STATE OF THE MARINE ENVIRONMENT REPORT FOR AHANTA WEST, ELLEMBELLE, JOMORO AND NZEMA EAST DISTRICTS IN THE WESTERN REGION OF GHANA

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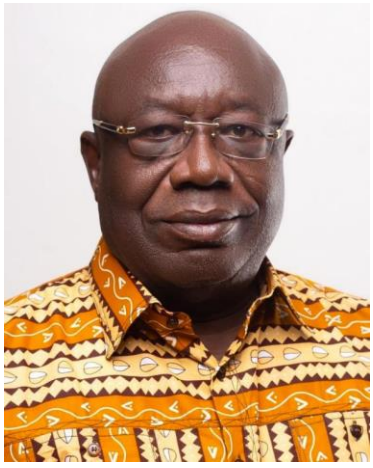
Disclaimer

In the preparation of this document, every effort was made to ensure the accuracy of the information gathered from a broad variety of data sources. However, the EPA cannot accept any responsibility of any misinterpretation resulting from information contained in this report/document.

Foreword



The marine and coastal environment are essential for life on earth and they perform a number of essential environmental functions including maintaining biological control, climate regulation, carbon dioxide absorption and erosion prevention. In addition, livelihoods of communities within the coastal zone and even beyond depend on the coastal and marine resources.

Efforts have been made by various actors to address the threats faced by the marine and coastal environment in the Western Region of Ghana. The diverse resources, human population increase and economic growth in the Western Region have resulted in considerable pressure on the marine and coastal environment leading to the degradation of a unique but vital ecosystems.

This report is based on the available primary and secondary information from relevant stakeholders involved in the management of Ghana's marine and coastal environment, in addition, traditional knowledge and expert elicitation was also employed and provides an overview of the current state of the marine and coastal environment in Ahanta West, Ellembelle, Jomoro and Nzema East Districts of the Western Region of Ghana.

The pressures identified and recommendations made would serve as a guide to inform decision and policy makers for current and future development planning while promoting protection/conservation of the marine and coastal environment for - present and future generations.

The Environmental Protection Agency and its stakeholders are delighted to present the state of the marine environment report for Ahanta West, Ellembelle, Jomoro and Nzema East Districts in the Western Region of Ghana and hopes that the findings and recommendations would support national and regional efforts in promoting the sustainable development of marine and coastal resources.

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List of Abbreviations and Acronyms

AGDP	-	Agriculture Gross Domestic Product
Bcf	-	Billion cubic feet
CBOs	-	Community Based Organisations
CBFMC		Community Based Fisheries Management Committee
CRC	-	Coastal Resources Center
CSIR	-	Council for Scientific and Industrial Research
DPSIR	-	Drivers, Pressures, States, Impacts and Response
DWTCTP		Deepwater Tano Cape Three Points
E & P	-	Exploration and Production
EAF	-	East Atlantic Flyway
ECOWAS	-	Economic Community of West African States
EE	-	Expert Elicitation
EEZ	-	Exclusive Economic Zone
EIA	-	Environmental Impact Assessment
EPA	-	Environmental Protection Agency
FAO	-	Food and Agriculture Organization of the United Nations
FON		Friends of the Nation
FPSO		Floating, Production, Storage and Offloading
GCLME	-	Guinea Current Large Marine Ecosystem
GDP	-	Gross Domestic Product
GSS	-	Ghana Statistical Services
HABs	-	Harmful Algal Blooms

ITLOS	-	International Tribunal for the Law of the Sea
IUCN	-	International Union for the Conservation of Nature
IUU		Illegal, Unregulated and Unreported
LI	-	Legislative Instrument
lIED	-	International Institute for Environment and Development
MESTI	-	Ministry of Environment, Science, Technology and Innovation
MMbo	-	Million barrels of oil
Mmscf	-	Million standard cubic feet
MoFAD	-	Ministry of Fisheries and Aquaculture Development
NGOs	-	Non-Governmental Organisations
NOAA	-	National Oceanic and Atmospheric Administration
NT	-	Near Threatened
OCTP	-	Offshore Cape Three Points
ORF	-	Onshore Receiving Facility
PA	-	Petroleum Agreement
PHC	-	Population and Housing Census
PP	-	Partly Protected
SLA	-	Sea Level Anomaly
SoME	-	State of Marine Environment
SST	-	Sea Surface Temperature
SSW	-	South-SouthWest
TEN	-	Tweneboah Enyenra Ntomme
UNEP	-	United Nations Environment Programme

UNESCO - United Nations Educational, Scientific and Cultural Organization

USEPA - United States Environmental Protection Agency

WCR - Wildlife Conservation Regulation

WRI - Water Research Institute

Executive Summary

The coastal area (land and seascapes) is home to a diverse array of marine and coastal species and contributes significantly to the country's economy. Coastal lands make up nearly 7% of the national land area. However, it is home to about 25% of the approximately 30 million population of Ghana. The high coastal population has increased demands and pressures on the limited coastal resources. This State of the Marine Environment Report provides an understanding of the state of of four districts (Ahanta West, Ellembelle, Nzema East and Jomoro) in the Western Region. It also details how the status of marine and coastal resources have been and are being impacted by the range of natural and human pressures. The Drivers, Pressures, State, Impacts and Responses (DPSIR) framework, Expert Elicitation (EE) and Traditional/Local Knowledge approaches were used to generate information for this assessment.

Three species of mangroves (red-dominant, white and black-least dominant) found in the study area are on the decline due to over-harvesting and habitat conversions. Five species of turtles have been identified in the area, three (Leatherback, Green and Olive Ridley) currently nest on the sandy beaches. The dominant fishery resources include sardinellas, anchovies, mackerels (marine) and tilapia (fresh/brackish water) species.

The assessment revealed environmental pressures to include fisheries activities, offshore hydrocarbon exploitation, plantation development, and sand winning, sea defence infrastructure, shipping, submarine cables and pipeline installations, tourism/recreation, and waste generation and disposal (marine debris and plastics). These human activities have impacted negatively on the habitat conditions, thus reducing their ability to continually provide quality ecosystem benefits. The overall status of habitats was rated during an Expert Elicitation workshop to be in good conditions. However, environmental quality was on the decline.

On fisheries, the impact has been noted to be high due to over-fishing, excessive fishing capacity, illegal, unregulated unreported (IUU) fishing and use of unapproved fishing methods. These have significantly impacted on the socio-economic well-being of persons who depend on the fisheries for their livelihoods. Waste generation and disposal, especially plastics, during an Expert Elicitation workshop are moderately impacting on the marine and coastal environment. Offshore hydrocarbon exploitation was noted to be still at its initial state, however, the environmental pressures of the industry on the marine and the coastal environment was on the ascendancy and therefore gives a cause for concern. On the average, the environmental pressure from submarine cables and pipelines installations, sea defence infrastructure, plantation development is low within the study area.

In order to address these challenges, the study recommends the need to promote effective collaboration among regulators, researchers, industry players and coastal communities, including Traditional Authorities, to manage the exploitation of the resources. In addition, continual monitoring and research application should be promoted. Sustainable financing is also highly recommended to ensure continuous conservation education, enforcement of requisite laws and regulations by the relevant institutions. Collaborative management (co-management) of the fisheries is recommended to strengthen the resource management capacity of fishermen.

This document is divided into 9 key sections namely: Introduction, Marine and Coastal Ecosystems, Productivity, Physico-Chemical and Ecological Processes, Introduced Species and Algal Blooms, Pressures and Risks to the Marine and Coastal Environment, Conclusion and Recommendations

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1.0 INTRODUCTION

1.1 General overview

Ghana has a coastline of about 550 km with an Exclusive Economic Zone (EEZ) of over 218,000 km^2 and a continental shelf of about 23,700 km^2 (Koranteng, 1984). The country's territorial waters extend 12 nautical miles while the EEZ extends 200 nautical miles; both from the low watermark. There are four administrative coastal regions; Central, Greater Accra, Western, and Volta. The coastal environment includes important ecosystems such as mangrove forests, lagoons and estuaries, and rocky and sandy beaches which are rich in biodiversity.

The coastal area of Ghana makes up nearly 7% of the national land area and is occupied by approximately 25% of the 30.8 million population (GSS, 2021). This high coastal population has increased demands and pressures on the limited resources. Among the pressures are overfishing, poor sanitation and wetland degradation.

Several physical infrastructures are situated within the coastal environment to support socio-economic activities. These include port facilities, canoe landing beaches for artisanal fishers, offshore and inshore gas pipelines, single-point mooring facilities, and submarine telecommunication cables. The offshore areas of the Western Region have become the hub for oil and gas activities.

Ghana is endowed with significant and valuable fish stocks. Fishing is carried within the EEZ with an Inshore Exclusion Zone (IEZ) of 6 NM or 30 m depth reserved for artisanal fishing. In socio-

economic terms, the fisheries sector is one of the most important sectors in Ghana, accounting for 1.0 % of Ghana's GDP for the period 2017-2020. Thus, contributing on average GHS 3.04 billion to the economy. The fisheries sector also provides direct and indirect employment and livelihood to about 10% of the population (MoFAD 2021). Fish contributes about 60% of the animal protein requirements of the country. Over the last decade, Ghana's per capita fish consumption was reported between 20 and 25 kg (MoFAD 2021).

Data from the Takoradi Port indicates a steady increase in maritime traffic between 2008 and 2020, with vessel calls increasing from 615 in 2008 to 1,046 vessels in 2020 (Ghana Ports and Harbours Authority, 2020). This increase in vessel calls may be attributed to the emerging oil and gas activities in the Western Region. Several companies have been licensed to carry out offshore bunkering.

Increased maritime activities and its interest has brought about conflicts in the use of marine space. The expansion of the offshore petroleum sector has resulted in frequent complaints about incursions by fishermen into oil production exclusion zone. Conversely, these economic activities in the maritime sector have also adversely impacted marine species such as marine mammals and turtles.

This report presents the State of the Marine Environment (SoME) with focus on the Western Region of Ghana. It covers four (4) out of the six (6) coastal districts of the region namely: Ahanta West Municipality, Ellembelle District, Jomoro Municipality, and Nzema East Municipality (Figure 1). These four districts have highly sensitive, diverse, and productive marine and coastal

ecosystems. They are also locations of intensive agriculture, fisheries, oil exploration and production, coastal tourism, industries and mining of minerals. The four districts have seen rapid development and population growth in the last decade resulting in an excessive burden on natural resources and environmental pollution. The accelerated development and emerging uncoordinated and intense use of the coastal and the marine zone calls for effective planning and sustainable use of the resources in this sensitive environment. As a contracting party of the Abidjan Convention, Ghana has undertaken to pilot a study on marine spatial planning in the selected four coastal districts of the Western Region to improve ocean governance.

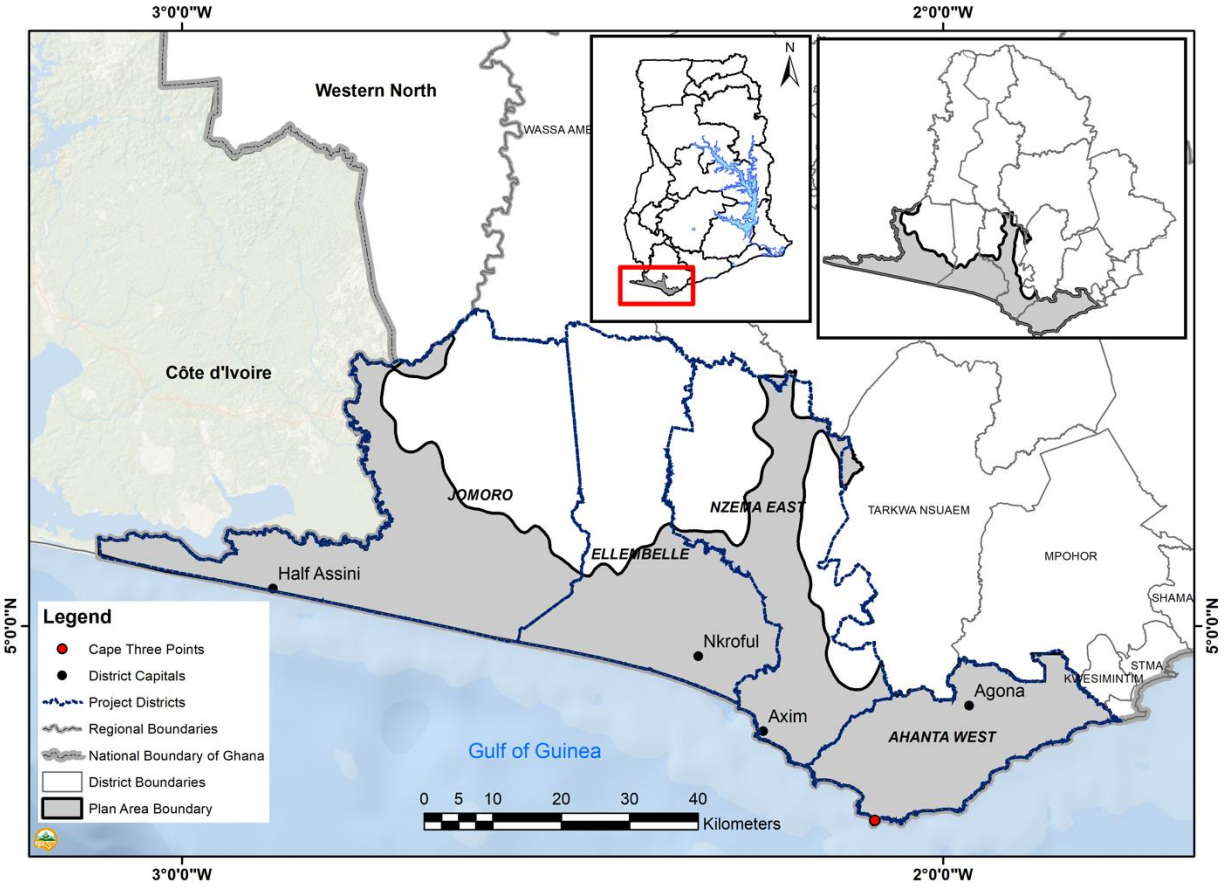


Figure 1: Map of study area

1.2 Physical features of Western Region

The Western Region is bordered on the east by the Central Region, the west by the Republic of Cote d'Ivoire, the north by Western North Region, and the south by the Gulf of Guinea. The Region falls within the equatorial climatic zone with temperatures ranging from 22°C to 34°C. The area experiences two rainy seasons from May to July and September to October with average precipitation of 1,600 mm per annum. The study area also experiences intermittent minor precipitations all year round. Relative humidity ranges from 70% to 90% and is the wettest zone in Ghana (WRSDF, 2011).

1.3 Demography

The population of the Western Region was estimated to be 1,664,586 and 2,060,585 in 2010 and 2021 respectively. The indigenes of the Western Region of Ghana are predominantly Akans (GSS, 2021). Population by district, for Ahanta West, Ellembelle, Jomoro, and Nzema East, for the years 2010 and 2021 are present in Table 1.

Table 1: Population by district and sex in the study area

	2010			2021		
District	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Ahanta West	50,999	55,216	106,215	75,219	77,921	153,140
Ellembelle	42,317	45,184	87,501	60,586	60,307	120,893
Jomoro	73,561	76,546	150,107	62,649	63,927	126,576
Nzema East	29,947	30,881	60,828	48,590	46,031	94,621

Source: GSS, 2010 and 2021

1.4 Methodology

This report is the product of a desktop compilation of reports and studies, workshops, stakeholder engagements, and field assessments' outcomes. In addition, Expert Elicitation (EE) was used to augment or fill information gaps. The Drivers, Pressures, States, Impacts, and Response (DPSIR) framework was adopted to analyse the relationship between the marine and coastal environment and the pressures of various anthropogenic activities within the study area.

There is the need to involve all relevant stakeholders during the assessment of the status or state of a resource so as to create a sense of belonging or ownership and provide backing required for long-term sustainability of the process.

1.4.1 Approach of Engagement

For carrying out this assessment, letters were written to key institutions involved in the management and regulation of marine and coastal resources to nominate officers to sit on the working group leading to the production of the state of marine environment report for 4 coastal districts in the Western region of Ghana. Nominated officers at the Inception workshop held in January 2019 conducted stakeholder analysis, identified and mapped stakeholders into primary and secondary stakeholders. In addition, the type and sources of data and information were identified. After which, official letters were written to the identified institutions/ organizations to provide the required data or information.

Generally, the three types of engagements i.e., consultation, informing and participation were used to interact with various stakeholders. As much as possible, efforts were made to use the local language during interactions and in cases that English language was utilized, translation was provided. The first stakeholder engagement which was Community entry was undertaken to the pilot project area from 15 – 18th April, 2019. The specific objectives of the stakeholder engagement were as follows**:** To introduce the project to the key stakeholders within the Ahanta West Municipality, Nzema East Municipality, Ellembelle District, and Jomoro Municipality in the Western region and to solicit for information/data and support ("buy-in") towards the achievement of the objectives. Concerns/issues raised by the various stakeholders served as guidance during the DPSIR assessment and the production of the draft report.

Finally, after the preparation of draft reports, a validation workshop was held to present major findings to stakeholders and also to verify whether all their concerns have been addressed in the state of marine environment report. Summaries of concerns identified by stakeholders are presented in Appendix I.

2.0 Marine and Coastal Ecosystems of the Western Region

The Ghana coastline is morphologically divided into three (3) sections: West, Central, and East Coasts. The West Coast extends 95 km from Ghana's border with Côte d'Ivoire to the estuary of the Ankobra River. The Central Coast covers 321 km, stretching from Ankobra River estuary near Axim in the Western Region to Prampram in the Greater Accra Region. The East Coast of 149 km of shoreline covers Prampram in the Greater Accra Region to the border with Togo (Ly, 1980). The study area falls within the west coast.

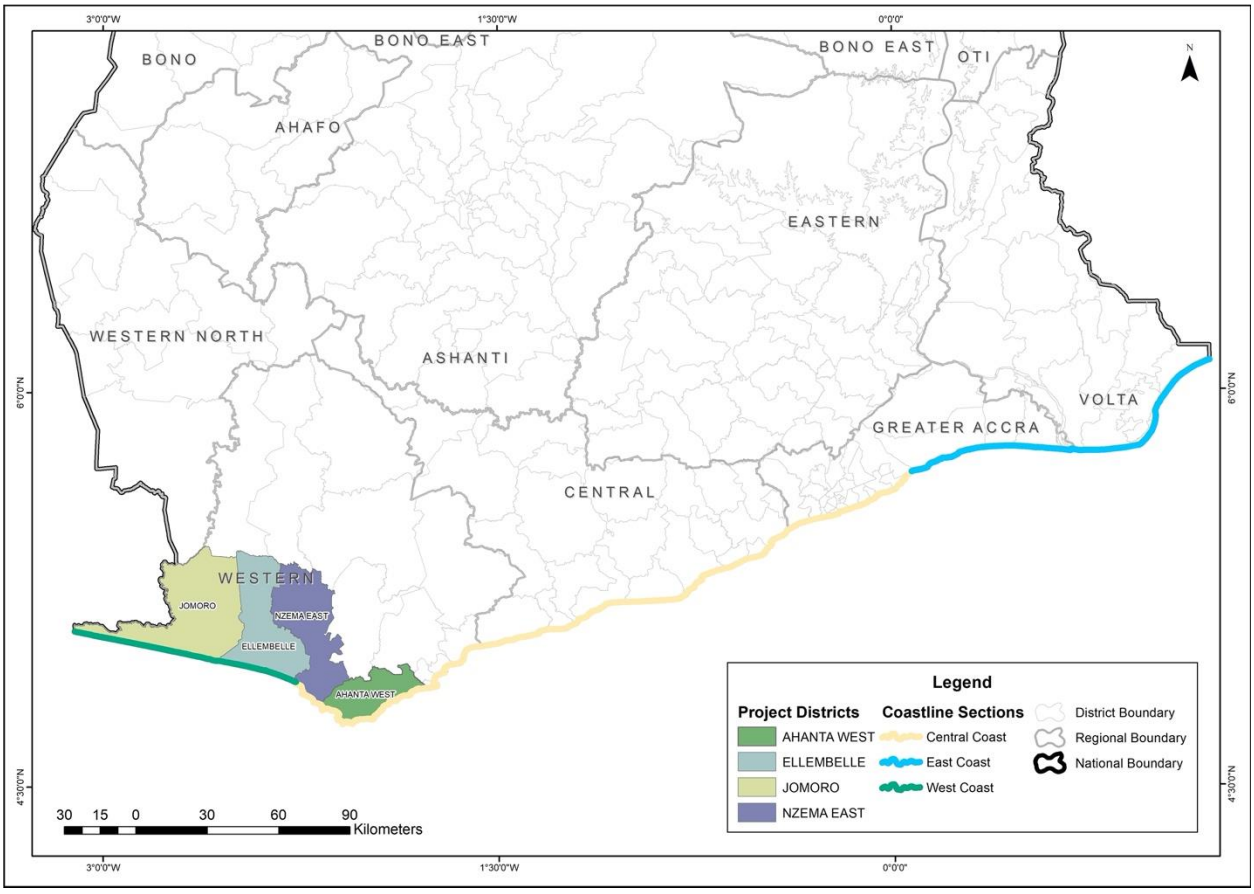


Figure 2: Map of Ghana's coastline showing divisions based on morphology

2.1 Characteristics of the Coastal Zone (Ahanta West to Jomoro)

The coastal area within the study area is largely rural in setting and influenced by traditional cultures and livelihoods. The coast is generally characterized by gentle slopes to flat sandy beaches patched with dune systems with elevations in most areas below 10 metres above mean sea level. There are isolated rocky outcrops or hills that protrude between sandy beaches or sometimes extending into the sea, forming rocky sea beds. There are capes and bays, most notably the Cape Three Points which is the southernmost tip of Ghana.

The coastline is linked to rivers, estuaries, lagoons, and ecologically significant wetlands that are habitats for diverse flora and fauna. The most notable is the Amanzule wetlands complex, which hosts the Nzulezu stilt village, a primary tourist attraction. Studies over the years have shown that the offshore coastal areas serve as resting and breeding sites for fishes and calving areas for cetaceans (Krzelj, 1972; Binet 1982, 1988; Brainerd, 1991; Binet and Marchal, 1993; Marchal and Picaut, 1978; Mehl et al., 2002; Aziable et. al., 2008; Toresen et al., 2016; Castro et al., 2017; and Staby et al., 2017). This area has been identified by the Ministry of Fisheries and Aquaculture Development for the creation of Marine Protected Area to protect fisheries and improve food security. The coastal area is dotted with hospitality facilities, dense human settlements with fish landing and processing areas. The coast has relics of many forts, including one of the oldest and most prominent Fort Sebastian.

Due to rising sea levels, most barrier beaches in Ghana are eroding at an estimated rate of 1m per year (CRC, 2013). Increased erosion, and sand winning at some beaches potentially contribute to land loss and the inland movement of the shoreline. Coastal communities in the study area are

highly vulnerable to flooding and erosion as these communities are mostly hemmed between the wetlands and the Atlantic Ocean. For example, the community of Sanwoma experiences semi-diurnal flooding daily due to tidal fluctuations and low topography.

In almost all the coastal communities, there are traces of coastal erosion. Besides the hazards posed to human activities, sea erosion has destroyed several hectares of coconut plantations. Most stakeholders in the coastal communities accept the fact that sand winning contributes immensely to coastal erosion, however, their perception is that small-scale sand winning for household use such as building and rehabilitation do not significantly add to the problem. The Hydrological Services Department of the Ministry of Works and Housing manages shoreline erosion using, boulders, gabions, groynes and revetments.

2.2 The Continental Shelf

The continental shelf of Ghana is generally narrow, extending outward between 20 and 35 km, except portions between Cape Coast and Takoradi, where it reaches up to 90 km (Armah & Amlalo, 1998). The continental shelf has distinct areas of mud, hard rocks and mixed deposits (Rijavec, 1980). It is traversed midway by an extensive strip of dead madreporite reef occurring at 70m depth and extends to the eastern borders of the country at the edge of the continental slope.

Three main functional zones of the shelf are recognized; the upper shelf which extends up to 40 m depth, a mid-shelf extending up to 100 m and the outer-shelf which is beyond 100 m and extending up to about 180 m depth at the edge of the continental slope (Koranteng, 2002). These zones are associated with some identified fish assemblages (Koranteng, 2002). The shelf is predominantly

soft bottom except the south and west of Cape Three Points where a mix of soft and hard bottom occurs. Both the bathymetry and sediment types affect fish assemblages and modified by the dynamics of the thermocline (Figure 3).

