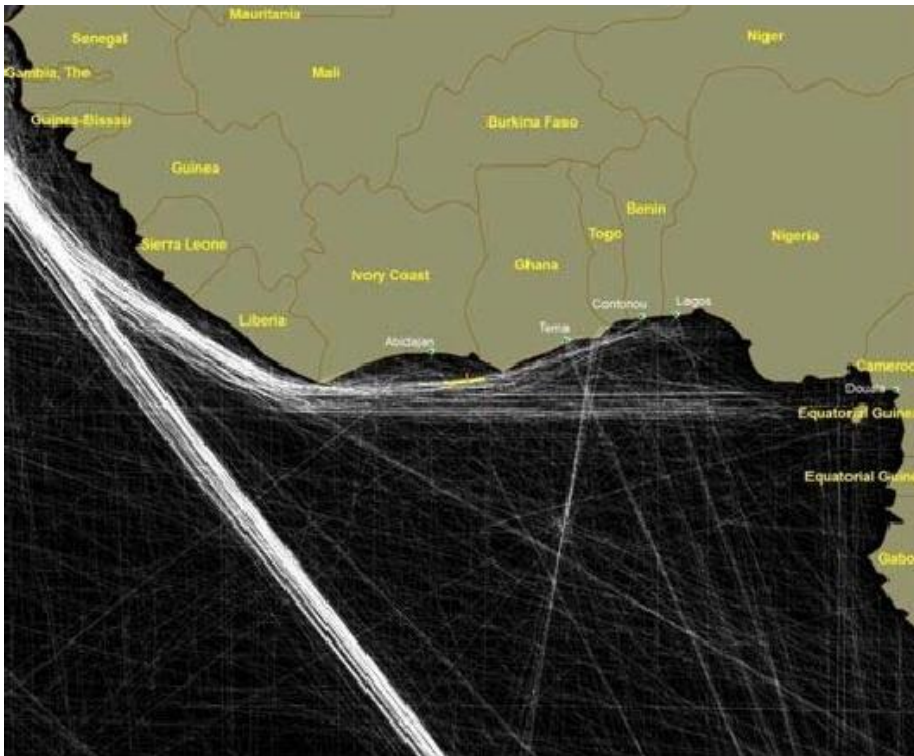


Figure 7-33 Shipping Lanes off West Africa

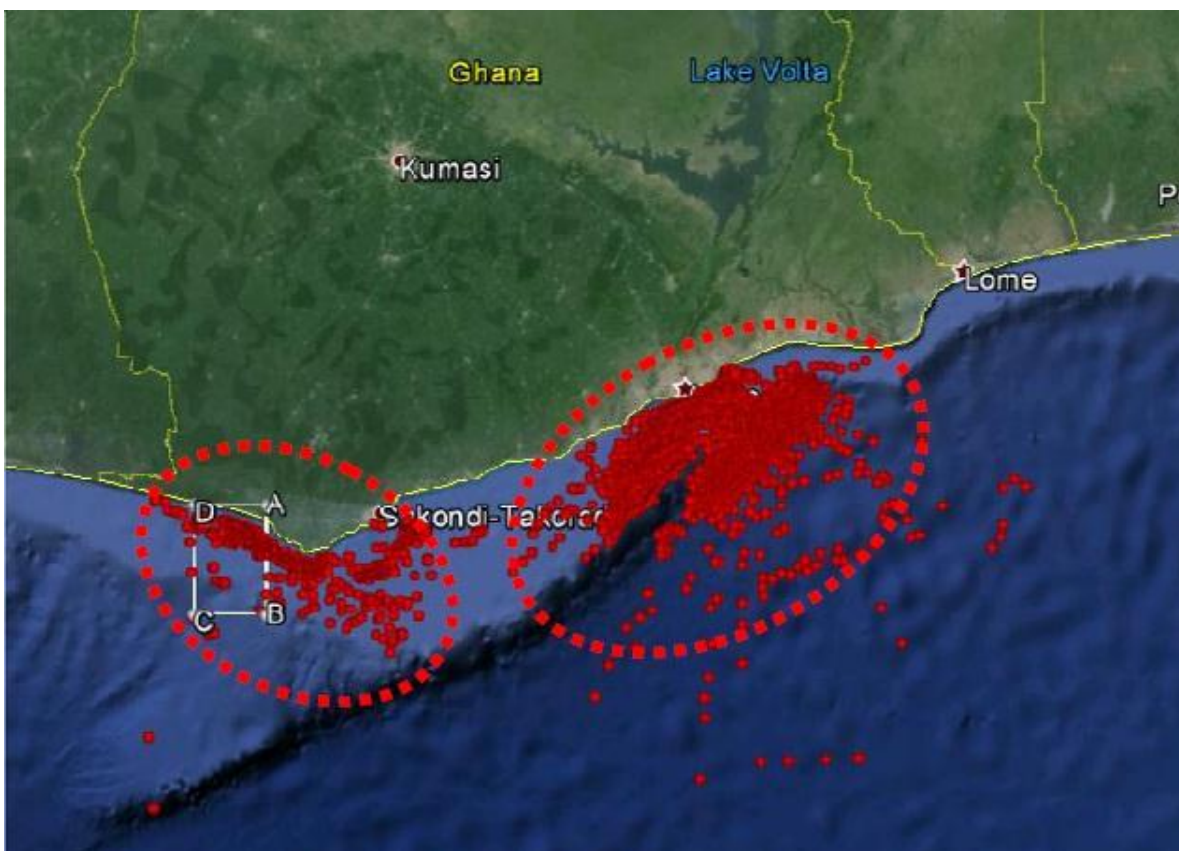


Figure 7-34 Fishing vessel distribution off coast of Ghana

While the exclusion zones around fixed-position vessels involved in the field development (i.e. drilling units, FPSO) are intended to prevent collisions and reduce risks, the movement of support

and service vessels associated with the Project could present hazards to other vessels that cross their paths, increasing the risks of collisions that could cause damage and/or injury, in particular during the installation of the Project as more significant numbers of vessels will be involved. Instead, during routine operations just two vessels will sail in and out of Takoradi port on a daily basis.

Moreover, the exclusion zones and increase in marine traffic associated with the proposed development, may require that any vessels that usually pass through the area to re-route to avoid it. This is essential for safety of life at sea, but could marginally affect commercial activities and livelihoods of vessels utilising the areas in the vicinity of the offshore development.

It is foreseen that established shipping lanes, particularly in approaches to harbour and in heavily travelled coastal waters, as well as standard vessel navigation and communication equipment will be used. Moreover, stand-by vessels and offloading tugs shall be present at the FPSO location. The set-up of these measures guarantees the reduction in collision risk between project vessels and commercial and fishing vessels. Furthermore, the larger number of vessels is foreseen during the brief installation phase and only two vessels are foreseen during the longer operations phase. Given these considerations, the impact from increased marine traffic is considered to be of **Low** Significance.

Table 7-18 Significance assessment of Increased Marine Traffic

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	Regional 2	Low 1	Small 2	6	Probable	LOW -

7.3.6 Perceptions and Expectations of Local Communities

With most large development projects, and particularly in the case of offshore oil and gas developments, expectations from local communities with regard to economic opportunities (employment or business opportunities) typically far exceed the actual opportunities that will be created by the project. In addition, while local communities usually bear the brunt of the negative direct and indirect impacts (such as those discussed above) of a project, the socio-economic benefits (in the form of contribution to the national economy) do not necessarily filter down to tangible or perceptible socio-economic benefits to the local communities. This may lead to a negative opinion of a project proponent in the local communities along the coast, and even to further damaging to the reputation of the oil and gas industry as a whole.

