National Marine Fisheries Service
Endangered Species Act Section 7
Biological Opinion

Title: Biological Opinion on the Provision of Financing of Eligible U.S. Goods and Services to be used in the Mozambique Liquefied Natural Gas Project in Mozambique

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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LIST OF ACRONYMS

ANSI – American National Standards Institute

ATON – Aids-to-Navigation

BA – Biological Assessment

BOD – Biological Oxygen Demand

BOP – Blowout Preventer

CCC – Criterion Continuous Concentration

COD – Chemical Oxygen Demand

COT – Crown-of-Thorns

DPS – Distinct Population Segment

EEZ – Exclusive Economic Zone

EIA – Environmental Impact Assessment

ENSO – El Niño-Southern Oscillation

EPA – U.S. Environmental Protection Agency

ERP – Emergency Response Plan

ESA – Endangered Species Act

ESPG – Environmental and Social Due Diligence Procedures and Guidelines

EXIM – Export-Import Bank of the United States

GIIP – Good International Industry Practice

GPS – Global Positioning System

IFC – International Finance Corporation

IMO – International Maritime Organization

ITS – Incidental Take Statement

IUCN – International Union for Conservation of Nature

IWC – International Whaling Commission

LAT – Lowest Astronomical Tide

LNG – Liquefied Natural Gas

LO-LO – Lift-On/Lift-Off

MARPOL – International Convention for the Prevention of Pollution from Ships

MEG – Monoethylene Glycol

MMOP – Marine Mammal Observation Procedure

MODU – Mobile Offshore Drilling Unit

MOF – Materials Offloading Facility

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NTU – Nephelometric Turbidity Unit

OSCP – Oil Spill Contingency Plan

PAH – Polycyclic Aromatic Hydrocarbon

PAM – Passive Acoustic Monitoring

PLET – Pipeline End Termination Structure

PS – Performance Standard

PTS – Permanent Threshold Shift

RO-RO – Roll-On/Roll-Off

ROV – Remotely Operated Vehicle

SBF – Synthetic-Based Fluid

SE – Standard Error

SEL – Sound Exposure Level

SERO – Southeast Regional Office

SOP – Standard Operating Procedure

SPL – Sound Pressure Level

SST – Sea Surface Temperature

TBL – Temporary Beach Landing

TL – Total Length

TSS – Total Suspended Solids

TTS – Temporary Threshold Shift

USFWS – U.S. Fish and Wildlife Service

ZHI – Zone of High Impact

ZOMI – Zone of Moderate Impact

1 INTRODUCTION

The Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS), which exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including reasonable and prudent measures (RPMs) deemed necessary or appropriate to minimize such impacts and terms and conditions to implement the RPMs (50 C.F.R. §402.14(h)(i)).

Updates to the regulations governing interagency consultation (50 C.F.R. 402) became effective on October 28, 2019 (84 FR 44976). This consultation was pending at the time the regulations became effective and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." We have reviewed the information and analyses relied upon to complete this biological opinion (Opinion) in light of the updated regulations and conclude the Opinion is fully consistent with the updated regulations.

The Federal action agency for this consultation is the Export-Import Bank of the United States (EXIM). EXIM proposes to provide financing of eligible goods and services on the high seas to be used in the Mozambique Liquefied Natural Gas (LNG) project in Mozambique. This consultation and the resulting biological opinion, and associated ITS were completed in accordance with section 7(a)(2) of the statute [16 USC 1536 (a)(2)], associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. This consultation was conducted by the NMFS Office of Protected Resources (OPR) Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we" or "our"). This Opinion and ITS were prepared by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402.

This document represents the NMFS opinion on the effects of these actions on blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), Southern right (*Eubalaena australis*), and sperm whales (*Physeter microcephalus*); green (Southwest Indian Distinct Population Segment [DPS], *Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), loggerhead (Southwest Indian Ocean DPS, *Caretta caretta*), and olive ridley sea turtles (All Other Areas that are non-Mexico Pacific breeding populations, *Lepidochelys olivacea*); African coelacanth (Tanzanian DPS, *Latimeria chalumnae*); giant manta ray (*Manta birostris*); green (*Pristis zijsron*) and largetooth sawfish (*Pristis pristis*); oceanic whitetip (*Carcharhinus longimanus*) and scalloped hammerhead sharks (Indo-West Pacific DPS, *Sphyrna lewini*); and the following ESA-listed corals: *Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Montipora australiensis*, *Isopora crateriformis*, and *Seriatopora aculeata*.

A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

EXIM received an application to support eligible goods and services related to the project on April 10, 2015. Following receipt of the application, EXIM staff began a due diligence review of the project in compliance with the requirements of EXIM's *Environmental and Social Due Diligence Procedures and Guidelines* (ESPG; adopted June 27, 2013, revised December 12, 2013). EXIM's due diligence review of the project under its ESPG benchmarks is against the International Finance Corporation (IFC) 2012 *Performance Standards on Environmental and Social Sustainability*. An assessment of the degree of compliance of the project with the ESPG/IFC Performance Standards is presented to the EXIM Board of Directors to inform its consideration of whether to authorize financial support to the project. In the course of its review, EXIM staff determined requested that financing of eligible goods and services to the project may constitute an action subject to regulations implementing section 7 of the ESA.

1.2 Consultation History

EXIM staff initially contacted NMFS regarding an ESA section 7 consultation for the project on April 21, 2016. As the project proponent began submitting baseline data and other information, NMFS began providing technical assistance to EXIM in May 2018 regarding ESA requirements and the preparation of a consultation initiation package. At the request of EXIM, NMFS confirmed the species list for the proposed action by correspondence dated December 18, 2018. EXIM requested confirmation of the species list by email dated June 1, 2019. NMFS provided additional information regarding species proposed for listing that may be in the project area and asked whether chambered nautilus (*Nautilus pompilius*) are present and need to be considered by email dated June 3, 2019. Based on information from EXIM and the project proponent during a meeting July 9, 2019, NMFS confirmed the species list provided in 2018 was still correct.

This Opinion is based on information provided by EXIM and the project proponent, including the BA. Our communication with EXIM regarding this consultation is summarized as follows:

- **September 13, 2019:** EXIM sent NMFS a letter via email requesting initiation of a formal ESA section 7 consultation for the pending application for EXIM financing of eligible U.S. goods and/or services to be used in the Mozambique LNG project. A BA for the project was sent with the consultation request letter.
- **September 30, 2019:** NMFS had a call with EXIM to discuss the timing for receipt of the acoustic report for the project and clarified that consultation initiation will begin once we receive the final noise report.
- **October 17, 2019:** NMFS had a call with EXIM to discuss the draft noise report and addendum to the BA being prepared based on the report. EXIM sent a copy of the noise report prepared by JASCO Applied Sciences (JASCO) for the project proponent the same day via email.
- **October 21, 2019:** EXIM sent NMFS a draft of the addendum to the BA analyzing the effects of noise as a result of project activities via email and requested NMFS comments on the draft document. NMFS sent EXIM a series of comments on the BA addendum via email.
- **November 6, 2019:** EXIM sent NMFS the final noise addendum to the BA via email.
- **November 18, 2019:** NMFS sent EXIM a formal consultation initiation letter for the proposed action via email and EXIM confirmed receipt the same day. NMFS formally initiated consultation as of November 6, 2019, the day the final noise addendum was received.
- **December 4, 2019:** NMFS sent EXIM a series of questions on the BA and other environmental documents prepared for the project to be sure we have the correct information regarding the proposed action and project scope to include in our Opinion.
- **December 26, 2019:** EXIM sent NMFS the initial responses to our questions they prepared in coordination with the project proponent via email. EXIM, NMFS, and the project proponent discussed the responses via telephone on **December 30, 2019**. EXIM sent updated responses on **January 11, 2020**.
- **January 17, 2020:** NMFS participated in an in-person meeting with EXIM, the project proponent, and lawyers and consultants for EXIM and the project. During the meeting,

the draft of the proposed action section from NMFS Opinion, which was shared in advance of the meeting, was discussed, particularly the portions of the document with questions from NMFS regarding the proposed action and avoidance and minimization measures.

- **January 21, 2020:** Weekly project meetings with EXIM, NMFS, and the project proponent resumed in order to address the action items from the in-person meeting, focusing on addressing NMFS questions regarding the proposed action and conservation measures. NMFS also sent a letter to EXIM via email confirming the consultation initiation date and consultation timeline this day. NMFS began sending additional information regarding standard measures that are incorporated in consultations for projects with similar activities and potential effects on ESA-listed species via email on this day as a follow up to the in-person meeting. The project proponent and EXIM also began sending follow up information via email this day in response to the action plan that was created after the in-person meeting.
- **January 27 and February 2, 2020:** The project proponent sent a revised version of the proposed action document and supplemental information to NMFS and EXIM via email.
- **February 5, 2020:** NMFS sent a revised version of the proposed action and action area to EXIM and the project proponent for review and comment in order to finalize this section of the Opinion.
- **February 11, 2020:** The project proponent sent their comments on the revised version of the proposed action to NMFS and EXIM via email.
- **February 18 and 20, 2020:** EXIM sent an email to NMFS on February 18, 2020 confirming that any credit documentation evidencing the federal action (the "EXIM Loan Facility") does not include the provision of EXIM financing for nearshore facilities that will be shared with the adjacent Area 4 project, including a temporary beach landing, offloading facility, and jetty, facilities which EXIM confirmed would be constructed in the absence of the EXIM Loan Facility. The email was a follow up to a conference call the same day regarding the components of the proposed action and associated consequences of the action. On February 20, 2020, EXIM confirmed that the EXIM Loan Facility will not include financing of any activities in territorial waters of Mozambique via telephone. EXIM also confirmed on that call that activities in territorial waters would support construction activities occurring on the high seas funded by the EXIM Loan Facility.
- **February 24, 2020:** NMFS participated in an in-person meeting with EXIM and the project proponent, and lawyers and consultants for EXIM and the project. During the meeting, the proposed action, action area, conservation measures, effects to ESA-listed species, and environmental baseline were discussed along with additional information NMFS needs to finalize the drafting of the opinion.

- **March 5, 2020:** NMFS provided the draft Opinion to EXIM via email for review and comment.
- **March 11 and 12, 2020:** EXIM sent NMFS an edited version of the draft Opinion incorporating comments from EXIM and the project proponent via email. In the email, EXIM noted that the project proponent was still reviewing some of the information, which was provided to NMFS via email on March 12, 2020.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species as a whole (50 C.F.R. §402.02).

This ESA section 7 consultation involves the following steps:

Description of the Action and the Action Area (Section 3): In the case of this consultation, this includes a description of the proposed action and some components of the overall LNG project that may be part of the EXIM Loan Facility and have the potential to affect ESA-listed species. In addition, because of the scope of the overall project and the potential for effects to ESA-listed species, we describe the action area as the area within which stressors from the action and larger project may have effects on the physical, chemical, and biotic environment. Effects, as defined below, may include the consequences of other activities caused by the proposed action as well as effects that may occur later in time and occur outside the immediate area involved in the action. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

Stressors Associated with the Action (Section 4): We discuss the potential stressors we expect to result from the action.

Status of Species (Section 5): We identify the ESA-listed species that are likely to co-occur with the stressors from the action in space and time and evaluate the status of those species. It is important to note that, because this consultation will take place in waters of the high seas, and in territorial waters and the Exclusive Economic Zone (EEZ) of Mozambique, there is no designated critical habitat in the action area. We also identify those *Species Not Likely to be*

Adversely Affected, detail our effects analysis for these species (Section 5.1), and identify the status of the *Species Likely to be Adversely Affected* (Section 5.2).

*Environmental Baseline (*Section 6): We describe the environmental baseline as the condition of the listed species in the action area, without the consequences to the listed species caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Effects of the Action (Section 7): Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. These are broken into analyses of exposure, response, and risk, as described below for the species that are likely to be adversely affected by the action. We include a section (Section 7.1) for stressors that are not likely to adversely affect the species that are analyzed further in this Opinion.

Exposure, Response, and Risk Analyses (Section 7.2): In the Risk Analysis, we evaluate the potential adverse effects of the proposed action on ESA-listed species under NMFS jurisdiction. To do this, we begin with problem formulation that identifies and integrates the stressors of the action with the species' status (Section 5) and the Environmental Baseline (Section 6) and formulate risk hypotheses based on the anticipated exposure of listed species to stressors and the likely response of species to this exposure. The number, age (or life stage), and sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong are identified to the extent possible based on available data. The effects analysis also assesses the consequences of the responses of individuals of ESA-listed species that are likely to be exposed to the populations those individuals represent, and the species those populations comprise.

Cumulative Effects (Section 8): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 9): With full consideration of the status of the species, we consider the effects of the proposed action within the action area on populations or subpopulations when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species.

The results of our jeopardy analysis are summarized in the *Conclusion* (Section 10). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species, then we must identify Reasonable and Prudent Alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(3)).

An *Incidental Take Statement* (Section 11) is included for those actions for which take of ESA-listed species is reasonably certain to occur in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015; ITS rule). The ITS specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i)). In the case of this consultation, lethal and non-lethal effects to ESA-listed species in the territorial waters of Mozambique are not considered prohibited take because the ESA's Section 9 prohibitions on take of endangered species and threatened species for which the take prohibition has been applied by rule, only apply to take occurring on the high seas and not in territorial waters. Therefore, no RPMs and associated terms and conditions are included in the ITS.

We provide discretionary *Conservation Recommendations* (Section 12) that may be implemented by the action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* (Section 13) is required (50 C.F.R. §402.16).

2.1 Evidence Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of Google Scholar, literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. Searches were used to identify information relevant to the potential stressors (oil and gas development, pile-driving and other coastal construction) and responses of ESA-listed species. This Opinion is based on our review and analysis of various information sources, including:

- Information submitted by EXIM
- Government reports
- Peer-reviewed scientific literature

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species under NMFS jurisdiction that may be affected by the action to draw conclusions on risks the action may pose to the continued existence of these species.

3 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas. "Action area" means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

The proposed action consists of EXIM's Board of Directors making a final decision to support, and EXIM providing such support for, the financing of eligible goods and services from the United States to be used in the development, financing, construction, and start-up operations of the project on the high seas, namely the infrastructure necessary to produce the offshore gas reserves. Part of the offshore components within the Golfinho Field extend just slightly outside the territorial waters of Mozambique, i.e. beyond 12 nautical miles (nm). EXIM funding will not be allocated to any of the operational phases of the project. Some components of the operational phase are discussed in the Cumulative Effects (Section 8) because they may have indirect effects to ESA-listed species in the action area.