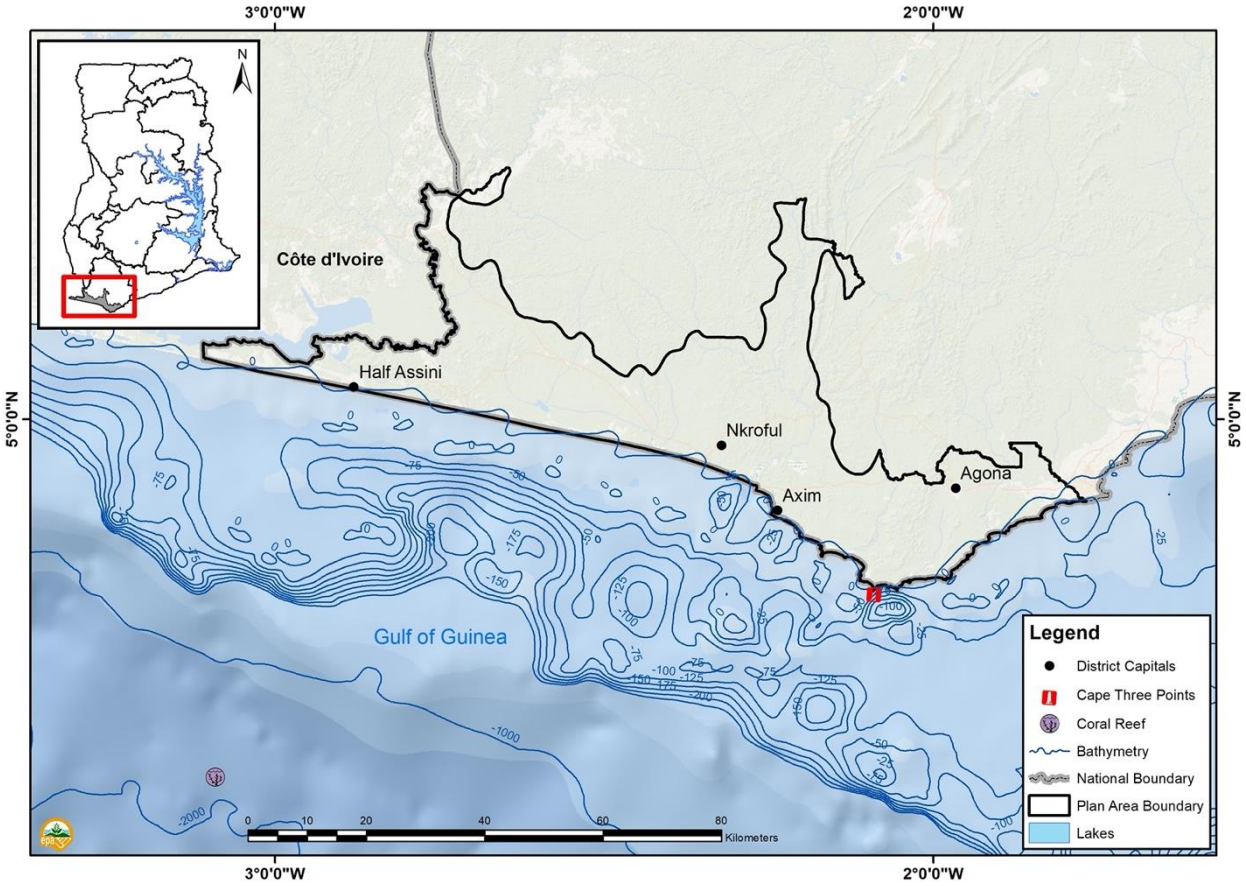


Figure 3: The configuration of the coastline and bathymetry within the study area

(Source: EPA, 2021)

2.3 Beaches

Beaches are dynamic environments located where land and sea meet. They are characterised by a zone of loose materials or sediments deposited by water or wind. The shoreline of the Western Region is predominantly sandy with a few areas of rocky outcrops.

2.3.1 Sandy Beaches

Sandy beaches in the Western Region such as New Town, Half Assini, Butre, Busua and Atuabo beaches (Figure 4) serve as important tourist attractions and service provision. The species diversity on sandy beaches is generally low, however, diversity is higher on fine grain flat beaches than on coarse grain steep sloped beaches. Ghost crab (*Ocypoda cursa* and *Ocypoda africana*) are the most common crab species found on sandy beaches and active at low tide. Other species include the isopod (*Excirolana latipes)*, amphipods (*Urothoe grimaldi)* and *Pontharpinia intermedia*, mysid (*Gastrosaccus spinifer)*, mole crab (*Hippa cubensi)*, polychaetes (*Narine cirratulus)*, *Glycera convoluta* and *Lumbrinereis impatien*s, bivalve *Donax pulchellus* and gastropods *Terebra micans* and *Olivancillaria hiatula*. The sandy beaches also serve as important nesting sites for sea turtles (EPA, 2020). Generally, sandy beaches within the study area were found to be in good condition with some sections namely Axim, Discove, Adojoa and Abuesi experiencing different levels of erosion.

2.3.2 Rocky beaches

Rocky beaches are inter-tidal areas made up of solid rocks, including other habitat types like steep rocky cliffs, platforms and rock pools. They are located mainly at Axim and Cape Three Points (Figure 5). Rocks serve as the substrate for a wide variety of species of macroalgae, barnacles, and littorinid snails that are distributed according to physico-chemical and biological factors.

Figure 4: Sandy beach at Beyin – Jomoro Municipal

Figure 5: Drone image showing the ariel view of rocky beach at Cape Three Points- Ahanta West Municipal

Algal mats on rocky shores serve as important micro-habitats for epifauna (i.e., crustaceans, macro-invertebrates) and fish. Species of macroalgae include: *Sargassum, Dictyopteris delicatula, Ulva fasciata, Chaetomorpha sp.* and *Lithothamnia sp.* (Lawson, 1956). The rocks are also substrate for barnacles, snails and limpets, examples of some common mollusc species found on rocky shores within the study area are presented in Table 2.

Table 2: List of Common Species of Mollusc found on Rocky Shores within the study area

Barnacles	Snails	Limpets
Chthamalus dentata	*Littorina punctata*	*Siphonaria pectinata*
Balanus tintinnabulum	*Nodilittorina meleagris*	*Fissurella nubecula*
	Nerita senegalensis	*Patella safiana*
	Thais haemastoma	

2.4 Wetlands

Ramsar Convention defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with fresh, brackish or salty water that is static or flowing including areas of marine water, the depth of which at low tide does not exceed six metres." The wetland ecosystem in the study area consists of depression wetlands, estuaries, lagoons, fringe forests, and mangroves.

2.4.1 Depression wetlands

Depression wetlands are confined water bodies. (Ahanta West), Belibangara (Jomoro) Ndumakaka (Jomoro) and Efasu (Jomoro) are examples of depression wetlands found in the study

area (EPA, 2021). These wetlands are generally small in size and fed mainly by rainfall (Figure 6). Rainfall is relatively high (>1800 mm) throughout the year and sustains these wetlands.

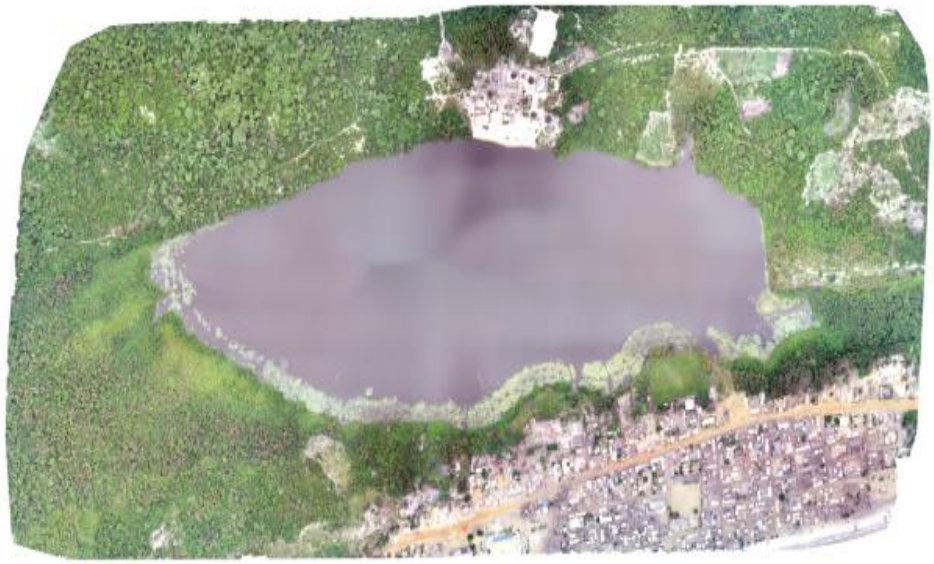


Figure 6: Aerial view of Belibangara Lagoon and associated wetlands – Jomoro Municipal

(EPA, June 2020)

2.4.2 Fringe Forests

Fringe forests occur along the western coastline between latitudes 4° 46' N and 4° 48' N and longitudes 2° 05' W and 2° 09' W. They are found mainly along the Ehunli (Figure 7) and Akpuhu Lagoons and the Nyile and Kpani Rivers confluence. The Cape Three Points Forest Reserve (4° 50' N and 2° 30' W) is a typical fringe forest. It has an area of about 51 km^2 and is about 12 km long on its north-south axis. It is the only extensive remnant of intact moist evergreen rain forest in Ghana (Hall & Swaine, 1976; Ntiamoa-Baidu et al., 2001, deGraft-Johnson et al, 2010).

A total of 141 plant species belonging to 58 families have been observed in the Cape Three Points Forest Reserve (CRC, 2000). It is an Important Bird Area (IBA) with a high level of biological diversity, recording over 27 tree species, 17 species of medium and large mammals, and 45 species of butterflies. This forest is dissected by small tributaries which feed the Nyani River on its western side and the Sweni Stream on the eastern side. Three globally-threatened bird species found in this forest are the hornbill (*Ceratogymna elata)*, the greenbulls (*Bleda eximius)* and the yellow-bearded greenbul (*Criniger olivaceus*,) which are all vulnerable and uncommon but characteristic of this type of primary forest (Dowsett et al., 2005).

Figure 7: Aerial view of Ehunli Lagoon and associated wetlands in Ahanta West Municipal (EPA, June 2020)

2.4.3 Mangroves

Mangroves are described as trees or large shrubs which grow within the intertidal zone in tropical and subtropical regions and have special adaptations to survive in this saline environment. The term mangrove is applied to both the individual plant and the ecosystem (UNEP-WCMC, 2020). Mangrove habitats play essential ecological functions for sustaining the ecosystem, including soil stabilization and coastal protection. They are also important natural filtration systems for pollutants, thus maintaining coastal water quality. Mangrove ecosystems provide important fish habitats, nurseries, and spawning grounds for fish species.

In Ghana, mangroves are found primarily in stands of small, medium and large expanses (Figure 7 and Table 3) around lagoons on the west coast and bordering the lower reaches and delta of the Volta estuary (FAO, 2005). They are extensive along the west coast between Coté d'Ivoire and Cape Three Points.

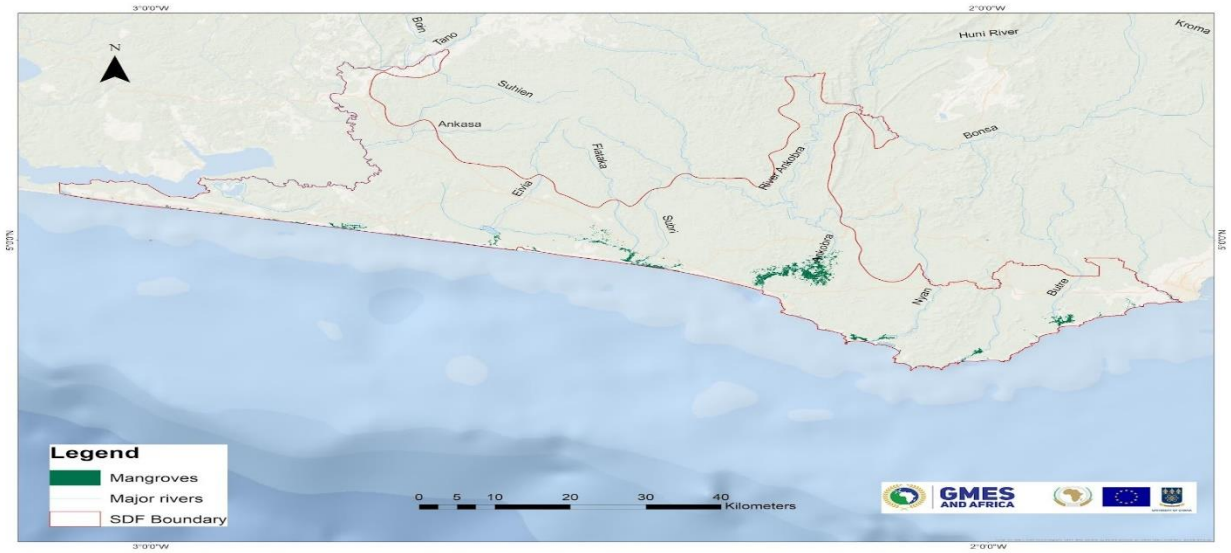


Figure 7: Map showing locations of Mangroves in the study area

Table 3: Distribution of Mangroves in the Four Coastal Districts

Municipality/District	Area (km^2)	Estimated Number of Trees
Ahanta West	3.81	1,066,792
Nzema East	7.95	1,431,700
Ellembelle	3.54	921,183
Jomoro	2.34	656,062
Total	**17.64**	**4,075,737**

(Modified from Nunoo and Agyekumhene, 2014).

2.4.4 Mangrove Species

Three (3) species of mangrove have been recorded in the study area. These are the white mangrove (*Avicennia germinans*), red mangrove (*Rhizophora racemosa*), and black mangrove (*Laguncularia racemosa*) (Figures 8, 9 & 10). The current estimated mangrove cover is around 17.64 km^2, distributed in all the four regions along Ghana's coast, with the study area recording the second most extensive and numerous stands of mangroves (Nunoo and Agyekumhene, 2014).

2.4.5 Mangrove Associated Species

A total of 8 species of animals belonging to six (6) families and five (5) species of plants belonging to 5 families have been recorded to be associated with mangroves within the study area (Nunoo and Agyekumhene, 2014) (Tables 4 and 5).

Figure 8: Avicennia germinans (white mangrove) in the study area

Figure 9: Rhizophora racemosa (red mangrove) in the study area

Figure 10:Laguncularia racemosa (Black mangrove) within the study area

Table 4: Flora associated with Mangrove

Family	Scientific Name	Common Name	Conservation Status	
			IUCN	WCR
Aizoaceae	*Sesuvium portulacastrum*	Shoreline purslane	DD	PP
Combretaceae	*Conocarpus erectus*	Button mangrove	LC	PP
Malvaceae	*Thespesia populnea*	Portia tree	LC	PP
Poaceae	*Paspalum vaginatum*	Saltwater couch	LC	PP
Pteridaceae	*Acrostichum aureum*	Golden leather fern	LC	PP

Table 5: Fauna associated with the Mangrove Stands

Family	Scientific Name	Common Name	Conservation Status	
			IUCN	WCR
Gecarcinidae	*Cardisoma armatum*	Rainbow land crabs	DD	PP
Ocypodidae	*Ocypoda africana*	African ghost crab	DD	PP
	Ocypoda cursor	African ghost crab	DD	PP
	Uca tangeri	Fiddler crabs	DD	PP
Ostreidae	*Crassostrea tulipa*	West African mangrove oyster	DD	PP
Periophthalmidae	*Periophthalmus papilio*	Mud skipper	LC	PP
Portunidae	*Callinectes amnicola*	Blue legged swimming crabs	DD	PP
Sesarmidae	*Sesarma huzardii*	Hairy mangrove crabs	DD	PP

LC - Least Concern; NT- Near Threatened; VU - Vulnerable; EN- Endangered; PP - Partly Protected; CP- Completely Protected; DD- Data Deficient.

(Source: Nunoo and Agyekumhene, 2014)

2.5 Estuaries

Estuaries are areas where saline water from the sea mixes with fresh water from inland rivers and are strongly influenced by the tidal regime. Estuaries also contribute to sediment transport either from rivers to the coastal plains downstream and the littoral zone, or upstream into the rivers due to wave action along the shores. Estuaries provide ecosystem services such as water filtration, nutrient and heat distribution, and provision of nursery habitats. Furthermore, these estuaries also serve as habitats for waterfowl, wildlife and fish (Armah, 1993; CRC-FON, 2011).

The estuaries within the study area include Butre, Kpani-Nyila in the Ahanta West district, Amanzule, Ankobra (Ellembelle districts) and Domunli in the Jomoro district (CRC-FON, 2011). Some rock outcrops characterise the Butre and Whin estuaries. Mangroves associated with the Ankobra, Amanzule, Domuli, and Kpani-Nyila (Figure 11 and 12) are at different levels of degradation (CRC-FON, 2010; 2011).

The estuaries were assessed using the DSPIR Framework during Expert Elicitation were in good condition and stable, but the quality seems to be on the decline due to human activities. Table 6 provides information on the name, location, size, and ecosystem services of estuarine wetlands within the study area.

Figure 11: Aerial view of Amanzule estuary and associated wetlands

Figure 12:Aerial view of Kpani-Nyila Estuary and associated wetlands in Ahanta West Municipal

(EPA, June 2020)

Table 6: Estuaries in the Study Area

Name of Estuary	Location	Size/km^2	Ecosystems Services
Whin	Ahanta West	2	WH, F
Butre	Ahanta West	3.5	WH, F
Kpani-Nyila	Ahanta West	3	WH, F
Ankobra	Nzema East/ Ellembelle	2.8	WH, F
Amanzule	Ellembelle	N/A	WH, F
Domunli	Jomoro	N/A	WH, F

N/A – Data not available

WH = Wildlife Habitat; F = Fishery

Source: Armah & Amlalo, 1998, CRC and FON, 2011

2.6 Estuarine and Lagoon Fish Species

The estuaries and lagoon ecosystems in the study area have a diverse fish population belonging to several families comprising Mugilidae, Clupeidae, Cichlidae, Gobiidae, Acanthuridae, Labridae, Bothidae, Haemulidae, Lutjanidae, Eleotridae, Gerreidae, Portunidae and Clariidae. A fish survey on the Ankrobra estuary documented 26 species belonging to 18 families (CRC/FON, 2010). The common fish species are *Sarotherodon melanotheron*, *Periopthalmus barbarous*, *Liza falcipinnis*, *Callinectes amnicola* and *Goniopsis cruentata*. Key fish species in the estuarine environment include the *Megalops spp* (tarpon); *Ethmalosa frimbriata* (Bonga shad), *Ilisha Africana* (Long-finned herring), *Elops lacerta* (Ten-pounder), *Sphyraena sphyraena* (Barracuda), *Citarichthys stampflii* (Flatfish), *Cynoglossus senegalensis* (Tongue sole), *Trachinotus gorensis* (Pompano), *Pseudotolithus elongatus, Pseudotolithus epipercus* (Drums*)* as well as the *Brachydeuterus auratus* (Burito) and *Pentanemus quinquarius* (Threadfin) (CRC/FON, 2010).

2.7 Habitat Quality Assessment

In June 2019 during an Expert Elicitation workshop, an assessment was conducted using the Drivers, Pressures, State, Impact and Response (DPSIR) framework in which fourteen (14) identified habitats found within the study area were assessed. Results indicated that the average score for habitats revealed very good condition for most places. Summary results of the average, high and low scores for the condition assessment in the Best 10%, Most 80% and Worst 10% of places are presented as in Figures 13, 14, and 15.

2.8 Habitat

In this section, marine biodiversity has been investigated by examining the status and trends of major marine and coastal habitats in the four coastal districts (Ahanta West, Ellembelle, Jomoro and Nzema East) of assessment. Their condition is defined by how they are affected by human activities, relative to their reference condition (the condition prior to the time when human impacts started to occur).

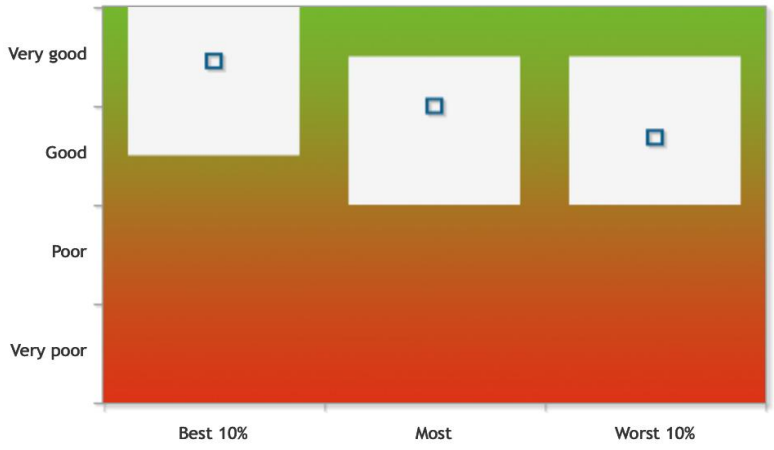


Figure 13 : Summary of Habitat Assessment in the study area.

Figure 14: Summary Results of Habitat Assessment for "most" places generated during Expert Elicitation

Assessment for most places

Component	Assessment grade				Confidence	
	Very poor	Poor	Good	Very good	In grade	In trend
West-african manatees	↙				■	■
Large pelagic eg. Tuna			↙		■	■
Inner shelf (0-50m) demersal fish assemblages eg. seabreams, cassava fish/croaker, snappers, cuttlefish		↙			■	■
Outer shelf (50-100m) demersal & benthopelagic fish assemblages, sea breams, cassava fish/croaker, snappers, cuttlefish		↙			■	■
Slope - demersal fish assemblages (>100m)			–		■	■
Large pelagic fish populations or stocks eg. sharks, rays and billfishes		↙			■	■
Small pelagics - inner shelf (0-50m)	↙				■	■
Cephalopods		↙			■	■
Inner shelf (0-50m) crustaceans	↙				■	■
Inner shelf – lobsters & related species	↙				■	■
Migrating and resident birds		↙			■	■
Turtles		↙			■	■
Dolphins			↙		■	■
Whales				–		

Legend

Grades	Very poor	Poor	Good	Very good
Recent trends	↗ Improving	– Stable	**Confidence**	■ High confidence based on high-quality data
	↙ Declining	? Unclear		■ Moderate confidence based on some limited evidence
	? Worst/best 10% of places			■ Low confidence based on expert judgement with little or no data

Figure 15: Summary Results of Fauna Assessment for "Most Places" generated during Expert Elicitation

3.0 Flora and Fauna in Marine Environment

3.1 Plankton

Plankton are of great importance to life as they form the base of the aquatic food web. Plankton live in waterbodies such as the ocean, river, lake, and lagoon with no swimming ability and are therefore passively carried by currents, waves, and tides. They could be plants (phytoplankton), animals (zooplankton) or bacteria. Sizes of plankton may range from small (microscopic) to larger forms (macroscopic). Planktons constitute the major contributor of global atmospheric oxygen and absorb carbon dioxide from the atmosphere thereby regulating global climate and temperature. The presence, absence, diversity and numbers of plankton can provide information on the quality of the environment, such as pollution, water quality, and eutrophication.

3.1.1 Phytoplankton

Phytoplankton are mainly composed of algae, diatoms, and dinoflagellates. The dinoflagellates form the main components of the marine phytoplankton population during the non-upwelling period, contributing about 50-90%, while diatoms dominate the upwelling seasons, constituting 90% (Anang, 1979). Furthermore, a positive correlation exists between physico-chemical factors/oceanographic regimes and the phytoplankton population, especially during the major upwelling period.

Diatom genera identified in the waters off Western Region include *Coscinodiscus, Thalassiothrix, Skeletonema, Therassiosira, Rhizosolinia, Nitzschia, Navicula, Guinardis* and *Blastodinium.* The dinoflagellates genera found in the area include *Ceratium, Peridium, Prorocentrum Dinophysis, and Gonyaulax. Ceratium* dominates the community, contributing about 90% of all species. They are relatively non-toxic and harmless organisms. However, they can cause red tides, if conditions

allow for excessive production. On the other hand, *Peridium*, *Prorocentrum*, *Dinophysis*, and *Gonyaulax* are toxic and harmful, if they should bloom. Nonetheless, their blooms have never been experienced in Ghanaian coastal/marine waters.

3.1.2 Zooplankton

Zooplankton, including ichthyoplankton (fish eggs and larvae), serve as food for higher-order organisms, including fishes. Zooplankton abundance and diversity are proxies for secondary production in the marine environment. The availability, abundance, timing, and composition of zooplankton determine the prospects of future exploitable fisheries resources. Zooplankton are also sensitive to environmental change and provide essential information on the ecological health of the seas.

A general decline has been observed in zooplankton displacement volume and biomass over the years in Ghana (Figure 16). Copepod (*Calnoides carinatus)*, which used to form a significant proportion of the zooplankton, is disappearing due to its sensitivity to high temperature Esi Bordah Quayson, *Personal communication*) (Figure 17). This development could result in a shift in the zooplankton community structure, mismatch, and its consequent impact on fishery resources as warmer species like *Temora stylifera* and *Pennilia avirostris* could take over colder ones like *C. carinatus.*

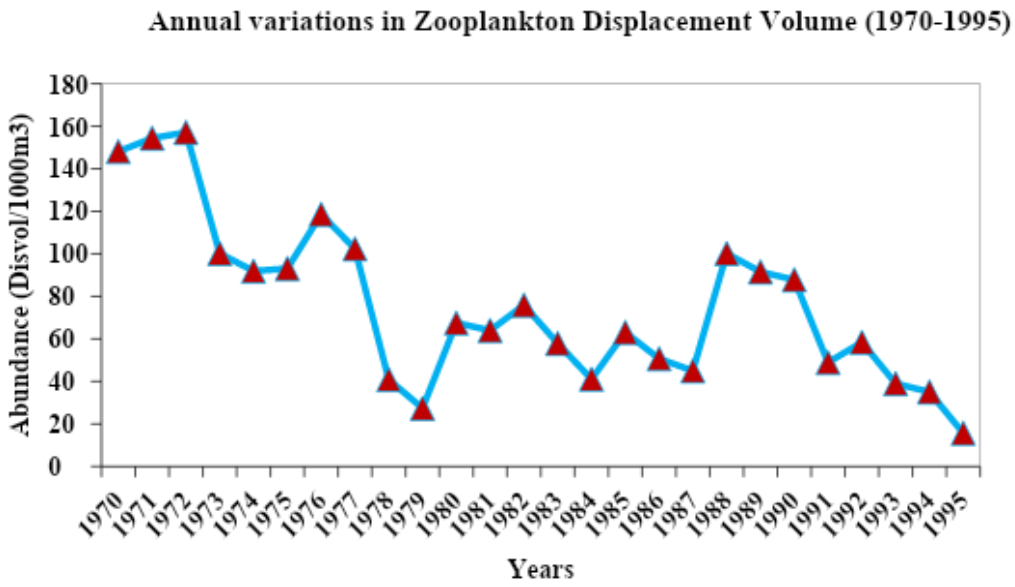


Figure 16: Annual Variations in Sardinella Larvae, Eggs and Zooplankton Displacement Volume

Source: FSSD, 1994

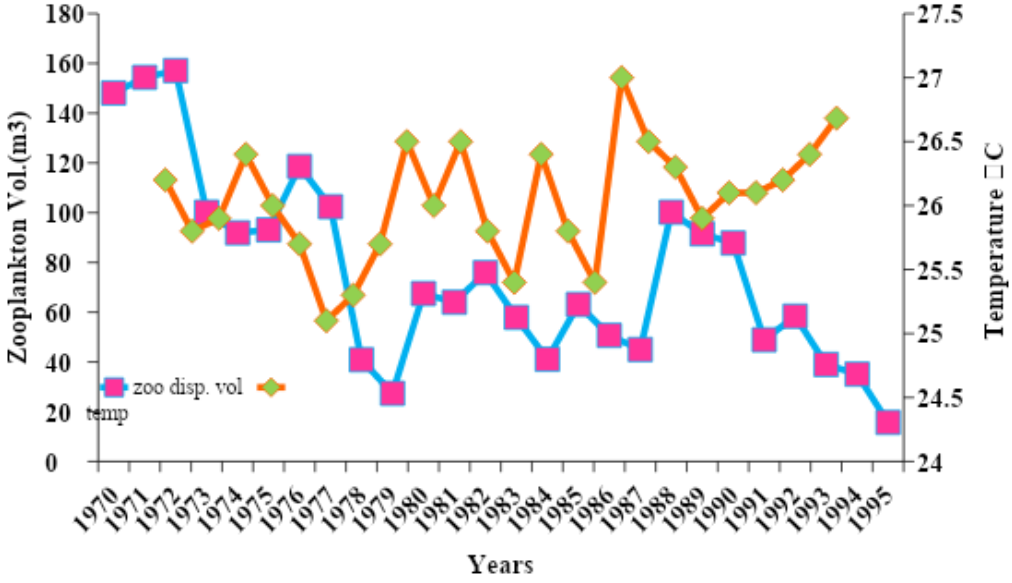


Figure 17: Zooplankton Displacement Volume and Temperature

Source: FSSD, 1995

Copepoda zooplankton (*Calanoidae, Cyclopoidae,* and *Harpacticoidae*) are most abundant during upwelling periods of which the calanoids form the majority. The calanoids constitute the principal food item in the diet of *Sardinella.* The declining trend in zooplankton displacement volume could influence the abundance of *Sardinella* in Ghanaian waters.