When asked about the principal problems affecting their communities, stakeholders consulted identified unemployment, negative effects on fishermen's livelihood due to decline in fishing catch, rise in cost of living and need for improved social infrastructure including hospital, roads, sanitation facilities, water supply, as the key concerns of the local communities. As illustrated by the discussions in this section, projects such as the OCTP Block development can result in impacts that raise or exacerbate these concerns. Local communities may therefore perceive these concerns as attributable to the project, whether they can be directly linked to the project or not.

Furthermore, stakeholders consulted for this ESHIA listed employment opportunities, improved utilities, health and educational infrastructure, as anticipated socio-economic benefits that would accrue to the local communities as a result of oil and gas development in the region, and the OCTP Block development in particular.

Overall, it is therefore highly advisable to adequately address stakeholders and their expectations. The potential **negative** impacts as a result of perceptions and unmet expectations of local communities are assessed to be of **Medium significance**.

Table 7-19 Significance assessment of perceptions and expectations of local communities

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Local 1	Medium 3	Great 3	8	Probable	MEDIUM -

7.4 IMPACTS ON HEALTH

Emissions and discharges as a result of project activities may reduce air and water quality and increase noise levels which may affect the health of employees. In fact during phase 1 where all activities are forecast offshore, employees on the offshore facilities are most at risk of the effects of the health impacts discussed above, but the implementation of standard occupation health and safety standards, including the use of personal protective equipment (PPE), and adequate training would decidedly reduce these risks.

Usually, any increase in health risks and decline in the health conditions in any region would increase pressure on the local health care system. Recent health data on Ghana health services show that local healthcare providers in the Western Ghana coastal communities are currently under capacity in terms of equipment, facilities, training opportunities and staff. This also implies that minimal additional pressure on the local health care system as a result of the proposed project development could reduce local communities' access to the existing services. However, it is worth noting that eni is currently involved in the implementation of a health services development project. Moreover, given the offshore nature of the Project in this phase it is possible to consider impacts on health of local community as negligible or absent.

The overall potential **negative** impacts on health of employees and local communities are assessed to be of **Low significance**.

Table 7-20 Significance assessment of Impacts on Health

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Medium 2	Small 2	7	Possible	LOW -

7.5 SUMMARY OF IMPACTS

Hereby provided a summary table containing evaluations of the potential environmental, social and health impacts of the proposed project.

Table 7-21 Summary evaluation of ESH impacts of proposed OCTP Block Development Project

Table 4-12 Summary Evaluation of EIA Impacts of Proposed CCH Block Development Project								
Potential Impact Identified	Impact Characterisation	Significance Evaluation Criteria						Impact Significance
		Consequence					Probability	
		Duration	Extent	Magnitude	N° of elements involved	Score		
Impact on Air quality component	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -
Impact on Water quality component	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -
Impact on Sea bed and marine subsoil	Direct	Long term 3	Local 1	Low 1	Very small 1	6	Definite	LOW -
Impact on sea bed Ecosystems and vegetation, flora & fauna	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -/+
Impact on noise component	Direct	Medium term 2	Local 1	Medium 2	Small 2	7	Definite	MEDIUM -
Disruption of fishing activities	Direct, Indirect, Perceived	Long term 3	Local 1	Medium 2	Small 2	8	Possible	LOW -
Increased Government revenue (contribution to national economy)	Direct, Indirect, Cumulative and Perceived	Long term 3	National 3	Low 1	Small 2	9	Probable	MEDIUM +
Employment opportunities	Direct	Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +/-
Procurement of goods and services	Direct	Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +
Increase in marine traffic	Direct, Cumulative	Short term 1	Regional 2	Low 1	Small 2	6	Probable	LOW -
Perceptions and expectations of local communities	Direct, Perceived	Long term 3	Local 1	Medium 3	Great 3	8	Probable	MEDIUM -
Community Health and Safety	Indirect Cumulative Perceived	Medium term 2	Local 1	Medium 2	Small 2	7	Possible	LOW -

7.6 CUMULATIVE IMPACTS

The aim of this Section is to assess the Cumulative Impacts following the guidance of the IFC document Good Practice Handbook (GPH) on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets, published in 2013.

The expected development of several projects in the coasts of the Western Region of Ghana to be added to the current Project, including ENI Phase 2 NAG development, TEN development and the Lornho Oil Service Port at Atuabo may result in a confluence of factors contributing altogether to the reduction in the environmental quality of the seawater and seabed sediments as well as in the air quality and freshwater quality. These are described in further detail in the following subsections.

7.6.1 Seawater quality

In terms of liquid discharges, the main impact associated is marine water pollution and the associated effects on marine ecosystems and economic activities based on those. The liquid discharges expected include drainage, sewage and other vessel discharges, produced water and hydrostatic test fluid discharges. The impacts of these discharges have been discussed in detail in the corresponding Sections. In terms of cumulative impacts of the components, the same liquid discharges can be generated by the same sources for the different components (i.e. vessel discharges, drainage) which can be coincidental in time and or geographical location in some instances, or different in nature by different sources (i.e. produced water by platforms, hydrostatic test fluid discharges by pipelines) which can be coincidental in geographical location, but not in time. The planned Phases will include similar construction and operational discharges.

In this context, discharges from the planned projects, due to compliance of relevant agreements and regulations (Marpol and Ghana's legislation) suggest a non-significant additional source. Potentially contaminated drainage from platforms will be treated, and the expected very low quantities will not significantly increase the general pollutant load. Hydrostatic test water discharge is not considered a major source of pollution to the general load, given its expected chemical nature. However final effect on marine water quality depends on dilution/dispersion capacity of the surrounding marine environment. Potential cumulative impacts in this respect would only be expected when dispersion plumes from sources could overlap, due to temporal and geographical coincidence of discharges from these sources. The effluents from Atuabo Port, whereas also treated to relevant standards, would not overlap in space with other discharges (15 km distance as a minimum), albeit they would be coincidental in time during operations with all offshore developments. As such, considering the distances from the other existing or planned/potential point sources, and the low probability of temporal and geographical coincidence of point and moving sources discharges, the probability of cumulative impacts of the OCTP Phase I project with other sources of marine pollution in this respect is low. With regards to long term accumulation of still residual contaminants from liquid discharges, as with the drilling fluids, it is not expected to become a significant risk with the planned projects, but could be if more projects accumulate.

In terms of turbidity, Project will generate minor increases in the main sources of increase in turbidity are the drilling material discharged to the sea and installation of the subsea structures or anchoring on the seabed. The characteristic of this impact in terms of accumulation of effects is that it is temporary in nature, both in the activity that generates it (construction, drilling) as well as the effect itself (the turbidity plume will settle in time). Only when there is simultaneous construction/installation of pipelines and platforms and/or drilling of wells, in an area where the turbidity plumes can overlap, there is the possibility of temporary accumulation of impacts. The distances between the developments planned in the coasts of Ghana are high enough to ensure that if any overlap of turbidity plume occurs, it will be associated to very low values of suspended solids, even with the nearest wells to be drilled for the OCTP Project Phase II (approximately 2 km). Additionally, these cumulative effects would occur only if there is an overlap in the drilling period within adjacent platforms, which is improbable. All the previous considerations lead to the

conclusion that the cumulative impact produced by the existing and planned activities taking place in the marine area of influence of the OCTP Phase I in terms of increased turbidity and associated and consequential effects are probably not higher than any of the single projects impacts.