The offshore project components include the construction of the underwater pipelines, development of the Golfinho Gas Field in the northern and eastern parts of Area 1, construction of the subsea production system, and commissioning of the subsea production system and pipeline. No EXIM financing will be used for the pipeline. However, the subsea pipeline is included in our analysis because pipeline construction is a consequence of the proposed action that would not occur but for the development of the offshore gas field (i.e. an activity that is caused by the proposed action; 50 C.F.R. §402.02).

The overall project includes offshore, nearshore, and onshore components. An LNG facility and supporting infrastructure will be constructed on the Afungi Peninsula in the Palma District of Cabo Delgado Province in northern Mozambique, where the offshore pipeline system from Area 1 will convey natural gas from the offshore production field and where nearshore facilities will be constructed to support the project, including a Marine Offloading Facility (MOF) and an LNG export jetty. Figure 1 provides an overview of the gas development and associated shoreline areas where facilities will be constructed under this and the neighboring Area 4 project and where early construction activities are already underway. All portions of the project that will occur in the territorial waters of Mozambique will not receive EXIM financing. It is important to note that the BA included various project components, such as the MOF and LNG jetty, in the analysis of effects to ESA-listed species in the action area because the EXIM Loan Facility had not been drafted at the time the BA was written. EXIM provided the relevant information regarding the draft content of the EXIM Loan Facility via conference call and email on February

18, 2020 and telephone on February 20, 2020. The MOF, export jetty, and other nearshore in-water structures that will be shared with the neighboring project would be constructed in the absence of the EXIM Loan Facility, are not considered consequences of the action, and are therefore included in the Environmental Baseline (Section 6). Some of these components, such as the first phases of the temporary beach landing (TBL) and associated dredging, are already under construction.

Some portions of the project that will occur in territorial waters, particularly the subsea pipeline, are described to assist in defining the overall "action area" and to allow NMFS to evaluate the effects of EXIM's action that include all consequences to ESA-listed species that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action (50 C.F.R. §402.02), as discussed previously.

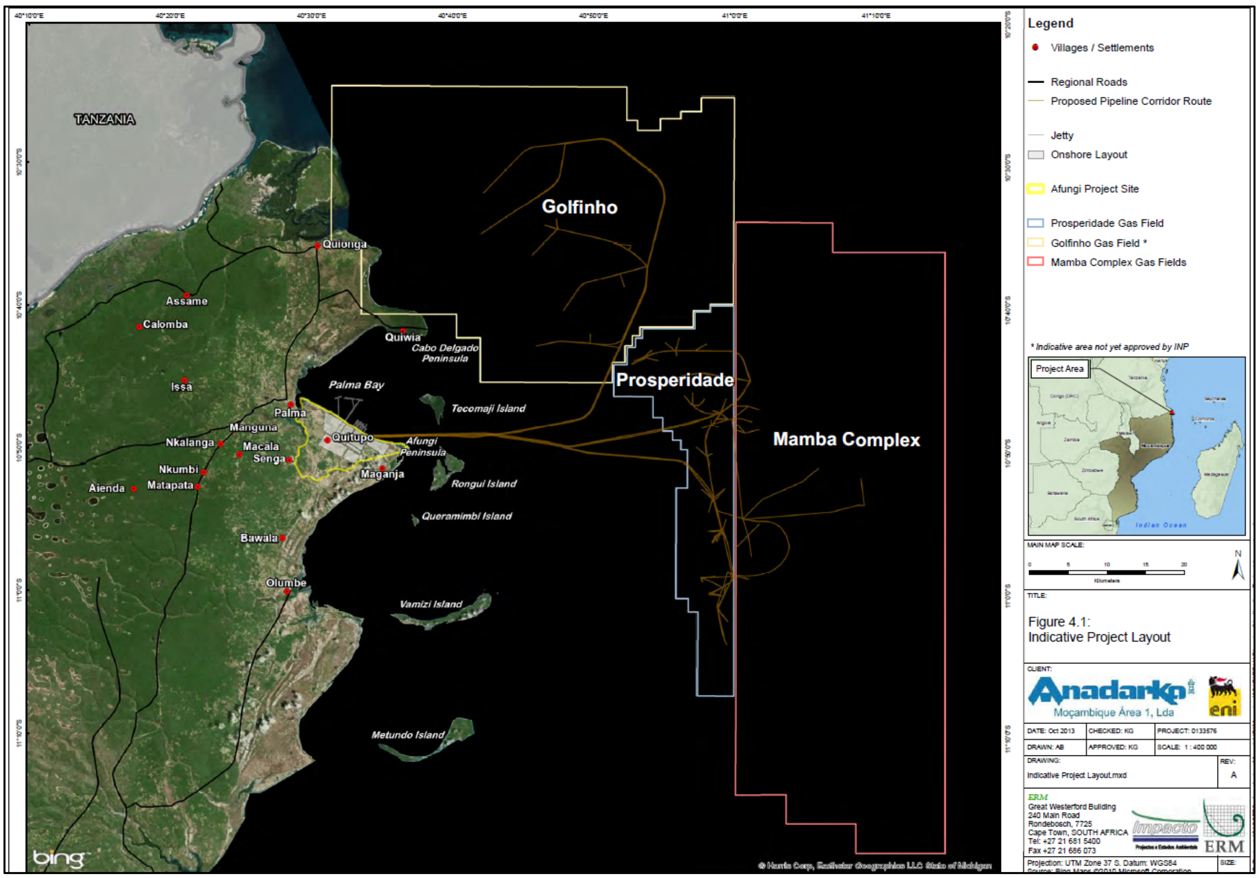

Figure 1. Overview of Area and Components for Area 1 (Golfinho gas field) and Area 4 (neighboring Area 4 project; from Impacto & ERM 2014)

3.1 Authorities under which the Action will be Conducted

EXIM is an agency of the United States created pursuant to the Export-Import Bank Act of 1945 (Act, 12 USC 635, as updated December 20, 2019). Section 2(a)(1) of the Act provides in part that, "the objects and purposes of [EXIM] shall be to aid in financing and to facilitate exports of goods and services, imports, and the exchange of commodities and services between the United States… and any foreign country or the agencies or nationals of any such country, and in so doing to contribute to the employment of United States workers" (12 USC 635(a)).

EXIM conducts a due diligence review of projects for which they have received an application to support eligible goods and services in keeping with the requirements of EXIM's 2013 ESPG. The ESPG benchmarks are compared to the eight IFC 2012 *Performance Standards on Environmental and Social Sustainability*. The IFC Performance Standards (PS) include:

- PS1: assessment and management of environmental and social risks and impacts
- PS2: labor and working conditions
- PS3: resource efficiency and pollution preventions
- PS4: community health, safety and security
- PS5: land acquisition and resettlement
- PS6: biodiversity conservation and sustainable management of living natural resources
- PS7: indigenous people (not applicable to this project)
- PS8: cultural resources

In the course of the ESPG review, EXIM staff also determine whether the financing of eligible United States good and services constitutes an action subject to United States regulations, including the ESA.

3.2 Proposed Activities

Natural gas will be extracted via subsea wells in water depths of approximately 1,500 meters (m) to 2,300 m (4,921 to 7,546 feet [ft]) from Area 1. The gas will be transported via subsea pipelines to the onshore LNG facility on the Afungi Peninsula. In deep water (i.e., water depths greater than 30 m [98.4 ft]), the pipelines will be laid on the seafloor. In nearshore areas of Tungue Bay (i.e., water depths less than 30 m [98.4 ft]), the pipelines will be buried below the seabed.

During all construction, a human safety temporary exclusion zone of 1,000 m (3,280.8 ft) will be established around all construction vessels, construction corridors, and nearshore infrastructure. During the operational phase of the Project, a permanent safety zone of up to 1,500 m (4,921 ft) may be developed around the MOF and LNG export jetty. Non-project personnel and vessels will not be permitted within the temporary or permanent safety zones.

The majority of project components involve the operation of vessels. In terms of ballast water from vessels during construction and operation of the project, compliance with the most recent International Maritime Organization (IMO) requirements, specifically the 2017 *International Convention for the Control and Management of Ships' Ballast Water and Sediments* (Ballast Water Management Convention) require that new vessels (keel laid after September 8, 2017) have a ballast water treatment system and vessels whose keel was laid before September 8, 2017 install an approved ballast water treatment system between September 8, 2019 and September 8,

2024. The Ballast Water Management Convention requires all ships in international trade to manage their ballast water and sediments according to a ship-specific ballast water management plan. All ships must carry a ballast water record book and an International Ballast Water Management Certificate. All ships engaged in international trade are required to manage their ballast water so as to avoid the introduction of alien species into coastal areas, including exchanging their ballast water in open seas, away from coastal waters (ideally at least 200 nm from land and in water at least 200 m [656 ft] deep). The convention also requires that, beginning in September 2017, new ships meet a performance standard specifying the maximum amount of viable organisms allowed to be discharged and that existing vessels meet this standard through the installation of a ballast water treatment system over a 5-year period beginning in September 2019.

Vessels will adhere to strict speed restrictions, distances between vessels, and reporting requirements for documenting sightings of marine mammals and sea turtles. The maximum transiting speed for vessels offshore is between approximately nine and 12 knots. In the bay, every vessel shall proceed at a safe speed commensurate with the safe navigation and maneuverability of the vessel. The *International Regulations for Preventing Collisions at Sea* apply and prevailing conditions will influence vessel operation. There will also be port management operating in the bay with signal flags to warn and guide vessels. Security vessels are the only vessels that operate without an observer and not subject to speed restrictions when they are responding to an emergency. Security vessels in Tungue Bay are motorized vessels. Personnel operating these vessels are given basic training regarding safety and environmental concerns (Section 3.2.4). Mobile Offshore Drilling Units (MODU) have their own security vessel or vessels that will operate out of Pemba until the nearshore facilities in Palma are capable of supporting these vessels.

The estimated dates of initial startup for the first LNG train and the first export shipment of LNG from the Project are during the first half of year 5 after the project sponsors' final investment decision, which was made in June 2019. The period covered by this consultation will extend through EXIM's disbursements under the EXIM Loan Facility during project construction, commissioning, and start-up, and until such time as environmental monitoring results indicate that conservation measures (see Section 3.2.4) for ESA-listed species identified in this Opinion are successfully completed based on agreed upon performance criteria.

3.2.1 Golfinho Gas Field Development

The Golfinho Gas Field is predominantly located in the northern and eastern portions of Area 1, approximately 45 km (24 nm) offshore from the LNG facilities in Tungue Bay (also known as Palma Bay) in water depths of approximately 1,500 m (4,932 ft). The environmental assessment prepared for the Project considered the drilling of 55 wells as a worst-case scenario. However, the drilling of 18 production wells is proposed as part of the Project. Any increase in the number of wells and additional requests for United States goods and services from EXIM in the future would be the subject of a new ESA section 7 consultation.

The 18 wells will be drilled and completed at a rate of approximately one well every 50 days, for a total of approximately 900 days. Commencement of drilling is planned for July 2021. A dynamically positioned MODU is proposed for drilling of the wells. The MODU would be mobilized from the Port of Pemba and would have a transit speed of 9 to 12 knots (10.4 to 13.8 mph). These ships are capable of self-propulsion, storing large amounts of equipment, rapid mobilization, and operating where mooring and anchoring are not feasible (Impacto & ERM 2014). An example MODU measures 221 m (725 ft) in length, 42.1 m (138 ft) in width, and 20.1 m (65.9 ft) in depth. Produced water and completion brines will be discharged from the MODU during drilling. The MODU would be supported by vessels mobilized from Pemba or Afungi (once the facilities in Palma Bay are operational) and a helicopter mobilized from Afungi. Support vessels would supply food, fuel, water, drilling fluid chemicals, oil well cement and chemicals, well tangibles (drill pipe, wellheads), equipment, tools, and other items (Impacto & ERM 2014). During exploratory drilling, there was one support vessel and one security vessel transiting between Pemba and the MODU.

Wells will be drilled in sections with the diameter of each section decreasing as depth increases. At the start of drilling operations, the top or surface section of the well will be drilled as an open hole, meaning the drilling mud and cuttings are not returned to the drilling rig. This part of the drilling operation is expected to generate 486 m^3 (17,163 cubic ft [ft^3]) of cuttings and approximately 508 m^3 (17,940 ft^3) of mud per well. Muds used in open hole drilling will be water-based. Before drilling the lower sections of the well, a marine riser is run between the drilling rig and the seabed with the drill string passing down the center of the riser. A blowout preventer (BOP) is installed on the wellhead and the marine riser is then connected from the rig to the BOP. The BOP consists of a series of valves and diverters designed to deal with erratic pressures and uncontrolled flow, if these are encountered within the gas reservoir. American Petroleum Institute Standard 53 (Blowout Equipment Systems for Drilling Wells) is the standard applied to the rigs' BOPs. This standard provides requirements for the installation and testing of blowout prevention equipment systems, which are comprised of the following required components for operation under varying rig and well conditions:

- BOPs
- Choke and kill lines
- Choke manifolds
- Control systems
- Auxiliary equipment.

The primary functions of these systems are to confine well fluids to the wellbore, provide a means to add fluid to the wellbore, and allow controlled volumes to be withdrawn from the wellbore.

Once the marine riser and BOP have been installed, drilling mud can flow back up to the rig where it is cleaned before reuse. Drilling mud will be separated from cuttings using shale shakers, dried where necessary, and returned to drilling fluid system. Drill cuttings will be dried and solids will be removed from the cuttings prior to their discharge to the sea. All muds from drilling the lower parts of the well are recycled. The contractor for Total will recover the muds and transport them to the next drilling job. Drilling muds used for the lower parts of the well are synthetic-based muds that are low in toxicity, biodegradable, and do not bioaccumulate (e.g., polycyclic aromatic hydrocarbon [PAH] content less than 0.001 percent and a total aromatic content of less than 0.5 percent).

Casing is used to isolate portions of the well to protect groundwater and to provide a support structure to the well, as well as to guarantee the safety and efficiency of drilling operations (Impacto & ERM 2014). Casing involves placing a string of protective steel pipe (casing) in the well and setting it in place by pumping specially formulated cement between the outside of the casing and the well bore wall. After a string of casing is in place, a smaller drill bit is used to drill a narrower well section. The process of drilling continues until the desired depth is reached, which will vary based on geologic conditions at each well.

Dispersion modeling indicates that total deposition footprints for sediments generated during well drilling will extend 3 km (1.86 miles) from well sites. Modeling estimates that sedimentation of at least 10 millimeters (mm) will occur within a one square kilometer (km^2; 247 acres [ac]) area around the drilling site and at least one mm within a 16 km^2 (3,953.69 ac) area beyond that (RINA 2019). Burial of the benthos by deposition of up to 10 mm will occur in a seafloor area of approximately 0.008 km^2 (1.98 ac) per well.