3.2 Macroalgae

Macroalgae occur along the entire coast of Ghana within rocky habitats. There is a vertical variation of organisms within the intertidal zone and horizontal variation along the shoreline. Green algae occupy the upper limits of the intertidal areas, with a few blue-green species associated with mangroves and areas with high nitrogen load.

In the Western Region of Ghana, algal species rarely occur between New Town and Sawohoma (Ankobra) due to the sandy nature of the beaches. However, the areas between Ankobra and Ahanta West have more favourable conditions for algal growth due to large expanses of rocky habitat (Table 7).

Table 7: Common occurring macroalgal species in the Western Region

Blue-Green algae	**Brown algae**	**Green algae**	**Red algae**
Bostrychia tenella	*Sargassum vulgare*	*Cladophora prolifera, Cladophora ruchingerii, Cladophora vagabunda*	*Hypnea musciformis*
Colponemea	*Padina durvellaie*	*Ulva fasciata, Ulva flexuosa*	*Hydropuntia dentata*
	Dictyopteris delicatula	*Bryopsis pennata*	*Centroceras clavulatum*
	Dictyota delicatula	*Codium guineense*	*Laurencia majuscula*
		Chaetomorpha antennina	
		Chaetomorpha linum	
		Caulerpa taxifolia	

3.3 Fish Productivity

A survey conducted by RV Dr. Fridtjof Nansen showed that the pelagic community has the highest average catch on the inner shelf (0-50 m) with a relative contribution of 49% of the total catch. This was closely followed by the demersal group (30%). The Carangids and the seabreams dominated the inner shelf catches while seabreams again dominated the outer shelf (51-100 m), followed by the snappers. The anchovies were detected in shallow waters, mostly at depths between 20 and 30 m (Toresen et al., 2016).

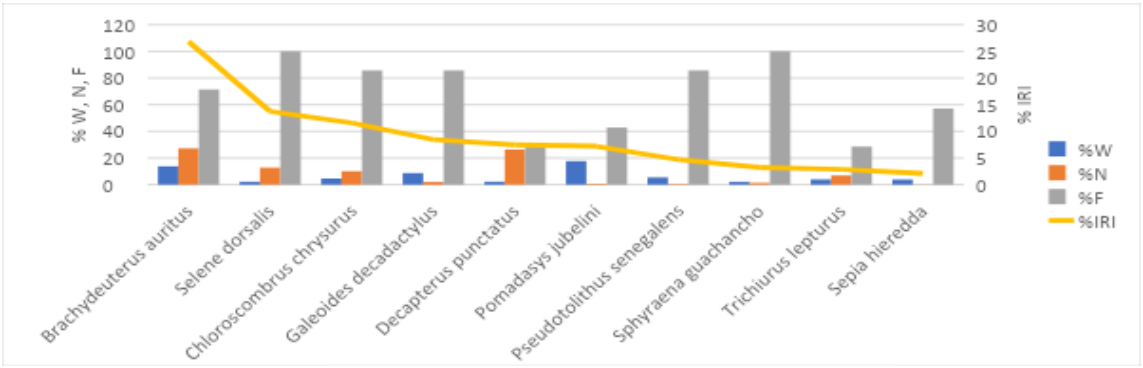
The sardinellas were confined to the upper shelf (<50 m), while most of the horse mackerel biomass was distributed on the broader shelf area (30-80 m depth) (Staby et al., 2017). The other group contributed about 18%. Cephalopods made up 2.0% of the catch, while shrimps and sharks contributed less than 1% to the catch rates.

The demersal group dominated catches on the outer shelf (51-100 m), contributing 47% of the total catch. The pelagic group had a relative contribution of 2%, with others 18% Cephalopods, sharks contributed 1% (Toresen et al., 2016). On the West Coast, the most important species are *Brachydeuterus auritus, Engraulis encrasicolus, Decapterus punctatus, Trachurus trecae, Selene dorsalis, Chloroscombrus chrysurus, Pagellus bellottii, Saurida parri, Trichiurus lepturus* and *Sphyraena guachancho.* Figure 18 and *Table* 8 depict the depth distribution of the fish communities (Toresen et al., 2016).

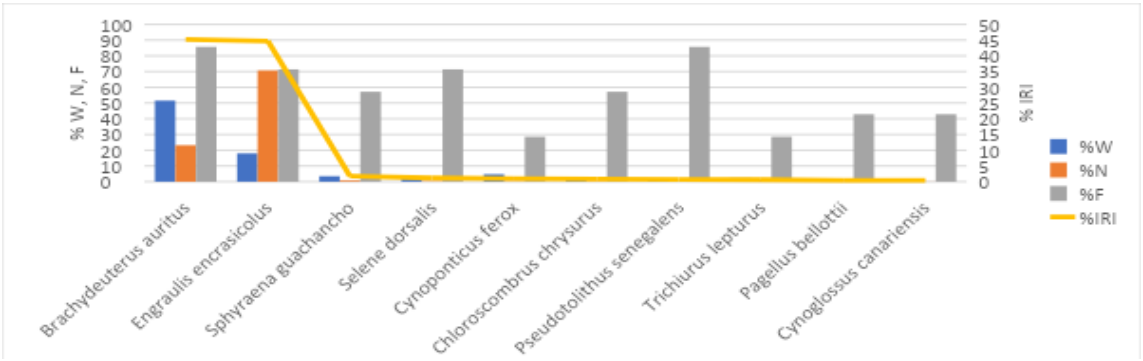
Table 8: Biomass Estimates (Tonnes) of Important Demersal Species on the Shelf by depth.

Group/species	**Biomass**			
Depth (m)	**0 - 30**	**30 - 50**	**50 - 100**	**Total**
Seabreams	1056	3069	8833	12959
Grunts	587	33	0	620
Croakers	473	91	3	567
Groupers	90	235	127	452
Snappers	76	80	1293	1450
Bigeye grunt	1426	4892	5983	12301
Carangids	2450	10733	6220	19403
Barracudas	825	1265	432	2522
Cephalopods	289	607	2418	3314
Total	**2284**	**3509**	**10256**	**16048**

a (0-30 m)



b (30-50 m)



c (50-100 m)

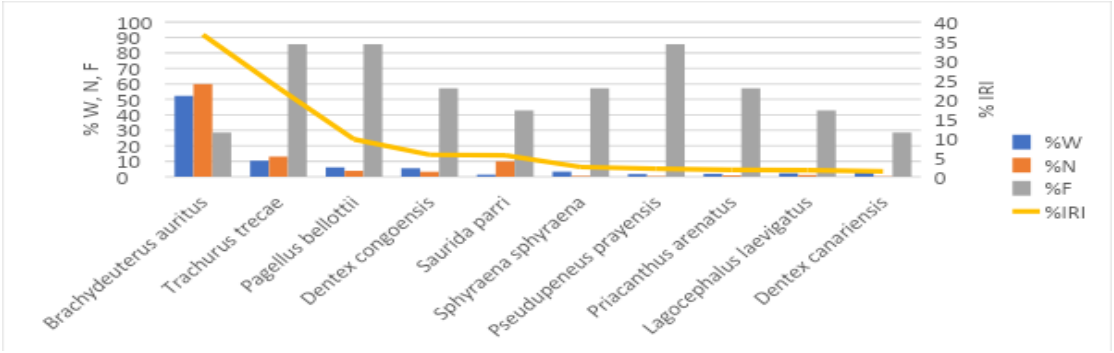


Figure 18: Depth distribution of fish communities for the 10 most important species per stratum on the west coast (a, b, and c),

Where:

%W is the percentage by weight
%N is percentage by number
%F percentage by occurrence and
%IRI percentage index of the relation

3.4 Marine Fisheries

In 2017, Marine fisheries provide about 70% of Ghana's total annual catch (MoFAD, 2021) of which the majority is from inshore artisanal fishing. The marine fisheries are mostly made up of small and large pelagics and demersals. The small pelagic group includes commercially important families such as the Engraulidae, Clupeidae, Carangidae, Scombridae, and Sphyraenidae, while the demersal group includes the Sciaenidae, Haemulidae, Serranidae, Sparidae, Lutjanidae, and Lethrinidae. The large pelagics are the tunas and tuna-like species. It is generally categorised into four subsectors:

i. Small scale (artisanal),
ii. Semi-industrial (inshore),
iii. Industrial
iv. Tuna.

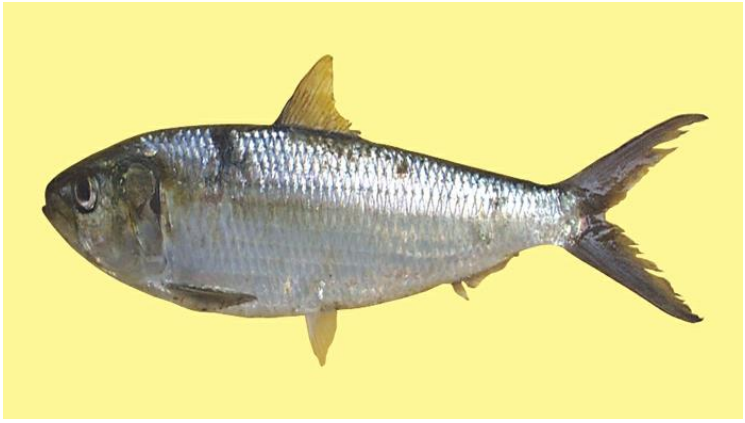


Figure 19: Round sardinella (Sardinella aurita)

Figure 20: Anchovy (Engraulis encrasicolus)

3.4.1 Pelagics fish species of the Western Region

The main small pelagic fish species contributing significantly to marine fish production in the Western Region are the Sardinellas, Anchovy, Chub mackerel, Scad mackerel, and Frigate mackerel. These small pelagics make up over 70% of the total fish landings in Ghana (Nunoo et al., 2014; FSSD, 2016). Threats to small pelagic fish species include conversion of lagoons and mangrove swamps, habitat degradation, overharvesting, use of illegal fishing methods and pollution (Polidoro et al., 2017; Asiedu et al. 2021).

Large pelagic fish species include tuna species, such as skipjack tuna (*Katsuwonus pelamis),* yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*), which is threatened. Billfish species, including Swordfish (*Xiphias gladius*), Atlantic blue marlin (*Makaira nigricans),* and Atlantic sailfish (*Istiophorus albicans*) are also exploited in lower but substantial quantities.

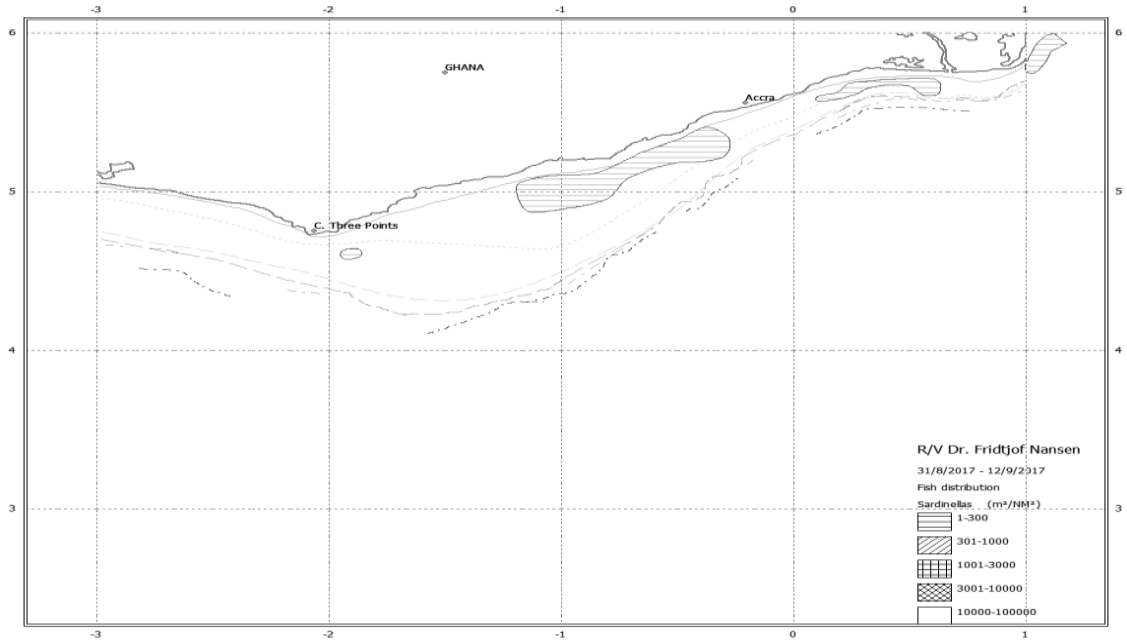


Figure 21: Distribution of Sardinellas off Ghana in 2017

(Source: Staby et al., 2017)

3.4.2 Demersal Fisheries

The demersals are exploited mostly by the industrial trawlers and are commercially important and highly valued. They include Seabreams, Burrito, Cassava/Croaker, Mullets, Snappers, Cuttlefish, and Shrimps. The main demersal species exploited in the Western Region are presented in Table 9.

Table 9: List of Demersal species exploited in the Western Region

Species	Common Name
Pagrus caeruleostictus	Blue-spotted Seabream
Dentex angolensis	Angola dentex
Dentex congoensis	Congo dentex
Dentex canariensis	Canary dentex
Dentex gibbosus	Pink dentex
Brachydeuterus auritus	Bigeye grunt
Pomadasys jubelini	Sompat grunt
Pomadasys incises	Bastard grunt
Pagellus bellottii	Red pandora
Pseudotolithus senegalensis	cassava croaker
Pseudupeneus prayensis	West African goatfish
Lutjanus fulgens	Golden African snapper
Lutjanus goreensis	Goreean snapper
Epinephelus aeneus	white grouper
Galeoides decadactylus	Lesser African threadfin
Lethrinus atlanticus	Atlantic emperor
Balistes capriscus	Grey triggerfish

Table 10: Fish Species in Ghanaian Waters Listed on the IUCN Red List

Scientific name	Common name	IUCN Conservation Status
Dasyatis margarita	Ray species	Endangered
Pristis pectinata	Wide sawfish	Critically endangered
Pristis perotteti	Largetooth sawfish	Critically endangered
Pseudotolithus senegalensis	Cassava fish /Croaker	Endangered
Raja undulata	Undulate ray	Endangered
Rhinobatos cemiculus	Blackchin guitarfish	Endangered
Rhinobatos rhinobatos	Common guitarfish	Endangered
Rhynchobatus luebberti	Lubbert's guitarfish	Endangered
Rostroraja alba	Bottlenose skate	Endangered
Sphyrna lewini	Scalloped hammerhead	Endangered
Squatina aculeata & *S. oculata*	Angel sharks	Critically endangered

3.4.3 Sharks and Rays

Sharks, skates and rays, and other shark-like species, collectively known as elasmobranchs, are found in the study area. They include the giant whale shark, dwarf lantern shark, scalloped hammerhead sharks (Figure 22), large manta ray, and tiny short-nosed electric ray. Billfishes (sailfish, marlin, and swordfish, etc.) also abound (Figure 23). The Elasmobranchs generally grow slowly, reproduce late in life, and have only a small number of offspring. They are apex predators that feed on a wide variety of smaller fish, shrimps, squids, and octopuses. Fishermen from Dixcove in the Ahanta West District in the project area primarily catch sharks and billfishes using drifting gill nets. They are landed and sold locally while the shark fins are processed and exported in a profitable trade from the harvest despite the generally declining resource numbers.

A study by Hen Mpoano in Axim, Dixcove, Shama in the Western Region & Tema in the Greater Accra Region showed a total of 4894 sharks, 2612 billfishes, 461 manta rays and 5 skates were landed from April to November 2017. Tables 13 and 14 show Sharks and Billfishes encountered during the study (Hen Mpoano, 2018).

Table 11: Conservation status of shark species landed at Axim, Dixcove, Shama in the Western Region & Tema in the Greater Accra Region

Common Name	Scientific Name	IUCN Conservation Status*
Bigeye thresher-fin	*Alopias supercilosus*	Vulnerable
Blue shark	*Prionace glauca*	Near Threatened
Common guitarfish	*Rhinobatos rhinobatos*	Endangered
Common thresher	*Alopias vulpinus*	Vulnerable
Tiger shark	*Galeocerdo cuvier*	Near Threatened
Great white shark	*Carcharodon carcharias*	Vulnerable
Sand tiger shark	*Carcharias taurus*	Vulnerable
Scalloped hammerhead shark	*Sphyrna spp.*	Endangered
Short-fin mako shark	*Isurus oxyrhincus*	Threatened

*Conservation Status (IUCN 2016)

Table 12: Billfish species landed at the 4 sites

Common name	Scientific name	IUCN Conservation Status
Atlantic Blue Marlin	*Makaira nigricans*	Threatened
Atlantic Sail Fish	*Istiophorus albicans*	Least Concern
Atlantic Sail Fish	*Istiophorus albicans*	Least Concern
Atlantic White Marlin	*Kajikia albida*	Endangered
Swordfish	*Xiphias gladius*	Least Concern

Conservation Status (IUCN 2016)

Figure 22: Scalloped Hammerhead

Source: Hen Mpoano. (2018).

Figure 23: Atlantic Blue Marlin (Makaira nigricans) found in the marine waters in the study area

Source: Hen Mpoano. (2018).

3.5 Birds

The Amanzule wetland and associated beaches have a diverse bird (avifauna) community, which consists of both resident and migrant species. Within this area,165 bird species belonging to 15 orders and 53 families have been recorded (Ntiamoa-Baidu et al., 2001; Owusu, 2007), constituting 24.2% of the 680 avifauna species recorded in Ghana. The resident birds constitute 17.4% of Ghana's 494 resident bird species (Ntiamoa-Baidu et al., 2001; Borrow & Demey, 2013). A total of 100 bird species breed within the Amanzule wetland (Ntiamoa-Baidu et al., 2001) and 44 bird species recorded within as seasonal migrants. This includes 30 Paleoarctic and one Neoarctic species (Ntiamoa-Baidu et al., 2001; Owusu, 2007; BirdLife International, 2019).

The Amanzule wetland is the only site along the Ghana coast where the Eurasian oystercatcher (*Haematopus ostralaegus)* has been observed with any degree of frequency (Ntiamoa-Baidu, 1991; Ntiamoa-Baidu et al., 2001). The entire Ghana coast supports 3 to 4% of the sanderling (*Calidris alba*) (Figure 24) population of the East Atlantic Flyway (EAF). (Ntiamoa-Baidu, 1991b; Gordon, 1995; Ntiamoa-Baidu et al., 1998; Ntiamoa-Baidu et al., 2000; Ryan & Ntiamoa- Baidu, 2000; Ntiamoa-Baidu et al., 2001; Ntiamoa-Baidu et al., 2014a). The stretch of the beach between the Ankobra and Amanzule estuaries supports 40 to 70% of the EAF sanderling population (Reneerkens et al., 2009; Ntiamoa-Baidu et al., 2014).

The Amanzule wetland is important for several bird species of conservation concern, according to the IUCN red list (BirdLife International, 2016; 2017; 2018). Ghana's Wildlife Regulations L.I. 685, 1357 and 1452 wholly protect all birds of prey and some egrets. Table 13 provides a list of birds that are of conservation concern.

Figure 24:Sanderling (Calidris alba)

(Photo credit: Jones Quartey)

Figure 25: Curlew sand pipers (Calidris ferruginea)

(Photo credit: Jones Quartey)

Figure 26: Common sand piper (Actitis hypoleucos)

(Photo credit: Jones Quartey)

Figure 27: Common ringed plover (Charadrius hiaticula)

(Photo credit: Jones Quartey)

Table 13: List of Birds of Global Conservation Significance found within the study area

Species		**Conservation Status**	
Common name	**Scientific name**	**IUCN**	**Ghana Wildlife Regulation**
African Skimmer	*Rynchops flavirostis*	Near Threatened	
Bar-tailed godwit	*Limosa lapponica*	Near Threatened	
Cattle egret	*Bubulcus ibis*		Wholly protected
Crown hawk eagle	*Stephanoaetus coronatus*	Near Threatened	Wholly protected
Curlew sandpiper	*Calidris ferruginea*	Near Threatened	
Eurasian curlew	*Numenius arquata*	Near Threatened	
Eurasian oystercatcher	*Haematopus ostralaegus*	Near Threatened	
Goliath heron	*Ardea goliath*		Wholly protected
Great white egret	*Ardea alba*		Wholly protected
Harrier hawk	*Polybroides radiatus*		Wholly protected
Hooded vulture	*Necrosyrtes monachus*	Critically Endangered	Wholly protected
Little egret	*Egretta garzetta*		Wholly protected
Palm-nut vulture	*Gypohierax angolensis*		Wholly protected
Red knot	*Calidris canutus*	Near Threatened	
Red-tailed buzzard	*Buteo augularis*		Wholly protected
West African Goshawk	*Accipiter toussenelii*		Wholly protected
Yellow-billed kite	*Milvus migrans* (*parasitus*)		Wholly protected

3.6 Turtles

The sandy beaches of Ghana support the breeding of a significant population of different species of turtles. Five species, Leatherback (*Dermochelys coriacea*), Green (*Chelonia mydas*), Olive Ridley (*Lepidochelys olivecea*), Loggerhead (*Caretta caretta*), and Hawksbill (*Eretmochelys imbricate*) are all documented to utilise the coastal areas for foraging and nesting (Irvine, 1946; Armah and Amlalo, 1998; Agyekumhene et al., 2014).

Although the Olive Ridley is the most common in the study area, Leatherback and Green turtles (Figure 23) also utilize the area for nesting (Amiteye, 2000; Agyekumhene, 2009; Agyeman et al., 2013). Loggerhead and Hawksbill turtles have been reported in fishery by-catch (Agyekumhene et al., 2014). Nesting by turtles in Ghana occurs primarily between October and March (Table 16), with peak nesting in November-December (Armah et al., 1997; Amiteye, 2000; Agyekumhene, 2009; Agyekumhene et al., 2014). However, early and late nesters sometimes deposit eggs outside these months (Agyekumhene, 2009). The green turtle was previously documented to nest from June to August, however, recent field surveys have reported the species to also actively nest during the October-March period (Ghana Turtle Conservation Project, *unpublished*).

Table 14: Status of Turtle species in the study area.

Common Name	**Scientific Name**	**Occurrence**	**IUCN Conservation Status**	**Nesting Periods (Month)**											
				J	F	M	A	M	J	J	A	S	O	N	D
Leatherback Sea turtle	*Dermochelys coriacea*	Common	Vulnerable												
Green Sea turtle	*Chelonia mydas*	Common	Endangered												
Olive Ridley Sea turtle	*Lepidochelys olivacea*	Most Common	Vulnerable												
Loggerhead Sea turtle	*Caretta caretta*	Rare	Vulnerable												
Hawksbill Sea turtle	*Eretmochelys imbricate*	Very Rare	Critically Endangered												

Likely Reported Confirmed

Source: Ghana Turtle Conservation Project (2019, *unpublished*)

Figure 28: Olive Ridley turtle (Lepidochelys olivacea)

Figure 29: Green turtle (Chelonia mydas)

Figure 30: Leatherback turtle (Dermochelys coriacea)

(Photo credit: Andrews Agyekumhene)

3.7 Crocodiles

There are 23 species of Crocodiles in the world, but only three are currently found in Africa. These are the Nile crocodile (*Crocodylus niloticus*), African Slender-Snouted Crocodile (*Crocodylus cataphractus*) and the African Dwarf Crocodile (*Osteolaemus tetraspis*) have all been reported to be found within the Greater Amanzule wetland (Ajonina, G., 2011, Agyekumhene, *Personal communication*).

The African Slender-Snouted and the African Dwarf crocodiles have been classified in the IUCN red list as Critically Endangered and Vulnerable respectively, and Completely Protected under Ghana Wildlife Conservation Regulations 1971, L.I. 685.

3.8 Marine Mammals

3.8.1 Sirenian

The West African manatee (*Trichechus senegalensis)* is the only reported sirenian in the country. They are usually found in estuaries and some fresh water bodies. In the Western Region, the West African manatee has been reported in the Abby Lagoon, a transboundary wetland shared by Ghana and Côte d' Ivoire (Ofori-Danson and Agbogah 1995).

3.8.2 Cetaceans

Based on monitoring of by-catches from artisanal fishers from 1996 to 2004, 18 species of cetaceans (17 odontocetes and 1 mysticete) were observed (Van Waerebeek et al., 2009). Table 15 shows the list of the eighteen species found in Ghana's waters.