In summary, the cumulative impacts on seawater quality (discharges and small-scale spills) is considered to be **Low** during construction and operation, and cumulative impacts of increased turbidity are considered **Not significant** for construction or operation

Deterioration in marine water quality could impact biodiversity, fisheries and local communities. Contaminants within the water column are likely to settle out and accumulate within the marine sediments, and negatively affect the benthic habitat and fauna as described in the following Sections.

7.6.2 Seabed

The cumulative impacts of the existing and future developments on the offshore seabed habitats and sediment composition will greatly depend on what kind of drilling fluids will be used. Use of drilling fluids with oil or heavy metal components could potentially have a significant cumulative effect on seabed habitats and organisms due to acute and/or chronic toxicity and bio-accumulation. If water based drilling fluids the cumulative impact will only depend on the physical effect of these drilling materials on the seabed. Considering the restrictions imposed by the Authorities of Ghana (a maximum of 2 % of NADF adhered to cuttings discharged, pre-approval of additives to be used in the muds) it is expected that biochemical effects will be limited.

In addition, and similarly to the effects due to turbidity, expected effects on seabed sediments and habitats due to deposition of cuttings will be restricted to the immediate vicinity of each well drilled. In this context biochemical effects from drill cuttings are not expected to extend beyond 1 km from each well, and physical effects are expected to cover a smaller surface. This accounts for approximately 3 km² of maximum physically disturbed area per well, with no overlapping among them. Considering the total number of wells existing (24 Wells on TEN Jubilee) development Project) and planned in the western coasts of Ghana (18 wells for the OCTP Project Phase I and 5 wells on OCTP Project Phase II) the final seabed surface potentially affected, 141 km², is not significant in relation to the total area of seabed covered by the different permits involved.

Smothering effects on benthic communities are expected to occur similarly around each well. In terms of offshore seabed habitats sensitivity the already existing information suggest that these are not particularly sensitive. Therefore, it is unlikely that there will be cumulative impacts from cuttings discharge on the marine environment. Only if there is an accumulation of projects beyond the mentioned in time and space, this issue could become relevant, as increasing quantities of residual oil and metals with cuttings could accumulate on the seabed.

In summary, the cumulative impacts during construction and operation phases on seabed are considered **Not significant**.

7.6.3 Air Quality

Regarding the cumulative impacts due to emissions to atmosphere from the various projects planned in the area, they are not considered to affect significantly the local air quality given the dispersion capacity of the surrounding atmosphere. Cumulative impacts in this respect would only be expected when atmospheric dispersion plumes from sources could overlap, due to temporal and geographical coincidence of emissions from these sources. The potential for temporal and geographical coincidence of the different sources within the OCTP Phase I project is very small. If the sources emit simultaneously in time (i.e vessels during construction or FPSO) they will be geographically sufficiently separated so that their dispersion plumes would not significantly overlap.

Thus the cumulative impact on the local air quality, and associated impacts on receptors, will be similar to the highest of the impacts from any of the components.

In summary, the cumulative impacts on air quality during construction and operation are considered **Not significant**.

Cumulative impacts are expected to occur, however, due to the potential GHG emissions from the various projects planned in the area. Unlike air pollutant emissions, in fact, greenhouse gases impacts are not limited to the proximity of the sources and are not subjected to dispersion in the surrounding atmosphere. GHG impacts occur, and need to be evaluated, at a global scale. Thus, cumulative GHG impacts are foreseen to occur and will increase the national emissions currently projected in Ghana's National GHG Inventory. To limit the significance of cumulative impacts, all Projects planned to be developed in the area shall implement feasible mitigation measures and design control procedures to allow to keep Project GHG emissions as low as possible.

7.6.4 Underwater Noise

With regards to noise, there will be several sources of underwater noise generated by the project components. Noise can be generated by the same sources for the different components (i.e vessel) which can be coincidental in time and or geographical location in some instances, or by different sources (i.e drilling rig, well testing, power generation during operation) which can also be coincidental in time and geographical location with other sources. In terms of other projects in the area, the existing platforms/rigs/FPSO do generate some noise, whereas the planned Phases will include similar construction and operational noise sources. The potential of cumulative noise impacts between project components would mostly come from cases where the noise output from different project components could coincide in time and location, so that a local cumulative effect could take place (superimposition of either or both power and frequency, affecting to a wider range of organisms). In terms of location it has to be considered that underwater noise can travel long distances from the source.

The noise impacts from each of the planned developments would be similar in nature and general magnitude as the ones assessed for the OCTP Phase I project but the potential for cumulative effects will depend somewhat on the level of simultaneity between the developments during drilling and construction. For operational noise sources, these are mostly related to service vessel and maintenance activities, resulting in a lower intensity and frequency of noise. The most relevant cumulative effect with regards to noise could arise from the increased traffic related to the Atuabo Port, but the proportion of vessel traffic related to the port operation itself is much higher than the activities of the offshore field operators, and as such not manageable by those. This circumstance, jointly with the cumulative impacts on marine safety and traffic associated issues determines the need of a Marine Traffic Management Plan for the area to be designed by the appropriate Ghanaian Authority in conjunction with the different operators.

In any case the underwater noise generated by the different activities will potentially affect marine fauna and specially mammal species. Potential disturbances to breeding animals are foreseen by a reduction of suitable habitats for breeding and feeding given the general increase in background noise levels expected. This will also result in behavioral changes, mainly in the form of avoidance of the area. However, it is expected that both turtles and marine mammals get habituated to these noise levels and return to normal activities and behavior after a given period of time as has been observed in other seas around the world where mammals are periodically recorded in noisy marine areas.

The cumulative impact from noise is therefore assessed as of **Low** significance during construction and operation phases.

7.6.5 Marine Fauna and Flora

The presence of simultaneous projects along the coast of the Western Region of Ghana may result in cumulative impacts on marine mammals and sea turtles, mainly derived from the increased underwater noise levels and the presence of infrastructures, vessels traffic and human activity along the beaches. As such there is the possibility of simultaneous traffic for all drilling, platform construction and pipeline installation, depending on the detailed schedule of works of each project. Regarding the potential simultaneous activity of the vessels and the drilling rigs, it is considered that it will not be significant in terms of increased probability of collision with marine fauna, given the relative areas of influence of each vessel or rig, and the low speed of all vessel types. In any case this simultaneous disturbance is likely to be temporary and localised at significant distances. Another potential cumulative impact expected on marine fauna is due to the increase in human presence and land take along the beaches (construction of pipelines of TEN and OCTP Phase II projects, new Lornho oil service port, OCTP Phase II onshore facilities construction and operation).

This is expected to result in a loss of suitable nesting habitats and especially in a reduction of reproduction success by an increased poaching on the already laid eggs, due to the increased human presence along the coast. In this context it is considered necessary to implement a biodiversity action plan (BAP) where this impact is addressed in collaboration with local entities. In summary, given the extension of suitable nesting habitats, the cumulative impacts on marine fauna and flora during construction and operation are considered **Low**

7.6.6 Economy and Employment

The emergence of the oil and gas (O&G) industry in the Western Region will lead to an increase in the number of people who are able to secure permanent employment in the area. The income earned will increase average household incomes and levels of disposable income. This will increase local spending power, the demand for goods and services, and attract stimulate further economic activity. In turn, it will also increase income stability in the area.

In summary, the significance of this positive cumulative impact is considered to be **Low** during operation and construction given the low levels of literacy, available skills and lack of technical training of the local population, which limit the extent to which they are able to access and benefit employment opportunities available, particularly during the operation phase of the O&G projects. If implemented effectively, the training provided by other oil & gas companies operating in the area and as a result of the Lornho Project would work to support this positive impact.