Natural gas from the production wells will flow through the subsea production system and connecting infrastructure to a manifold that will combine flow from other wells and direct the gas into the pipeline for transit to the shoreline LNG facilities in Tungue Bay. Once the drilling phase is complete, the bottom of the well will be prepared to the required specifications and the production tubing and “down hole” tools associated with the safety valve will be installed.

The subsea production system of pipeline end termination structures (PLETs) and connecting infrastructure will be laid directly on the seabed. The PLETs, trees, manifolds, pipelines, umbilicals, and carbon steel mudmat supports will be installed over a seafloor area measuring 350 km^2 (86,486.9 ac) with a water depth of approximately 1 km (3,280.8 ft). The components of the subsea production system will be lowered to the seafloor from dynamically positioned vessels. Remotely Operated Vehicles (ROV) will be used to identify the location for installation of the components in order to avoid sensitive habitats. The final locations and layout of the system will be determined as reservoir engineering work continues. The subsea control system will be located onshore at the LNG facility.

The construction of the subsea production system and pipeline will take approximately 24 months. Once construction is complete, the subsea production system and pipeline will be checked and tested such as through hydrostatic testing to verify that all components will perform as engineered during operation. Hydrotest water will contain pollutants such as corrosion inhibitors. During commissioning, the six-inch glycol line will have water in it that will be removed by pushing monoethylene glycol (MEG) through the line from shore to displace the water and charge the line. Approximately 20 barrels of MEG will be discharged at the end of the line in approximately 1,000 m (3,280.8 ft) of water. MEG has been rated to pose little to no risk to the environment by the Convention for the Protection of the Marine Environment of the North-east Atlantic, or OSPAR Convention (OSPAR Agreement 2013-06, updated 2018). Hydrotest water may contain inorganic sulfite salts, residual biocides and dyes and can have a high turbidity level, high velocity and low dissolved oxygen (DO) content in comparison to natural waters. The estimated volume to be discharged over the testing cycle is 120,700 m^3 (4.262 million ft^3) released at approximately 9,500 liters per minute (2,509.6 gallons per minute [gpm]) through the 22-inch (in) diameter pipes and at approximately 4,900 liters per minute (1,294.4 gpm) through the 16-in diameter pipes. This equates to a discharge velocity of approximately 0.65 meters per second (2.13 feet per second). It is likely that, rather than discharges being continuous over a course of up to 12 days, discharges will be discontinuous as segments of the system are tested. Hydrotest water will be discharged as part of testing in a water depth of 30 m (98.4 ft) in the main approach channel and in 1,500 m (4,921 ft) of water at the manifolds.

A temporary exclusion zone for all non-project vessels and personnel of approximately 1,000 m (3,280.8 ft) will be required around all construction vessels and corridors. Offshore vessels may operate 24 hours per day seven days a week during peak construction of the subsea system for approximately 24 months.

3.2.2 Pipelines

During peak pipeline and nearshore construction activities (discussed in Section 6), up to 40 construction vessels could be present in the field at any one time. For the pipeline construction, these vessels would include a pipeline lay barge, split hopper barge, dredgers, and smaller support vessels such as crew transfer vessels. Large vessels such as the pipeline lay barge will be approximately 250 m (820 ft) long and would move at an average speed of 2 knots (2.3 mph). Vessels such as the split hopper barge would transit between points along the pipeline route to the dredge disposal site. Smaller support vessels would travel from the MOF to the pipelay barge or dredger as needed for things like crew changes (RINA 2019).

The pipeline route in Tungue Bay was selected to avoid coral habitat and seagrass where possible. The Golfinho pipeline will extend from the shore in a northeasterly direction for approximately 2 km (1.24 miles) before turning north for approximately 7 km. The pipeline then heads east-northeast for approximately 7 km (4.35 miles). This last section of the pipeline in Tungue Bay will cross a portion of the fringing reef near the Cabo Delgado Peninsula on the north edge of the bay.

In the bay, the pipeline and umbilicals will be placed in a trench dug into the seabed. There will be three main lines measuring 22-in in diameter and some ancillary lines that will carry fluids, measuring up to 16-in diameter, placed in the trench. In deep water where installation will be direct lay on the seafloor, there is a slight diversion of the lines and then they converge again. Dredging is required not only to create a trench for the pipelines but also to provide adequate depth under the pipelay barge to install the lines, based on information from the project proponent. Anchor points for vessels used in dredging for the pipeline and nearshore facilities have been designated as circular areas with a radius of 400 m (1,312.3 ft; see Figure 2).

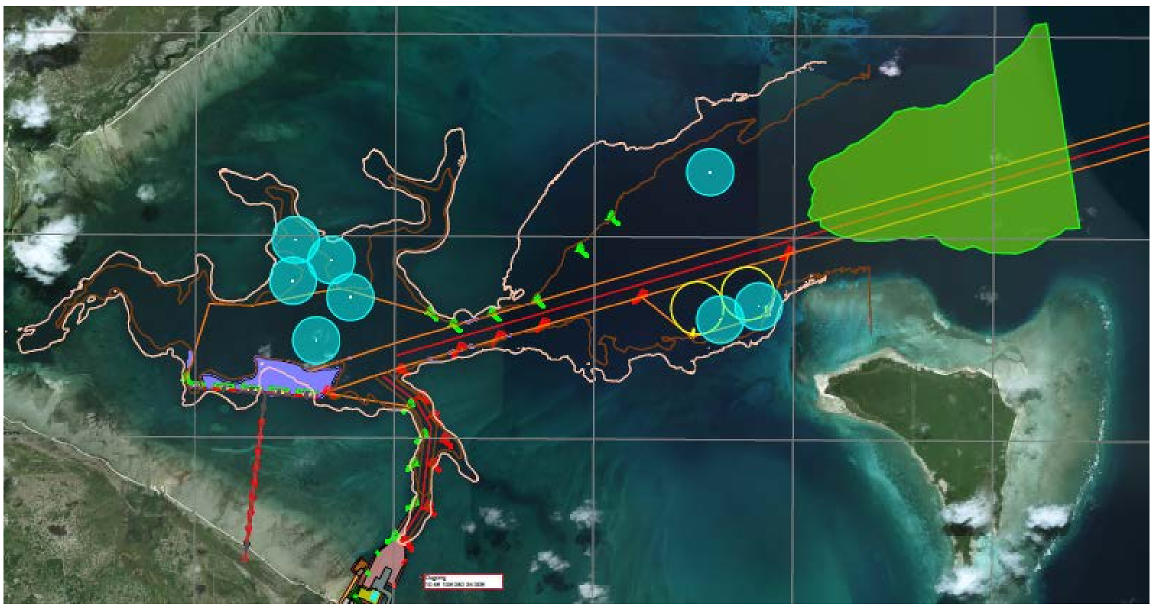

Figure 2. Image of bay showing nearshore construction areas, dredging areas, and nearshore pipeline route. The circles are the radii of anchor points for construction vessels (provided by Total).

As indicated in Table 1, the pipeline trench will be approximately 26 m (85.3 ft) wide along the majority of the pipeline route but the dredged width and depth will vary along the pipeline route due to differences in aspects like seabed characteristics or to accommodate the pipelaying vessel (e.g., the reef crossing requires a 120 m [393.7 ft] wide dredged area to accommodate the pipelay vessel). Most of the pipeline route in Tungue Bay will be dredged using a trailing suction hopper dredge (TSHD) in sandy areas. The reef crossing will be dredged using a cutter suction dredge along a segment of reef measuring at most 2.8 km (1.74 miles). Shallow nearshore areas along and close to the shoreline will be dredged using an excavator on land or pontoons (see Table 1). Approximately 6 million cubic meters (Mm^3; 211.9 million ft^3) is expected to be dredged. The majority material dredged from the bay will be disposed of in the offshore disposal site rather than being used in project construction.

Table 1. Dredging methods along pipeline segments (provided by Total from Contractor's Execution Plan)

From [km]	To [km]	Width [m]	Depth [m]	Method	ID	Governing	Disposal Location
0.000	0.200	60	1.9/2.9m below seabed	Excavator	Onshore	Pipeline spacing and burial depth	Onshore
0.200	0.770	40	2.9m below seabed	Elevated Excavator	Intertidal	Pipeline spacing and burial depth	Onshore
0.770	1.645	40	2.9m below seabed	Excavator on pontoon	Bay South Pull	Pipeline spacing and burial depth	Offshore Disposal Area
1.645	5.560	80/26	-7.0 LAT or 1.9/2.9m below seabed	Excavator on pontoon	Bay South lay	SWPLB Stingray	Offshore Disposal Area
5.560	13.260	26	2.9m below seabed	TSHD	Channel Crossing	Pipeline spacing and burial depth + vertical bending radius pipeline	Offshore Disposal Area
13.260	16.010	120/26	-11.0 LAT or 2.9m below seabed	CSD	Reef	Pipeline spacing + horizontal bending radius pipeline and burial depth	Offshore Disposal Area

From [km]	To [km]	Width [m]	Depth [m]	Method	ID	Governing	Disposal Location
16.010	16.638	26/31	2.9m below seabed	TSHD	First Plateau	Pipeline spacing and burial depth	Offshore Disposal Area

Where TSHD = Trailing suction hopper dredge; CSD = cutter suction dredge; LAT = Lowest Astronomical Tide; SWPLB = shallow water pipelay barge

The TSHD is part of a vessel designed to support and operate the dredge and receive dredged materials. The use of the trailing suction hopper dredge requires the lowering of the drag head at the end of the suction pipe to the seabed with a system of winches and gantries. A high capacity dredge pump installed inside the dredge creates a vacuum in the drag head. The vacuum, combined with the mechanical excavation of the seabed by the dredge, creates a sand-water mixture inside the drag head. The dredge pump (or pumps) transfers the mixture of sand and water to the hopper of the dredging vessel. Water from the dredged material drains via the overflow system in the hopper. The project proponent noted in a February 2, 2020 email to NMFS that the contractor has the appropriate equipment, specifically sea turtle excluder devices, to reduce potential suction of sea turtles into the draghead while this type of dredge is in operation. Surveys will be done prior to dredging but are likely to use ROVs rather than divers for safety reasons, meaning the presence of sea turtles may be underestimated because the animals will likely move away from an ROV. The contractor will be required to develop a specific plan or procedures, including mitigation, to be protective of sea turtles when using TSHD for approval by the project proponent.

The cutter suction dredge is stationary and is mounted on a pontoon, which is positioned with a spud-pole at the back and two anchors at the front. The spud of the CSD will remain within the dredging footprint. The anchors for the dredge will be located outside the dredging footprint. In the reef area, the CSD anchors will be box anchors, which are steel boxes weighing up to 180 tons. On the north side of the reef, the contractor plans to install eight box anchors before dredging operations commence. The pipelay barge will also use these anchors during pipeline and umbilical installation. The anchors will be removed once backfill of the pipeline has concluded. On the south side of the reef where softer substrate is present, 18-ton Stey/Shark anchors will be used to anchor the CSD. On the south side of the reef, the pipelay barge will use 12-ton Delta Flipper anchors.

The rotating cutting head of the CSD loosens the substrate and the in-board centrifugal pump (or pumps) transports the loosened material to a discharge pipe for disposal. The cutterhead may be electronically or hydraulically driven. The cutterhead encloses the suction intake of the centrifugal dredge pump. The cutter suction dredge has to dredge its flotation channel, which will be approximately 120 m (393.7 ft) wide, through the reef in order to create the trench for pipeline installation through the reef.

Dredged material from the use of the TSHD will be transported via split hopper barge and disposed of at the offshore disposal site, which has a water depth of at least 200 m (656 ft). The split hopper barge would dispose of dredged material at the water surface or a hopper barge mounted dredge slurry pump to dispose of dredged material through a spreader pipe that may have a diffuse head. Dredged material from the reef crossing will be pumped to the offshore disposal site from the dredge via a temporary floating pipeline. The offshore disposal site was originally considered a secondary disposal site but was later designated as the primary disposal site for dredged material because of its depth and the results of surveys using a ROV that found low biodiversity in the area in comparison to the originally proposed disposal site. However, ROV surveys will be done prior to any disposal activities to be sure coelacanth habitat or deepwater coral are not present. Dredged material disposal will not take place in sites within the larger offshore disposal area where African coelacanth habitat or deepwater corals are observed during ROV surveys. Onshore temporary storage of dredged material is not contemplated at this time, but could be done in the future. In addition, there may be a need for temporary storage of dredged material in the intertidal zone. This area will be within the footprints where the TBL and MOF will be constructed.

Once dredging of the trench is complete, the subsea pipelines and umbilicals will be laid in the trench. The pipeline will be installed via a purpose-built lay barge. In Tungue Bay, the lay barge will be anchored in place and, once a section of pipeline is laid, the anchors will be moved along either side of the pipeline route to allow the lay barge to move forward and install the next section of pipe. Joints of pipe will be welded into a pipe string onboard the vessel. Once the pipeline and umbilicals are laid, rock berms will be placed and sand will be used to backfill. In the pipeline section through the reef, a rock cover will be placed over the backfilled pipeline. Rock to be used will be quarried stone sourced from the United Arab Emirates and will not have contaminants or non-native marine invasive species. Sand for backfill material will be from a borrow area in the bay (Figure 3). Approximately 4.25 Mm^3 (150.09 million ft^3) will be dredged for backfill material. The total time estimated for dredging, pipe laying, and backfill of dredged areas is 15 to 16 months.

Within the zone of moderate influence (ZOMI), which is defined by the project as the construction footprint plus 500 m (1.640.4 ft) around this footprint, the BA states that natural reef recovery is expected to occur within seven years and seagrass is expected to recover within five years. During our January 17, 2020, meeting, it was clarified that recovery is defined as the restoration of pre-construction topography through backfilling of the pipeline trenches in the bay and the use of backfill with adequate rugosity in the reef. The reef crossing will be the only area where stone will be placed over the backfilled dredge area. Monitoring during and after pipeline construction will be done to determine the extent and type of mitigation that may be done to offset project impacts.