Table 15: List of Cetaceans found within the study area

Scientific Name	Common Name
Delphinus capensis capensis	Long-beaked common dolphin
Feresa attenuata	Pygmy killer whale
Globicephala macrorhynchus	Short-finned pilot whale
Grampus griseus	Risso's dolphin
Kogia sima	Dwarf sperm whale
Lagenodelphis hosei	Fraser's Dolphin
Megaptera novaeangliae	Humpback whale
Orcinus orca	Killer whale
Peponocephala electra	Melon-headed whale
Physeter macrocephalus	Sperm whale
Pseudorca crassidens	False killer whale
Stenella attenuata	Pantropical spotted dolphin
Stenella frontalis	Atlantic spotted dolphin
Stenella longirostris longirostris	Spinner dolphin
Stenella clymene	Clymene dolphin
Steno bredanensis	Rough-toothed dolphin
Tursiops truncatus	Common bottlenose dolphin
Ziphius cavirostris	Cuvier's beaked whale or goose-beaked whale

3.9 Amphibians

Seventy-eight (78) amphibian species have been recorded in Ghana (Frost, 2017). However, recent discoveries and descriptions of new amphibian species in Ghana suggest that Ghana's amphibians may have been incompletely inventoried (Rödel et al., 2009, Kpan et al., 2018; Ofori-Boateng et al., 2018;). Ofori-Boateng et al., (2018) reported 12 amphibian species from four families and seven genera to occur within the study area. Table 16 is a list of amphibians in the Greater Amanzule Wetland and their conservation status. One of these amphibian species, *Phrynobatrachus alleni*, is listed as Near-Threatened by IUCN. All frog species are partly protected by the Wildlife Conservation Regulation 1971, LI 685.

3.10 Reptiles

Table 17 presents the species of reptiles documented in the study area. They include three sea turtle species, tortoises, snakes, and crocodiles.

Table 16: Amphibians found in Greater Amanzule Wetland Area

Family	Scientific Name	English/Common Name	Year Recorded	
			2016	2018
Arthroleptidae	*Arthroleptis sp.*	Squeaking frog	+	
Bufonidae	*Amietophrynus maculatus*	Hallowell's toad	+	
	Amietophrynus regularis	African bouncing toad	+	
Hyperoliidae	*Afrixalus nigeriensis*	Nigeria banana frog	+	
	Hyperolious fusciventris	Lime reed frog	+	+
	Hyperolious guttulatus	Dotted reed frog	+	
	Leptopelis spiritusnoctis	Gbanga forest tree frog	+	+
	Morerella cf. cyanophthalma		+	
Phrynobatrachidae	*Phrynobatrachus alleni*	Allen's river frog	+	
	Phrynobatrachus tokba	Forest river frog		+
	Phrynobatrachus gutturosus	Guttural river frog	+	
	Phrynobatrachus latifrons	Ahl's river frog	+	+
	Phrynobatrachus sp.		+	
	Phrynobatrachus sp[1]			+
	Phrynobatrachus sp[2]			+
Pipidae	*Xenopus tropicalis*	Western clawed frog	+	
Ptychadenidae	*Ptychadena longirostis*	Mpacha Grass Frog		+
	Ptychadena mascariniensis	Mascarene Grass Frog	+	+
	Ptychadena sp[1]			+
Ranidae	*Amnirana albolabris*	White-lipped frog	+	+
	Aubria subsigillata	Brown ball frog	+	+
	Hoplobatrachus occipitalis	Crowned bullfrog	+	+

(Source: Ofori-Boateng et al. 2016, 2018)

Table 17: Conservation Status of Reptiles in the Study Area

Scientific Name	English Name	Conservation Status	
		IUCN	WCR
Turtles			
Dermochelys coriacea	Leatherback	VU	CP
Lepidochelys olivacea	Olive Ridley	VU	CP
Chelonia mydas	Green	EN	CP
Caretta caretta	Loggerhead	VU	CP
Eretmochelys imbricate	Hawksbill	CR	CP
Tortoise			
Kinixys homeana	Homes Hinged back tortoise	VU	PP
Kinixys erosa	Forest Hinged Tortoise	DD	PP
Polemedusa subrufa	Marsh Terrapin	DD	PP
Crocodiles			
Osteolaemus tetraspis	Dwarf Crocodile	VU	CP
Crocodylus niloticus	Nile Crocodile	LC	CP
Crocodylus cataphractus	African Slender-Snouted Crocodile	CR+	CP
Snakes			
Python sebae	African Python		PP
Naja nigricollis	Black Cobra		PP
Python regia	Royal Python		PP
Bitis rhinoceros	Gaboon Rhinoceros viper	LC	CP
Others			
Varanus niloticus ornatus	Nile Monitor		CP

LC - Least Concern; NT- Near Threatened; VU - Vulnerable; EN- Endangered; PP - Partly Protected; CP- Completely Protected; Empty cell - Data Deficient.
Source: Hen Mpoano, 2016.

4.0 Physico-Chemical and Ecological Processes

4.1 Sea Surface Temperature

Sea water temperature is one of the most important factors that affect the abundance and distribution of fish and plankton species (M.A.M. El Gammal et al., 2017, Trombetta et al., 2019). There are four hydrographic regimes in Ghana's coastal and marine environment: a major (July – September) and minor (December/January – February) upwellings where the temperature ranges between 22°C and 25°C, major (March – May) and minor (October–November) thermal stability with temperature values from 26°C to 28°C (FSSD, 2000-2017). Figures 31 and 32 depict the seasonal and annual variation in temperature over the years.

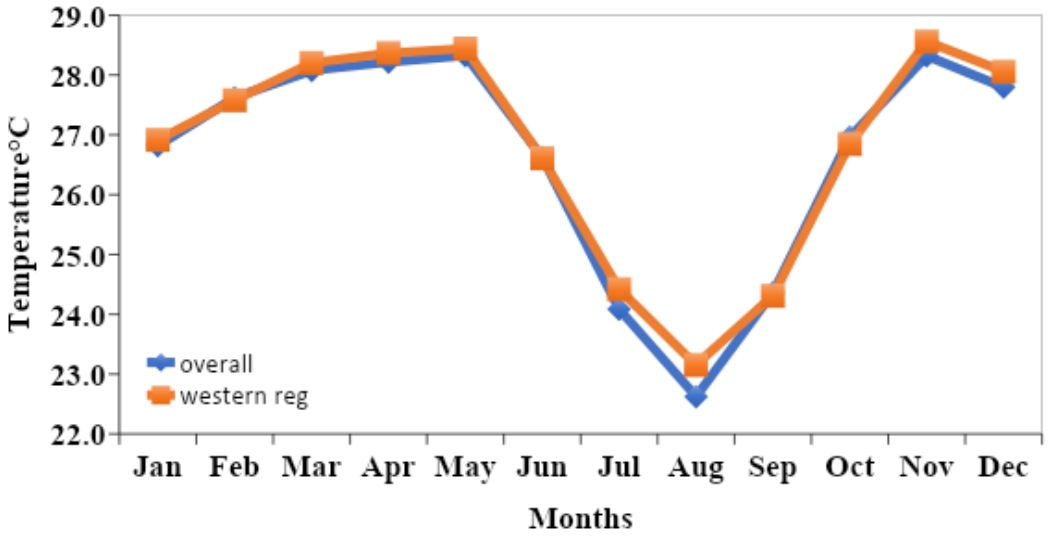


Figure 31: Seasonal Variations in Temperature from 2000 to 2017 along the coast of Ghana

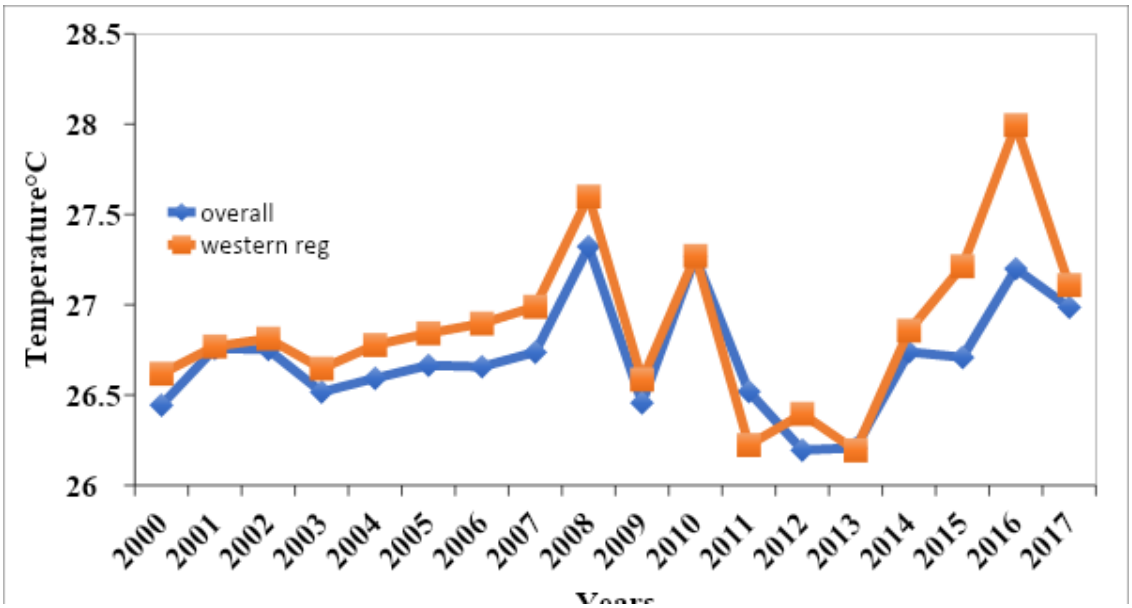


Figure 32: Variations in Annual Sea Surface Temperature between 2000 to 2017 along the coast of Ghana

Sea surface temperature varies between 22° and 26°C, generally increasing offshore. Temperatures are colder towards the west, ranging from 20°C - 25°C inshore and offshore. The coastal and marine waters of Cape Three Points are the coldest (Figure 25) (Staby et al., 2017). There is a high temperature gradient in the upper 50 m of the water column, dropping by about 5 - 6°C from the surface. Within the bottom of the continental shelf, temperatures generally range from 17 to 18°C, but lower temperatures of 14 -15°C have been measured at the 200 m depth, which further decreases to 3 - 4°C at 2000 m depth (Staby et al., 2017).

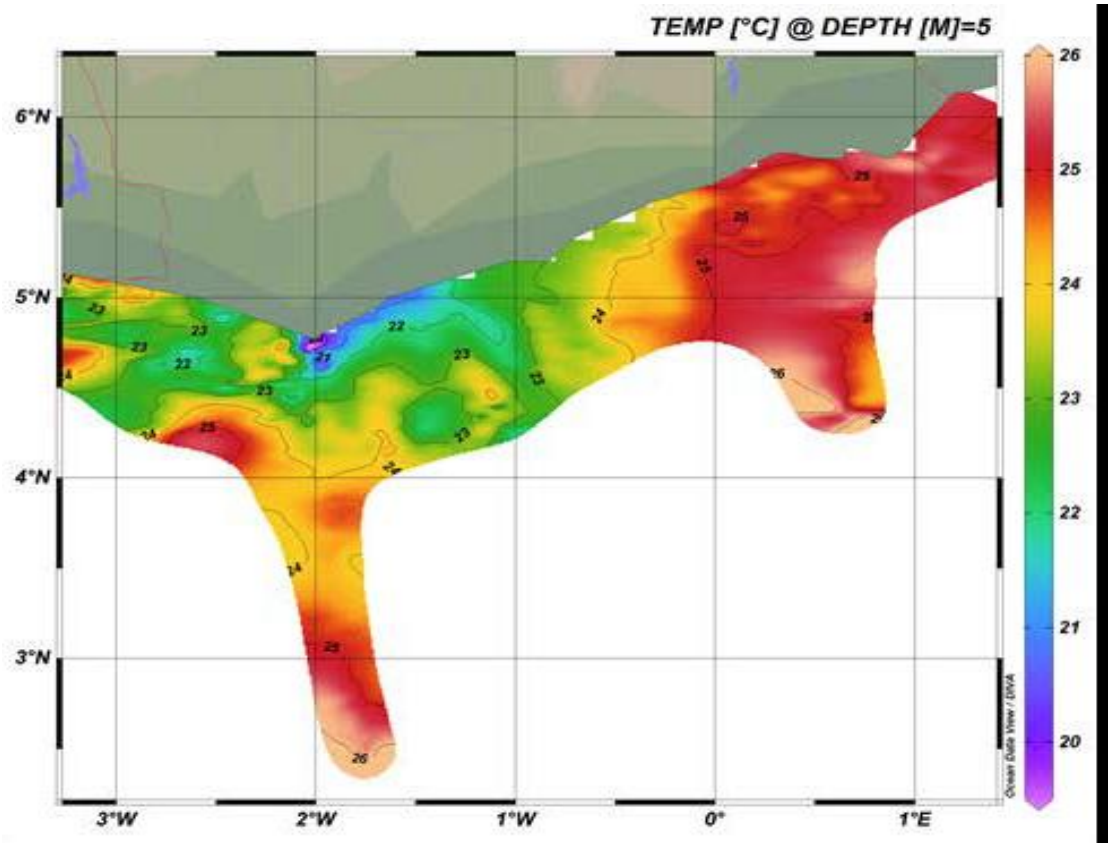


Figure 33: Horizontal distributions of temperature in surface waters at a 5m depth along the coast of Ghana.

(Source: Staby et al., 2017)

4.2 Salinity

Salinity controls buoyancy position and depth of biological factors in particular fish and plankton within water column. Salinity does not vary much and reaches it maximum (34.71‰) and minimum (33.73‰) values during the upwelling and thermal stability periods respectively. Monitoring coastal and marine salinity shows a maximum of 32.94 ‰ and 34.71‰ respectively. According to the Nansen survey 2017, salinity was above 35.8‰ almost along the entire coast as well as off Cape Three Points (Staby et al., 2017).

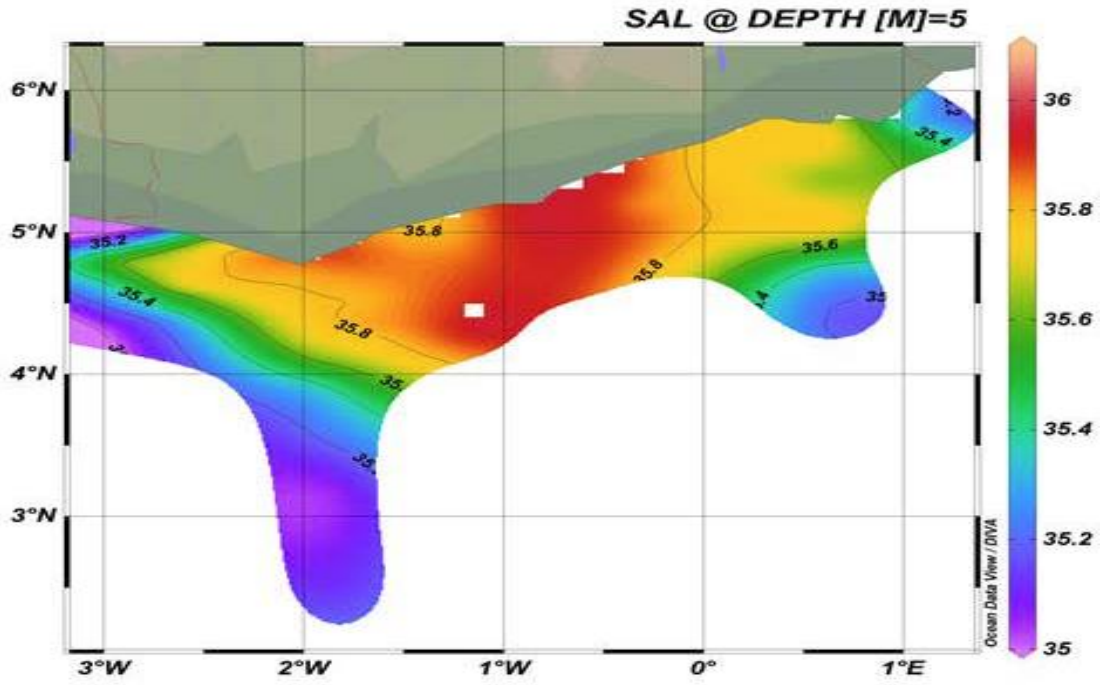


Figure 34: Horizontal Distribution of Salinity along the coast of Ghana

(Source: Staby et al., 2017)

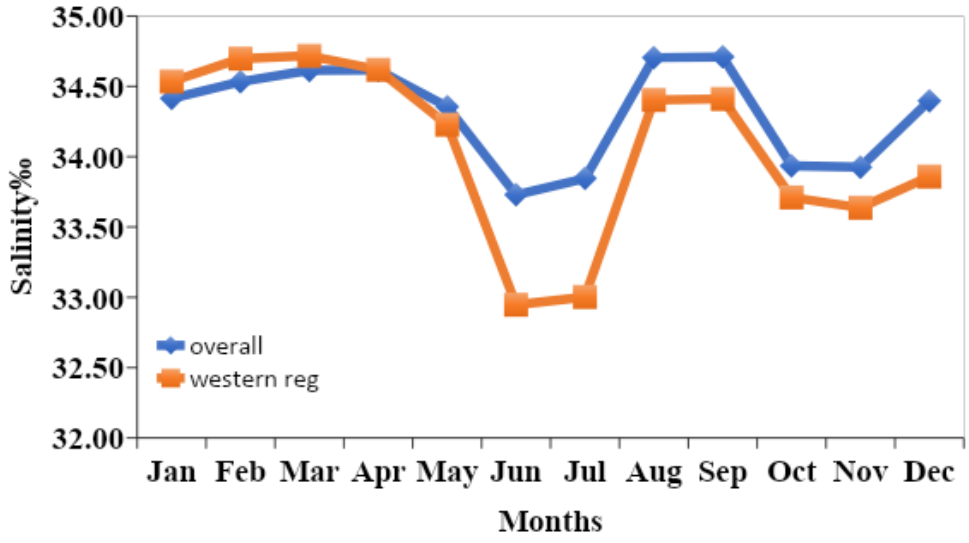


Figure 35: Monthly Salinity Variations from 2000 to 2017 along the coast of Ghana compared to that of Western Region

Source: FSSD, 2000 to 2017

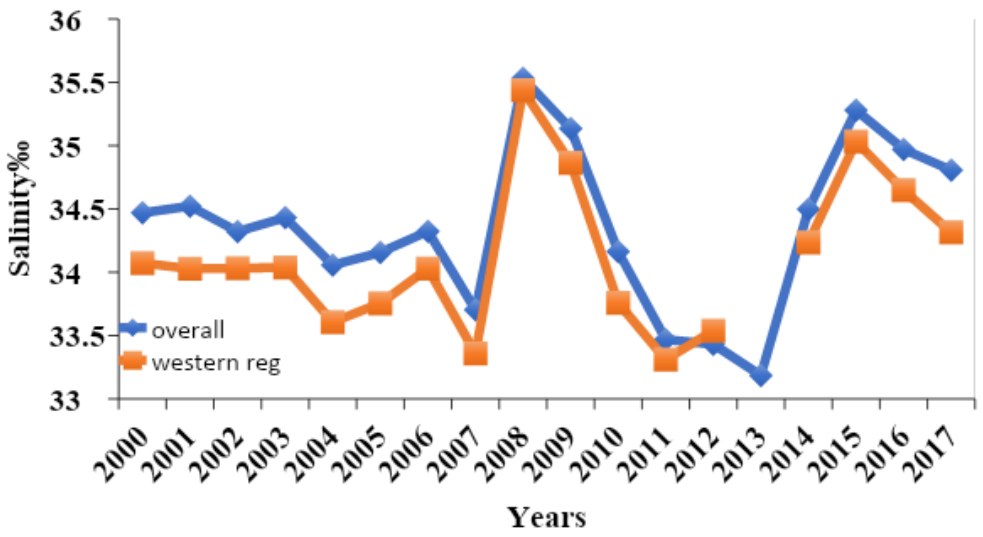


Figure 36: Annual Salinity variations from 2000 to 2017 along the coast of Ghana compared to that of Western Region

Source: FSSD, 2000 to 2017

The R/V Dr. Fridtjof Nansen Survey conducted in 2017 reported bottom salinity above 35.8‰ along the entire shelf. A layer with salinity greater 36‰ was observed further offshore at depths between 25-100m. Below 100m, salinity decreased from 35.8‰ gradually to 34.5‰ at 700-800m before increasing again to above 34.8‰ at 1300m depth (Staby et al., 2017).

4.3 Seasonal Upwelling and Productivity

Ghana's coastal and marine environment forms part of the Guinea Current Large Marine Ecosystem (GCLME) and part of the Ghana-Cote d'Ivoire upwelling system. This area is highly productive, particularly the marine waters of the Western Region of Ghana. The major upwelling period (July - September) is characterised by low temperature, high dissolved oxygen content and high salinity. This period also favours high biological production including fish and plankton. In

addition, the upwelling events sustain the small pelagics which results in seasonal and annual fluctuations in their abundance (Koranteng and MaClade, 2000).

Upwelling is affected by the movement of thermocline oscillations between 20 m and 50 m towards the surface. The duration and intensity of upwelling is measured by an upwelling index which is temperature-dependent. The overall upwelling index values range between 12 and 20 with an average value of 15.8, while that of the Western Region ranging between 9 and 20, with the average value of 14.2 (Figure 37).

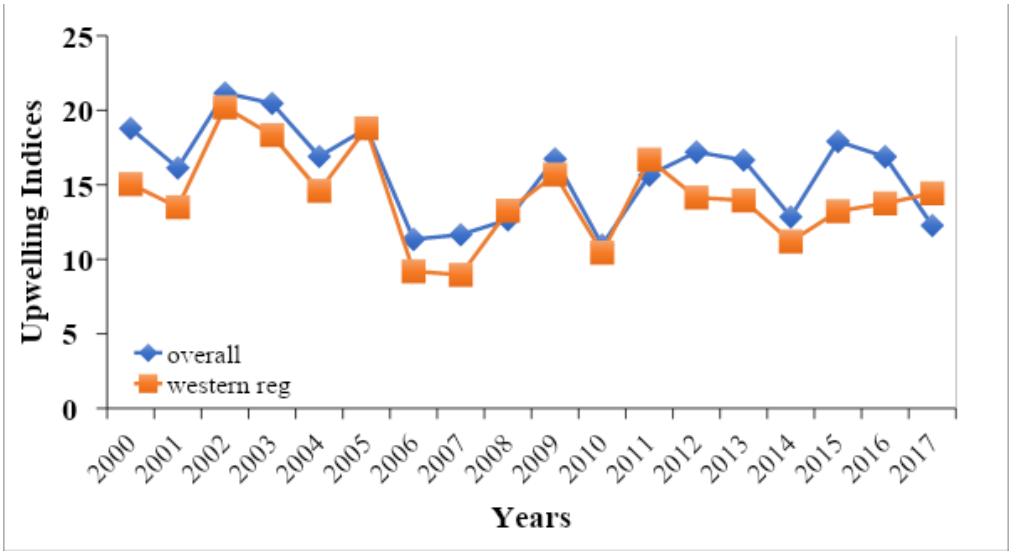


Figure 37: Upwelling Index for 2000 to 2017 along the coast of Ghana compared to that of Western Region

Source: FSSD Data Set, 2000 to 2017

Locally occurring upwelling off Cape Three Points has been reported by Staby et al. (2017). As the upwelled water is rich in nutrients, high phytoplankton abundance is usually observed during the major upwelling period, which then declines during the non-upwelling period.

4.4 Waves and Swells

The waves variation of the Gulf of Guinea are fairly similar and the coastline experiences periodic high-energy wave conditions (Sagoe-Addy and Appeaning Addo, 2013). The mean period and mean significant wave heights are 10.9 s and 1.4 m, respectively (Appeaning Addo et al., 2008; Angnuureng et al., 2013). The most common amplitude of waves in the region is about 1.0 m. Swells attaining heights of approximately 5 to 6 m infrequently occur with a 10 to 20-year periodicity. The peak wave period for the swells generally falls in the range of 7 to 14 s with the swells originating from the oceanic area around the Antarctica continent (Wiafe et al., 2013). The mean wave incidence is South-South West (SSW).

4.5 Sediment Transport Processes

Coastal sediments are derived mainly from fluvial deposits and erosion of older unconsolidated deposits exposed at the shoreline (Ly, 1980). Major rivers in the Western Region that drain into the sea are the Pra, Tano and Ankobra, with sediment discharge ranging from 117,247 m^3 to 774,173 m^3 annually (Boateng et al., 2012). These volumes are likely to increase from increasing land-based activities such as farming and illegal small-scale gold mining activities ("Galamsey"). Waves and currents constantly move sediment along and across the surf zones due to the turbulence generated by breaking waves. These, coupled with the shallowness of the bottom and type of soils which make it easier for sediment to be dislodged and results in the formation of various landforms. In addition, currents generated from wave breaking (longshore current) processes along the surf zone play a key role in the transportation of sediment along the shore, from the west to east direction some of which are deposited along beaches.

4.6 Currents

The principal current along the Ghana coastline is the Guinea Current in an eastward direction, an offshoot of the Equatorial Counter Current, driven by westward wind stress and confined to a layer of 10 to 40 m thickness (Tullow Ghana Limited, 2009). The angle of attack on the coastline is dependent on the orientation of the beach with respect to the true north. On high spatio-temporal scales, the direction of the longshore currents could change based on the morphology of the coastline (Angnuureng et al. 2019). The presence of barriers, coastal defense systems, and other features could also alter the direction of the current. The longshore currents average approximately 1 m/s and vary between 0.5 and 1.5 m/s (Allersma and Tilmans, 1993).

4.9 Tides

The tide on the coast of Ghana could be regular, semi-diurnal, or microtidal with average range of Neap and Spring tides increasing from west to east. Tidal variations are low yet could significantly modulate coastal processes (Abessolo et al., 2016; Angnuureng et al., 2018). They regulate the intensity of waves arriving on the coast. The average range recorded for Takoradi varies around 0.90 m with a Neap tide range of 0.58 m and a spring range of 1.22 m (Tullow Ghana Limited, 2009). Some communities within the study area experience regular flooding from tidal waves or storm surges and periodic overflows from lagoons, destroying properties (CRC, 2013).

4.7 Coastal Erosion

A mean erosion rate of 4.018 m/year for the period 1895-2005 has been estimated for the Western Region, with sections eroding as high as 11.64 m/year (Boye et al., 2018). The highest rates are recorded around the western section between Ankrobra Estuary and New Town, which is

predominantly sandy. The eastern section, characterized by resistant rocks interspaced with embayment, recorded lower rates of erosion (Boye et al., 2018). Figure 38 shows long term shoreline change rates of the western coast of Ghana.

Anthropogenic activities such as sand mining along the coast, urbanization, destruction of coastal vegetation has led to a considerable increase in coastal erosion. For example, the shorefront of most communities in the Ahanta West District is reported to have eroded between 50 to 200 m in the last 4-5 decades (CRC, 2010). Coastal erosion is a threat to ecosystems, including mangroves, wetlands, salt marshes and flood plains.