Inflation and Exacerbation of Economic Vulnerability

The larger population and worker presence both from the Project and other possible developments in the area could increase the demand for goods and services. Although this has positive economic benefits for secondary business development, this may in turn exacerbate price increases for accommodation, food and other retail goods within the surrounding area which can negatively affect the ability of vulnerable persons within the communities to access and afford these goods and services. In response to this, however, there may be an increase in secondary businesses exploiting new local markets by bringing in larger quantities of goods at lower prices.

In summary, although this is expected to temper the inflationary action, the overall cumulative impact on price inflation is considered to be **Medium** during construction and operation.

Tourism

The tourism sector in the Western Region has been highlighted as an area for potential growth. While the Project will have a positive impact on tourism by increasing the demand for accommodation and tourism facilities, there is potential conflict between the tourism sector and the increase in industrial land-use associated with O&G projects. Multiple projects may alter the sense

of place of the area and detract tourists who visit the area to experience the rural and natural beauty of the destination.

Mitigation measures for this impact include the development of a tourism development framework, which must be owned by the Regional government. eni and other developers will partner with local government to develop such a framework.

In summary, and after mitigation, the significance of this cumulative impact is considered to be **Low** during construction and operation

7.6.7 Livelihoods

The accelerated influx of people to the area as a result of other O&G developments in the area will be associated with increased pressure on land, natural resources and ecosystem services. Economic migrants entering the area may also want to pursue fishing and farming activities. This, together with additional exclusion zones and onshore land take from other projects, could have a impact on the livelihoods of the host communities. The exclusion zone associated with one project may not have an adverse impact of fishing activities, and is not anticipated to result in reduced fish catches. If, however, there are multiple exclusion zones within a certain fishing area, these restrictions could result in reduced catches.

Considering this effect within a baseline context of already historically declining fish catch, the cumulative impact on fisheries based livelihoods is considered to be of **High** significance during construction and operations.

Cumulative impacts on farming activities are expected to have no contribution from the OCTP Phase I project as it does not include any kind of onshore activity.

The increased human pressure on natural resources and development of new transportation infrastructures may lead people accessing previously undisturbed land and therefore an increase of the potential for habitat degradation / land use change. An increase in population in the area will also lead to an increase in demand for natural resources such as wood for building houses and for fuel, which in turn will lead to further environmental degradation.

In summary, this impact is considered to be of **Medium** significance during construction and operation.

Mitigation for the impacts on livelihoods and ecosystem services will include working with local and regional governments to develop effective measures and procedures to encourage sustainable resource management. Mitigation measures within the Fisheries Management Plan will also be focused on the management of this impact.

Post Decommissioning and Livelihoods

The combined effect of all the anticipated O&G and infrastructure projects within the area over similar time periods may lead to a transformation of the economy and livelihood strategies of local communities from largely subsistence agriculture and farming to wage labour over the construction period, for example. If this transition does not occur in a sustainable way, this could result in economic dependency of locally impacted communities on the O&G sector.

The result of post-decommissioning job losses could have a negative economic and psychological impact on members of the local population, in particular those who have come to rely solely on the O&G sector for their source of livelihood. Local communities may also come to depend on or expect supplementary livelihood support from social investment projects from foreign companies as part of their social investment strategies in the area. The poorly managed exit by companies from such projects can impact upon communities further.

Mitigation will include working with local, regional and national government as well as other Operators in developing a sustainable social investment and exit strategy, focused on addressing how social investments can benefit project affected people and project employees in a sustainable manner. The exit strategy will also define actions to mitigate the potential residual impact of withdrawing these benefits post-decommissioning.

8 MITIGATION AND MANAGEMENT MEASURES

Having assessed the potential impacts all impacts identified shall be considered for mitigation and control through preventive, mitigative and ameliorative measures; appropriate control and management measures shall be defined and undertaken according to the significance rating of each impact

These measures shall be incorporated into the proposed project development to minimize or completely eliminate the key impacts. The approaches to the mitigation measures include enhancement (for the positive impacts), prevention, reduction, avoidance and compensation (for the significant negative impacts).

The mitigation measures for each (significant and adverse) impact of the proposed Project activities are generally identified based on the associated effect to the environment. The significance of the impact, probability or likelihood that the impact will occur and the severities of its consequence (as determined from the risk assessment matrix) constitute the indices used for determining the mitigation requirements as illustrated in Table 8-1 and Figure 8-1.

Subsequently, the specific mitigation measures satisfying the mitigation requirement were established putting into consideration available resources and competencies, on-site conditions, public concerns and technology.

Table 8-1 Impact significance, control and management actions.

Ranking	Impact level	Control and Management Actions	
4 – 6	Low	Actions in the short term	Ensure that policy and control measures are adequate to control the impact
		Actions in the long terms	Verify that monitoring and reporting activities are properly established to guarantee the correct application of policy and ensure that control measures remain adequate
7 – 9	Medium	Actions in the short term	Check if current policy and control measures are adequate, and revise them according to set appropriate objectives for improvement
		Actions in the long terms	Develop adequate plans and activities for control measures, ensuring that they are approved and implemented with timescales set and resources (budget and personnel) allocated.
10 – 12	High	Actions in the short term	Plans and activities are implemented to mitigate the impact as soon as possible. Interim reduction measures are established.
		Actions in the long terms	Long-term plans and activities are developed. parameters and KPIs are set and properly measured, monitored, reported and verified. Targets are set for improvement and feedback used for corrective actions.
13 – 16	Critical	Actions in the short term	Immediate emergency measures to reduce impact. Align the current level of control and implemented measures to best available practices to address the issue. Parameters and KPIs are measures, monitored, reported and verified. Targets are set for improvement and feedback used for continuous improvement.
		Actions in the long terms	The company demonstrates the delivery of continuously improved performance through Research and Development, technology and innovation, training of the personnel, strategic partnership and input and feedback from internal and external stakeholders.

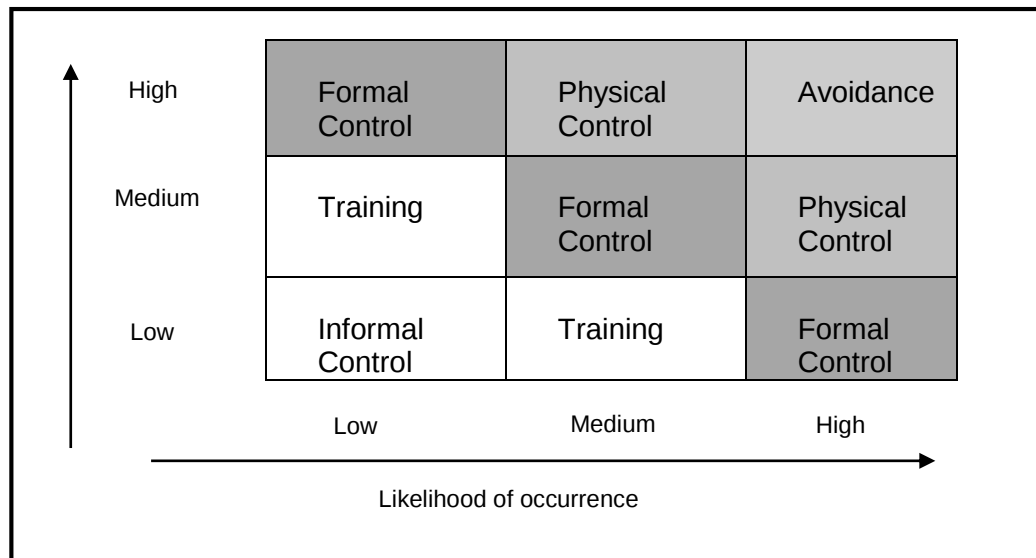


Figure 8-1 Matrix for determination of mitigation measures

The definitions of the various approaches to impact mitigation to be considered are presented below.