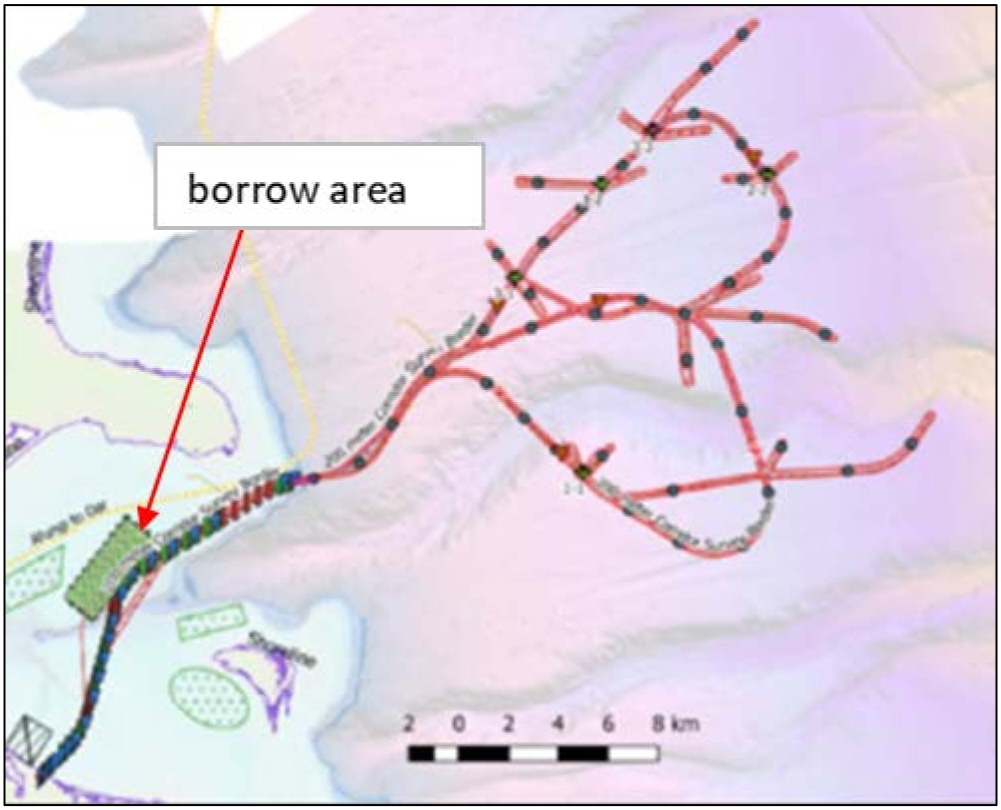

Figure 3. Approximate location of borrow area along pipeline route for covering trench (provided by Total)

Modeling of turbidity plumes that may be generated during dredging was completed. Modeling results indicate that turbidity plumes with concentrations of 10 to 15 and 15 to 20 mg/L will be generated during TSHD, although much of the dredging using this type of dredge will take place in areas without seagrass or coral according to information in the BA (RINA 2019). Similar ranges for turbidity plume concentrations were calculated for modeling of dredging using CSD. CSD dredging will take place in a coral reef. Continuous dredging through the fringing reef with CSD will generate 1,400 cubic meters (m^3; 49,440.5 ft^3) of material per hour of which 20 percent will be fines. Modeling indicates that maximum sedimentation above 4 centimeters (cm; 1.57 in) in seagrass areas will be largely limited to the ZOMI with the exception of the MOF area. Maximum sedimentation above 7 cm (2.57 in) could occur beyond the ZOMI, though it is not expected to occur in areas of the highest coral cover (Impacto & AECOM 2019). Disposal of dredged material in the offshore disposal site from the reef area will be done through a pipeline to the offshore disposal site so sediment concentrations over 5 mg/L are not anticipated in the water column (RINA 2019).

The estimated total habitat area to be affected by the construction of the pipeline, including dredging, pipeline installation, and backfill (Table 2) include coral reef and seagrass areas. Mitigation measures will be implemented during construction to reduce the effects of dredging, including physical impacts, noise and turbidity, to these habitats and the marine environment in the bay. These measures are described in more detail in Section 3.2.4. The project proponent is also conducting a pilot coral transplant study to determine the feasibility of coral translocation and assess whether it will be a successful mitigation technique to offset some of the impacts of pipeline construction to corals.

Outside the bay in deeper waters (approximately 30 m [98.4 ft]) almost 17 km (10.56 miles) from shore, the pipelines will be laid directly on the seafloor.

Table 2. Estimate of the Areas of Habitat Affected by the Pipeline Footprint (from RINA 2019)

Pipeline		
Biotope and Substrate Affected	**Area in Hectares (ha)**	**Area in Acres (ac)**
Total Area	96	237.2
Acropora Fore Reef	9	22.24
Reef Flat	2.2	5.44
High-density seagrass	2.7	6.67
Low/Moderate density seagrass	11.5	28.42
Mixed (including seagrass and corals)	15.1	37.3

3.2.3 Terrestrial Facilities

The onshore project components include the construction of the LNG facility and support infrastructure, including processing facilities, storage tanks, temporary and permanent worker housing, construction and maintenance areas, supplemental construction laydown areas, an airstrip, power generation facilities, waste handling and disposal facilities, water and wastewater treatment facilities, and roads and fences. The EXIM Loan Facility would include financing for the construction of terrestrial components, many of which will be shared with the neighboring project and some of which are already under construction. Onshore project components that are already under construction and shared with the neighboring project are discussed further in the Environmental Baseline (Section 6).

The components of onshore construction that are exclusive to the Area 1 project and likely to result in indirect effects to ESA resources, specifically water intakes and outfalls for a desalination plant, wastewater treatment plant, and cement plant, are presented in this section of the Opinion.

Prior to construction of a desalination plant, groundwater will be used to provide water for construction. The desalination plant will have intakes and outfalls in the bay for processing of seawater to potable/process water during project construction and operation. The intake will have a screen with a maximum opening dimension of 100 by 100 mm (3.94 by 3.94 in). The dimensions of the intake will ensure that the flow velocity through the intake screen will be less than 0.15 meters per second (0.49 feet per second). The intake and outfall are in an area with sparse seagrass and are in close proximity to one another. The outfall will discharge brine at ambient temperature from the water treatment process with a continuous flow rate of 433 m^3/hr (114,386 gallons per hour [gph]) during the first 18 months of filling and compaction activities when more water is needed. The outfall will have a 100 m (328.1 ft) mixing zone and will have to comply with Mozambique water quality standards (Table 3). The brine discharge rate is expected to be 62 to 93 m^3/hr (16,378.7 to 24,568 gph) once the onshore facilities are in operation.

The terrestrial facilities will also include a wastewater treatment plant that will discharge to the bay from the same outfall as the brine discharge. The discharge will meet Mozambique water quality standards with permissible concentrations of contaminants and physical characteristics as described in Table 3. During construction, there will be a temporary outfall next to the MOF with diffusers terminating in approximately 3 m of water for the discharge of effluent and brine. Combined effluent flow rates will be 0.15 m^3 per second (0.49 feet per second), 80 percent of which will be from the desalination plant. The wastewater treatment plant will discharge treated effluent to the bay at a continuous flow rate of two to 60 cubic meters per hour (m^3/hr; 2,118.9 ft^3 per hour [ft3/hr]) when two LNG trains have been constructed. This combined outfall will have five subsidiary 6-in lines spaced at 24 m (78.7 ft) intervals and extending 11 m (36.1 ft) below the sea surface from the LNG jetty approximately 1,200 m (3,937 ft) offshore. This flow could increase if new trains are constructed, although the flow rate is expected to decline to 3.5 to 15 m^3/hr (123.6 to 529.7 ft^3/hr) during onshore operations. During operation, treated sewage effluent will discharge from beach outfalls. Stormwater from the LNG processing areas and other areas of the facilities will be managed. Clean surface runoff, which is runoff from areas deemed not at risk from oil or chemical contamination, will be allowed to discharge to the surrounding environment with no collection or treatment.

There will also be effluent to nearshore waters from the concrete batch plant that will be constructed to serve the project. The continuous flow rate will be 0.5 to one m^3/hr (17.66 to 35.3 ft^3/hr) from month 7 to month 25 of terrestrial construction. The contractor will develop and present a detailed list of effluent content and management measures to minimize potential impacts of the discharge on the environment to the project proponent. If effluent cannot be recycled or reused, it will be treated and disposed of in keeping with Mozambique's regulations and water quality standards (Table 3).

Table 3. Effluent Limits for Wastewater Discharge (from Company Water and Wastewater Management Plan)

Parameter	Permissible Maximum Value	Units	Source of Limit
Color	Dilution 1:20	Presence / absence	Mozambican Decree 18/2004
Odor	Dilution 1:20	Presence / absence	Mozambican Decree 18/2004
pH (at 25º C)	6.0 – 9.0	Sorensen scale	Mozambican Decree 18/2004
Temperature	35º C	º C	Mozambican Decree 18/2004
Biological Oxygen Demand (BOD)	30	mg/l	IFC General HSE Guidelines 2007
Chemical Oxygen Demand (COD)	125	mg / l O2	IFC General HSE Guidelines 2007
Total Suspended Solids (TSS)	50	mg / l	IFC General HSE Guidelines 2007
Total Phosphorus	10	mg / l	Mozambican Decree 18/2004
Total Nitrogen	15	mg / l	Mozambican Decree 18/2004
Total Coliform Bacteria	400	MPN/100 mls	IFC General EHS Guidelines 2007
Oil and Grease	10	mg/l	IFC General EHS Guidelines 2007
Free Residual Chlorine	0.2	mg/l	Good Industry Practice

3.2.4 Conservation Measures

EXIM will coordinate with NMFS regarding the specific requirements for submission of data and the performance criteria to be used to track the effects of the proposed action on the ESA-listed species identified in this Opinion. EXIM will provide NMFS with project environmental monitoring reports submitted to EXIM (either in their entirety or excerpts, as appropriate), and other environmental documents as needed, in order to track the implementation and effectiveness of mitigation and restoration activities related to the ESA-listed species identified in this Opinion. The schedule and formatting of information to be submitted to NMFS will be established within three months of finalization of monitoring and reporting requirements under the final EXIM Loan Facility.

The applicant has incorporated avoidance and minimization measures in alignment with international industry best practice to protect environmental resources. NMFS expects the following measures will be protective of ESA-listed species in the action area during certain project activities.

Marine Mammal and Sea Turtle Observation Procedure (MMOP):

The MMOP has been developed to avoid or minimize impacts to marine mammals and sea turtles in keeping with good international industry practice (GIIP) during all in-water construction operations associated with the Project. The measures in the MMOP include:

- The role of observers will be exclusively to look for marine mammals and sea turtles and record sightings in pre-established templates (see Appendix A). Observers will be trained through accredited institutions and will have valid certificates. Observers will also record sightings of large fish.
- An adequate number of trained observers (trained to look for and identify marine mammals and sea turtle species) will be present on vessels as required during all construction works that have the potential to affect marine mammals and sea turtles (e.g. dredging, pile-driving) to keep a watch for the presence of these animals. Only security patrol boats will not have assigned observers.
- Observers will record sightings of marine mammals, sea turtles, and large fish, which will provide additional data on species presence because the area is data poor in order to develop additional avoidance strategies as needed, such as changes in transit routes. The marine mammal sightings data will include location, species, and group size and will be collated on a monthly basis to generate maps and trends.
- Operational speeds will be established and enforced to ensure safety of all activities and minimize potential harm to aquatic fauna. This will entail establishing maximum speeds, as well as reducing travelling speeds and /or gradually diverting speeds if whales, dolphins or sea turtles are sighted, to prevent or minimize chance of collision. All vessel speeds in the bay are governed by port rules, which state that vessels have to operate at safe speeds commensurate with onsite conditions such as weather, and vessel maneuverability.
- If any species of marine mammals, particularly whales, are sighted near the path of a vessel, the vessel will reduce speed and gradually divert to avoid the marine mammal or slow down to idling speed, if this can be done safely.
- Instruct helicopters to maintain a minimum height of 500 m (1,640.4 ft) over bird foraging areas, surfacing cetaceans or groups of turtles, and prohibit circling or hovering over marine mammals (e.g. for casual viewing) unless essential for safety or emergency purposes.
- Minimize non-essential lighting on vessels, and shield and/or reduce the number of lights shining directly onto the water as far as possible to maintain safe operation.
- Prohibit all crewmembers from killing or causing injury to marine fauna (any crewmembers found to have deliberately killed or caused injury to marine fauna should

be dismissed immediately and removed to shore). Reporting of incidents will be used to assess compliance.

- Undertake environmental awareness training of all crewmembers, which includes training on the conservation status of cetaceans and turtles.

Ballast Water and Biofouling:

- All project vessels will be required to comply with the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78). Therefore, port reception facilities will be required for vessels based at the facility such as support vessels and tugs and facilities for effective waste disposal.
- Construction vessels entering the bay will have to exchange ballast water before entering.
- All vessels entering Palma Bay that are linked in any way to the Project are to comply with current IMO guidelines concerning ballast water discharge and treatment (IMO Ballast Water Management Convention of 2017).
- All vessels entering Palma Bay are to comply with IMO guidelines regarding biofouling of hulls (2011 *Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species*).
- Prior to the establishment of the Port Reception Facilities in Palma Bay (i.e., during the construction phase) vessels associated with the Project contractors will comply with MARPOL 73/78 at a minimum and utilize MARPOL-compliant waste facilities elsewhere, likely in Pemba, which is the main support area for the project during construction, for offloading wastes.

Well Drilling and Subsea Pipeline:

- No oil-based muds will be used in drilling.
- ROV surveys will be done to determine the presence of deepwater reefs, coelacanths, and potential obstructions in Area 1. An area with a radius of approximately 175 m (574 ft) will be surveyed at each proposed drilling well location.
- Survey all candidate pipeline corridors in the deepwater offshore by ROV and realign corridors to the extent practical if they intercept deepwater reef structures during construction.
- Survey all deepwater locations for subsurface infrastructure by ROV and avoid to the extent practical areas of high and low relief deepwater reef structures.
- A subsurface discharge chute extending approximately 10 to 15 m (32.8 to 49.2 ft) in depth should be employed for the overside disposal of treated drill cuttings and residual muds. This will reduce the size of the deposition footprint.
- Residual discharges of treated drill cuttings and residual muds should be restricted to distances greater than 175 m (574 ft) from deepwater high-relief reefs as determined by ROV video surveys.