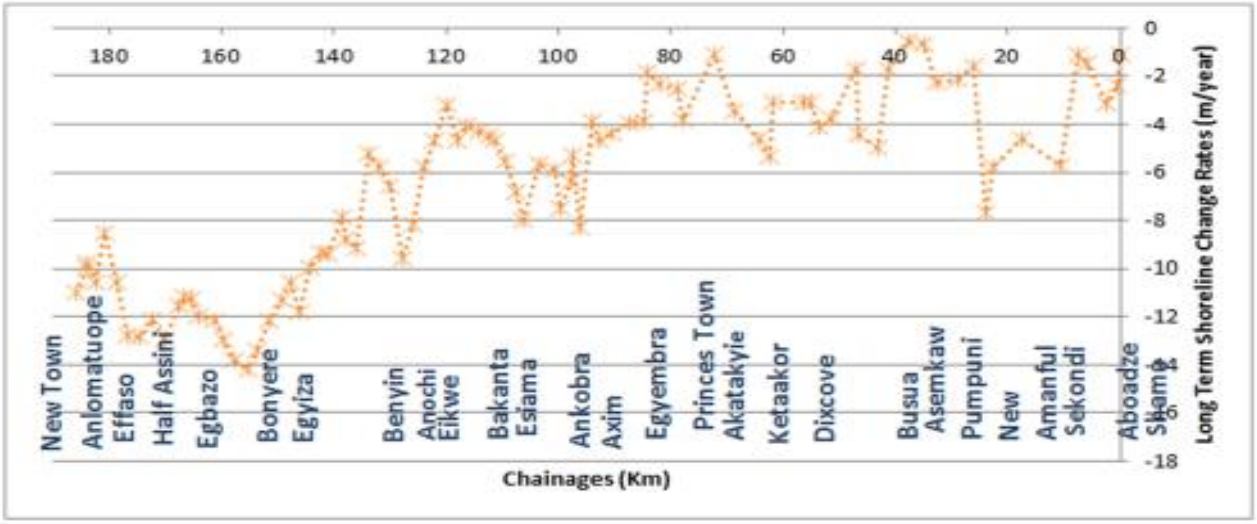


Figure 38:Long Term (1895-2005) Shoreline Change Rates along the Western Coast of Ghana

Source: Boye et al., 2018

4.8 Sea Level

Time series data of daily sea level anomaly (SLA) due to wind and pressure variations obtained from Era-Interim hindcast reanalysis range from 0 to 4mm and 0.03 to 0.1m respectively.

Atmospheric pressure variations are larger than wind effects due to the narrow shelf and winds are generally weak. An increase in pressure variation would correspond to beach advance (less erosion), while a decrease may correspond to beach erosion (Evadzi, 2017; Angnuureng et al., 2018). The sea level is rising (Figure 39) along the coast of Ghana at an estimated rate of 3.3 mm/year (Sagoe-Addy & Appeaning Addo, 2013) in tandem with the global trend (Armah et al., 2010). This is estimated to increase further (Armah et al., 2010).

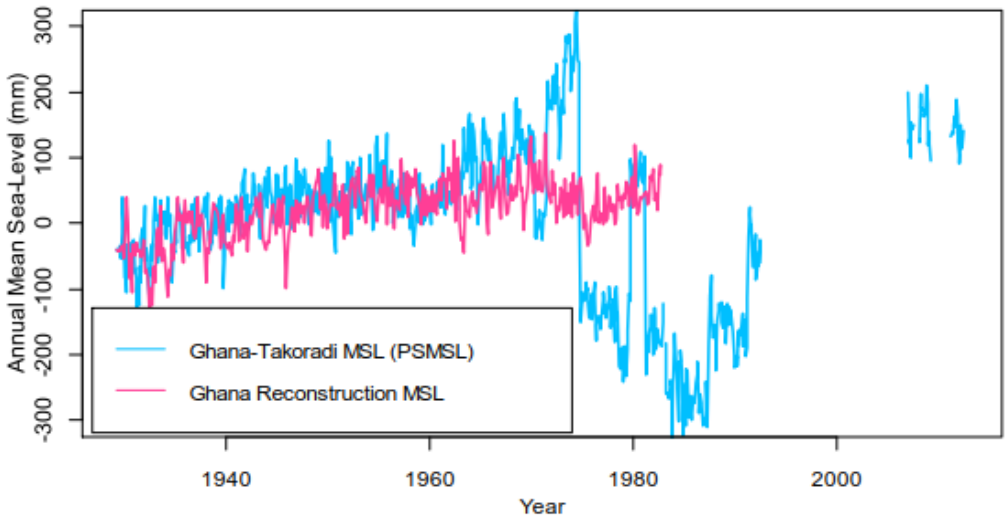


Figure 39: Sea Level trend observed at Takoradi in the Western Region – Ghana

4.9 Land-Based Nutrients Supply

Nutrients are required for the synthesis of organic matter and tend to limit primary productivity. Common limiting nutrients in coastal waters include nitrogen, phosphate and silica. High concentrations of nutrients in aquatic environments are of concern as they can cause eutrophication, a condition characterised by accelerated growth of algae and other plant forms, high turbidity and depletion of dissolved oxygen due to decaying organic matter. Nitrates and phosphates are commonly applied to agricultural fields as fertilizer and may be transported by surface runoff into the coastal environment.

Previous studies on nutrients of some water bodies of the Western Region of Ghana (Belibangara, Amansuri, Domunli, Ankobra, Kpani-Nyila and Butre) reported nitrate and phosphate concentrations in the ranges of 0.20 ± 0.05 to 2.85 ± 0.63 mg/L and 0.05 ± 0.01 to 0.36 ± 0.09 mg/L, respectively (CRC and FoN, 2011). The acceptable levels of nitrate (0.1-1 mg/L) and phosphate (0.1-1 mg/L) for aquatic life (NOAA/USEPA, 1998) were exceeded in some cases. The study also found algal blooms in the Domunli lagoon and the Amansuri estuary, which interfered with fishing activities through fouling of both fish and fishing nets.

4.10 Marine Debris

UNEP (2009) defines marine debris as “any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.” It may be derived from marine sources (e.g., shipping and fishing activities, aquaculture, and ocean dumping) or land-based sources (e.g., urban and industrialized areas, dumpsites, river discharge and littering from recreational use of the coast) (Tubau et al., 2015). Marine litter has been found to be

widespread (Barnes et al., 2009) with plastics being the predominant constituents (60 to 80%), among others, such as glass, metals and discarded fishing gears (Derraik, 2002, Van Dyke et al., 2016). Marine litter is an issue of global concern due to its adverse economic, aesthetic, human health and ecological impacts (UNEP, 2009). Although some studies have been conducted on marine litter along the eastern coast of Ghana e.g., Van Dyke et al., (2016), such detailed studies are lacking for the western coast.

4.11 Freshwater Inflow and Surface Runoff

The hydrology of the study area is driven by rivers, streams and lagoons. These include freshwater Amanzule , Tano, Ankobra, Kpani-Nyila, Butre and Whin rivers (Figure 40). These waterbodies are subject to seasonal flooding especially during the major rainy season.

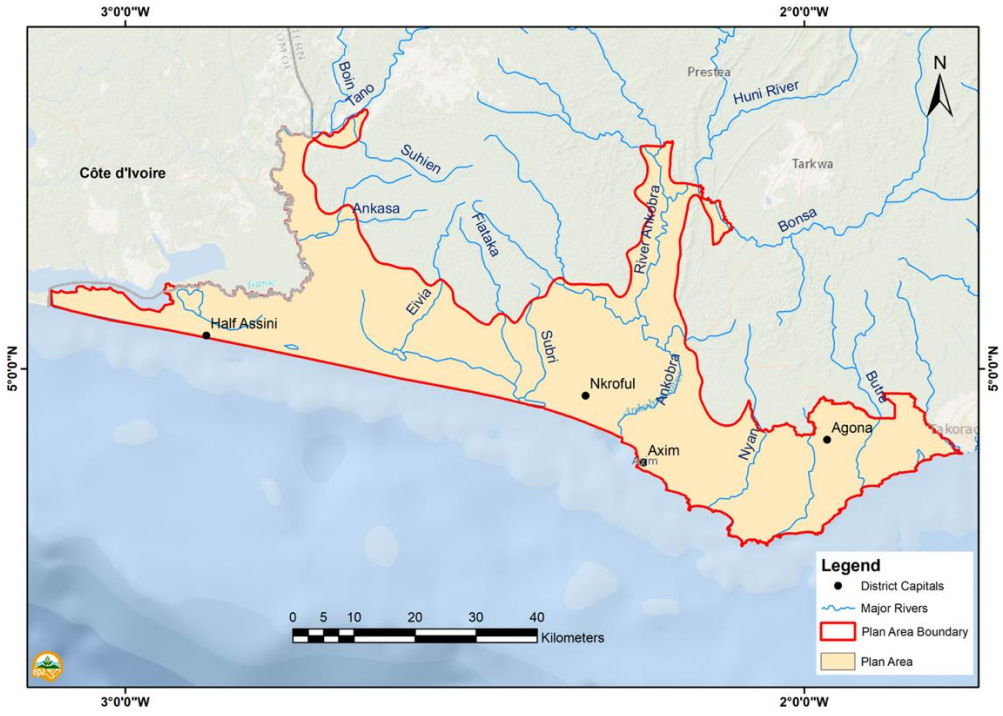


Figure 40: Major rivers in the study area.

4.11.1 Ground Water

The underlying rocks in the study area are dominated by Cenozoic and Mesozoic sediments with three aquifers, namely a shallow, sandy, unconfined aquifer (2 - 4 m deep) containing fresh meteoric water, intermediate aquifer (6 -120 m), mostly saline, and a deep limestone aquifer (120-300 m) where fresh groundwater occurs under artesian conditions (Lonrho, 2012). Recharge of the freshwater aquifer systems is by direct infiltration of precipitation through fractured highland fronts and the sandy weathered zone. In addition, saltwater infiltration occurs from the sea to create an interface at some depth, away from the coastline.

4.12 Surface Water

The largest rivers in the study area are the Ankobra and Tano, while the largest lagoons in the region are the Tano/Abby/Ehy and Domunli lagoons near Half Assini, Amanzule lagoon near Beyin and Ehunli lagoon near Princes Town. The Amanzule river flows eastwards, and drains the Amanzule wetland system and seasonally inundated areas (flooding up to 1m in the wet season).

5.0 Introduced Species and Algal Blooms

Algal blooms occur when algae grow out of control (high biomass) (Figures 33 and 34), with debilitating effects on humans, fish, marine mammals, and birds. For example, in 1993, an *Ulva clathrata* (green algae) bloom caused massive fish kills in the nearshore, estuaries, and lagoons within the Jomoro and Ellembelle Districts. (Figure 41 - 42).

Since 2011, *Sargassum species* have invaded the coastline of Ghana widely between March and October each year, with varying scale and intensity. This situation is not yet fully understood.

The invasion of both *Ulva clathrata and Sargassum species* has affected the livelihoods of fishing communities, hospitality industries and the aesthetic scenery of the beaches (EPA, 2016) (Figure 35). The *Sargassum spp.* invasion is an emerging situation is likely to worsen with time. When washed ashore, the decaying material emit offensive odour with unsightly environment (EPA, 2016). There is no known data on the impact of the bloom on the ecological function of the marine environment or near shore community structure.

Figure 41: Ulva clathrata (green algae) invasion in Jomoro & Ellembelle districts - Western Region (2010)

Figure 42: Fishermen dragging beach seine net full of Ulva clathrata (green algae) instead of fish in Jomoro and Ellembelle districts - Western Region (2010).

Figure 43: Sargassum species on the coast at Sanzule in the Ellembele District, 2020

The Tano River and Tano/Abby/Ehy Lagoon complex on the Southwestern border of Ghana with La Cote d'Ivoire has a large population of invasive water plants dominated by Water hyacinth (*Eichhornia crassipes),* the Kariba weed (*Salvinia molesta),* the Red water fern (*Azolla filliculoides),* Water lettuce (*Pistia stratiotes)* and the Hippo grass (*Vossia cuspidata).* According to a 2004 report by Ghana EPA, up to 25 km of the surface of the Ghanaian side of the Tano-Abby-Ehy River and Lagoon complex was covered by an estimated 5000 hectares of these weeds which was predicted to increase at a rate of 5 hectares per annum.

In the terrestrial environment, major invasive species such as the Trumpet tree or snakewood (*Cecropia peltata*) and Siam or Devil weed, locally known as "Akyeampong" (*Chromolaena odorata*) are now commonly found on the coast of the Western Region.

6.0 Pressures – Environmental and Socio-economic Impacts

At the Expert Elicitation workshop was held in June 2019, an assessment was conducted using the DPSIR framework. An evaluation was carried out to assess the impact of eleven (11) identified driving forces namely fisheries, shipping, ports, submarine cables and pipelines, offshore hydrocarbon, tourism and recreation, sea defence infrastructure, plantation development, sand mining, population and offshore developments (i.e., others) on the quality (state) of the marine and coastal environment within the study area. In addition, the effects of the environmental pressures on socio-economic benefits derived from the various driving forces were investigated. Summary result is presented in Figure 44.

Assessment of environmental pressures and socio-economic benefits

Component	Environmental pressure				Socio-economic benefits			
	High	Signi-ficant	Mod-erate	Low	Few/ no	Some	Signi-ficant	High
Fisheries	↙						↙	
Shipping				↙		↗		
Ports								
Submarine cables & pipelines				–				↗
Offshore hydrocarbon industries			–				↗	
Tourism & recreation			↙				↗	
Sea defense infrastructure				–				↗
Plantation development (eg. Rubber)				–			↗	
Mining (sand winning)				↙		↙		
Waste			↙		↙			
Others		↙			↙			

Legend

Grades environmental pressure	High	Significant	Moderate	Low	
Grades socio-economic benefits	Few / no	Some	Significant	High	
Recent trends	↗ Improving	– Stable	↙ Declining	? Unclear	Not available

Figure 44: Summary Results of Assessment of Environmental Pressures and Socio-Economic Benefits generated during Expert Elicitation

6.1 Fisheries

Ghana's coastal fishery is exploited by three main fleets – artisanal, semi-industrial, and industrial (including Tuna) fleets (Figure 37). The target species of the artisanal fishery are the small pelagic fish, mainly Anchovy, Sardinella, Mackerel, and some demersal fish and cephalopods. The semi-industrial fishery comprises small to medium size boats (8-37m) with inboard engines that target similar species as the canoes. The industrial fleet are licenced to fish beyond the Inshore Exclusion Zone (IEZ). They target high priced demersal fish. The tuna vessels are deep-sea faring and fish only tuna species. They use pole and line and purse seine.

Over the last two decades, annual fish production, especially the small pelagic fisheries, has declined drastically resulting from over capitalization, overfishing and illegal fishing, and to some extent climate change/global warming (MoFAD, 2021).

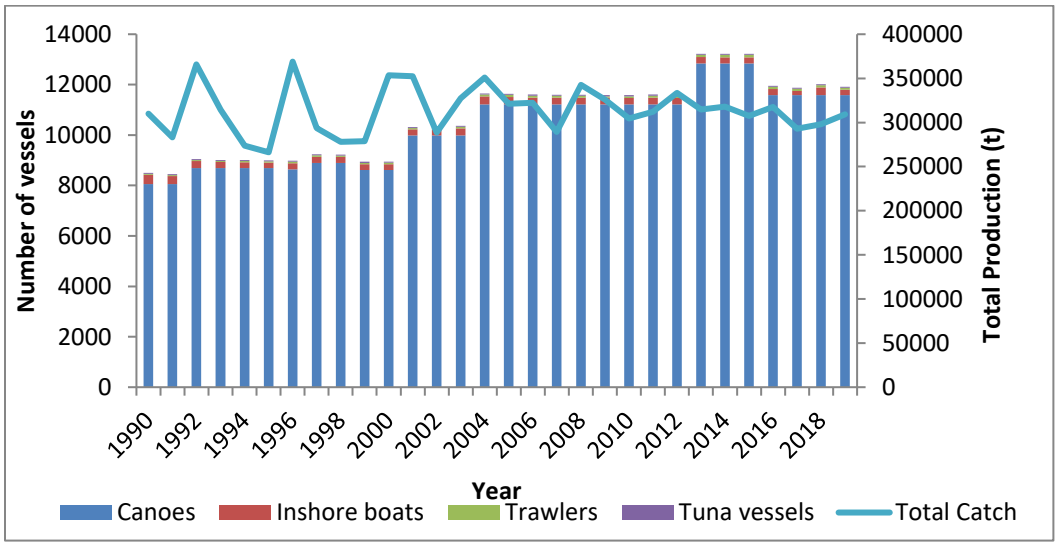


Figure 45: Evolution of the Ghanaian fishing fleet and catches from 1990 to 2018

Source: MOFAD, 2021

Examples of illegal forms of fishing include the use of high-intensity light under water to attract fish, use of monofilament nets, explosives, obnoxious chemicals and illegal trawler to canoe transshipment. Occasional incidence of algal blooms (*Enteromorpha flexuosa* - known as 'green-green') in the Ellembelle and Jomoro Districts also impact the fishery sector. Thus, the environmental pressures of the fisheries industry is high and significantly impact the socio-economic benefits derived by the population depending on the fishery for livelihood (Figure 44).

6.2 Shipping

Shipping is the major transportation system employed by coastal states, including Ghana, for international trade in essential commodities, including cocoa, manganese, bauxite, timber construction materials, and finished products. The shipping industry plays a crucial role in sustaining growth in a country's trade and commerce (Kuntoji & Rao, 2015) The discovery and production of oil and gas within the Western Region has increased vessel traffic. The increased shipping traffic (Figure 46) may contribute to the pollution load from ballast water and illegal dumping of waste into the marine environment. These could have possibly led to the introduction of invasive species. In addition, accidental oil spillage may result in tar balls deposited along the coast. These challenges pose a major risk to the marine and coastal environment as more discoveries and oil and gas fields continue.

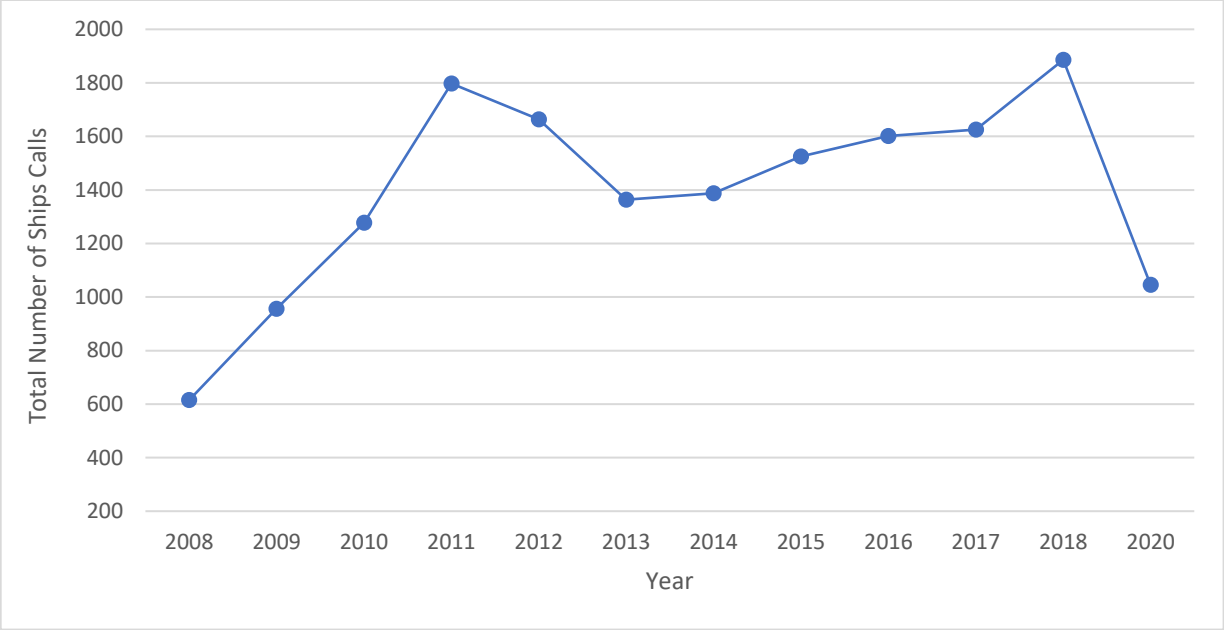


Figure 46: Ship calls at the Takoradi Port in the Western Region from 2008 to 2020

(Source: GHPA, 2021)

6.3 Offshore Oil and Gas Industries

Ghana discovered oil in commercial quantities in 2007 in the Offshore Cape Three Points in the Western Region. Oil production started in 2010 and since then, the oil industry contributed an average of 3.8% of Ghana's GDP between 2013 and 2018 (GSS, 2019). The current offshore hydrocarbon industry is made up of three (3) production fields, with a number of other wells drilled for exploration (Figure 47). The following oil and gas fields are currently producing in commercial quantities:

i. Jubilee Field, produced by Tullow Ghana Ltd;

ii. Tweneboah Enyenra Ntomme (TEN) Field produced by Tullow Ghana Ltd; and

iii. Sankofa-Gye Nyame Field produced by ENI Exploration and Production Ghana Ltd.

Oil and gas activities are noted to consume large amounts of chemicals, from drilling to production. Chemical discharges, drill cuttings, tank cleaning, oil spills, acid works and debris from subsurface works continue to pressure the quality of the marine environment. As the exploration and production activities intensify, more pollutants would be released into this environment, contributing to the pollution load and reducing the quality of the marine environment.

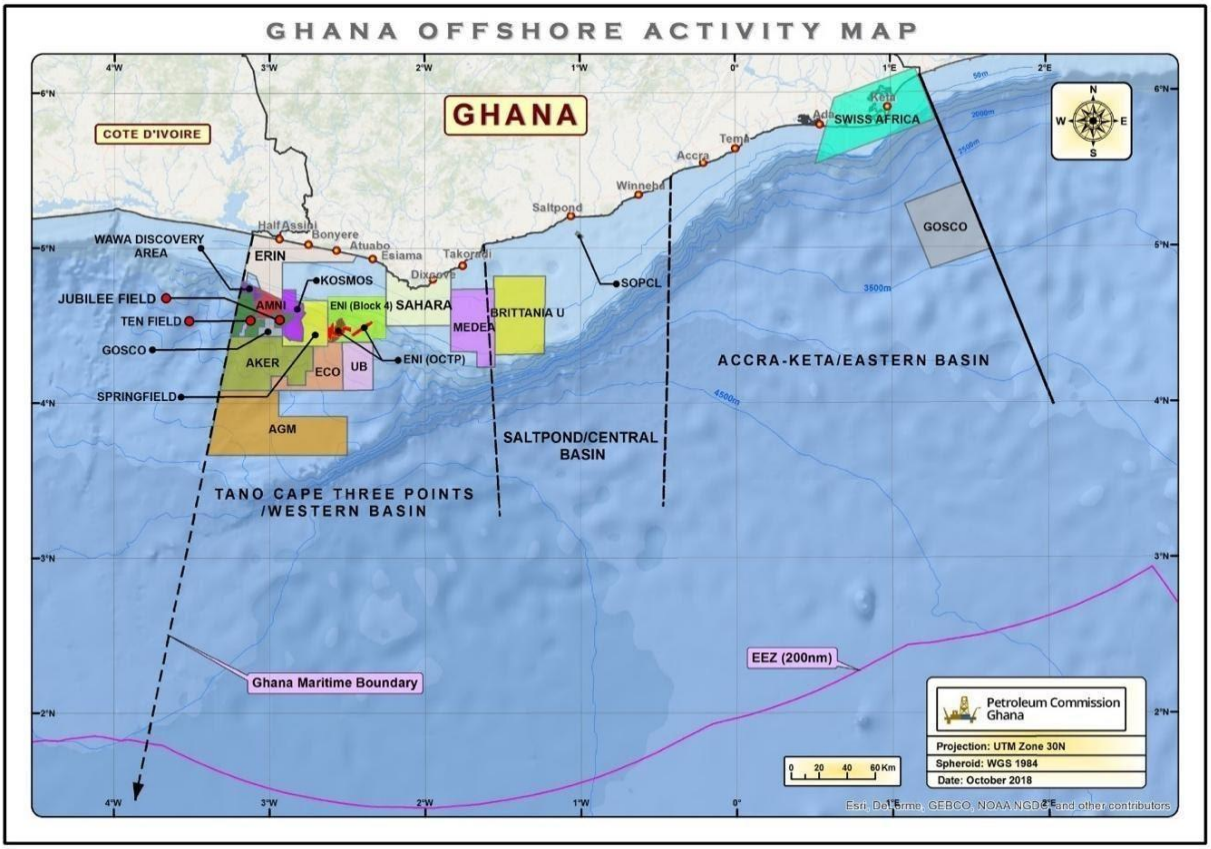


Figure 47: Ghana's offshore activity map showing the location of seventeen (17) offshore concessions in the Western Basin in red box

(Source: Petroleum Commission 2020)

6.3.1 Offshore Pipelines

Ghana's Oil and Gas discoveries has led to the development of infrastructure including construction of offshore pipelines to evacuate the gas to processing and receiving facilities onshore in the study area and beyond. Gas evacuation from offshore started in November 2014. A 20-inch diameter offshore gas export pipeline with a capacity of 120 MMScf connects offshore gas to a Gas Processing Plant – a distance of 58 km – at Atuabo in the Ellembelle District (Ghana Gas Company Limited, 2021).

The TEN Fields discovery of oil and associated gas resulted in another 29 km of 10-inch pipeline constructed from the TEN to the Jubilee Field to connect to the 58 km offshore pipeline to enable the TEN Field gas to be evacuated to shore for processing and utilization.

The Sankofa-Gye Nyame Field also has significant quantities of non-associated gas. The non-associated gas is processed on the Floating, Production, Storage and offloading (FPSO) and exported through a 63 km, 20-inch export pipeline to an Onshore Receiving Facility (ORF) at Sanzule in the Ellembelle District. The offshore pipeline and the ORF were commissioned in 2018. The capacity of the offshore pipeline is 180 MMScf. The lying on the seabed of these three (3) offshore pipelines do not release any pollutants to the marine environment. However, the potential to impede movement of creeping organisms or impact sensitive habitats for some species exists. Therefore, construction of more pipelines and underwater heavy-duty operations should be carefully managed to reduce the potential adverse impacts on the seabed.

The onshore gas processing facilities at Sanzule and Atuabo have increased vehicular traffic and human activities imposing more pressure on the coastal resources. This is expected to escalate with the anticipated increase in oil and gas activities.