Enhancement: These are measures proffered to ensure that significant beneficial impacts of the existing facilities and proposed project are encouraged.

Prevention: These are measures proffered to ensure that significant and adverse potential impacts and risks do not occur.

Reduction: These are measures proffered to ensure that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practicable.

Formal control: This involves the application of documented policy, process or procedure in mitigating the impacts of the project activities.

Informal Control: This involves the application of sound judgment and best practice in mitigating the impacts of project activities.

Physical control: This involves the application of physical processes or instruments (pegs, flags, sign post etc), not necessarily requiring any special technology, in order to mitigate the impacts of a project or impacts.

Avoidance: This involves the modification of plans, designs or schedules in order to prevent the occurrence of an impact or impacts.

Training: This involves personnel awareness in specific / specialized areas.

Management Procedure for Mitigation Measures

The management procedures to be employed for the establishment of mitigation measures for the identified impacts are presented in Figure 8-2. Mitigation measures are subsequently proffered for adverse significant potential impacts. These measures (prevention, reduction, control strategies) shall be developed for the adverse impacts through review of industry experience (past project experience), consultations and expert discussions with multi-disciplinary team of engineers and scientists.

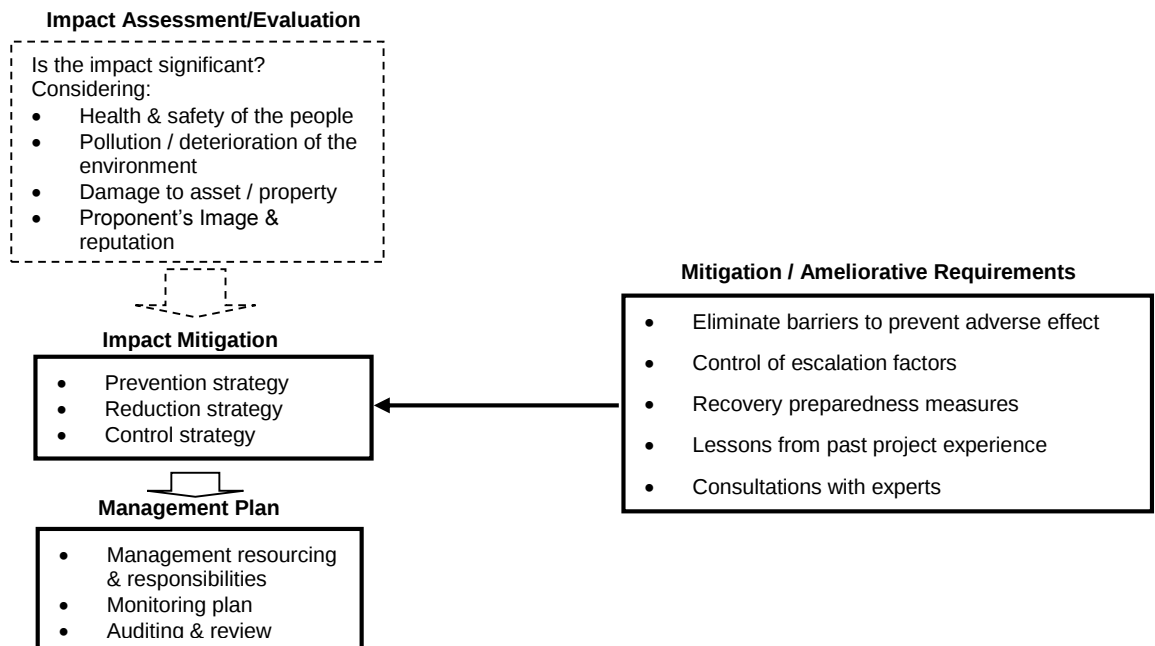


Figure 8-2 Management Procedure for Mitigation Measures

8.1 IMPACT ASSESSMENT RECOMMENDED MITIGATION MEASURES

This section of the report presents the mitigation (preventive, reduction and control) measures and alternatives considered to ensure that the associated and potential impacts of the proposed well drilling, completion and production testing, laying of flowlines, installation of FPSO and installation of well heads and umbilicals on the ecological and socio-economic environment are eliminated or reduced to as low as reasonably practicable (ALARP), thus preserving the ecological and social integrity of the existing environment. These cost effective measures have been proffered with reference to best industry practice and ESH considerations.

Based on the impact assessment matrix in the previous section, the overall ratings of impact significance High, Medium or Low were established for each identified impact. The proffered mitigation measures for the identified potential significant impacts are presented in paragraphs 8.1.1 - 0 below.

8.1.1 Mitigation of Impacts on the Biophysical Environment

Potential Impact	Key recommended mitigation measures
Emission of pollutants into atmosphere	- ensure generators, barges etc are maintained at optimal working condition in accordance with operating manual; - ensure application of emissions monitoring and control techniques; - encourage the use of mufflers on equipment manifold where necessary to filter particulates and thus reduce its emission into the air.
Generation of noise	- ensure all noise generating work equipment and vessels are maintained at optimal conditions as stated in the equipment operating manual - encourage the use of equipment with low noise ratings - encourage the use of mufflers on equipment manifold
Discharge of cooling water into the sea – Hot waste water	- discharge of cooling waters only in surface waters - limit to minimum necessary the amounts of anti-biofouling used in cooling waters
Discharge/availability of nutrients and organic matter	- ENI Ghana shall develop an appropriate Waste Management Plan before project commencement - As a minimum all operational waste shall be separated at source to enhance efficiency in waste handling and disposal - Also, training on waste management will be conducted for project site personnel
Damages to morphological structures and benthic biocenoses	- The pipeline laying technology is such that will reduce bottom sediments disturbance and possible loss of benthic organisms; - The procurement of a drilling rig with dynamic positioning and offline activity for drilling activities will reduce bottom sediments disturbance and possible loss of benthic organisms - ENI Ghana shall develop an appropriate Waste Management Plan before project commencement - Also, training on waste management will be conducted for project site personnel - ENI Ghana shall treat all effluents (spent mud, cement, cuttings, etc.) in accordance with regulatory requirements - The water-depth and density of organisms present in the area are such that render the impact negligible - Project will adhere to IMO Guidelines for the Control and Management of Ship's Ballast Water and Sediments (Ballast Water Management Convention). As a results all vessels involved in the Project, including the FPSO, will develop a Ballast Water Management Plan and carry a Ballast Water Record Book

Potential Impact	Key recommended mitigation measures
Mobilisation and resuspension of sediments	- The pipeline laying technology is such that will reduce bottom sediments disturbance and possible loss of benthic organisms; - The water-depth and density of organisms present in the area are such that render the impact negligible
Physical presence of structures and vessels	- ENI Ghana shall ensure that abandoned well head is properly capped - Post demobilization checks shall be carried out prior to commencement of development operations in the area to check incidence of well leaks - Ensure that pipeline is protected - Compliance with vessel speed and wake restrictions. - Support and small vessel movements in the vicinity (100 m) of cetaceans will be strictly forbidden unless absolutely necessary for personnel safety
Release of pollutants, biocides and metals in solution	- ENI Ghana shall develop an appropriate Waste Management Plan before project commencement; - ENI Ghana shall ensure adequate implementation of the Waste Management Plan; - Also, training on waste management will be conducted for project site personnel - Operators shall be trained on safe handling practice; - ENI Ghana will ensure proper handling of chemicals. - ENI Ghana shall employ chemicals with lowest toxicity levels in all its operations - Material safety data sheets (MSDS) shall be provided for chemicals on site - ENI Ghana shall treat and discharge all effluents (spent mud, cement, cuttings, etc.) in accordance with regulatory requirements