- Drill rigs will have an efficient solids control and mud recirculation system, including shakers, mud cleaners, dryers, and centrifuges for the treatment of drill cuttings.
- Water-based muds and low toxicity additives should be used whenever possible (e.g., concentrations of mercury and cadmium in the barite should not exceed 1 mg/L and 3 mg/L, respectively).
- Synthetic-based muds that are low in toxicity, biodegradable, and do not bioaccumulate will be used (e.g., PAH content less than 0.001 percent and a total aromatic content of less than 0.5 percent). No oil-based muds will be used.
- All chemicals used should conform with the revised Cefas Offshore Chemical Notification Scheme and the OSPAR Commission's list of substances that pose little or no risk.
- Treated cuttings discharged into the sea will have a maximum oil concentration in accordance with GIIP.
- Prior to commencing discharge/disposal of hydrotest water, prepare a hydrotest disposal procedure that considers point of discharge, rate of discharge, chemical use and dispersion to align with GIIP.
- ROV surveys will be done before and after drilling at each well to monitor effects to the seabed on a well-by-well basis.
- ROV transects will be monitored at least one month prior to dredging and continue to six months beyond the completion of drilling activities to determine trends in sedimentation from drilling and cuttings disposal at sites of sensitive communities.

<u>Marine Construction:</u>

Water quality monitoring will be conducted during in-water construction of the MOF, TBL, and LNG jetty in accordance with the following:

- Quarterly monitoring of water quality will begin when marine construction commences and will include sample stations in the central and southern sections of Palma Bay at 15 sites. Control sites in areas where impacts from project construction are not anticipated will also be selected.
- Monitoring will target inorganic nutrients (nitrogen: 500 micrograms per liter [µg/L] nitrate nitrogen [NO_3-N], 600 µg/L ammonia+ammonium [NH_3+NH_4-N]; phosphorus: 50 µg/L orthophosphate as phosphorus [PO_4-P]), colored dissolved organic matter, hydrocarbons (0.25 mg/L tainting; 15 mg/L sheen formation), saline brine (greater than 40 practical salinity units [PSU]), turbidity (as TSS equivalents: 30 mg/L), photosynthetically active radiation, cholorphyll fluorescence (chlorophyll a: greater than 2 µg/L), pH (greater than 7.0 and less than 9.0), DO (2 mg/L) plus temperature and conductivity against depth.
- Seagrass and warm water coral monitoring will begin prior to commencement of marine construction. Full surveys will be done in wet and dry season during construction and

then annually over project lifetime. Photographic surveys will be conducted monthly during dredging activities.
- Data collected from test and reference sites will be used to detect changes in seagrass and coral communities. Sedimentation data will be collected using traps to measure sedimentation rates and pavers to measures sedimentation depth. The threshold at which intervention will be required for seagrass and coral communities will be a 15 percent deterioration in quality from baseline condition. If degradation of 10 percent is observed over two consecutive survey rounds, investigation of causes will be required.

Commissioning:

Hydrotest water is required to meet IFC standards prior to disposal, which are:

- Total hydrocarbon content: 10 milligrams per liter (mg/L)
- pH: 6 to 9
- Biological Oxygen Demand (BOD): 25 mg/L
- Chemical Oxygen Demand (COD): 125 mg/L
- Total Suspended Solids (TSS): 35 mg/L
- Phenols: 0.5 mg/L
- Sulfides: 1 mg/L
- Heavy Metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn): 5 mg/L total
- Chlorides: 600 average, 1,200 maximum mg/L.

Training, Education, and Awareness:

A Training Matrix will be developed based on identified needs and focus areas such as environmental protection. The Matrix will include the preparation and implementation of plans/programs on environmental communication and education. Implementation measures for environmental awareness will apply to all workers involved in the construction and movement of infrastructure on the seabed in order to prevent the accumulation of hard structures in areas with unconsolidated sediments in the gas fields offshore to minimize risk to benthic communities.

As part of an ongoing Assessment and Improvement Program, a number of measures will be implemented including:

- Contractors will be required to implement field-based inspection programs that demonstrate their implementation of and, in some instances, the effectiveness of the mitigation measures.
- The Project will inspect the contractors’ documents to verify that they have implemented the required programs.

- Contractors will be required to implement field-based environmental monitoring (sampling and analysis) and social monitoring to monitor the effectiveness of the mitigation measures, assess impacts and demonstrate compliance with legal and other requirements.
- The Project will conduct similar monitoring events and verify contractors' monitoring activities.
- Audits will be carried out internally by the Project to ensure compliance with EMP and regulatory requirements; and compliance with management systems, standards, policies and procedures. Qualified staff will perform audits, and results will be described in a report that will determine the severity of non-compliances, as well as the recommended remedial action.
- As part of the Environmental and Social Management System the Project will implement a formal environmental and social tracking system that will include the details of all environmental and social non-compliance, identify the corrective actions required, assign actions/timings to responsible parties and indicate the status of the actions required.
- AMA1 will be responsible for appointing an independent consultancy to undertake annual private environmental audits, as established under Decree 25/2011 of June 15, 2011. The reports of these audits will be submitted to MITADER.
- Conduct internal environmental audits and, if requested by regulatory authorities or by external auditors, may share the reports of those audits.

<u>Emergency Management Plan:</u>

The emergency management plan for the Project sets out measures to control and respond to emergencies as they arise, including addressing environmental protection. The document will be updated continually to ensure the appropriate responses are planned for any emergency that could reasonably be expected to occur. There will also be discreet response plans required from contractors per their contract scopes of work.

The Emergency Management Plan will address appropriate responses for the higher-risk chemical spill scenarios in the marine environment. Specific measures therein include:

- A detailed spill model will be used to update the Oil Spill Contingency Plan (OSCP) within the Emergency Response Plan (ERP), to further develop a plan that is adequate to address potential spills into the marine environment
- Evaluate chemicals for environmental, safety and technical performance prior to procurement. As far as practical, the least hazardous chemicals will be selected.
- Procedures for response to chemical spills will be included in the ERP. These will include locations of spill containment and recovery equipment.
- A detailed assessment will be undertaken following spill modelling to determine the potential environmental and socio-economic impact. The assessment will focus on the spill size, type(s) of material spilled and potential spill location(s). Results will be

incorporated into the ERP and the OSCP to inform risk reduction options and to be adopted before a construction activity begins.

- In the event of an accidental spill of hydrocarbons, the project or contractor will safely activate pollution control plans according to the convention OPRC90 or equivalent requirements. These emergency preparedness and response plans address materials and equipment for spills on ground and on water. Fire preventing and firefighting equipment will be available for fires on land and on water. Tugs will be included as part of the marine emergency preparedness and response plans.

<u>Dredging:</u>

The Project includes plans to address, among other things, potential responses to exceedances of Total Suspended Solids (TSS) thresholds.

Specific measures for dredging include:

- Dredging activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the observer, has been achieved.
- ROV surveys will be conducted prior to dredging to select the final pipeline corridor and reduce the width of the pipeline corridor to be dredged to as low as practically possible in order to minimize impacts to seagrass and corals.
- Prior to the commencement of dredging coral reef and coral basement formations between Tecomaji and Rongui Islands, as well as along the Golfinho pipeline route, undertake a pilot test of the selected dredge technique to check whether the chosen technique is likely to generate plumes of very fine material in the pipeline corridor through coral basement and corals.
- If the pilot test shows plumes of material occur, turbidity levels will be monitored. Mitigation measures will be focused on the control of turbidity outside of the dredging footprint which is defined as the zone of high impact (ZHI), in which acute (lethal) levels of disturbance will occur, but within the boundary of the ZOMI, which is within 500 m (1,640.4 ft) of the ZHI plus a 25 m (82 ft) buffer.
- Within the ZOMI, the proposed turbidity limits will be:
  - TSS greater than 100 mg/L for a maximum occurrence of 86 hours (cumulative, not necessarily consecutive hours), which is equivalent to six percent of the 60-day rolling period, corresponding to the duration of monitoring
  - TSS of between 30 and 100 mg/L for a maximum occurrence of 202 hours, which is equivalent to 14 percent of the 60-day rolling period, corresponding to the duration of monitoring.
- Outside of the ZOMI, turbidity should not exceed 10 mg/L TSS above ambient levels for more than 72 hours (five percent of the time) in a 60-day rolling period.
- Modifications to dredging will also be triggered when the following thresholds are exceeded in the course of the same 60-day rolling period as noted in the previous bullet:

  - TSS greater than 1,000 mg/L for a maximum occurrence of 14 hours (i.e., one percent of the 60-day rolling period, corresponding to the duration of monitoring) and/or
  - TSS greater than 5,000 mg/L for a maximum occurrence of three hours (i.e., 0.2 percent of the 60-day rolling period, corresponding to the duration of monitoring).
- Contractors are required to develop case-specific dredging plans for the management of specific dredging activities to avoid and minimize the effects of dredging-induced turbidity on sensitive organisms and their habitats.
- When TSHD is used, contractors will monitor the dredge spoil stream to determine whether turtles have been sucked into the dredge. If there are signs that turtles have been affected by the dredging, measures such as turtle excluder devices, which will be maintained ready to use by the contractor, will be installed immediately.
- Contractors will monitor turbidity in near real-time[1] within and outside the ZOMI. Where levels exceed prescribed thresholds, corrective actions such as slowing down the rate of dredging, moving to a new location, changing dredge equipment, using barriers (screens), installing silt curtains, or stopping dredging for a period of time to mitigate the effects of dredging on sensitive organisms or their habitat and allow turbidity to return to pre-construction levels.
- Monitoring will commence at least 24 hours prior to start of dredging and will continue until 24 hours after last disposal of cuttings.
- Compliance should be monitored daily at points around the individual trenching/dredging operations with compliance defined as the mean of the measurements not exceeding the specified thresholds.
- A minimum of three sites within 500 m (1,640.4 ft) of dredging and marine facility construction areas plus a minimum of one site in reef where pipeline trenching will occur will be monitored. Control sites should also be selected away from any predicted impacts from dredging to monitor background/natural levels.
- A system of alarms will be in place such that, as exceedances of the TSS thresholds approach, a suite of adequate measures can be selected and implemented on a case-by-case basis.
- Biological monitoring at stations within the ZOMI and zone of influence beyond. The results of monitoring will also be used to determine the amount of mitigation that will be required to offset impacts.

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[1] Because the TSS thresholds are time-based and to ensure the project does not exceed these thresholds such as by implementing additional mitigations in time to avoid an exceedance, the project proposes monitoring real-time turbidity in nephelometric turbidity units (NTU) and convert this to TSS. The turbidity sensors use the optical backscatter intensity technique. Site-specific conversion coefficients are determined to enable determination of TSS based on NTU readings by measuring in-water turbidity for different TSS concentrations under controlled conditions in the laboratory on-site using sediment and by undertaking in situ verification measurements.

- During dredging, measures will include reclaim management where applicable, as part of an adaptive management approach. Reclaim management includes deposition and offshore disposal with the turbidity monitoring.
- Undertake dredging according to the requirements of the Ecology Monitoring Plan for the Project that will ensure that dredging operations will not adversely affect the quality of use of beaches at Palma Bay. The plan requires monitoring of the marine environment during dredging and maintenance dredging activities over project lifetime. The plan includes monitoring of the offshore disposal area.
- Enhance the recolonization and regrowth of seagrass by providing suitable substrate such as shell grit for the attachment of germinating seagrass, or similar procedures where practical.
- Align the pipeline to avoid as much impact to the coral bommies to the extent practical. Where bommies are impacted, place either concrete blocks or quarried stone in “clumps” in the disturbed area. Quarried stone will be “clean” to ensure that there are no contaminants or non-native species. Quarried stone and/or artificial reef structures will be placed in the reef area where dredging occurred in order to provide cover for coral recolonization and add rugosity to the backfilled area. The contractor has a contractual obligation to do this and must prepare and submit a restoration plan for Total to review and approve.
- Involve a coral taxonomist in detailed surveys along the pipeline corridor prior to construction to determine the presence of ESA and International Union for Conservation of Nature (IUCN)-listed coral species. As far as is practical, collect representative samples of individual coral colonies present in the pipeline corridor, including listed species, and translocate these away from area directly affected by construction.
- *Disposal:* Surveys will be conducted to identify any coelacanth habitat (caves) or deep water coral habitats within the offshore dredge material disposal site and avoid impact to any sensitive areas during dredge material disposal.
    - Benthic communities adjacent to the placement area pre- and post-dredging will be monitored to characterize taxonomy, abundance and biomass distributions to assess whether turbidity from dredge material disposal affects sensitive areas such as coral habitats near the disposal site.
    - The locations of dredge material disposal in the designated offshore area will be recorded for each dredging activity.
    - Disposal of dredge material will be restricted to the designated dredge placement area.
    - Monitoring using repeatable ROV transects will begin at least one month prior to dredging and continue for six months after dredging activities have been completed. Monitoring will be done monthly in the dredge disposal area to determine trends in sedimentation at sites of sensitive communities.

Marine Construction Noise:

- In waters up to 200 m (656.2 ft) deep, the observer shall conduct pre-startup constant monitoring at least 30 minutes prior to commencement of the sound-producing activity. The sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected by the observer in the 500 m (1,640.4 ft) monitored zone.
- If there is a break in dredging sound output for a period greater than 30 minutes then pre-start monitoring must be undertaken prior to restarting dredging activity.
- Passive acoustic monitoring (PAM) will be used to monitor underwater sound generated during marine construction, including due to increased vessel traffic. Buoys will be deployed for PAM attachment or the system will be used onboard vessels.
- PAM systems will also be used in order to determine appropriate startup procedures for construction activities at night or during conditions of low visibility.
- PAM monitoring will be continuous at survey sites in the nearshore, in Palma Bay, and offshore beginning prior to commencement of marine construction and ending upon completion of marine construction. PAM records will be processed to identify temporal presence/absence of marine mammals and to identify trends in presence/absence compared to periods of noise generation during marine construction.

4 POTENTIAL STRESSORS

Stressors are any physical, chemical, or biological agent, environmental condition, external stimulus or event that may induce an adverse response in either an ESA-listed species or its designated critical habitat. There is no designated critical habitat in the action area of this consultation. The action consists of EXIM financing eligible goods and/or services on the high seas to be used in the Mozambique LNG project and the consequences of the proposed action. The project includes the development of an offshore gas field, the dredging and installation of a submerged pipeline, and onshore facilities. The major categories of potential stressors from the construction activities associated with the project are:

- Noise from vessel operations, helicopters, dredging, and well drilling
- Strikes/collisions with vessels, ROVs, equipment
- Marine debris from vessels and in-water construction
- Entanglement, entrapment, and/or impingement in water intakes of vessels and terrestrial facilities, lines, in-water equipment and structures, and hopper dredge
- Changes in water quality from outfalls from vessels, water treatment plants during construction (including a wastewater treatment plant, a desalination plant, and a cement plant), hydrotest waters, drilling muds and cuttings, stormwater discharge during construction, and turbidity from dredging, well drilling, and other in-water construction, and vessel anchoring

- Habitat loss and/or damage from temporary and permanent structures, dredging, accidental groundings, and vessel anchoring and propeller wash
- Introduction of non-native species in ballast water and on ship hulls
- Lighting on vessels and along the shoreline

Stressors that will continue during the operational phase of the project are discussed in the cumulative effects section of the Opinion (Section 8).