6.3.2 Decommissioning of infrastructure

As offshore oil and gas structures age and become obsolete, they will require decommissioning. However, if not properly managed, decommissioning of facilities may result in adverse environmental and socio-economic impacts. Challenges associated with decommissioning will become particularly pronounced because of the deteriorating materials and associated maintenance requirements.

Policies on complete removal assume that 'leaving the seabed as you found it' represents the most environmentally friendly decommissioning options. However, some structures, including wells and associated pipelines transporting oil and gas, can develop abundant and diverse marine species communities during their production life and can support communities of regional significance (Macreadie et al., 2011). The removal of structures is unlikely to represent best environmental practice in all cases (Fowler et al., 2014). Ghana is yet to carry out any decommissioning of oil and gas structures.

6.3.3 Impacts

Potential impacts on the marine environment from oil and gas activities are generally well known and vary depending on the size, type and location of activity. Oil and gas activities in the marine

environment generally occur away from shallow-water nearshore environments. The nearshore environment is associated with processing plants and port facilities. Extraction or production activities in Ghana are currently concentrated in coastal Western Region.

There is the potential for the marine environment, including species, to be affected by oil and gas activities. Such impacts may include underwater noise from seismic surveys, support vessels, drilling or pile-driving, seabed disturbance from the physical footprint of subsea infrastructure and drilling discharges (O'Rourke & Connelly, 2003).

The extent, duration and severity of impacts vary depending on the biological sensitivities of the marine environment (O'Rourke & Connelly 2003). In many cases, impacts are highly localized (Carr et al., 1996). However, the long-term effects of many activities on the marine environment are unknown. Therefore, quantifying cumulative impacts from activities and separating these from other anthropogenic stressors continue to be challenging in the oil and gas industry.

There is also risk from hazardous events such as oil spills. Knowledge of the risks and impacts of oil spills and how to mitigate them, has increased dramatically following significant spill incidents internationally in recent years (Lubchenco et al., 2012).

Ghana has a national oil spill contingency plan which requires companies in the oil and gas industry to develop oil spill contingency plans to guide their response activities. There is, however, the need for greater investment in marine baseline studies. This will support modelling and monitoring of operational discharges and their impacts, and increase preparedness for emergency

response in the event of a spill. Currently, the oil and gas industry can be considered to have a low impact on the marine environment.

On the average, the environmental pressure from the hydrocarbon industry is low within the study area. The socio-economic benefits derived from the hydrocarbon industry are significant and will improve with time.

6.4 Solid waste disposal

The coastal districts of interest to the project are experiencing a gradual and steady population growth compared to other districts in the region. Population growth and related activities comes with increased waste generation. Waste management (collection, haulage, processing, recycling and disposal of waste materials) is a challenge to local governments due to inadequate infrastructure and financing.

The waste streams are mainly plastics and organic materials. Plastic waste comprises mainly polyethylene terephthalate (PET) bottles, polythene bags, empty water sachets, styrofoam containers and wrappers. The shift and implementation of a more convenient mode of packaging food, beverages, drinking water, and other products brought the plastic packaging revolution to replace the traditional packaging with leaf wrappers, brown paper and metal cups. However, the packaging revolution has not been correspondingly backed by an appropriate waste management system, leaving the environment littered with plastic wastes and creating unsightly scenery, public health issues and environmental problems.

The district assemblies are responsible for the management of waste in the districts and have outsourced to companies and institutions. Rapid urbanization and increased population growth have resulted in the generation of large quantities of municipal waste across major urban cities in Ghana, outstripping local authorities' ability to manage and dispose of waste in a sanitary manner (Lissah et al.,2021). Waste improperly disposed of eventually end up in the marine environment and beaches. Investigations into the death of cetaceans (whales and dolphins) on the beaches in the districts revealed plastics as a major contributing factor, as they are ingested by these animals (EPA, 2014). Large quantities of plastics are also hauled in fishermen's nets impacting their catches and sometimes destroying their nets. Increasing population and changes in lifestyles of the coastal communities with corresponding waste management issues which need to be addressed with policies and infrastructure into the next decade. Municipal wastes, especially single use plastics, impact the marine environment moderately with no socio-economic benefits

6.5 Tourism and Recreation

The coastline of the Western Region of Ghana is endowed with scenic beauty making the area one of the most attractive destinations to both local and international visitors. Some of the attractions include sandy beaches, estuaries, bird and turtle watching sites, and beach resorts.

Located on the coastline of Ahanta West, Ellembelle, Jomoro and Nzema East Districts are five (5) forts which were included among the Forts and Castles of Volta, Greater Accra, Central and Western Regions that were designated as World Heritage Site in 1979 by UNESCO. These include Forts Metal Cross (Dixcove), St. Anthony (Axim), Groß Friedrichsburg (Princess Town),

Apollonia (Beyin) and Batenstein (Butre). These forts serve as tourist destinations (Figures 48 – 51).

Figure 48: Fort Groß Friedrichsburg located at Princess Town in Ahanta West Municipal

Figure 49: Fort Metal Cross located at Dixcove in Ahanta West Municipal

Figure 50: Fort Apollonia located at Beyin – Jomoro District

Figure 51: Fort St. Anthony located at Axim, Nzema East Municipal

Also, a number of beach resorts provide attractions and services, including water sport, conferences, and spa facilities. Some of these facilities perform conservation duties by protecting turtles and have designated their facilities for turtle watching and awareness creation on the importance of turtles. The peak of turtle watching is between December and January. There is also a bird-watching at Azulenuanu at the Amanzule River estuary in Ellembelle District, where over wintering migratory birds congregate. International visitors heavily patronize these areas.

The numbers of tourism, recreation facilities and seaside residences have increased in the last decade, primarily driven by oil and gas-related activities. These tourist facilities are likely to contribute to coastal degradation and pollution through the discharge of untreated effluent, beach litter and altering coastal vegetation if their activities are not monitored effectively.

6.6 Sand mining

The Western Region boasts of beautiful sandy beaches that play vital roles in the ecological and socio-economic development of the region and the nation. However, these critical roles are being undermined by increased incidence of illegal human activities, including beach sand mining (Mensah, 1997) which is heavily patronized by the construction sector in the coastal areas of Ghana.

Although the laws of Ghana, including the Beach Obstruction Ordinance 1897 (CAP 240), Environmental Assessment Regulations 1999, LI 1652, Wetland (Ramsar Sites) Management Regulations 1999, LI1659, and Minerals and Mining Act 2006, Act 703, prohibit unauthorized mining of sand at the beaches, the problem persists.

The process of sand mining has accelerated coastal erosion in many areas and is expected to be aggravated by global climate change. As a result, the government has been compelled to commit millions of dollars to manage sea erosion through sea defence projects for long stretches of coastline. Although this initiative is commendable, it distorts the natural beauty of the coast and modifies the ecological dynamics of the beaches and the interaction between the sea and estuaries or lagoons. Sand mining also destroys nesting grounds for shorebirds and sea turtles. These species are exposed to undue risks from the removal of the sand which would eventually affect the survival of the species.

The problem of illegal sand mining may persist in the foreseeable future due to non-compliance and lack of alternatives. A typical commercial beach sand mining activity is presented in Figures 52 and 53.

Figure 52: Beach sand winning at Sunset Beach, Half Assini – Jomoro District

(EPA, 2018)

Figure 53: Beach sand mining and increased erosion at Esiama in the Ellembelle District

(EPA, 2018)

6.7 Other Pressures

6.7.1 Offshore developments

Oil and gas production involves a variety of activities that impact the marine ecosystem. The production infrastructure includes offshore platforms and export/import terminals, refineries and tankers and tanker traffic which are all imminent threat of oil pollution.

Fishermen have shown concern and agitated that the oil and gas industry was affecting their livelihoods. For instance, there is a 500 m exclusion zone around the oil rigs or floating platforms which also serve as protected areas for fish. Large shoals of fish are found around these platforms due to their high intensity lights. Also, fishermen have attributed the increased occurrences of brown algae (*Sargassum*) to oil production and claim the phenomenon was not observed prior to oil production. Another occurrence is the collision of canoes with oil and gas service vessels.

6.7.2 Population pressures

The population of the study area increased from 404,651 in 2010 to 495,230 in 2021 (GSS, 2021). This implies an increasing pressure on community infrastructure and waste management facilities and increased dependence and use of natural resources this could lead to a reduction in the coping and receptive capability of the environment.

7.0 Risks to the marine and coastal environment

7.1 Risk Assessment

Within the study area, a total of 14 potential risks were identified and assessed at an Expert Elicitation workshop held in June 2019. The assessment examined whether the risks were likely to exert a significant impact in a 5 or 50 years' timeframe (Figure 54). The assessment was based on the likelihood of the occurrence and the consequence for the marine and coastal environment within the four target districts.

The risks identified include climate change, oil and gas production, loading and transportation of crude oil, pollution, overfishing and illegal fishing as significant risks to the marine and coastal environment within 5 years. Furthermore, algal bloom, coastal development, pollution from coastal non-point source, mining and tourism were identified as moderate to low risk within the 5-year period. Risk factors relating to algal bloom, eutrophication, mining, oil and gas and tourism, were assessed to increase from moderate to the significant risk category over the 50-year timeframe. Over the same period, coastal development is expected to increase from moderate to high significant risk.

Group	Risk factor	Risk in 5 years				Risk in 50 years			
		High	Signi-ficant	Mod-erate	Low	High	Signi-ficant	Mod-erate	Low
Fishing	Illegal fishing continues unchecked		☒			☒			
Oil and gas	Exploration well blowout and spill			☒			☒		
Loading and transportation of crude oil	Tanker accidents, rupture of transfer hose, ship collision, Bunkering, cargo tank explosion, FPSO Hull damage, Turret leak and oil spills		☒			☒			
Coastal erosion	Coastal erosion will continue	☒				☒			
Climate Change	Sea level rise will cause inundation		☒				☒		
Pollution	Pollution as it relates to food safety		☒				☒		
Tourism	Tourism causes environmental damage			☒			☒		
Mining	Siltation of estuaries and coastal waterways from mineral mining			☒			☒		
Algal blooms	Harmful Algal Blooms (HAB) impacting water quality and fisheries			☒			☒		
Eutrophication from coastal non-point sources	Pollution will affect the marine environment			☒			☒		
Port facilities	Port facilities will cause environmental damage				☒			☒	
Fishing	Overfishing		☒			☒			
Pollution	Pollution from thermal plants will lead to environmental damage				☒		☒		
Coastal Development	Loss of biodiversity would continue and lead to environmental change due to industrialisation, introduction of invasive species, population increase and urbanisation			☒		☒			
Ballast water	Introduction of pollutants and invasive species				☒			☒	

Legend

Risk value	☒
Risk grades	High
	Significant
	Moderate
	Low

Figure 54: Summary Risk Assessment Results For 5- and 50-Year Timeframe generated during Expert Elicitation

7.2 Water Quality

Monitoring reports on coastal waters of the Western Region showed coastal water quality to be generally good. However, the quality could deteriorate if anthropogenic activities such as illegal mining ("galamsey") (Figure 55), improper disposal of municipal and domestic wastes are not efficiently managed. This calls for the enforcement of existing laws, promotion of waste segregation at source and employment of appropriate schemes for final disposal of waste.

Figure 55: A section of the Ankobra River showing degraded water quality as a result of illegal mining within the catchment

(EPA, 2020)

7.3 Mangroves

Deforestation has been reported to account for the loss of about 70% of Ghana's mangrove forest (lIED, 1992). Mangroves are exploited mainly for fuelwood (firewood, charcoal, wood for fish smoking), construction materials (timber, beams and poles, fence posts, thatch), fishing ("atidza"), and are also cleared for industrial (salt) and agricultural (aquaculture) developments (Nunoo and Agyekumhene, 2014). A survey by Sackey et al., (1993) indicated that over-harvesting and pollution from industrial and domestic wastes are responsible for the poor state of the mangrove forest in Ghana. Armah (2006) also reported the conversion of mangrove stands into agricultural lands and salt pans, as well as the expansion of towns and villages as major sources of destructive threats to mangroves in Ghana. Disruptions to natural flow of rivers (dams, dykes, and sea defense walls, etc.) deprive wetlands downstream of their normal hydrological dynamics and potentially affect mangroves along the watercourse.

Along the western coast of Ghana, mangrove and other resources such as fish, oysters and crabs are exploited by fringe communities. Over-exploitation has resulted in mangrove stands being at the secondary or tertiary development stage (Ayensu et al., 1996). Pollution from direct dumping of waste has also resulted in the degradation of mangrove vegetation in the target area.

7.3.1 Management of Mangroves in Ghana

The Wildlife laws of Ghana provides a management framework for mangrove habitats in protected areas. Unfortunately, there are no protected areas in the project area. The *National Wetlands Conservation Strategy* promotes the participation of stakeholders from local communities in the sound management of mangrove resources. The Environment Impact Assessment Regulation 1999

(L.I. 1652) also protects mangroves and associated resources. Furthermore, traditional practices including taboos and customary laws exist to protect mangroves. The Ghana Wildlife Division and Non-Governmental Organisations such such Hen Mpoano (NGOs) have undertaken restoration and sensitization activities to conserve and protect the mangrove in the project area.

7.4 Coastal Development

The discovery of oil in the Western Region has led to the development of a variety of infrastructure within the study area, especially hotels, resorts, and guest houses. There have been reclamations of wetlands in some areas for the construction of oil and gas related infrastructure. The risk associated with coastal development was ranked as moderate and expected to increase to high in the next 50 years.

7.5 Coastal Erosion

Coastal erosion is one of the identified risk factors within the project area. Anthropogenic activities such as sand mining and construction of beach front facilities have led to increased erosion in the area. The risk of coastal erosion was ranked as high for both 5- and 50-years' timeframe.

7.6 Marine Debris

Marine debris on the beaches of the four districts was dominated by plastic waste from land-based sources. These are impacting negatively on marine life and coastal tourism.

7.7 Invasive Alien Species

Increase in invasive species along the coast of the Western Region has been attributed to untreated ballast water discharge. Ghana is a signatory to the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which requires ships to manage their ballast water to remove aquatic organisms and pathogens or render them harmless before release at a new location. This is aimed at preventing the spread of invasive species and potentially harmful pathogens. The risk of invasive species spreading was ranked as low in a 5-year period and moderate in a 50-year perspective.

7.8 Petroleum and Other Resources

The risk of oil and gas exploration and its associated activities such as loading and transporting crude oil and natural gas was ranked as significant and expected to increase to high within the next 50 years. To manage the oil and gas industry in Ghana, the regulators have put in place frameworks, such as the development of environmental impact assessment and oil spill contingency plans by oil and gas companies to address some of the foreseen risks.

7.9 Climate Change

The impacts of climate change experienced in Ghana include long periods of drought, erratic rainfall patterns, increase in sea surface temperatures and rising sea level. These have implications for important sectors such as the fisheries, agriculture, water, health, energy, and tourism. With an average reduction in rainfall amounts, freshwater resources will also be affected which could lead to water stress and impacts on coastal habitats. Assessment of ocean temperatures shows that the ocean surface has generally been warming (Rhein et al., 2013), which could impact ocean upwelling and productivity with implication for fish catch. Projections for the West Africa region

shows substantial decline in annual fish catch and about 50% decline in fisheries related jobs. Total annual loss in revenue is estimated to be over US$300 million in the region (Lam et al., 2012). The already eroding coastline will be affected by increasing sea level. The risk of climate change was ranked as significant.

8. Conclusions

- This report is a study that assessed the conditions and quality of the marine and coastal environment in four out of the six coastal districts of the Western Region of Ghana, namely, Ahanta West, Ellembelle, Nzema East, and Jomoro districts.

- Environmental pressures identified include fisheries, coastal erosion, sand winning, sea defence infrastructure, shipping, submarine cables and pipeline installations, offshore hydrocarbon exploitation, plantation development, tourism and recreation, and waste generation and disposal (marine debris and plastics).

- Generally, habitats within the study area were found to be in good condition. However, the quality is on the decline due to human activities that negatively impact the habitat conditions, and reducing the ability for such habitats to continually provide ecosystem benefits.

- The environmental pressures of the fisheries industry is high and significantly impact the socio-economic benefits derived by the population depending on the fishery for livelihood.

- On the average, the environmental pressure from the hydrocarbon industry, submarine cables and pipelines, sea defense infrastructure, plantation (rubber) development is low within the study area. However, the socio-economic benefits derived are significant and will improve with time.

- Wastes, especially single use plastics, impact the marine environment moderately with no socio-economic benefits.

- Three species of mangroves; red (*Rhizophora species*), white (*Avicennia species*), and black (*Laguncularia species*) are found in the study area, with the red mangroves being the most dominant and the black, the least, in terms of coverage.

- Mangrove resources in the target area are declining, mainly due to overharvesting and habitat conversion.

- Although five species of sea turtles are reported in the study area, only three - Leatherback, Green and Olive Ridley turtles presently nest on the sandy beaches. The remaining two species, i.e., Loggerhead and Hawksbill turtles have been reported and occasionally entangled in the nets of fishermen. Sea turtles provide tourism value in the study area but their numbers are threatened by poaching, egg collection, sea defence structures and beach sand mining.

- The discovery and production of oil and gas has enhanced rapid development in all sectors of the economy in the western corridor of Ghana.

- Sargassum species (*Sargassum natans* and *Sargassum fluitans*) are occasionally observed in large volumes on the shores of the west coast leading to significant fouling of the beaches and fishing nets.

9.0 Recommendations

The recommendations from the study are grouped into seven sections and presented in the table below:

Table 18: Recommendations

Recommendations	Action/Programme/Initiative	Responsible Institution(s)/Agencies	Timeframe
1. Monitoring and Promoting Applied Research	• Set up mechanisms to monitor and manage the occurrence of invasive seaweed, *Sargassum* and *Ulva* species especially in the coastal waters. • There should be a study to explore the possibility of using the algae for organic compost, briquette, etc.	**Lead:** • Environmental Protection Agency **Support:** • Fisheries Commission • Ghana Immigration Services • Academia • Council for Scientific and Industrial Research - Water Research Institute • Ghana Navy • Ghana Maritime Authority • Non-Governmental Organisations/Community Based Organisations • Traditional Authorities • Communities • District Assemblies	Short (0-2yrs.)
	• Monitor the spread of invasive water plants, namely water hyacinth (*Eichhornia crassipes)*, Kariba weed (*Salvinia molesta)* and Water lettuce (*Pistia stratiotes) Hippo grass (Viossa cusbidata*) and continuously introduce their biological control agents to keep them under control.	**Lead:** • Environmental Protection Agency **Support:** • Academia • Council for Scientific and Industrial Research - Water Research Institute • Non-Governmental Organisations/Community Based Organisations • Fisheries Commission • Water Resources Commission • Communities	Short (0-2yrs.)

Recommendations	Action/Programme/Initiative	Responsible Institution(s)/Agencies	Timeframe
	• Conduct further research on the impact of climatic change and global warming on fisheries.	• District Assemblies • Fisheries Commission • Academia • NGOs/CBOs • Coastal Communities • District Assemblies	Long (5-10 yrs.) Continuous
	• Conduct regular monitoring and collect data on coastal morphodynamics for management purposes.	• Academia • Environmental Protection Agency • CSIR - Water Research Institute, • Non-Governmental Organisations/Community Based Organisations • Water Resources Commission • Hydrological Services Department • District Assemblies	
2. Sustainable Financing	• Source for funds both in-country and externally to support recommended actions.	**Lead:** Government of Ghana **Supporting** • Municipal, District Assemblies • Environmental Protection Agency • Academia • Council for Scientific and Industrial Research - Water Research Institute • Non-Governmental Organisations/Community Based Organisations • Fisheries Commission • Water Resources Commission • Development Partners	Short (0-2yrs) Continuous
3. Sustainable natural resource utilisation	Develop capacity building plans to provide alternative livelihood and assist coastal communities to reduce their direct dependence on the natural resources.	• Environmental Protection Agency • District Assemblies • Non-Governmental Organisations/Community Based Organisations • Development Partners • Academia	Medium (3-5yrs. continues)

Recommendations	Action/Programme/Initiative	Responsible Institution(s)/Agencies	Timeframe
4. Conservation Education	Create public awareness and behavioral change on the importance of natural resources and the need for conservation	• **Lead:** Environmental Protection Agency, Ghana Education Service **Support:** • Academia • Fisheries Commission • Forestry Commission • Non-Governmental Organisations/Community Based Organnisations	Short – Long Term (0-10 yrs. continues)
5. Enforcement and Management	Designate Greater Amanzule wetland as a gazetted protected area to increase its protection level.	• Forestry Commission • District Assemblies • Environmental Protection Agency • Attorney Generals Department • Marine Police Unit – Ghana Police Services • Traditional Authorities • Non-Governmental Organisations/Community Based Organnisations	Short – Long Term (0-10 yrs; continues)
	Restore degraded mangrove and other natural resource areas to enhance their ecological integrity.	**Lead:** • Forestry Commission • Municipal, District Assemblies • Environmental Protection Agency **Supporting:** • Non-Governmental Organisations • Community-Based Fisheries Management Committees	Short (0-10 yrs.; continues)
	Prohibit sand mining activities on the beaches to reduce sediment loss.	• Municipal, District Assembles, • Minerals Commission • Environmental Protection Agency • Ghana Police Services	Short – (0-2yrs. recurrent)
	Strengthen traditional norms and taboos to support national regulations.	• Traditional Authorities • District Assembly • Environmental Protection Agency • Ghana Education Service	Short (0-10 yrs. continues)

Recommendations	Action/Programme/Initiative	Responsible Institution(s)/Agencies	Timeframe
		• Ghana Police Services	
	Infrastructure should be put in place to Waste Management	**Lead:** • Municipal, District Assembles **Support:** All relevant institutions	
6. Strengthening existing institutions to carry out their mandate	Build the capacity of relevant institutions technically, financially, and logistically to enhance their regulatory functions.	• Fisheries Commission • Municipal, District Assembles • Environmental Protection Agency • Academia • Wildlife Division – Forestry Commission	Short – Medium Term (0-2 yrs. continues)
	Encourage the establishment of Community Fisheries Management Committees and ensure sustainable management of fishery resources.	**Lead:** • Fisheries Commission **Support:** • Municipal, District Assembles, • NGO	Medium Term (continues)
	Design and deploy flood early warning systems to reduce the impacts caused by flooding on some coastal communities.	• Municipal, District Assemblies, • Environmental Protection Agency • Academia • Hydrological Services Department • National Disaster Management Orgranisation • Media • Ghana Meteorological Authority	Meduim – Long
7. Ocean Governance	• Developing and adopting an Integrated Marine/Ocean Policy for the country. • Adopting the use of Marine Spatial Planning. • Assessing the State of the Marine Environment. • Adopting a Blue Economy approach to Ocean Governance. • Identifying and designating Marine Protected Areas (MPAs).	• All relevant stakeholders	Medium – Long Term (continues)

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11.0 Appendix I

Summary: Issues raised by Stakeholders during various Consultation

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
22 - 24 January 2019	Start-up/inception workshop for SoME Working Group.	Institute of Environmental Studies, Amasaman – Ghana.		▪ Coastal erosion, ▪ Illegal unregulated unreported (IUU) fishing ▪ Mangrove degradation ▪ Offshore hydrocarbon exploitation ▪ Over fishing ▪ Plantation development ▪ Sand winning ▪ Sea defence infrastructure ▪ Shipping, ▪ Submarine cables and pipeline installations ▪ Tourism and recreation ▪ Use of unapproved fishing methods Waste generation and disposal (marine debris and plastics).		• Issues raised would be used for assessment using the DPSIR Framework & Expert Elicitation.
15 April, 2019	STMA	Regional Minister's Office Sekondi – Takoradi	Hon. Kwabena Okyere Darko-Mensah	• Reasons for selecting 4 districts out of the 7 coastal	• The project was being piloted & funds are limited	• Liaise with LUPSA Head Office to

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
		Metropolitan Assembly.	Regional Minister including the Hon. Eugenia Kusi Deputy Minister and Chief Director	districts as the coastline or marine environment is interconnected. • Moreover, the discovery of oil is along the entire western region. Therefore, all the districts should be considered as effects of pollution would not be restricted to the selected districts. • The specific role of the Regional Coordinating Council. • Reasons for omitting the Regional Land Use & Spatial Planning Authority (LUSPA) Representative from the visiting Team. • The extent of decentralization of the Environmental Protection Agency (EPA) permitting procedures.	and therefore the essence of the selection of the four districts. • The team acknowledged the need to include the Regional LUSPA to be co-opted to the working group particularly for activities to be undertaken in Western Region. • The decentralization is ongoing, and some level of assessments and permits are granted in the region.	include the regional representative.
16 April, 2019	Jomoro Municipal	Jomoro Municipal Assembly - Half Assini – Western Region.	Municipal Coordinating Director and other Departmental Heads	• Assured the Team of their support for the implementation of pilot project and the admonished all		

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				relevant stakeholders to provide information for the successful implementation of the project.		
			Fishermen & Fishmongers	• The spokesperson for the group expressed their displeasure that some stakeholders such as the Semi-Industrial & industrial fishing groups should be consulted & involved since they must also observe and comply with the Marine Spatial Plan to ensure marine resources are protected. • The problem with dwindling fisheries resources is a result of laxity in the enforcement of fisheries laws in comparison with that of the enforcement in Cote D'Ivoire. • The sea floor is the habitat for vital resources, and that	• All stakeholders would be involved in the project, and each has unique and valuable information that would be necessary for the project. • Enforcement is the duty of all and sundry & not a specific institution, and that drive for the country is to educate and promote voluntary compliance. • Notwithstanding the above enforcement is ongoing though with known challenges.	• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure voluntary compliance.

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				trawling destroys these resources.		
16 April, 2019	Ellembelle	Nkroful	Municipal Coordinating Director & other Departmental Heads	• Pledged their support for the successful implementation of the project & encouraged all relevant stakeholders to provide information.		
16 April, 2019	Ellembelle	Nkroful	Fishermen & Fishmongers	• The challenge with dwindling fisheries stocks as a result of laxity in the enforcement of fisheries laws in comparison with that of the enforcement in Cote D'Ivoire • Illegal Small-Scale Gold Mining ("Galamsey)" has adversely affected water quality at estuarine & mangrove areas which has affect the spawning sites and inadvertently contribute to dwindling fish stocks of some species (i.e., "kanan").	• Enforcement is the duty of all and sundry and not a specific institution, and that drive for the country is to educate and promote voluntary compliance. Notwithstanding the above enforcement is ongoing though with known challenges • The fight against "galamsey" is continuing, and we all hope to overcome this menace. • The closed season for fisheries sector has been	• Liaise with Fisheries Commission to establish the historical trends in fishing along with the main communities within the four districts. • Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure voluntary compliance.