8.1.2 Mitigation of Impacts on the Socio-economic Environment

Potential Impact	Key recommended mitigation measures
Employment and procurement of goods and services	- Preferentially employ Ghana nationals to fill available positions in the OCTP Block project. Give preference to Ghana nationals with the appropriate skills. Formalise this policy in eni HR guidelines and contractors' agreements; - Train Ghana nationals currently employed by eni so that they can eventually assume positions/functions in the OCTP Block project initially or currently undertaken by employees of other nationalities; - Effectively communicate available employment opportunities, required skills and resources and training programmes to the local communities in the Soyo region.
Procurement of goods and services	- Preferentially procure goods and services from Ghana sources, where possible and subject to reasonable financial criteria; - Procure resources (such as food supplies) at a local level (Western region), if available. Formalise this policy in eni's procurement guidelines and contractors' agreements;
Disruption of fishing activities	- Develop, in consultation with the relevant coastal communities, a grievance mechanism through which fishermen can raise concerns with regard to activities and their grievances can be addressed; - Implement mechanisms to compensate individuals who can demonstrate loss of income due to project activities; and - Implement measures to mitigate the potential negative impacts on the biophysical environment, particularly impacts that could negatively impact on the resources targeted by fisheries operating in the area.

Potential Impact	Key recommended mitigation measures
Increase in marine traffic and disruption of offshore navigation	• Inform local fishermen from the coastal communities of coastal Western regions of the offshore activities, locations, vessel movements routes and timing; • Inform other users of the sea about the timing and location of offshore activities through the issuing of Notices to Mariners; • Comply with international safety standards with regards to offshore navigation on all project-related vessels; • Intercept and redirect any vessels potentially entering designated exclusion zones; • Ensure potential conflicts between project-related vessels and other users of the sea are addressed in emergency response planning.
Increase in Government revenues (contribution to national economy)	• Implement mitigation measures to maximise employment of Ghana nationals and procurement of Ghana goods and services; and • Encourage and lobby for the responsible investment by the government of oil-generated revenue, particularly in the Western region.
Perceptions and expectation of local communities	• Develop and implement, in consultation with local authorities, sectoral institutions and communities, Corporate Social Responsibility (CSR) initiatives that identify, evaluate and select a range of opportunities to address the key concerns of the local communities in line with existing sectoral policies and plans; • Effectively communicate available employment opportunities, required skills and resources and training programmes to the local communities in the Western region; and • Ensure on-going consultation with local communities with regard to progress with the project and changing community needs. • Acknowledge the authority of the local chiefs in all activities, particularly in eni's CSR initiatives; • Ensure a transparent and appropriate grievance mechanism is in place, whereby local communities communicate incidents with eni personnel and or contractors/suppliers visiting the communities; • Work with the local communities and government to identify local infrastructure needs, including housing, and support initiatives to improve such infrastructure.

8.1.3 Mitigation of Impacts on Health

Potential Impact	Key recommended mitigation measures
Community health and safety	<u>For local Communities:</u> • Develop and implement, in consultation with local communities and relevant local authorities and as part of Corporate Social Responsibility (CSR), the needed Community Health (CH) initiatives that identify, evaluate and select a range of opportunities to support or invest in increasing the capacity of local health care systems in the Western region through capacity building, infrastructure revamping, equipment top up and monitoring/evaluating activities; <u>Within the fence (in-house):</u> • Monitor the prevalence of communicable diseases among employees and contractors, and work with local health care providers if additional measures to deal with the possible increased risk of communicable diseases to local communities are required; • Ensure emergency response plans are in place to deal with all potential emergencies, including support vessel (and helicopter) and offshore facilities emergency plans; and • Prevent/Mitigate the potential impacts of pollution as a result of emissions, discharge of effluent and waste disposal. • ENI Ghana shall provide and enforce use of appropriate PPE by worksite personnel at all times.

9 ENVIRONMENTAL MANAGEMENT PLAN

This chapter presents the Environmental Management Plan (EMP) developed for the proposed project activities. An environmental management plan (EMP) is essentially a management tool and standalone component of an EIA that provides the assurance that the mitigation measures developed for the significant impacts of a proposed project are implemented and maintained throughout the project lifecycle. It outlines management strategies for safety, health and environment stewardship in the proposed project implementation. It states in specific terms how the project proponent's commitments will be implemented to ensure sound environmental practice.

9.1 EMP APPROACH

ENI Ghana has designed the EMP of the proposed project in line with its Health, Safety and Environment (HSE) policy and in accordance with ISO 14001 Environmental Management System specifications. The EMP for the proposed drilling project, installation of flowlines, installation of FPSO and installation of well-heads and SURF systems shall be a "live document" which shall be reviewed periodically with the incorporation of various mitigation measures for potential impacts and shall form the basis for the actual project implementation.

Compliance with the legal standards on safety and environment is regarded as the minimum requirement, and must be satisfied during all phases of the Project development. In order to reduce the risk of an adverse effect on the environment to the lowest level that is reasonably practicable, an objective of the engineering design will be to apply the ALARP principle. Figure 9-1 illustrates this principle graphically.

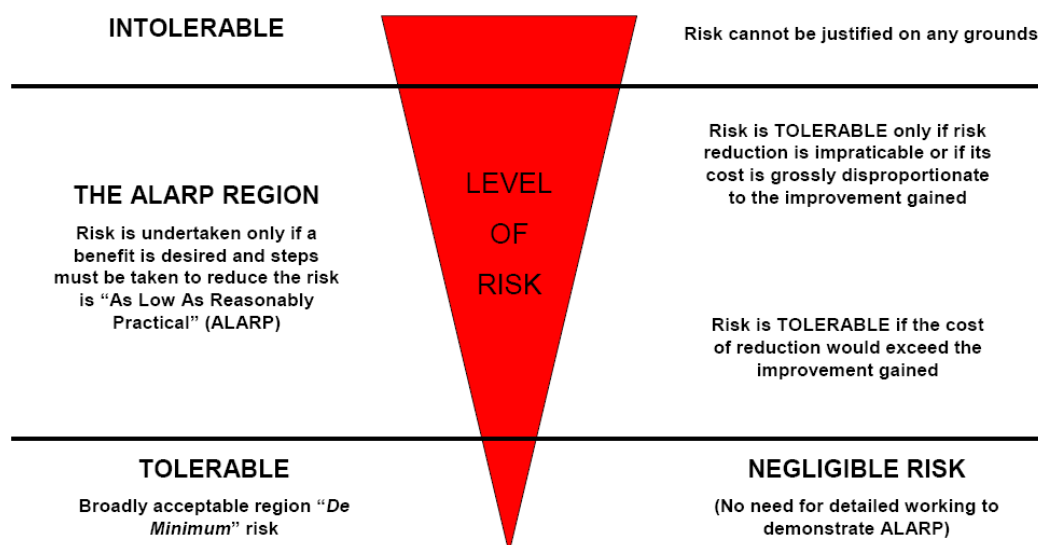


Figure 9-1 Level of Risk and ALARP

9.2 EMP OBJECTIVES

The EMP is designed to:

- ensure that all mitigation measures prescribed in the ESHIA document for eliminating, minimizing, and enhancing the projects adverse and beneficial impacts are fully implemented; and
- provide part of the basis and standards needed for overall planning, monitoring, auditing and review of environmental and socio-economic performance throughout the project activities.