5 Endangered Species Act Resources That May Be Affected

This section identifies the ESA-listed species that potentially occur within the action area (Table 4) that may be affected by the proposed action. This section first identifies the species that may be affected, but are not likely to be adversely affected by the proposed action. The remaining species deemed likely to be adversely affected by one or more of the proposed activities in the action area considered in this Opinion are carried forward through the remainder of this Opinion.

Table 4. Threatened and Endangered Species That May Be Affected by the Proposed Action

Species	**ESA Status**	Recovery Plan	Critical Habitat
Marine Mammals			
Blue whale (*Balaenoptera musculus*)	E – 35 FR 18319, December 2,1970	07/1998	----
Fin whale (*Balaenoptera physalus*)	E – 35 FR 18319, December 2,1970	75 FR 47538	----
Sei whale (*Balaenoptera borealis*)	E – 35 FR 18319, December 2,1970	76 FR 43985	----
Sperm whale (*Physeter microcephalus*)	E – 35 FR 18319, December 2,1970	75 FR 81584	----
Southern right whale (*Eubalaena australis*)	E – 35 FR 18319, December 2, 1970	----	----
Fish			
African coelacanth (*Latimeria chalumnae*), Tanzanian Distinct Population Segment (DPS)	T – 81 FR 17398, March 29, 2016	----	----
Green sawfish (*Pristis zijsron*)	E – 79 FR 73978, December 12, 2014	----	----
Largetooth sawfish (*Pristis pristis*)	E – 79 FR 73978, December 12, 2014	----	----
Giant manta ray (*Manta birostris*)	T – 83 FR 2916, January 22, 2018	----	----

Species	**ESA Status**	Recovery Plan	Critical Habitat
Scalloped hammerhead shark (*Sphyrna lewini*), Indo-West Pacific DPS	T – 79 FR 38214, July 3, 2014	----	----
Oceanic whitetip shark (*Carcharinus longimanus*)	T – 83 FR 4153, January 30, 2018	----	----
Sea Turtles			
Green sea turtle (*Chelonia mydas*), Southwest Indian DPS	T – 81 FR 20057, April 6, 2016 (original listing 1978)	63 FR 28359	Not in action area
Hawksbill sea turtle (*Eretmochelys imbricata*)	E – 35 FR 8491, June 2, 1970	12/1993	Not in action area
Leatherback sea turtle (*Dermochelys coriacea*)	E – 35 FR 8491, June 2, 1970	63 FR 28359	Not in action area
Loggerhead sea turtle (*Caretta caretta*), Southwest Indian Ocean DPS	T – 76 FR 58868, September 22, 2011 (original listing 1978)	63 FR 28359	Not in action area
Olive ridley sea turtle (*Lepidochelys olivacea*), All other areas (i.e., all non-Mexico Pacific breeding populations)	T – 43 FR 32800, July 28, 1978	05/1998	----
Corals			
Acropora pharaonis	T – 79 FR 53852, September 10, 2014	----	----
Acropora retusa	T – 79 FR 53852, September 10, 2014	----	----
Acropora speciosa	T – 79 FR 53852, September 10, 2014	----	----
Montipora australiensis	T – 79 FR 53852, September 10, 2014	----	----
Isopora crateriformis	T – 79 FR 53852, September 10, 2014	----	----

Species	**ESA Status**	Recovery Plan	Critical Habitat
Seriatopora aculeata	T – 79 FR 53852, September 10, 2014	----	----
T = threatened, E = endangered			

5.1 Species Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed that are not likely to be adversely affected by the action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species. If we conclude that an ESA-listed species is not likely to be exposed to the proposed activities, we must also conclude that the species is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species that co-occur with a stressor of the action but are not likely to respond to the stressor are also not likely to be adversely affected by the action. We applied these criteria to the ESA-listed species in Table 4 and we summarize our results below.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial*, *insignificant*, or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did affect a listed species), but it is very unlikely to occur.

5.1.1 ESA-Listed Elasmobrachs

Giant manta rays are typically found offshore in the open ocean though these animals are sometimes found around nearshore reefs and estuarine waters, which are present in the action area. Giant manta rays feed in the water column on plankton. Giant manta rays have been observed along the coast and offshore in the action area, though sightings are infrequent according to project documents. According to information in the BA, giant manta rays have not been reported in coastal waters inshore of Cabo Delgado Peninsula and so are not expected to be found in nearshore waters that will be affected by the project.

The oceanic whitetip shark is usually found offshore in the open ocean, along the continental shelf, or around oceanic islands in waters from the surface to at least 152 m (498.7 ft) in depth. Oceanic whitetip sharks are highly mobile and prefer open ocean conditions, including for foraging. Bycatch of this species in the tuna fishery occurs in the action area (Romanov 2002) but sightings of this species in the action area are infrequent according to project documents.

Scalloped hammerhead sharks (Indo-West Pacific DPS) are targeted in shark fisheries in Mozambique and are caught as bycatch in other fisheries, such as the tuna fishery (Romanov 2002) in the action area. Juveniles and neonates of this species have the potential to be present in nearshore waters of bays, though none was observed during surveys conducted for this project, including a characterization of the fish assemblages in Palma Bay (Unsworth et al. 2015). It is possible that part of the hammerhead shark bycatch reported in the action area is of juveniles but there is not sufficient information to enable a determination of the life stages of the species in the action area. The species is also present in offshore waters based on bycatch data and environmental documents prepared for the project.

Largetooth and green sawfish were not documented in the action area during surveys conducted for the project and are not reported as bycatch in local fisheries. These species utilize deepwater gravelly sediments as foraging habitat when adults. Young sawfish use shallow nearshore waters of estuaries as nursery habitat and there is one reported sighting of a sawfish (species not included) in an estuarine area of the Cabo Delgado Peninsula where the project is located.

Of the stressors associated with the project, those from vessel operation, marine debris from vessels and in-water construction, noise from marine construction and vessel traffic, and changes in water quality are those with the potential to affect giant manta ray, oceanic whitetip sharks, scalloped hammerhead sharks, and largetooth and green sawfish. In addition, although juvenile and neonate scalloped hammerhead sharks and juvenile sawfish have the potential to be present in bays, which means activities resulting in habitat loss or degradation have the potential to affect these life stages of the species including through affects to prey species in the bay, there are no reported sightings of scalloped hammerhead sharks in nearshore waters where activities such as dredging will occur. As noted above, a sawfish was sighted and reported in the action area, but no additional information, including identification of the species, was reported. Disposal of dredged material in the offshore disposal site has the potential to affect habitat for largetooth and green sawfish, given that gravelly sediments have been found in portions of the disposal site, but these species have not been observed during surveys of the site.

Dreding and MODU operations have the potential to affect ESA-listed elasmobranchs due to noise generated by these activities. Zeddies et al. (2019) extrapolated source levels for dredging noise to 63 kilohertz (kHz) using the trend of the source levels in bands below 20 to 40 kHz, and used the same extrapolation for compacting of backfill in the pipeline trench. Modeled dredge source levels were split between the vessel (below one kHz) and the cutterhead (one kHz and above based on Robinson et al. 2011; as cited in Zeddies et al. 2019). The CSD was modeled as having the greater effects than the TSHD with a sound effects level (SEL) at the source of up to 200 (dB) re 1 micropascal squared per hertz per meter (μPa^2/Hz/m). Vibrodensification was modeled as having a SEL at the source of up to 180 dB re 1 μPa^2/Hz/m. The dynamic positioning thrusters of the MODU were modeled as having a lower source SEL level than vibrodensification of approximately 175 dB re 1 μPa^2/Hz/m (Zeddies et al. 2019). Data for elasmobranchs, which do not have a swim bladder, suggest they can detect sound between 20 hertz (Hz) to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2003; Ladich and Fay 2013; Myrberg 2001; Myrberg Jr. 1978; Olla 1962). In general, information regarding the effects of noise on fish hearing and behaviors is limited. Zeddies et al. (2019) determined that dredging within the bay using the CSD could result in temporary effects to fish hearing up to 250 m (820.2 ft) from the dredging activity and 2 km (1.24 miles) for TSHD. MODU operation could result in injurious effects to fish within 250 m (820.2 ft) of operation of the drilling unit and behavioral effects within 200 m (656.2 ft). Zeddies et al. (2019) used thresholds of 206 dBre 1 µPa as the peak sound pressure threshold for injury to fish, and 150 dB re 1 µPa as the threshold for behavioral effects to occur, which are based on the 2008 interim criteria and do not differentiate between fish with and without a swim bladder. Grouping fish according to the presence of a swim bladder and whether or not that swim bladder is involved in hearing, and the known hearing frequency ranges (audiograms) for fish groups, is considered the best approach for the purposes of analyzing acoustic effects. Based on the recommended criteria and thresholds in the *2014 American National Standards Institute (ANSI) Guidelines* (Popper et al. 2014) and consultations such as those NMFS has completed with the Navy, which are different from those used by Zeddies et al. (2019), fish without a swim bladder are not likely to experience a temporary threshold shift (TTS) from exposure to sound from dredging and MODU operations.

The conservation measures (Section 3.2.4) that are part of the project, including those to minimize the potential effects of noise associated with all marine construction activities and of dredging and dredge material disposal are expected to reduce the possibility that giant manta rays, oceanic whitetip and scalloped hammerhead sharks, and largetooth and green sawfish will be affected measurably by marine construction activities associated with the project. Because of the apparent rarity of largetooth and green sawfish in the action area and the lack of sightings reports or other data indicating they are present with any frequency, effects to these species as a result of the proposed action are extremely unlikely to occur and therefore discountable. Similarly, given that giant manta rays, oceanic whitetip sharks, and scalloped hammerhead sharks are likely to be present infrequently in offshore waters, and earlier life stages of scalloped hammerhead sharks are not reported in nearshore waters where stressors such as habitat degradation and loss from activities such as dredging will be greater, we believe effects to these species as a result of the proposed action are extremely unlikely to occur and therefore discountable. Therefore, we believe the proposed action is not likely to adversely affect giant manta rays, oceanic whitetip sharks, scalloped hammerhead sharks (Indo-West Pacific DPS), largetooth sawfish, and green sawfish.

5.1.2 African Coelacanth

This species is reported in waters off Tanzania and in the greater Western Indian Ocean region. The species is not reported in fishery catches in the action area but deepwater surveys do indicate that there are submarine canyons that may provide suitable habitat for the species (Green et al. 2009).

Stressors associated with the project that could affect the African coelacanth (Tanzanian DPS) include noise primarily from well drilling because the species is typically present in water depths of at least 100 m (328 ft), marine debris, habitat loss or degradation from deepwater construction activities and dredged material disposal, and impacts to water quality associated with well drilling and dredged material disposal. Despite reported sightings of the species in the action area, the project proponent has incorporated conservation measures (Section 3.2.4), such as ROV surveys of the deepwater dredged material disposal site prior to any disposal activities and of the offshore gas field prior to any well drilling activities in order to avoid directly impacting areas that may provide habitat for the species.

Because of the depth at which the species would be present, if it does occur in the action area, as well as the conservation measures developed by the project proponent to be protective of this species, we believe effects to this species as a result of the proposed action are extremely unlikely to occur and therefore discountable. Therefore, we believe the proposed action is not likely to adversely affect the African coelacanth (Tanzanian DPS).

5.1.3 Blue, Fin, Southern Right, Sei, and Sperm Whales

Based on information provided by EXIM and the project proponent, blue and fin whales are present in deep offshore waters at least seasonally, but are not common in the action area. According to the International Whaling Commission (IWC), blue whales from three different stocks transit through waters of the Mozambique Channel and are observed seasonally on the Madagascar Plateau. Little data are available for fin whales in the Indian Ocean. No sightings of these two whale species were reported in the action area during the preparation of project documents and previous seismic surveys. The IWC divided the Southern right whale into management units based on their distribution, breeding aggregations, and population separation with Mozambique and Madagascar considered separate from other populations. Mozambique historically had a wintering population off its coast but commercial whaling led to overharvest of this population. While Southern right whales are now protected under Mozambique regulations, they have not been observed in the action area based on information from EXIM and the project proponent and, if present, would only be in offshore waters.

Sperm and sei whales have been sighted in the action area during past seismic surveys and environmental surveys conducted for the project. Sperm whales are present in the action area year-round, although males are migratory. Sei whales are present seasonally in the action area during astral winter (June-August). Despite the documented presence of these species in the action area, during a February 24, 2020 in-person meeting, the project proponent reported they have no records of ship strikes occurring during any of their exploratory drilling in the action area or during seismic surveys conducted in the action area and Area 4 since 2007.

Of the stressors associated with the project, those associated with noise from helicopter and vessel operations and well drilling activities, vessel strike, marine debris, and changes in water quality that could affect the availability of prey are the most likely to affect blue, fin, Southern right, sei, and sperm whales. The conservation measures that are part of the project (Section 3.2.4) include measures to avoid and minimize effects to marine mammals from vessel and helicopter operations, noise associated with drilling and other marine construction activities, and changes in water quality that could affect prey availability for these species.

Marine mammals use sound for communication, feeding, and navigation. To better reflect marine mammal hearing, Southall et al. (2007) recommended that marine mammals be divided into hearing groups, and NMFS made modifications to these groups to divide pinnipeds into two groups and to re-categorize hourglass and Peale's dolphins (*Lagenorhynchus cruciger* and *Lagenorhynchus australis*, respectively) from mid-frequency to high-frequency cetaceans (NMFS 2016b; 2018b; Table 5).

Table 5. Marine Mammal Functional Hearing Groups (Southall et al. 2007; NMFS 2016b)

Hearing Group	Generalized Hearing Range
Low-frequency cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger*, *Lagenorhynchus australis*)	275 Hz to 160 kHz
Phocid pinnipeds (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

The impetus for dividing marine mammals into functional hearing groups was to produce thresholds for each group for the onset of TTS and permanent threshold shift (PTS). The 2016

NMFS guidance and 2018 revisions include a protocol for estimating PTS onset thresholds for impulsive (e.g., airguns, impact hammer pile drivers, explosions) and non-impulsive (tactical sonar, vibratory pile drivers) sound sources. The thresholds serve as a tool to help evaluate the effects of activities employing different sound sources.