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				• Illegal fishing methods have also affected the sustainability of the fishing industry. • Consideration of the timing of the closed season should be linked to the fishing expedition of the communities. For example, the Sardinella species abundance and harvest occurred in April at Brewire in the Ahanta West, the Ankobra area in July and then Half Assini in September. Therefore, a general close season would not yield the right results.	discussed with various stakeholders to come up with the date.	
	Ellembelle	Atuabo	Traditional Authority (Awulae Amihere Kpanyinli III - Eastern Nzema Traditional Area)	• Main pressures at the coastal area have been sand winning & coastal erosion leading to millions of cedis for construction of sea defence. • Need for traditional authorities to be	• Agency would collaborate with the Assembly and Traditional authorities to prevent coastal sand winning which might contribute to coastal erosion in by proposing	• Liaise with the Wildlife Division and other stakeholders to ascertain the nature and importance of birds at Ampain.

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				given a backed legal role to ensure the protection of the coastal and marine environment. • Lack of alternative sites inland that could be used as sand winning sites for the communities. • Non enforcement of laws on coastal sand winning. • Intention to reserve an area at "Ampain" for the protection of migratory birds.	alternative area burrow pits inland	• Increase awareness on coastal sand winning
		Benyin	Traditional Authority (Awulae Annor Adjae III – Western Nzema Traditional Area)	• The knowledge of fisheries has been available and having a project to collate now seem to suggest there are external pressures to push for such an agenda rather than from the institutions. • The increased interest (including the oil and gas development) in the marine environment seems	• The project is supported by the Abidjan Convention and was a result of project proposals submitted and accepted by the Abidjan Convention. • Countries benefitting from the support include Ghana Benin & Cote D'Ivoire.	• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure compliance

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				to restrict the fishing activities. • The need to establish plans to ensure oil and gas production becomes complementary to the fishing industry. • The "Nzulezu" and adjoining wetlands serve as spawning grounds and have been preserved over the years. • Illegal activities of trawlers & other industrial and semi-industrial fleets have contributed to the decline in fishery stocks. • Innovative approaches to stimulate fisheries resources are capital intensive and cannot be afforded by the ordinary fisherman. • Fish cultured under aquaculture is perceived to have some features such as taste and nutrition.	• The essence of the project is to document ecologically and or biologically significant or important or sensitive areas to inform policies. • Due to the international dimension of the project government would favourably consider the adoption of the document. • Efforts are being made to include all relevant stakeholders in the process. • Enforcement of fisheries laws is ongoing though with known challenges	

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				• The government should consider supporting fishermen particularly during the closed season. • Formal education should not be used as an alternative to sustainable fishing. For example, there is an incentive (scholarships) drive for the youth to be educated to shift from fishing to other career paths and thereby to ignore the factors adversely affecting the fishing industries. • Fishing industry's employment transcends coastal communities up the northern regions looking at the mid and downstream activities. • The connection between government policies and the project; i.e., how the team could convince the government to		

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				adopt the document to be generated).		
17 April 2019	Nzema East Municipal Assembly	Nsein	Traditional Authority (Awulae Agyefi Kwame II – Nsein Traditional Area)	• Lack of inspection of fish & gears both at sea & at landing sites. • Inadequate (low) staff strength of Fisheries Commission leads to illegal fishing activities as fishermen go to sea without any form of supervision. • Decentralization of employment for that native who has a worth of experience can help to ensure compliance of fisheries laws. • Evaluation & testing laboratories should be constructed to complement efforts of enforcement as done in Cote D'Ivoire. • Activities of industrial & semi-industrial fleets should be checked	• The various institutions would collaborate to create awareness on sustainable development	• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure compliance

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				to comply with the existing laws. • Need for education on the effect of plastic pollution on the marine environment. • Attitudinal change of stakeholders required to save our fishing industries. • Consultation with the various traditional councils offer good time & opportunities for members to be part of the project		
	Nzema East Municipal Assembly	Axim	Municipal Coordinating Director and other Departmental Heads	• Support the team by encouraging all relevant stakeholders to provide information for the successful implementation of the project		
	Nzema East Municipal Assembly	Axim	Lower Axim Traditional Authority (Awulae Attribrukusu III – Lower Axim Traditional Area)	• Mining operations affecting the water quality of the Ankobra and fishing stocks. • The closed season (for the fishery sector) is		• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				important and must be observed to sustain the fishing industry. • Attitudinal change of stakeholders required to save our fishing industries. • The need to integrate traditional and legal strategies to enforce fisheries laws.		ensure compliance
	Nzema East Municipal Assembly	Axim	Fishermen & Fishmongers	• The essence of the closed season as the focus is on only the sardinella species. (Since the trade and fishing of tuna and other species are global perspectives). The duration of the closed season is too short as it may be not contributing to the rejuvenation of the fish stock. • Laxity in the enforcement of fisheries laws affecting sustainable fishing. • Light fishing is a serious threat to sustainable fishing.		• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure compliance

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				• Activities of industrial and semi-industrial fleets should be checked to comply with the existing laws. • Mining operations affecting the water quality of the Ankobra and fishing stocks.		
17 April 2021	Ahanta West Municipal Assembly	Agona Nkwanta	Municipal Coordinating Director and other Departmental Heads	• Support the team by encouraging all relevant stakeholders to provide information for the successful implementation of the project. • Timelines for key activities should be provided for planning.	• The team would work out the schedules for further consultation, and each stakeholder would be communicated to the Assemblies in due course.	
17 April 2021	Ahanta West Municipal Assembly	Dixcove	Lower Dixcove Traditional Authorities (Nana Kwesi Agyeman IX - Discove Traditional Area)	• The critical nature of the fishing industry to employment and standard of living within the coastal communities. • Illegal fishing methods and laxity in enforcement leading to the collapse of the fishing industry.		• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure compliance.

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				• Development of alternative livelihood programme should be considered as long-term investment & oil and gas companies should have a least a 10 to 20-year plan to achieve the desired results. • The government should provide Compensation/subsidies and/ or logistical support due to the high cost of fishing.		
	Ahanta West Municipal Assembly	Dixcove	Fishermen & Fishmongers	• Illegal fishing methods & inadequate enforcement of fisheries laws & supervision of Fisheries Commission had led to the collapse of the fishing industry. • Destruction of bottom dwellers (resources) as a result of pair trawling. • Need for the establishment of	• Enforcement is the duty of all and sundry and not a specific institution, and that drive for the country is to educate and promote voluntary compliance. • Notwithstanding the above enforcement is ongoing though with known challenges	• Fisheries Commission should devise strategies to enforce the laws to win the trust of fisherfolks to ensure compliance • Liaise with Fisheries Commission to establish the resources (flora and fauna) within Butre and Meamia

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				monitoring & patrol teams at sea. • The marine section between Butre to Meamia is endowed with resources essential for the survival of the fishing industry & should be protected. • Improper disposal of waste upstream of lagoons inland has adversely affected fish & other marine fauna when such waste reaches the sea.		
June 24 - 28 2019	N/A	City Escape Hotel, Airport Residential Area - Accra		• Coastal erosion, • Illegal unregulated unreported (IUU) fishing • Mangrove degradation • Offshore hydrocarbon exploitation, • Over fishing, • Plantation development, • Sand winning, • Sea defence infrastructure, • Shipping,	•	•

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
				• Submarine cables and pipeline installations, • Tourism and recreation, • Use of unapproved fishing methods. • Waste generation and disposal (marine debris and plastics).		
4 December 2019	Stakeholder validation workshop Consulted: *Municipal Coordinating Director & Other Departmental Heads*	Takoradi - Western Region.		•	•	•
5 December 2019	Stakeholder validation workshop	Takoradi - Western Region.	Stakeholder validation workshop **Stakeholders Consulted:** ▪ *Awulae Agyei Kwame II (Nsein Traditional Area).* ▪ *Nana Kwesi Agyeman IX Traditional Area & Lower Dixcove* ▪ *Nana Kofi Bentil*	•	• Coastal erosion, • Illegal unregulated unreported (IUU) fishing • Mangrove degradation • Offshore hydrocarbon exploitation, • Over fishing, • Plantation development, • Sand winning, • Sea defence infrastructure, • Shipping,	•

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
			Awulae Attibrukusu III of Lower Axim Traditional Area. ▪ Awulae Annor Adjaye III - Western Nzema Traditional Council ▪ Awulku Amihere Kpanyuli - Eastern Nzema Traditional Council ▪ Obaahema Akyeba ▪ *Konkohema Abelena* **Representative from the following institutions:** ▪ *Western Regional Coordinating Council* ▪ *Ahanta West Municipal Assembly* ▪ *Centre for Coastal Management,*		• Submarine cables and pipeline installations, • Tourism and recreation, • Use of unapproved fishing methods. • Waste generation and disposal (marine debris and plastics).	

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
			University of Cape Coast ▪ *Dept of Marine & Fisheries Science – University of Ghana* ▪ *Development Planning Unit* ▪ *Environmental Protection Agency* ▪ *Fisheries Commission* ▪ *Fishermen & Fishmongers from the 4 project districts.* ▪ *Friends of the Nations* ▪ *Ghana Canoe Fishermen Council - Axim* ▪ *Ghana Canoe Fishermen Council - Jomoro* ▪ *Ghana Canoe Fishermen Council – Ellembelle* ▪ *Ghana Maritime Authority*			

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
			▪ *Ghana Navy* ▪ *Ghana Police Services (Marine Police)* ▪ *Ghana Ports & Harbours Authority* ▪ *Ghana Wildlife Society* ▪ *Institute of Environment & Sanitation Studies - UG* ▪ *Land Use and Spatial Planning Authority* ▪ *Land Use Spatial Planning Area* ▪ *Ministry of Environment, Science, Technology & Innovation* ▪ *Petroleum Commission* ▪ *Physical Planning Department* ▪ *R.B.A WRU* ▪ *Ghanaian Times* ▪ *TV3/Connect FM*			

Date	District	Location	Stakeholders Consulted	Key Issues Raised	Response	Actions
			▪ *Radio 360* ▪ *Empire FM*			

Measuring the State of the Oceans and Coasts:

Guidelines for the Production of State of Marine Environment Assessments and Reports Based on Expert Elicitation

A background paper by GRID-Arendal

1. Background

It is fundamental to marine environmental management that states have the capacity to assess and monitor the condition and trend of coastal and marine ecosystems within their jurisdiction. Undertaking integrated assessments can be expensive and time consuming, but sound information is critical to understand the State of the Marine Environment (SOME) to underpin decision-making and achieve or maintain ocean health. Most importantly, large-scale integrated assessments must not be overly biased by information that is limited only to places or issues that are well studied, since this might result in outcomes that are not balanced or properly represent conditions across the whole of the area assessed.

Further, SOME assessments are a critical data source used by global assessments like the UN World Ocean Assessment (www.worldoceanassessment.org), or large regional assessments like the ones produced under the umbrella of UNEP's Regional Seas Programme.

In order to support the production of the first global ocean assessment a series of regional workshops have been conducted over the last 2 years to identify relevant assessments, regional experts and capacity gaps. At the workshops for the SE Asian Seas (Sanya City, China), the Caribbean (Miami, USA), Western Indian Ocean (Maputo, Mozambique), the South Atlantic (Abidjan, Côte d'Ivoire) and recently the Eastern Indian Ocean (Chennai, India), experts from developing states have articulated that, while there is no scarcity of marine environmental experts, the capability to undertake SOME assessments and reports is a major gap due to both the lack of systematic monitoring data and proficiency in environmental reporting.

With the intention of exploring options to bridge this gap, regional and national pilot capacity-building workshops have been held in Bangkok, Thailand, Sept. 2012 (Ward, 2012; Feary et al., 2014); Abidjan, Côte d'Ivoire, Oct. 2013; and in Freetown, Sierra Leone, Feb. 2014. The purpose of the workshops was threefold: i) to expose national or regional experts to the expert elicitation methodology; ii) to produce an initial expert elicitation assessment of the national or regional target areas; and iii) test the potential of the EE methodology and process for the production of SOME reports.

The process and methodology described in this paper is largely based upon the Australian SOME process and report developed in 2011 (State of the Environment 2011 Committee, 2011; Ward et al., 2014) and we acknowledge the authors of that report for a significant portion of the content presented below. The experience and lessons learnt from the pilot workshops have been used to optimize the process and the methodology to better match the needs and challenges raised by the experts from developing states participating in the World Ocean Assessment process and encountered during and after the workshops and the production of the actual reports. This paper is intended to provide background information for individuals or agencies interested in learning more about the Marine Environment Expert Elicitation (SOME-EE) process, its advantages and disadvantages and the steps necessary in order to complete a SOME report. It also provides background and guidelines for experts who are intending to participate in a SOME-EE workshop; it explains the underlying concepts and the approach followed during the workshop so that experts can be prepared to fully participate at an optimum level of engagement.

2. The SOME Report Production Process

The expert elicitation methodology is essentially a scientific consensus methodology, aimed at generating an assessment of any chosen parameters by synthesising information available in existing assessments, scientific publications and data in conjunction with the subjective judgment of experts across a broad base of evidence related to those parameters. The method has been applied successfully in a range of situations, including the 2011 Australian SOME Report (State of the Environment 2011 Committee, 2011), and has the advantages that it is cost- and time-effective, it utilizes the existing knowledge of marine experts from the target region and it can incorporate non-conventional knowledge and information.

In the absence of comprehensive regional or national indicator datasets, the SOME-EE process uses consultation with national and regional experts to gauge expert opinion about the condition of the marine and coastal ecosystems and dependent socio-economic sectors. There are commonly datasets from local areas, and there are many sub-regional scale studies and short-term datasets about various aspects of marine ecosystems, but these have often a too coarse resolution and are not part of a systematic collection of data and knowledge routinely synthesised for reporting purposes. The SOME-EE process draws upon these disparate datasets and the knowledge-base dispersed across a broad range of sources and institutions to capture a representative sample of existing expert knowledge about the condition of the national or regional marine and coastal environment in a manner that can be used for reporting purposes.

The ultimate success in the production and the legitimacy of a report ensuing from an expert elicitation process depends on the thoroughness of the steps leading to and after the elicitation has been carried out. An ideal procedure should include the following steps but of course this should be revised to ensure it matches the needs and constraints of the state or region for which the report is being produced (Fig. 1):

1. Identification of National Experts and Stakeholders: This step begins with the Identification and charting of the national and/or regional public and private bodies, agencies and organizations that, in addition to the one with the mandate of producing the report ("the reporting agency"), deal with the major aspects of marine and coastal environment research, monitoring, management and regulation ("the stakeholders"). In principle the steps following the stakeholder mapping should

try to involve a representative fraction of the experts engaged by those bodies, agencies and organizations as this will improve the quality of the assessment and ensure the report holds a legitimate basis for decision-making. The reporting agency should announce the initiation of the report production process and invite the relevant stakeholders to participate in the process through the nomination of experts. The expert nomination should be confirmed by the reporting agency together with clarification on the mode and roles of involvement of the experts having due regard to time and budgetary constraints. An editorial board/committee for the report should be appointed by the reporting agency at this stage. This step is critical because if the experts invited are not representative of all aspects of the marine environment, or if they are skewed in number towards one particular discipline (eg. biology), then the assessment will be biased. In most cases a minimum representation of each of the key discipline areas (eg. ecology, biology, fisheries, physical sciences and socioeconomics) will be needed. Experts representing the full range of marine sectors are needed to produce a rigorous assessment. Upon acceptance, each participant should be provided with detailed background information on the assessment process.

2. Relevant information identification and compilation: The reporting agency, with the support of the experts nominated, should initiate the identification and collation of relevant information (publications, scientific papers, databases and data sets) and make it electronically available to all experts involved.

3. Expert review of the assessment themes and parameters: A suggested structure for the assessment built around a set of themes and parameters is included below. Of course, not all may apply directly to a particular region, but they provide a guide for the design of the assessment to

be carried out. Experts will be requested to review and make suggestions on the parameters for condition, threats and risk, and the elicitation procedures. They will also review the collated relevant information and suggest additions.

4. Expert Elicitation assessment: The EE assessment is carried out during a workshop or series of workshops, attended by the appointed experts. The scores assigned to the parameters (as described below) are recorded during the workshop. Notes are taken by a rapporteur on the discussion and the details of relevant reports, papers or other documents are recorded. The interaction and discussions during the workshop/s should allow the editorial board to identify potential authors to participate in the subsequent report-writing phase of the process.

5. Report drafting: The scores of the assessment parameters and any details are compiled, analyzed by the reporting agency and provided in a concise and organized way to the editorial committee. These are distributed to the different author/s appointed for the different themes/chapters who are tasked with producing draft chapters based on the outcomes of the EE assessment and any generic introductory insight they may want to bring in. The editorial committee should also produce text for any introductory chapters describing the scope, approach, process and methodology used to produce the report. The editorial committee should then compile and edit a first draft with focus on completeness and evenness of the different sections of the report.

6. Report reviewed, revised and published: Once the first draft is compiled by the Editorial Committee it should be circulated to all the experts involved in the EE assessment and writing of the report in order to be thoroughly reviewed. This review exercise could be done remotely but the

organization of a validation workshop could bring added value as it would provide the editorial committee a good sense of the overall endorsement of the whole of the report by the experts that have contributed to its production. Next, peer reviewed by an independent, geographically diverse, group of experts that have not been involved in its production is carried out and the report is revised by the authors taking into account the reviewers' comments. The peer-reviewed, final version of the report may go through technical edition, graphic design and layout processes prior to publication.

This whole process may differ in duration depending on the natural and political heterogeneity of the assessment area, the number of experts to be used for the assessment and the specific steps chosen from the ones suggested above. A reasonable duration would normally be between 6 and 18 months.

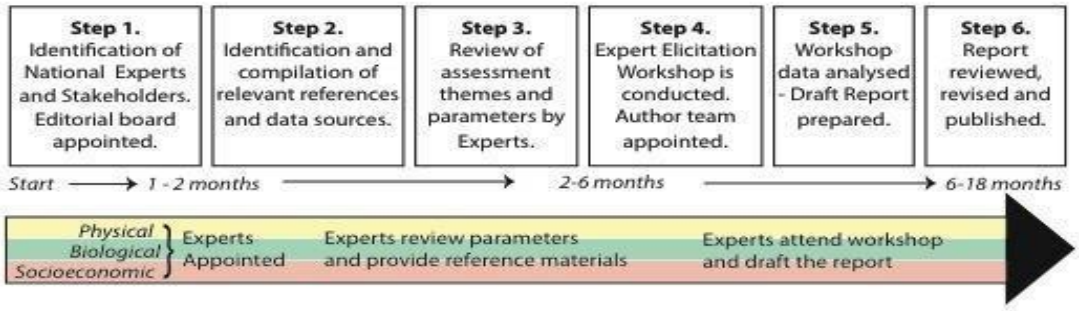

Figure 1. Diagram illustrating the time-line for one complete cycle of the SOME-EE process. Between 6 and 18 months are needed to plan and execute the process.

3. The SOME Assessment Expert Elicitation Method

3.1. Assessment Framework

The United Nations World Ocean Assessment (www.worldoceanassessment.org) uses the Drivers-Pressures-State-Impacts-Response (DPSIR) framework (Fig. 2) as a basis on which to build its structure and organize its content. The DPSIR, in turn, clearly identifies the place of assessment of environmental condition (the State) within a broad management framework. The purpose of SOME assessments is to fulfill the need of measuring the "State" and the "Impacts" in order to design new government policy "Responses" as well as to gauge the effectiveness of those already implemented.

The DPSIR framework suggests at least three possible approaches for structuring any SOME assessment: i) Pressures; ii) Habitats; and iii) Ecosystem Services.

Using pressures to structure an assessment has the advantages that the associated human activities are commonly linked with data collection and reporting structures for regulatory compliance purposes. For instance, permits that are issued for offshore oil and gas development require specific monitoring and reporting obligations be met by operators. Pressures are linked to socioeconomic benefits that states derive from marine based industries and the inclusion of socioeconomic aspects is a key component of the World Ocean Assessment.

Using marine habitats to structure an assessment has the advantage that habitat is the property that inherently integrates many ecosystem features, including higher and lower trophic level species, water quality, oceanographic conditions and many types of

anthropogenic pressures. The cumulative aspect of multiple pressures affecting the same habitat, that is often lost in sector-based environmental reporting, is captured by using habitats as reporting and assessment units.

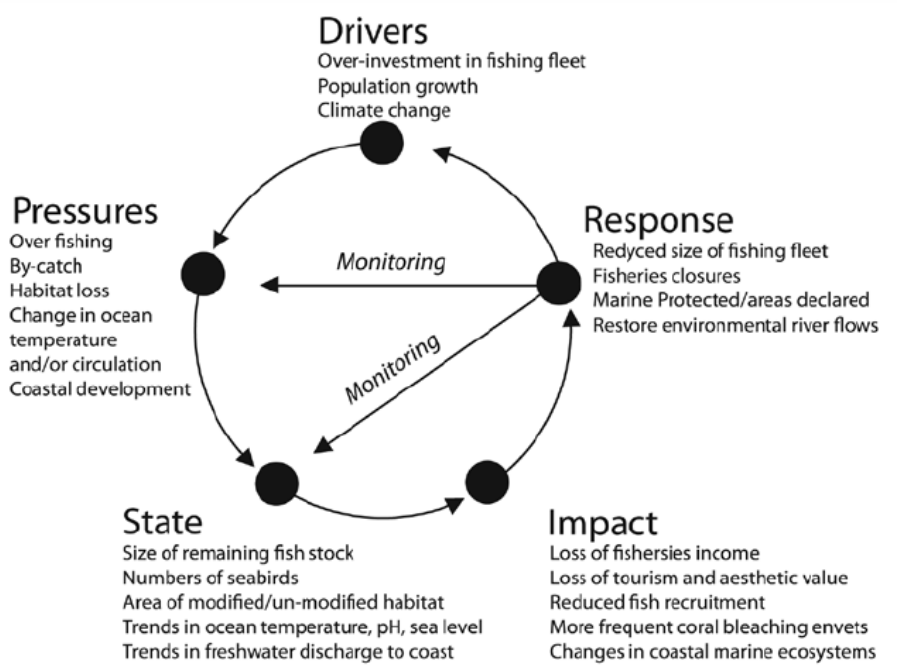

Figure 2. Drivers-Pressures-State-Impact-Response (DPSIR) Framework as used by the UN World Ocean Assessment in relation to the ocean environment. Drivers result in Pressures that have an effect on the State of the environment (the assessment of which is the purpose of SOME reporting). The implementation of monitoring is required to gauge the effectiveness of policy Responses.

Using ecosystem services to structure an assessment follows the approach of the Millennium Ecosystem Assessment. This has the key advantage of broad acceptance in environmental reporting. It includes provisioning services (food, construction materials, renewable energy, coastal protection) while highlighting regulating services and quality-of-life services that are not captured using a pressures or habitats approach to structure the assessment.

Given that all three approaches have their own particular advantages, all three approaches should be included in the structure of SOME Assessments as far as possible.

3.2. Assessment Parameters

Based on the approach adopted by the UN World Ocean Assessment, the present SOME-EE process will use the following condition parameters for the condition assessment: habitats and the species they support, ecosystem processes (and services) including physical and chemical processes, pressures and socioeconomic benefits.

Most condition parameters used in the SOME-EE process are the same between all assessments, regardless of country or region, because they are common to all marine environments. For example, the habitats that most assessments will need to consider include estuaries, bays, beaches, intertidal flats, etc. Many regions already have programs in place to monitor specific environmental indicators (see review by Johnson et al., 2013) that can provide input to the assessment and identify parameters for scoring. Other parameters can be added if they are viewed as being of particular importance to a given region. Using a standard set of parameters that have been widely considered in other regions enables direct comparisons to be made and eliminates any bias (or the appearance of bias) in the choice of parameters; for example, where a list of parameters might appear heavily slanted towards those that are at risk in a particular region from a particular pressure.

Parameters may be chosen from any level of the natural biophysical and taxonomic hierarchy of ecosystems and biodiversity of the region under consideration. However, participants should recognise that SOME reporting is of necessity a broad overview process. Each parameter will be the focus of an assessment, and so each parameter should be relevant to (or an important part of) the region as a whole.

In addition to the condition assessment, the SOME assessment also includes an assessment of the risks (risks assessment) faced by the components/parameters assessed. Risks are identified impending threats to the condition of the components/parameters assessed here. The risks are assessed over both short (5 year) and long (50 year) timescales.

3.3. Grading System

Grading scores for condition assessment

During the assessment workshop, scores will be assigned by the expert participants to each condition parameter on a scale from 1 to 8, where 1 is consistent with the poorest state of condition of the grading criterion, and 8 is the highest level. Scores are assigned on the basis of group consensus. Based on the scores agreed by the experts, four grades are derived as follows: 1 to 2 = Very Poor, 3 to 4 = Poor, 5 to 6 = Good and 7 to 8 = Very Good.

GRID-Arendal has created a web-based system to facilitate the capture and display of scores for the different parameters discussed here (see Appendix 1). The web site allows for the real-time capture and display of data (scores for parameters, confidence, risks) during the workshop and provides a template for the production of a State of the Marine Environment Report.

Grading statements

A key part of the process is developing and applying a set of grading statements that have been uniquely derived for each major aspect of the assessment to represent the four grades of condition (Very Poor, Poor, Good, Very Good). Grading statements provide guidance to inform the experts about the thresholds they should use in determining a score. They are general, descriptive terms of the spatial extent, temporal extent, and magnitude of improvement or decline in condition of the parameters in relation to the selected benchmark (i.e. how to assess pressures, socioeconomic benefits, habitats, species, ecosystem processes, physical and chemical processes both in terms of condition and spatially). Each statement is associated with a range of numeric scores to guide the experts in reaching an agreed score for the parameter in question.

Confidence estimates

Each score is also assigned a confidence estimate (High, Medium or Low) based on the expert's current state of knowledge and judgement. In general terms, a high level of confidence implies that there are published peer-reviewed papers or refereed reports that support the scores attributed to the parameter in question. A medium level of confidence may be based on one or more expert's knowledge of unpublished data, un-refereed reports or other information. A low confidence score is given where the experts agree to assign a score based mainly on expert opinion and inference.