This has been developed to manage negative impacts/effects, enhance benefits and ensure good standards of practice are used throughout the project. These objectives shall be achieved by:

- ensuring compliance with all stipulated legislation on protection of the biophysical and socio-economic environment and ENI HSE policy;
- integrating environmental and socio-economic issues fully into the project development and operational philosophies;
- promoting awareness on the management of the biophysical and socio-economic environment among workers;
- rationalizing and streamlining existing environmental activities to add value to efficiency and effectiveness;
- ensuring that only environmentally and socially sound procedures are employed during the project implementation; and
- continuous consultations with the relevant regulatory bodies, community leaders (local heads/chiefs, clan heads, landlords, etc), youth leaders, community based organizations (CBOs), and other stakeholders throughout the project lifecycle.

9.3 STRUCTURE AND RESPONSIBILITY

The implementation of the project EMP will be achieved through a management structure described in the Organizational chart shown in Figure 9-2.

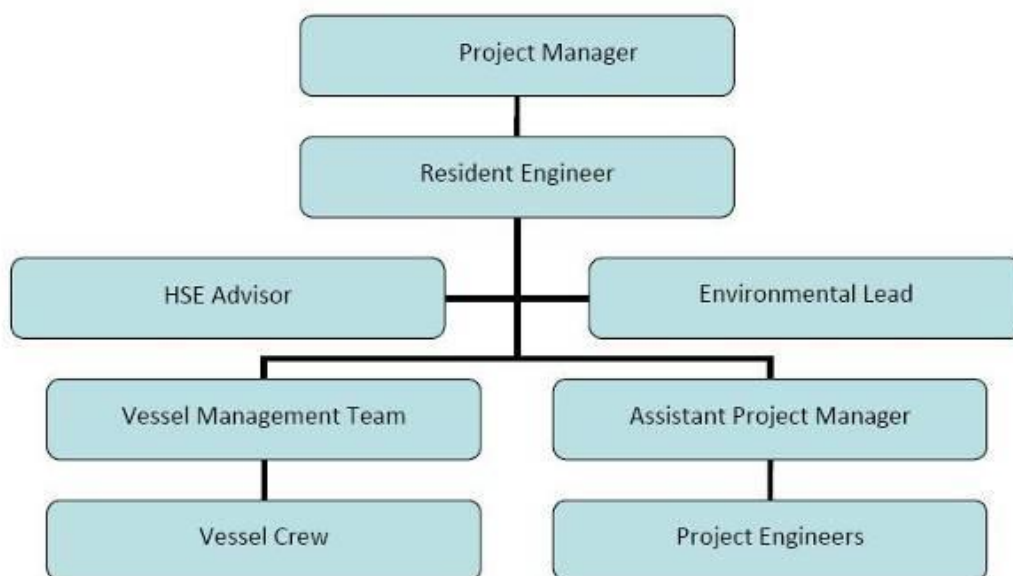


Figure 9-2 Environmental Management Schematic of OCTP Block Development Project

9.4 EMP IMPLEMENTATION FRAMEWORK

The framework for the implementation of this EMP is strongly based on a repeated process of continuous improvement which comprises of eleven (11) elements, each with underlying principle and set expectations.

Overview of each of the eleven primary elements is presented as follows.

- Management Leadership, Commitment, and Accountability: Ensures that the workers understand the goals and management commitment to excellence in safety, health, environment, and operational integrity.
- Risk Assessment and Management: Ensures that risks involved in operations are recognized so that they can be appropriately addressed through facility design and/or operating practices.

- Facilities Design and Construction: Ensures elements for the protection of people and the environment are incorporated into the design of facilities and the plans for installation and operation.
- Process and Facilities Information/Documentation: Ensures that the systems designed to protect people and the environments are appropriately documented.
- Personnel and Training: Ensures that personnel understand the systems that are in place and are appropriately trained to perform required roles with respect to their functions.
- Operations and Maintenance: Ensures that facilities are maintained and operated in ways that ensure the protection of people and the environment.
- Management of Change: Ensures that new personnel are informed of existing systems that all affected personnel are informed of changes in the systems, and that safety and environmental aspects are considered when making changes.
- Third Party Services: Through contract, oversight and other mechanisms, third party contractors are held to the same standards as ENI Ghana.
- Incident Investigation and Analysis: Seeks to understand the causes of any incidents so that effective controls or systems can be implemented to prevent recurrence.
- Community Awareness and Emergency Preparedness: Though not highly applicable in offshore project far removed from communities, ensures appropriate outreach and awareness programmes are implemented to establish effective emergency procedures and to allay concerns.
- Operations Integrity Assessment and Improvement: Ensures that the safety and environmental performance is monitored against targets to ensure eni Ghana is meeting its goals to protect people and the environment and seeks the means to improve the systems and processes, particularly when goals are not being met.

9.5 CORE ELEMENTS OF EMP

In line with the objectives summarized in sections 9.1 and 9.2 above, the main elements of this EMP are:

- overall project organizational chart (including HSE) organogram;
- preliminary EMP guidelines;
- guidelines for waste management;
- overall safety philosophy/guidelines;
- contingency plan for oil spills;
- environmental monitoring plan;
- guidelines for audit and review;
- guidelines on maintenance and facility management; and
- guidelines for decommissioning and abandonment.

9.6 GUIDELINES FOR MITIGATION MEASURES

The guidelines covering the various project phases, activities/aspects and impacts, mitigation measures and designation of responsibilities for implementation, were presented in chapter five and give detailed information on waste management, safety, emergency response/contingency. A detailed environmental monitoring plan, audit and review as well as decommissioning and abandonment are presented in Annex G.

10 DECOMMISSIONING

ENI Ghana shall ensure that all assets (including wells, production facilities, flowlines/risers, pipelines etc.), which have reached the end of their useful life span, shall be decommissioned and either dismantled and removed or abandoned, in accordance with statutory requirements and standards. This will entail the following scope of work.

ENI shall develop a sound and acceptable plan, which will describe how all assets are to be decommissioned and their planned state after abandonment. The plan will consider all technically feasible options for decommissioning and abandonment, including alternative uses for the assets, in accordance with ENI policy and government regulations.

Well suspension or abandonment operations will be carried out in accordance with the regulatory guidelines and best Industry practice. Once drilling activity has been completed, the well will either be producing or suspended and may be later abandoned, depending on production. During abandonment, an abandonment programme will ensure the isolation of the various zones from each other and from the surface in accord with the regulatory guidelines. Casing and wellhead equipment will be recovered from the well and the well will be capped at least 3 meters below seabed.

Following equipment recovery, a recorded site survey will be carried out using an ROV around the previous wellhead position and a hundred meter radius around the position as debris and dropped object survey. In the event the well is suspended for future entry for any purpose, down hole formations will be isolated from each other and from the surface using cement and mechanical plugs as required. Once the BOP and riser assembly has been removed, corrosion cap will be installed on the subsea wellhead.

A recorded site survey will be carried out using the ROV as debris and dropped object survey will be completed over a 50 meter radius around the wellhead locations.

Abandonment Report

ENI shall also prepare final report on condition of all assets abandoned prior to relinquishment. The Abandonment Report will include as a minimum:

- Operating and Technical Data (data on the asset thorough its operating life; e.g., location, repairs, etc.);
- Financial Data on the Abandoned Asset; and
- Final Abandoned Condition.