The dredging associated with pipeline construction is not expected to result in a SEL threshold that would cause injurious acoustic effects to mid-frequency cetaceans (sperm whales; Zeddies et al. 2019). Zeddies et al. (2019) calculated that there could be injurious SEL effects to low frequency cetaceans (baleen whales) within 70 m (229.6 ft) for the TSHD and 50 m (164 ft) for the CSD. Given that the baleen whales in the action area are deep water species, it is unlikely they would be in the bay where pipeline dredging will occur. Dredging that will take place in deeper water could result in behavioral responses using a sound pressure level (SPL) 120 dB re 1 µPa from 5,000 to 40,000 m (3.1 to 24.8 miles) from dredging activity based on acoustic modeling by Zeddies et al. (2019). The only baleen whale species observed in the action area is the sei whale, which is present seasonally, thus reducing the likelihood of exposure of these animals to the acoustic effects of dredging that could result in a behavioral response.

The required operation of vessels in offshore waters at slow speeds (maximum of approximately 11 knots) is expected to minimize the possibility for vessel collisions, because the probability of lethal injury to large whales has been shown to drop below 0.5 at 11.8 knots (Vanderlaan and Taggart 2007). Blue, fin, and Southern right whales are apparently rare in the action area. Information from the project proponent that oil and gas exploration activities in the action area since 2007 have not resulted in any reports of vessel collisions with whales, including sei and sperm whales that are reported in the action area. Based on this, as well as the conservation measures that are expected to minimize the potential effects of the project on these species, we believe effects to these species as a result of the proposed action are extremely unlikely to occur and therefore discountable. Therefore, we believe the proposed action is not likely to adversely affect blue whales, fin whales, Southern right whales, sei whales, and sperm whales.

5.1.4 Leatherback, Loggerhead, and Olive Ridley Sea Turtle

Leatherback sea turtle nesting is not reported in Tungue Bay and may not occur at all in northern Mozambique. The Mozambique sea turtle monitoring program, which includes monitoring of nesting in Quirimbas National Park offshore of Pemba, has never recorded leatherback nesting since monitoring began in 2005 (Fernandes et al. 2018). Leatherbacks are an offshore species except during the nesting season when adult females and hatchlings may be in nearshore waters while transiting to/from nesting beaches but appear to be more common in the south (Robinson et al. 2018). Williams et al. (2017) report leatherback nesting only in the south of the country. If leatherbacks are present in the action area, they are likely to be offshore, but the species has not been reported in sightings data during surveys in the action area based on information provided by EXIM and the project proponent.

Nesting of loggerhead sea turtles (Southwest Indian DPS) is not reported in Tungue Bay, although individuals may forage within the action area and some studies indicate the species is present in offshore waters. At Quirimbas National Park, which is part of the Mozambique sea turtle monitoring program, most of the live marine turtle sightings were loggerheads and greens (Fernandes et al. 2018), but green sea turtles are the dominant nesters. Robinson et al. (2018) and Williams et al. (2017) report that loggerheads are more common in the south of Madagascar possibly because the majority of nesting takes place in South Africa. Less than 100 females nest annually in Mozambique (Baldwin et al. 2003) and nesting is reported mainly in the south of the country (Williams et al. 2017).

Olive ridley sea turtles (non-Mexico breeding populations) have not been observed in the action area during surveys conducted for the project. No nesting of the species is reported in Mozambique. The majority of nesting by this species in the Indian Ocean occurs in India in three arribadas (synchronized, large-scale nesting). The species has been reported in the Rovuma River area a few kilometers from the project southward, so there is a potential for olive ridley sea turtles to forage in the action area.

Stressors associated with the action that could result in effects to leatherback, loggerhead (Southwest Indian Ocean DPS), and olive ridley (non-Mexico breeding populations) sea turtles include noise from marine construction, including pipeline construction and well drilling, and vessel and helicopter operations, marine debris, changes in water quality, strikes/collisions, loss of or damage to foraging habitat and prey due to marine construction and vessel operations, introduction of non-native species in ballast water and on ship hulls that compete with prey species targeted by these three turtle species, and entanglement, entrapment, and impingement including in the TSHD. Zeddies et al. (2019) calculated that dredging using the TSHD and CSD could result in injurious or behavioral acoustic effects to sea turtles within 20 m (65.6 ft) of dredging activity. Offshore, noise from the MODU could result in injurious effects to sea turtles up to 27 m (88.6 ft) from the drilling and behavioral effects up to 80 m away (Zeddies et al. 2019).

Given the apparent rarity of these three sea turtle species in the action area coupled with the conservation measures meant to reduce the impacts of stressors such as those from vessel and helicopter operations, dredging, and ballast water, we believe effects to these species as a result of the proposed action are extremely unlikely to occur and therefore discountable. Therefore, we believe the proposed action is not likely to adversely affect leatherback, loggerhead (Southwest Indian Ocean DPS), and olive ridley (non-Mexico breeding populations) sea turtles.

5.2 Status of Species Likely to be Adversely Affected

This Opinion examines the status of ESA-listed green (Southwest Indian Ocean DPS) and hawksbill sea turtles, and ESA-listed corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*) that may be adversely affected by the action.

The evaluation of adverse effects in this Opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories in the action area. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers or distribution" that is part of the jeopardy determination as described in 50 CFR §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations published in the Federal Register, status reviews, recovery plans, and on the NMFS Web site: [https://www.fisheries.noaa.gov/topic/endangered-species-conservation].

5.2.1 General Threats Faced by Sea Turtles

Sea turtles face numerous natural and anthropogenic threats that shape their status and affect their ability to recover. Many of the threats are the same or similar in nature for all listed sea turtle species, and those identified in this section are discussed in a general sense for all sea turtles. Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Fisheries

Incidental bycatch in commercial fisheries is identified as a major contributor to past declines, and threat to future recovery, for all of the sea turtle species (NMFS and USFWS 1991;1992;1993;2008; NMFS et al. 2011). Domestic fisheries often capture, injure, and kill sea turtles at various life stages. Sea turtles in the pelagic environment are exposed to U.S. Atlantic pelagic longline fisheries. Sea turtles in the benthic environment in waters off the coastal United States are exposed to a suite of other fisheries in federal and state waters. In addition to domestic fisheries, sea turtles are subject to direct as well as incidental capture in numerous foreign fisheries, further impeding the ability of sea turtles to survive and recover on a global scale. For example, pelagic stage sea turtles, especially loggerheads and leatherbacks, circumnavigating the Atlantic are susceptible to international longline fisheries including the Azorean, Spanish, and various other fleets (Aguilar et al. 1994; Bolten et al. 1994). Bottom longlines and gillnet fishing is known to occur in many foreign waters, including (but not limited to) the northwest Atlantic, western Mediterranean, South America, West Africa, Central America, and the Caribbean. Shrimp trawl fisheries are also occurring off the shores of numerous foreign countries and pose a significant threat to sea turtles similar to the impacts seen in U.S. waters. Many unreported takes or incomplete records by foreign fleets make it difficult to characterize the total impact that international fishing pressure is having on listed sea turtles. Nevertheless, international fisheries represent a continuing threat to sea turtle survival and recovery throughout their respective ranges.

Non-Fishery In-Water Activities

There are also many non-fishery impacts affecting the status of sea turtle species, both in the ocean and on land. Hopper dredges, which are frequently used in ocean bar channels and sometimes in harbor channels and offshore borrow areas, move relatively rapidly and can entrain and kill sea turtles (NMFS 1997). Sea turtles entering coastal or inshore areas have also been affected by entrainment in the cooling-water systems of electrical generating plants. Other nearshore threats include harassment and/or injury resulting from private and commercial vessel operations, military detonations and training exercises, in-water construction activities, and scientific research activities.

Coastal Development and Erosion Control

Coastal development can deter or interfere with nesting, affect nesting success, and degrade nesting habitats for sea turtles. Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Lutcavage et al. 1997; Bouchard et al. 1998). These factors may decrease the amount of nesting area available to females and change the natural behaviors of both adults and hatchlings, directly or indirectly, through loss of beach habitat or changing thermal profiles and increasing erosion, respectively (Ackerman 1997; Witherington et al. 2003;2007). In addition, coastal development is usually accompanied by artificial lighting which can alter the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings that are drawn away from the water (Witherington and Bjorndal 1991). In-water erosion control structures such as breakwaters, groins, and jetties can impact nesting females and hatchling as they approach and leave the surf zone or head out to sea by creating physical blockage, concentrating predators, creating longshore currents, and disrupting of wave patterns.

Environmental Contamination

Multiple municipal, industrial, and household sources, as well as atmospheric transport, introduce various pollutants such as pesticides, hydrocarbons, organochlorides (e.g., dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCB], and perfluorinated chemicals [PFC]), and others that may cause adverse health effects to sea turtles (Iwata et al. 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Acute exposure to hydrocarbons from petroleum products released into the environment via oil spills and other discharges may directly injure individuals through skin contact with oils (Geraci 1990), inhalation at the water's surface, and ingesting compounds while feeding (Matkin 1997). Hydrocarbons also have the potential to affect prey populations, and therefore may affect listed species indirectly by reducing food availability in the action area.

Marine debris is a continuing problem for sea turtles. Marine debris is a problem due primarily to sea turtles ingesting debris and blocking the digestive tract, causing death or serious injury (Lutcavage et al. 1997; Laist et al. 1999). Schuyler et al. (2015) estimated that, globally, 52 percent of individual sea turtles have ingested marine debris. Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives; this figure is supported by data from Lazar and Gračan (2011), who found 35 percent of loggerheads had plastic in their gut. A Brazilian study found that 60 percent of stranded green sea turtles had ingested marine debris (Bugoni et al. 2001). Loggerhead sea turtles had a lesser frequency of marine debris ingestion. Plastic may be ingested out of curiosity or due to confusion with prey items. Marine debris consumption has been shown to depress growth rates in post-hatchling loggerhead sea turtles, increasing the time required to reach sexual maturity and increasing predation risk (McCauley and Bjorndal 1999). Sea turtles can also become entangled and die in marine debris, such as discarded nets and monofilament line (NRC 1990; Lutcavage et al. 1997; Laist et al. 1999).

Climate Change

See Section 6.2.1 for a discussion of the threat of climate change to sea turtles.

Other Threats

Predation by various land predators is a threat to developing nests and emerging hatchlings. The major natural predators of sea turtle nests are mammals, including raccoons, dogs, pigs, skunks, and badgers. These mammals, as well as ghost crabs, laughing gulls, and the exotic South American fire ant (*Solenopsis invicta*), prey upon emergent hatchlings. In addition to natural predation, direct harvest of eggs and adults from beaches in foreign countries continues to be a problem for various sea turtle species throughout their ranges (NMFS and USFWS 2008).

Diseases, toxic blooms from algae and other microorganisms, and cold stunning events are additional sources of mortality that can range from local and limited to wide-scale and affecting hundreds or thousands of animals.

5.2.1.1 Status of Green Sea Turtle (Southwest Indian DPS)

The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (Figure 6; 81 FR 20057). The Southwest Indian DPS is found in the Indian Ocean near the east coast of Africa (number 4 in Figure 4).

Species Description and Life History

The green sea turtle (*Chelonia mydas*) is the largest of the hardshell marine turtles. It has a circumglobal distribution, occurring throughout nearshore tropical, subtropical and, to a lesser extent, temperate waters.

Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific

(Figure 4). Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean (Figure 4).

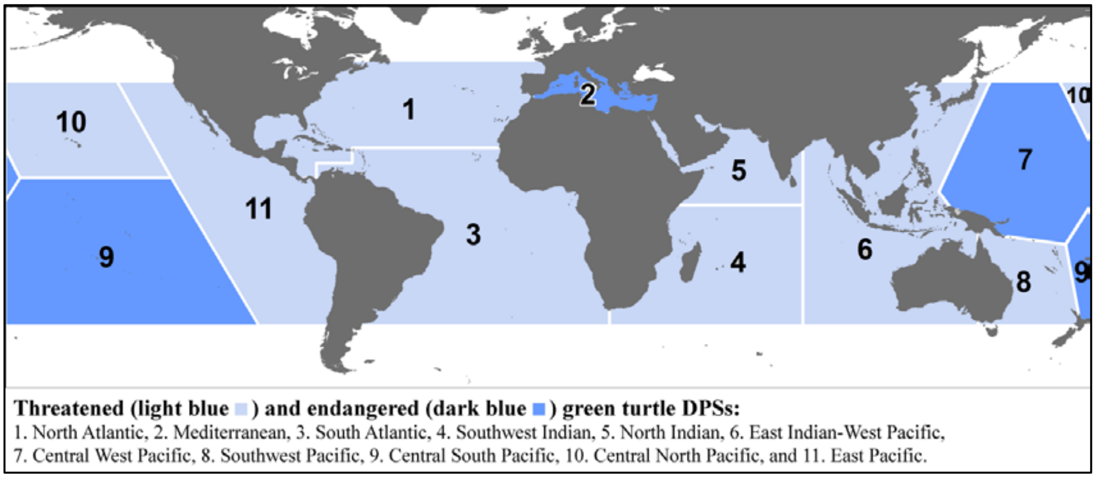

Figure 4. Map depicting DPS boundaries for green turtles

Age at first reproduction for females is 20 - 40 years. Green sea turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is 2 - 5 years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

Population dynamics

Abundance

Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). There are thirty-seven nesting sites for the Southwest Indian DPS, with an estimated nester abundance of 91,059 (Figure 5). The largest nesting site is on Europa, Eparses Island, a small atoll in the Mozambique Channel, which hosts thirty percent of nesting females for the DPS (Seminoff et al. 2015).