3.4. Benchmarks

In forming judgements about the condition of any parameter, a "benchmark" (a point of reference for the condition) is needed. Ideally, the benchmark is the condition of the parameter prior to the

time when human impacts started to occur. In practice, benchmarks are mainly chosen for convenience and to represent times when data are available.

"Ideal" benchmarks will vary greatly from one part of the world to another; it may be the time of European settlement in one place, or before the Roman Empire in another. Humans may have had significant impacts on some ecosystems prior to the "benchmark" time and impacts may have accumulated gradually over a long time period afterwards. Where it is difficult to identify an appropriate benchmark we recommend that the year 1900 be used. This date (1900) has the advantage that most scientific observations of the marine environment are subsequent to it.

The use of a benchmark should not be confused with an objective for management; it is not the purpose of the SOME-EE process to make recommendations on national marine environmental goals or polices. The establishment of a benchmark is only for the purpose of quantifying environmental change relative to the present time.

4. Condition assessment

In the assessment workshop, grading scores are given for three aspects of each condition parameter: 1) the condition in the worst-impacted 10% of the region under consideration; 2) the condition in the least-impacted 10% of the region under consideration; and 3) the condition in most (the remaining 80%) of the region under consideration. The scores are given based on pre-agreed condition-specific grading statements.

The logic of selecting "10%" of an area for best and worst scores is justified for several reasons. Firstly, an area of 10% of the region under consideration has a higher predictive power than extreme examples of small spatial extent for detecting and/or resolving significant changes created by human activities. By looking at the worst and the best 10% of the region, both ends of the gradient are assessed, providing two independent measures and thereby constraining the "most" (80%) to a score within the identified range.

In addition to giving scores and confidence estimates, the experts will next judge the recent trend in each parameter as declining, stable or improving. The trends are assessed only for the last 5 years (and not in relation to the benchmark). The reason for this is to provide policy- and decision-makers with feedback on how policy responses have or have not had the desired effect. The choice of 5 years is based on the typical recurrence interval of SOME reporting in many states and also because it is unlikely that measurable differences in condition could be detected in less than 5 years following policy changes implemented by government. A confidence estimate is also assigned to trends agreed by the experts (High, Medium, Low).

4.1 Habitats

To score habitats, experts will follow these steps:

Estimate a consensus score for the condition of habitats in the Best 10% and Worst 10% of the habitat (eg. relative to 1900). Score both the area and condition of habitat; for example if it is estimated that 10% of the area of habitat has been destroyed since the benchmark date then the Worst 10% of that habitat will have a score of 1. Conversely, if 100% of the habitat area is in the

same (pristine) condition that prevailed in relation to the benchmark, then the Worst 10% of that habitat will have a score of 8.

Estimate a consensus score for the condition of the habitats in Most areas of the habitat (eg. relative to 1900).

Assign a confidence grade for the each of the condition estimates (High, Medium, Low).

Estimate the trends for each of Best 10%, Worst 10%, Most (Improving, Declining, Stable) over the last 5 years.

Assign a confidence grade for the each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of the condition and trends of each habitat.

Habitats	Grading statements for habitats that occur in the state and/or region under consideration.
Very Good (7-8)	The habitat type is essentially structurally and functionally intact and able to support all dependent species
Good (5-6)	There is some habitat loss or alteration in some small areas, leading to minimal degradation but no persistent substantial effects on populations of dependent species
Poor (3-4)	Habitat loss or alteration has occurred in a number of areas, leading to persistent substantial effects on populations of some dependent species
Very Poor (1-2)	There is widespread habitat loss or alteration, leading to persistent substantial effects on many populations of dependent species

4.2 Species

To score species, experts will follow these steps:

Estimate a consensus score for the condition of populations of the species in the Best 10% and Worst 10% of places where they occur (eg. relative to 1900). Score both the area and condition of species; for example if it is estimated that the species is no longer found in 10% or more of its rage relative to the benchmark date, then the Worst 10% of that species will have a score of 1.

Estimate a consensus score for the condition of the species in Most areas of the habitat (eg. relative to 1900).

Assign a confidence grade for each of the condition estimates (High, Medium, Low).

Estimate the trends for each of Best 10%, Worst 10%, Most (Improving, Declining, Stable) over the last 5 years.

Assign a confidence grade for each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of the condition and trends of each the species.

Species	Grading statements for different species assessed, given what is best understood about their status and trends expressed in terms of populations and groups of species including threatened, endangered or protected species.
Very Good (7-8)	Only a few, if any, species populations have declined as a result of human activities or declining environmental conditions

Good (5-6)	Populations of a number of significant species but no species groups have declined significantly as a result of human activities or declining environmental conditions
Poor (3-4)	Populations of many species or some species groups have declined significantly as a result of human activities or declining environmental conditions
Very Poor (1-2)	Populations of a large number of species or species groups have declined significantly as a result of human activities or declining environmental conditions

4.3 Ecological processes

To score ecological processes, experts will follow these steps:

Estimate a consensus score for the condition of ecological processes in the Best 10% and Worst 10% of the habitat (eg. relative to 1900). Score both the area and condition of ecological processes; for example if it is estimated that human activities have caused the ecological processes to no longer occur in 10% or more of the places where it did occur relative to the benchmark date, then the Worst 10% of that ecological process will have a score of 1.

Estimate a consensus score for the condition of the ecological process in Most areas (eg. relative to 1900).

Assign a confidence grade for each of the condition estimates (High, Medium, Low).

Estimate the trends for each of Best 10%, Worst 10%, Most (Improving, Declining, Stable) over the last 5 years.

Assign a Confidence grade for each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of the condition and trends of each the ecological processes.

Ecological Processes	Grading statements for the main ecological processes, and affects from human activities
Very Good (7-8)	There are no significant changes in ecological processes or ecosystem services as a result of human activities
Good (5-6)	There are some significant changes in ecological processes as a result of human activities in some areas, but these are not to the extent that they are significantly affecting ecosystem functions
Poor (3-4)	There are substantial changes in ecological processes as a result of human activities, and these are significantly affecting ecosystem functions in some areas
Very Poor (1-2)	There are substantial changes in ecological processes across a wide area of the region as a result of human activities, and ecosystem function is seriously affected in much of the region

4.4 Physical and chemical processes

To score physical and chemical processes, experts will follow these steps:

Estimate a consensus score for the condition of physical and chemical processes in the Best 10% and Worst 10% of the habitat (eg. relative to 1900). Score both the area and condition of physical and chemical processes; for example if it is estimated that human activities have caused the

physical and chemical process to no longer occur in 10% of the places where it did occur relative to the benchmark date, then the Worst 10% of that physical and chemical process will have a score of 1.

Estimate a consensus score for the condition of the physical and chemical process in Most areas (eg. relative to 1900).

Assign a confidence grade for the each of the condition estimates (High, Medium, Low).

Estimate the trends for each of Best 10%, Worst 10%, Most (Improving, Declining, Stable) over the last 5 years.

Assign a confidence grade for the each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of the condition and trends of each the physical and chemical processes.

Physical and Chemical Processes	Grading statements for the main physical processes as modified by human activities
Very Good (7-8)	There are no significant changes in physical or chemical processes or ecosystem services as a result of human activities
Good (5-6)	There are some significant changes in physical or chemical processes as a result of human activities in some areas, but these are not to the extent that they are significantly affecting ecosystem functions
Poor (3-4)	There are substantial changes in physical or chemical processes as a result of human activities, and these are significantly affecting ecosystem functions in some areas
Very Poor (1-2)	There are substantial changes in physical or chemical processes across a wide area of the region as a result of human activities, and ecosystem function is seriously affected in much of the region

4.5 Pests, Introduced Species, Diseases and Algal Blooms

Definitions of what constitutes Pests, Introduced Species, Diseases and Algal Blooms may need to be first agreed based on a review of regional and national studies. The term 'pest' generally refers to marine plants or animals that are not native to the region but have been introduced by human activities such as shipping; they have the potential to significantly impact marine industries and the environment. Any other non-indigenous species introduced to the marine environment by humans is considered to be an 'introduced species'. When considering the spatial frame of reference, it should be viewed from the perspective of the habitats affected. So if the pests, introduced species, diseases and algal blooms are confined to coastal and estuarine habitats, for example, then the best 10% would refer to coastal and estuarine habitats affected least and the worst 10% would refer to coastal and estuarine habitats affected most. To score the pests, introduced species, diseases and algal blooms experts will follow these steps:

Estimate a consensus score for the impact of pests, introduced species, diseases and algal blooms in the Best 10% and Worst 10% of the relevant habitats (eg. relative to 1900). Score both the area and degree of impact caused by pests, introduced species, diseases and algal blooms; for example, if it is estimated that pests, introduced species, diseases and algal blooms are not found in 10% of the habitats where they do occur elsewhere in the region, then the Best 10% will have a score of 8. Conversely, if it is estimated that an introduced species has completely displaced an indigenous species in 10% of the area of habitats where they previously occurred, then the Worst 10% will have a score of 1.

Estimate a consensus score for the impact of pests, introduced species, diseases and algal blooms in Most areas (eg. relative to 1900).

Assign a confidence grade for the each of the condition estimates (High, Medium, Low).

Estimate the trends for each of Best 10%, Worst 10%, Most (Improving, Declining, Stable) over the last 5 years.

Assign a confidence grade for the each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of the impact of Pests, Introduced Species, Diseases and Algal Blooms .

Pests, Introduced Species, Diseases and Algal Blooms	Grading statements for Pests, Introduced Species, Diseases and Algal Blooms
Very Good (7-8)	The incidence and extent of diseases and algal blooms are at expected natural levels, there are insignificant occurrences or numbers of pests, and the numbers and abundance of introduced species is minimal.
Good (5-6)	Incidences of diseases or algal blooms occur occasionally above expected occurrences or extent, and recovery is prompt with minimal affect on ecosystem function. Pests have been found, but there have been limited ecosystem impacts. The occurrence, distribution and abundance of introduced species are limited and have minimal impact on ecosystem function.
Poor (3-4)	Incidences of disease or algal blooms occur regularly in some areas. Occurrences of pests require significant intervention or have significant effects on ecosystem function. The occurrence, distribution and abundance of introduced species triggers management responses, or have resulted in significant impacts on ecosystem functions.
Very Poor (1-2)	Disease or algal blooms occur regularly across the region. Occurrences of pests or introduced species are uncontrolled in some areas, have displaced indigenous species and are seriously affecting ecosystem function.

4.6 Pressures and socioeconomic benefits

This part of the assessment is carried out in three steps. First, the pressures associated with separate industries that impact the condition of the marine environment are assessed. The total environmental footprint of the industry is examined and given a score based on the expert's judgement of the industries' impact on all aspects of the marine environment, including condition of habitat, species, ecosystem processes and physical-chemical processes.

To score environmental impact of marine-based industries (pressure), experts will follow these steps:

Estimate a consensus score for the condition of the environment that coincides with the spatial footprint (i.e. the space where the industry operates) of the industry (eg. relative to 1900). For Best 10% and Worst 10% areas, we focus on the spatial footprint of where the industry operates. For example, if it is estimated that the condition of the environment has not changed within an area of 10% of the industry footprint (with reference to the benchmark), then the Best 10% of places will have a score of 8. Changes in condition of the environment should be attributable only to the industry under assessment. For example, if two or more industries are impacting on the same habitat, we try to score only the impact of the one industry we are assessing.

Estimate a consensus score for the condition of the environment that coincides with the spatial footprint of the industry in Most areas (eg. relative to 1900).

Assign a confidence grade for the each of the condition estimates (High, Medium, Low). The confidence score may be influenced by uncertainty in attribution of impact where two or more industries are impacting on the same area.

Estimate the trend for the condition of the environment within the footprint of the industry (Improving, Declining, Stable) over the last 5 years that is attributable only to the industry under assessment (i.e. not including changes related to other, additional pressures, etc.).

Assign a confidence grade for the each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of pressures.

Pressures	Grading statements for pressures - the environmental impact of marine-based industries.
Very Good (7-8) Low Pressure	This industry has caused no significant changes in the overall environment (condition of habitat, species, ecosystem processes or physical and chemical processes) within its footprint.
Good (5-6) Moderate Pressure	This industry has caused some significant changes in some components of the overall environment, but these are not to the extent that they are significantly affecting ecosystem functions.
Poor (3-4) Significant Pressure	This industry has caused substantial changes in many components of the overall environment, and these are significantly affecting ecosystem functions in some areas of its spatial footprint.
Very Poor (1-2) High Pressure	This industry has caused substantial changes in many components of the overall environment across its spatial footprint and ecosystem function is seriously affected.

The second step is to assess the totality of all socioeconomic benefits that society receives from the industry. There are several aspects that must be evaluated, including:

1) whether it is a major national employer, paying fair wages, either through direct employment or supporting industries;

2) whether or not the state receives significant taxes, royalties and/or license fees and if a significant portion of profits remain in the country;

3) whether the industry exploits a sustainably managed renewable resource;

4) whether the industry contributes to education and training programs, human health or medical benefits for its employees;

5) whether the industry creates national infrastructure such as roads, communication systems or other facilities;

6) whether the industry is mainly or wholly owned by national interests (i.e., the profits from the industry remain in the country).

The industry is given a score of from 0 to 8 based on the expert's judgement.

To score socioeconomic benefits of marine-based industries, experts will follow these steps:

Estimate a consensus score for the socioeconomic benefits derived from the industry. Consider the spatial footprint of the industry and score the best and worst 10% of areas in terms of socioeconomic benefits received.

Estimate a consensus score for the socioeconomic benefits derived from the industry in Most areas (eg. relative to 1900).

Assign a confidence grade for each the benefits estimate (High, Medium, Low).

Estimate the trends for the socioeconomic benefits (Improving, Declining, Stable) over the last 5 years.

Assign a confidence grade for the each of the trend estimates (High, Medium, Low).

Record the main anchor references, and any commentary/notes relevant for the assessment of socioeconomic benefits.

Socioeconomic benefits	Grading statements for the benefits society receives from marine industries – this is the total benefit including employment, taxes, royalties and license fees paid to the state, education and training, human health benefits and infrastructure (buildings, roads, etc.). It includes both the direct employment benefits as well as dependent and supporting industries.
Very Good (7-8) High benefits	The industry is mainly or wholly owned by national interests and is a major national employer both through direct employment as well as through supporting industries. The state receives significant taxes, royalties and/or license fees and a significant portion of profits remain in the country. The industry exploits a sustainably managed renewable resource and contributes to one or more of: education and training programs, human health and medical benefits and national infrastructure.
Good (5-6) Significant benefits	The industry is an important national employer both through direct and indirect employment and the state receives taxes, royalties and/or license fees. The industry may contribute to education and training programs, human health or medical benefits.
Poor (3-4) Some benefits	The industry is a minor employer both through direct and indirect employment and the state receives some taxes, royalties and/or license fees. The industry is partly or mainly foreign-owned.
Very Poor (1-2) Few or no benefits	The industry is mainly or wholly foreign-owned and is not a nationally important employer, with most/all employment based overseas. The industry exploits a non-renewable resource (or an unsustainably managed renewable resource) and the state receives very little from taxes royalties or license fees from this industry.

The third step is to plot the environmental and socioeconomic scores for the industry on a graph to classify its overall rating (Fig. 3). Thus, each industry will be rated as having either: 1) low environmental pressure and high socioeconomic benefit; 2) low environmental pressure and low

socioeconomic benefit; 3) high environmental pressure and high socioeconomic benefit; or 4) high environmental pressure and low socioeconomic benefit.

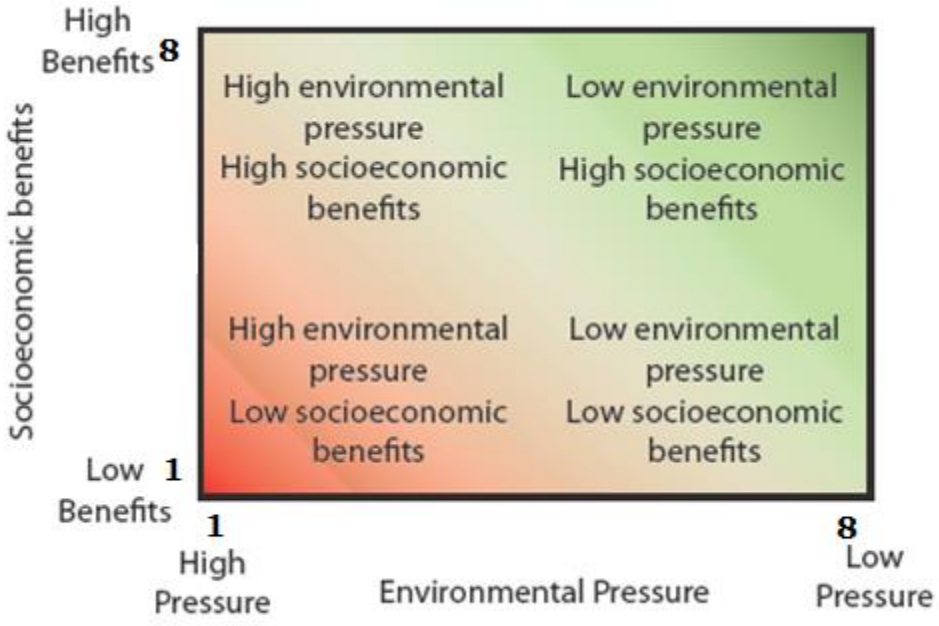

Figure 3. Matrix for assessment of environmental pressures and economic benefits for marine-based industries. The optimum situation is for the combination of low environmental pressure (shown in green) to coincide with high socioeconomic benefits. The worst situation is for the combination of high environmental pressure (shown in red) to coincide with low socioeconomic benefits.

5. Risk assessment

The condition, pressure and socioeconomic assessment part of the workshop is backward-looking in time; it is essentially attempting to describe the current state of the marine environment by comparing what is known of the present environmental state to a benchmark. Recent trends in

environmental condition are also examined over the past 5 years. It is a statement of the current situation of the marine environment.

In contrast, the risk assessment part of the workshop is forward-looking. Its purpose is to provide a forecast, using statements of the situation that the marine environment is likely to be in if current policies are not changed. It is designed to provide policy- and decision-makers with feedback on the short-term (5 year) and long-term (50 year) consequences of current policies and to highlight specific risks that are deemed by the workshop experts to warrant the greatest attention. It is emphasised that the experts are instructed to only consider what is likely to occur if there are no changes to current policies; experts are not allowed to second-guess what decisions governments may or may not take in the future.

As in the case of parameters selected for condition assessment, the risks assessed in the workshop will be a combination of those which are nearly universal to all maritime nations and others which are of particular significance to the nation or region considered in the workshop. A list of standard risk scenarios is as follows:

- The risk that illegal and unreported fishing will increase
- The risk that overfishing will cause fish stocks to collapse
- The risk that oil exploration will result in a blowout or major spill
- The risk that shipwrecks will cause a major oil spill
- The risk that global sea level rise will cause coastal inundation
- The risk that pollution will cause seafood poisoning
- The risk that tourism will cause environmental damage

- The risk that catchment disturbance will cause siltation of estuaries
- The risk that use of fertilizers will cause widespread eutrophication
- The risk that harmful algal blooms will occur

The risk assessment is a two-step process. Experts first assess the likelihood that a risk will occur: a) in the next 5 years; and b) in the next 50 years. The experts are then asked to judge the consequences of an event occurring in terms of its overall impact on the marine environment. The addition of scores gives the risk as per Figure 4.

Likelihood This is the probability of the impact occurring over a 5-year or 50-year timescale, taking into account the effectiveness of present and recently implemented (not planned) management arrangements and activities.	
Almost certain (score = 5)	Expected to occur often within 5 (50) years
Likely (score = 4)	Expected to occur at least once within 5 (50) years
Possible (score = 3)	Occurrence is possible within 5 (50) years
Unlikely (score = 2)	Occurrence is unlikely within a 5 (50) year period
Rare (score = 1)	Not expected to occur within a 5 (50) year period

Consequence/Impact This is the extent and severity of the expected impact taking into account the effectiveness of present and recently implemented (not planned) management arrangements and activities.	
Catastrophic (Score = 5)	Impact will seriously affect the ecosystem in the region, disrupting major ecosystem structure or function, and have recovery periods of more than 20 years (potentially irreversible)
Major (Score = 4)	Impact will seriously affect the ecosystem in the region, disrupting major ecosystem structure or function, and have recovery periods of less than 20 years
Moderate (Score = 3)	Impact will affect the ecosystem in the region, disrupting some aspects of ecosystem structure or function, and have recovery periods of less than 5 years
Minor (Score = 2)	Impact will be very limited spatially (<10% of area) and affect only minor components the ecosystem in the region
Negligible (Score = 1)	Impact is spatially confined to a minor area (<5%) and cannot be detected outside of that area.

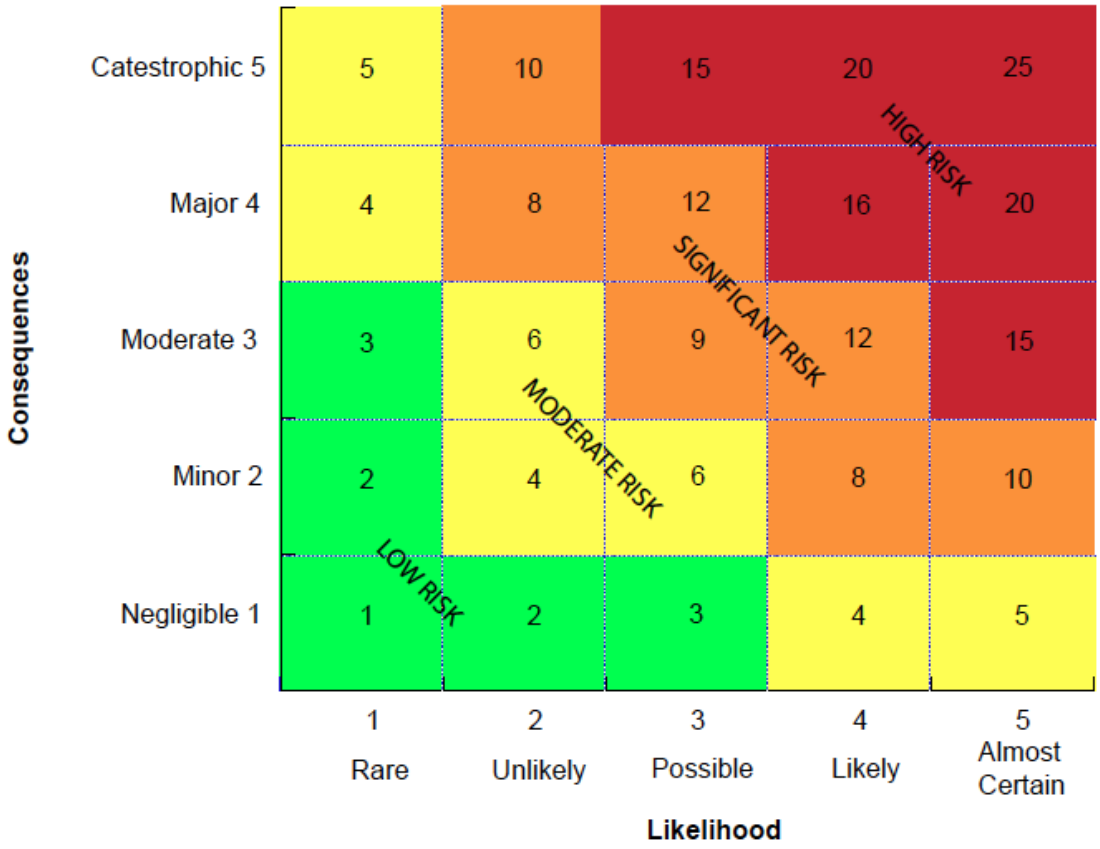

Figure 4. The Inherent Risk Rating score for each risk is calculated by multiplying the Likelihood and Consequence ratings. This provides a risk score of between 1 and 25 that gives a qualitative risk rating of High (15-25), Significant (8-12), Moderate (4-6) or Low (1-3).

6. Conclusions

The Production of State of Marine Environment Assessments and Reports based on Expert Elicitation provides an alternative to the classical data intensive environment reporting methods which may prove very useful to allow make most use of existing expert knowledge in regions where environmental data has not been recorded and reported in a systematic way. The existing expert knowledge may be enough and the only available means to draw an assessment that allows stakeholders taking decisions to initiate or improve environmental management without further

delay in hope that enough systematic data is recorded. The Expert Elicitation Approach if used to the full extent of its capacity may deliver a high quality report within a limited budget.

The pilot workshops conducted so far have proven to be very useful means of gathering available knowledge in the pilot regions and have received very good feedback for the experts participating in it as they allowed a quick and meaningful integration of the knowledge existing in a certain region. Ongoing efforts should lead to the finalization of the Reports emanating from these workshops in the near future.

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12. Appendix II

Web-based System for State of the Marine Environment Reporting

A web-based system to capture and analyse workshop Scores created by GRID-Arendal was utilised: http://some.grida.no, with the following main features:

A core set of marine environmental and socio-economic parameters is included in the system. This set is based upon the WOA chapters. The set of parameters can easily be adapted with relevant parameters for a country or region identified by experts.

Relevant data and information identification and compilation: the system allows the capture of relevant information sets. Important reference datasets and publications that are identified by the experts during the development process of the SOME reports can be added to the website, either as external links or uploaded to the web site in pdf, word or other formats.

The website allows for the real-time capture and display of data and statistics (scores for parameters, confidence, risks) during the workshop.

The website provides a template for the production of a State of Marine Environment Report. This outline is based upon the DPSIR system, the WOA outline and other relevant report templates (e.g. SOE report of Australia). The content and graphics can be exported and used as the basis for a national or regional SOME report or the contents can be adapted for use within other formats as required.

The database allows direct correlation to the outline of the World Ocean Assessment, thereby permitting cross-referencing and combining outcomes of the assessment to optimize it as a contribution to the international effort.

Another key aspect is that the diagrams and outputs that are produced by the website are designed for easy communication of the workshop results to policy and decision-makers. The diagrams are

simple, jargon-free and clearly communicate the main findings of the judgments made by the experts. The system allows the assignment of different roles to contributing experts during the development process of the SOME reports: main editors, contributors, reviewers, etc. Contributors can be made responsible for one or more chapters in the SOME outline. Draft versions of the report can be circulated to all participants for updating and review of the report and workshop outcomes, including recording of key references and anchors that may have been overlooked.