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SUMMARY AND CONCLUSIONS

The ESHIA of the proposed drilling, Installation/ Operation of FPSO and Mooring System. Installation and Operation of Well Heads and SURF system in OCTP Block, has been a combination of data obtained from literature review and existing EIA reports as well as execution of field studies. The overall goal of the ESHIA is to ensure that potential impacts of the proposed project are identified, evaluated and adequate mitigation measures are proffered for significant impacts, while the positive impacts are enhanced. This will consequently provide necessary data/evidence that will ensure the issuance of an environmental impact statement (EIS) for the proposed project.

The proposed project may significantly impact the national economy as well as the overall well-being of the people. It should also increase Ghana's total hydrocarbon reserve, production capacity and ultimately enhance the country's present image and position in OPEC. It would also result in the provision of direct and indirect employment opportunities as well as increased derivation funds to local and state governments and other government agencies/commissions.

The adverse impacts of the project would be in the form of injury/loss of life from operational accidents/incidents, chronic/acute health condition for onsite personnel due to exposure to hazardous chemicals and harsh weather, degradation of air quality from emissions from topsides, degradation of seawater column quality and loss of biodiversity resulting from disturbance of the seabed, oil spills/leaks, and wastes/effluents disposal. These adverse impacts can be prevented, reduced or controlled following implementation of the recommended mitigation measures.

Consequently, an EMP has been developed to ensure effective implementation of prescribed mitigation measures and for proactive environmental management throughout the project's life span. The EMP shall be implemented within the framework of ENI's Environmental Management System (EMS).

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ANNEX 1 COPY OF SCOPING APPROVAL LETTER

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Our Ref.: 2178/02/34



Environmental Protection Agency

P. O. Box MB 326
Ministries Post Office
Accra, Ghana

February 10, 2014

**The Managing Director
ENI Ghana Exploration and Production Limited
1st Floor, UNA House
No.12 Airport Bypass Road
PMB KA 185
Airport City – Accra**

Attn: Juan Deffis

Dear Sir,

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)
PROPOSED GHANA OFFSHORE CAPE THREE POINT (OCTP) BLOCK PHASE 1
FIELD DEVELOPMENT PROJECT

We refer to your the Scoping Report on the above proposal submitted to the Agency, in accordance with the Environmental Assessment Regulations, 1999 (LI 1652).

The report has been duly reviewed and attached are areas/issues identified for consideration and inclusion in the EIA Terms of Reference (ToR).

You are advised to proceed with the Environmental Impact Assessment (EIA) for the proposed Ghana Offshore Cape Three Point (OCTP) Block Phase 1 Field Development Project and submit twelve (12) copies of the draft Environmental Impact Statement (EIS) including a softcopy in line with Environmental Assessment Regulations, 1999 (LI 1652).

Do not hesitate to consult with the Agency for further guidance necessary to facilitate a satisfactory EIA study.

Yours faithfully,



**Kojo Agbenor - Efunam
Deputy Director/Petroleum Dept.
for: Executive Director**

ANNEX 2 EVIDENCE OF RESPONSE TO GHANA EPA SCOPING REPORT REVIEW COMMENTS

The table below contains a summary presentation which highlights how eni Ghana has given response to Ghana EPA review comments dated 10th February 2014 to the Scoping Report for the proposed Ghana OCTP Block Phase 1 Field Development Project.

Response to EPA review comments on the Scoping Report for the proposed Ghana Offshore Cape Three Point (OCTP) Block Phase 1 Field Development Project		
Item	EPA Review Comment	Evidence of Responses Provided
Consultations	Extensive consultations have been done. However the report does not show how the concerns raised were assessed and used in identifying the key issues of concern. This is the essence of scoping	Stakeholder Engagement (Attachment A to draft E(SH)IA Report) duly updated; an issues Matrix has been elaborated.
	Consider Ghana Gas as one of your major stakeholders and bring any issue they have on board.	Stakeholder Engagement (Attachment A to draft E(SH)IA Report) duly updated; eni BID (Background Informaitn Document) was sent to Ghana Gas for their examination and provision of feedback.
Legal Requirements and Policy Framework	Environmental Assessment Regulations L.I. 1652 of 1999 has not been amended.	Revised (cfr. par. 3.1.3 of draft E(SH)IA Report)
	Local content is now a law, check it out (L.I. 2204)	Revised and updated (cfr. par. 3.1.12 of draft E(SH)IA Report)
	It is not true that Ghana is not party to the OPRC Convention (page 30). Please do check the IMO status again.	Revised (cfr. par. 3.2.2 of draft E(SH)IA Report)
Baseline	Baseline: page 38. Update information on corals. Ghana has a live coral reef in the western part of the country. The Fridtjoff Nansen cruise in 2009 and 2012 revealed this.	The Fridtjoff Nansen baseline information present through the EPA website has been consulted and referenced in the draft E(SH)IA Report (see par. 4.9.2).
	Page 80: Primary data: The report talked about a survey. When is the survey going to be carried? Have you considered the Fridtjoff Nansen baseline report to find out whether the data generated would not be adequate for what the intended survey would do so as to avoid duplication of effort?	Details of survey and dates involved are included in the draft E(SH)IA Report, par. 4.1, pg. 126

Impact Assessment	The conduct of Fisheries Impact Assessment was raised by the Fisheries Commission as a legal requirement and it is important that ENI responds to this and takes it on board. This is essential given concerns about the beaching of whales in recent years.	Has been developed as a separate stand-alone report. FIA report structure was agreed upon during discussions held with the Fisheries Commission in February 2014.
	The effects of having two FPSOs possibly in close proximity should be considered. This is likely to create conditions for the public particularly fishermen to complain. It is essential we have enough information through the assessment to enable us respond adequately.	Distance from other exploration field in the area is such as not to have to consider the cumulative impact; shall be specified in the FIA report.
	The environmental matrix on page 63 is not clear. Why should noise be a potential impact and at same time be an environmental component?	The environment matrix has been modified; Noise is cited only as an impact on other environmental components (see Par. 7.2, tables 7.5 – 7.10, pgs. 313-318).
	Onshore impacts was not given due attention in the scoping. There are issues related to offshore waste coming onshore and an increase in supply base support activities since we would have 2 producing fields. Some indication of impacts would be useful.	Waste treatment and disposal by waste type have been described for each project phase in both Chapter 2 (Project Description) and Chapter 7 (Impacts). Furthermore, the eni Ghana Waste Management Plan has been elaborated and included as Attachment E to the draft E(SH)IA Report. Important to note that waste treatment occurs offshore.
EMP	There are currently no drilling cuttings management facilities onshore Ghana. Your proposal to bring cuttings ashore for treatment must be looked at critically. You'll have to convince the Agency that you set up or has a facility that can treat all the cuttings onshore to the Agency's satisfaction before permit can be given for such a proposal. The management of drill cuttings and mud must be given due attention in your EIA.	Drill cuttings shall be treated and discharged offshore, in accordance with local regulation requirements (see par. 2.7.11) Local regulation permits the discharge into the sea of drilled cuttings contaminated by synthetic/pseudo oil based mud system with a residual oil on cuttings content less than 3% of dry matter if discharged beyond 500 m water depth ("Ghana EPA Guidelines for Environmental Assessment and Management in the Offshore Oil and Gas Development" article 12 and section 7).

ANNEX 3 LIST OF ATTACHMENTS TO GHANA OCTP BLOCK PHASE 1 E(SH)IA REPORT

ATTACHMENT A: STAKEHOLDER ENGAGEMENT REPORT

ATTACHMENT B: BASELINE RESULTS

ATTACHMENT C: FISHERIES IMPACT ASSESSMENT (stand alone document to be delivered directly to the Ghana Fisheries Commission)

ATTACHMENT D: OIL SPILL CONTINGENCY REPORT

ATTACHMENT E: WASTE MANAGEMENT PLAN