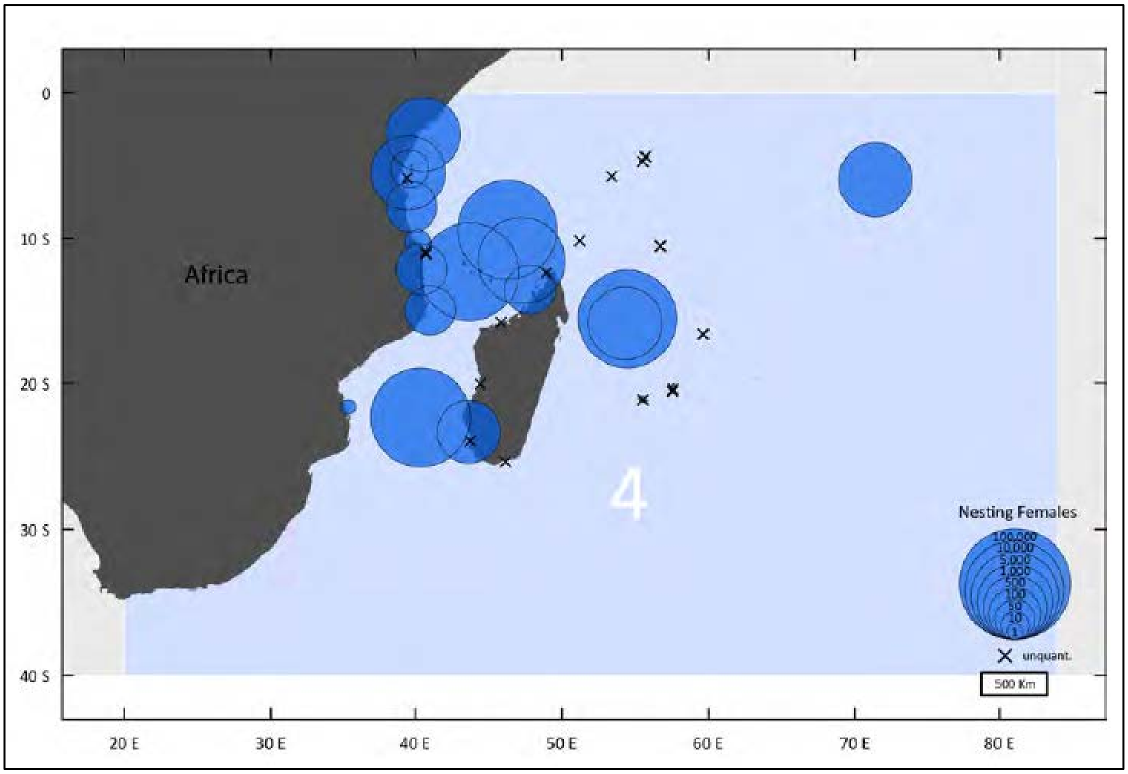

Figure 5. Geographic range of the Southwest Indian distinct population segment green turtle, with location and abundance of nesting females (from Seminoff et al. 2015)

Population Growth Rate

Trend data is lacking for a number of nesting sites in the Southwest Indian DPS, and it is not possible to determine the population growth rate for the DPS. At several protected nesting sites with long-term data available, nesting is stable or shows signs of increase. At Glorieuses, Europa, and Mayotte, all within the French Eparses Islands, annual growth rates have been 3.5, 2.0, and 0.9 percent, respectively. Other sites within the DPS such as the Comoros Islands and the Seychelles show increasing trends, although growth rates cannot be calculated.

Genetic Diversity

Genetic studies of green turtles in the Southwest Indian DPS identified seven haplotypes and a mix of common and widespread haplotypes, indicating high genetic diversity. Despite gaps in genetic sampling of the northern rookeries, there is a moderate degree of spatial structuring within the DPS, with at least two genetic stocks: the South Mozambique Channel, and the North Mozambique Channel (Seminoff et al. 2015). Most green turtle rookeries in the Indo-Pacific separated by 500 km (310.7 miles) or more are genetically distinct but some less than 200 km (124.3 miles) apart show significant genetic differentiation and others 1,000 km (621.3 miles) apart are similar (Vargas et al. 2015).

Distribution

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, subtropical and, to a lesser extent, temperate waters. The Southwest Indian DPS is comprised of green turtles in Madagascar, eastern Africa from Kenya to South Africa and island nations in western Indian Ocean. Major nesting beaches for the DPS are found in the French Eparses Islands, Mayotte and the outer Seychelles islands.

Status

Once abundant in tropical and subtropical waters, green sea turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift net, long-line, set-net, pound-net and trawl fisheries kill thousands of green sea turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Historically, green turtles in the Southwest Indian DPS were subject to harvest, severely depleting the population. The DPS is currently threatened by incidental capture in fisheries and by climate change, as sea level rise could eliminate nesting habitat on many low-lying atolls in the region. Conservation measures have been put in place by several countries establishing protected nesting areas and monitoring programs, which are believed to be contributing to the increasing population trends. The Southwest Indian DPS is considered to have a low risk of extinction in the next hundred years, and has shown itself to be resilient to past harvest.

Critical Habitat

There is no designated critical habitat for the Southwest Indian DPS. The North Atlantic DPS includes green sea turtle critical habitat designated on September 2, 1998, which includes waters surrounding Culebra Island, Puerto Rico, which is outside the action area of this consultation.

Recovery Goals

NMFS has not prepared a Recovery Plan for the Southwest Indian DPS green turtle. In general, listed species that occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296; June 15, 1990).

5.2.1.2 Status of Hawksbill Sea Turtles

The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

Species Description and Life History

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans (Figure 6).

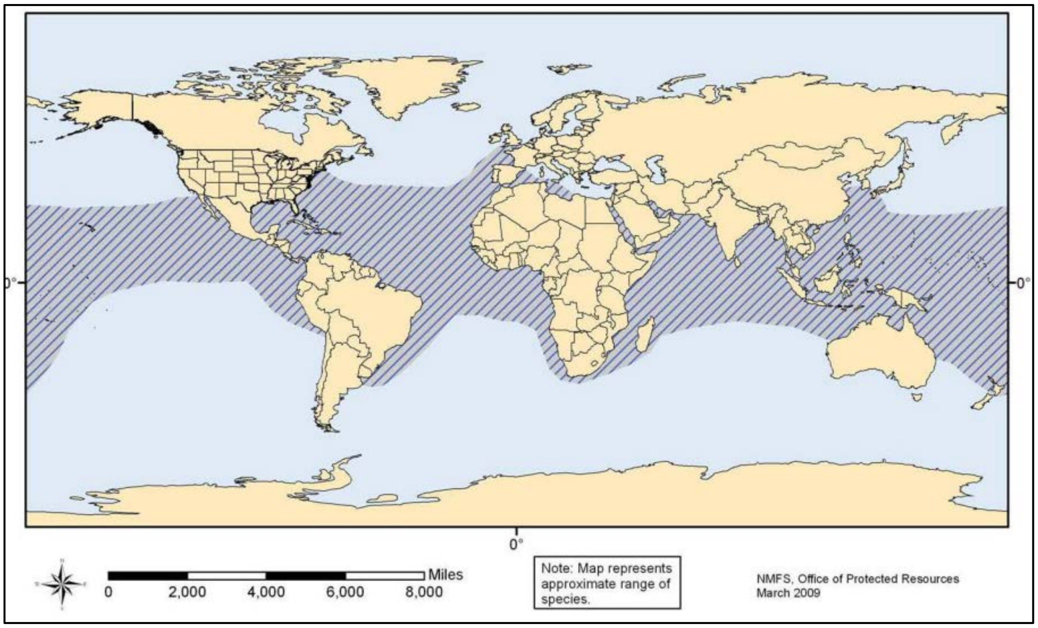

Figure 6. Map identifying the range of the endangered hawksbill sea turtle (http://www.nmfs.noaa.gov/pr/pdfs/rangemaps/hawksbill_turtle.pdf)

Hawksbill sea turtles reach sexual maturity at 20 – 40 years of age. Females return to their natal beaches every two to five years to nest (an average of three to five times per season). Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22 – 25 cm (8.66 to 9.84 in) in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. Adult hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging locations ranges from a few hundred to a few thousand km (Horrocks et al. 2001; Miller 1998).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section is broken down into: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the hawksbill sea turtle.

Abundance

Surveys at 88 nesting sites worldwide indicate that 22,004 – 29,035 females nest annually (NMFS and USFWS 2013). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining.

Population Growth Rate

From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15 percent annually (Heppell et al. 2003); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2013).

Genetic Diversity

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (Monzón-Argüello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000-300,000 years ago (Leroux et al. 2012).

In general, genetic diversity within Indo-Pacific hawksbill rookeries is high compared to other ocean basins (Vargas et al. 2015). Genetic structure among Indo-Pacific rookeries indicated that most rookeries separated by 500 km had significant genetic divergence and could, for the most part, be considered geographically distinct populations. Study of mitochondrial DNA suggests that the 14 Indo-Pacific hawksbill rookeries studied (Iran Northwest, Iran Southeast, Saudi Arabia, Aldabra Group Seychelles, Chagos Archipelago, East Malaysia, Peninsular Malaysia, Western Australia, northeast Arnhem Land Northern Territory, Milman Island north Queensland, and Solomon Islands) belong to 8 different genetic stocks (Vargas et al. 2015).

Distribution

The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbills can be found in *Sargassum* mats; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997).

Status

Long-term data on the hawksbill sea turtle indicate that 63 sites have declined over the past 20 to 100 years (historic trends are unknown for the remaining 25 sites). Recently, 28 sites (68 percent) have experienced nesting declines, 10 have experienced increases, three have remained stable, and 47 have unknown trends. The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in Southeast Asia where collection approaches 100 percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

Critical Habitat

NMFS designated critical habitat for hawksbill sea turtles on September 2, 1998 around Mona and Monito Islands, Puerto Rico, which is outside the action area for this consultation.

Recovery Goals

The 1992 and 1998 Recovery Plans for the U.S. Caribbean, Atlantic and Gulf of Mexico, and U.S. Pacific populations of hawksbill sea turtles, respectively, contain complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the Recovery Plans:

- Identify important nesting beaches
- Ensure long-term protection and management of important nesting beaches
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters
- Identify important marine habitats; protect and manage populations in marine habitat
- Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion
- Prevent the degradation of reef habitat caused by sewage and other pollutants
- Monitor nesting activity on important nesting beaches with standardized index surveys
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation
- Determine nesting beach origins for juveniles and sub-adult populations

5.2.2 General Threats Faced by ESA-Listed Corals

Corals face numerous natural and anthropogenic threats that shape their status and affect their ability to recover. Because many of the threats are the same or similar in nature for all listed coral species, those identified in this section are discussed in a general sense for all corals. All threats are expected to increase in severity in the future. More detailed information on the threats to listed corals is found in the Final Listing Rule (79 FR 53851; September 10, 2014). Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Several of the most important threats contributing to the extinction risk of corals are related to global climate change, which are discussed further in Section 6.2.1.

Ocean Warming

Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years.

In addition to coral bleaching, other effects of ocean warming can harm virtually every life-history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. Average seawater temperatures in reef-building coral habitat in the wider Caribbean have increased during the past few decades and are predicted to continue to rise between now and 2100. The frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past two decades and is predicted to continue to increase between now and 2100.

Ocean Acidification

Ocean acidification is a result of global climate change caused by increased CO_2 in the atmosphere that results in greater releases of CO_2 that is then absorbed by seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification affects adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

As CO_2 concentrations increase in the atmosphere, more CO_2 is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in CO_2 and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans and is predicted to increase considerably between now and 2100. Along with ocean warming and disease, we consider ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100, although individual susceptibility varies among the listed corals.

Diseases

Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (e.g., pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly described genetic defects. Coral disease often produces acute tissue loss. Other forms of "disease" in the broader sense, such as temperature-caused bleaching, are discussed in other threat sections (e.g., ocean warming because of climate change).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically, though the prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality.

Trophic Effects of Reef Fishing

Fishing, particularly overfishing, can have large-scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs ("phase shifts"). Even fishing pressure that does not rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control.

With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Sedimentation

Human activities in coastal and inland watersheds introduce sediment into the ocean by a variety of mechanisms including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction.

The most common direct effect of sedimentation is sediment landing on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. In addition, corals can actively remove sediment but at a significant energy cost. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Nutrient Enrichment

Elevated nutrient concentrations in seawater affect corals through two main mechanisms: direct impacts on coral physiology, and indirect effects through stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. Anthropogenic nutrients mainly come from point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling, also bring nutrients to coral reefs.

5.2.3 Status of ESA-Listed Corals

5.2.3.1 Indo-Pacific Acroporid Corals

Acropora are sessile colonies that spawn their gametes into the water column; the larvae can survive in the planktonic stage from four to 209 days (Graham et al. 2008). This has allowed many *Acropora* species to have very wide geographic ranges, both longitudinally and latitudinally (Wallace 1999). However, sessile colonies must be within a few meters of each other to have reasonable success in fertilization (Coma and Lasker 1997). All species of the genus *Acropora* studied to date are simultaneous hermaphrodites (Baird et al. 2009), with a gametogenic cycle in which eggs develop over a period of about 9 months and testes over about 10 weeks (Babcock and Heyward 1986; Szmant 1986; Wallace 1985). Fecundity in *Acropora* colonies is generally described as ranging from 3.6 to 15.8 eggs per polyp (Kenyon 2008; Wallace 1999). Mature eggs of species of *Acropora* are large when compared with those of other corals, ranging from 0.53 to 0.90 mm in mean diameter (Wallace 1999). For five *Acropora* species examined by Wallace (1985), the minimum reproductive size ranged from four to seven cm, and the estimated ages ranged from three to five years.

Acropora spp. release gametes as egg-sperm bundles that float to the sea surface, each polyp releasing all its eggs and sperm in one bundle. Fertilization takes place after the bundles break open at the sea surface. Sperm concentrations of 106 milliliters per liter have been found to be optimal for fertilization in the laboratory, and concentrations of this order have been recorded in the field during mass spawning events. Self-fertilization, although possible, is infrequent. Gametes remain viable and achieve high fertilization rates for up to eight hours after spawning (Kenyon 1994). Embryogenesis takes place over several hours, and further development leads to a planula that is competent to settle in four to five days after fertilization.

Many *Acropora* have branching morphologies, making them potentially susceptible to fragmentation. Fragment survival can increase coral abundance in the short-term but does not contribute new genotypes (or evolutionary opportunities) to the population.

Although spawners with long larval lives can eventually become distributed over broad geographic areas, as is typical for *Acropora,* the year-by-year replenishment of populations requires local source populations. For example, Vollmer and Palumbi (2007), using DNA sequence data, determined that *Acropora cervicornis* in the Caribbean have limited realized gene flow despite long-distance dispersal potential.

Acropora pharaonis

Acropora pharaonis is present in the western/northern Indian Ocean, including the Red Sea, and areas in the Pacific Ocean (Figure 7). *Acropora pharaonis* is reported to occur in depths from five to 25 m (16.4 to 82 ft) in reef slope and back reef habitats, including upper reef slopes, mid-slope terraces, and lagoons.

Figure 7. Map showing the range of confirmed, predicted, and historic distribution of *Acropora pharaonis* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Population dynamics

Veron (2014) reports that *Acropora pharaonis* occupied 3.6 percent of 2,984 dive sites sampled in 30 ecoregions classified by Veron in the Indo-Pacific. The mean abundance rating for the species was 1.80 on a one to five rating scale at the sites in which it was found (Veron 2014). All of the sites identified by Veron (2014) were in the Indian Ocean. Based on the semi-quantitative system of Veron (2014), the species' overall abundance was characterized as "common in the Red Sea, uncommon elsewhere." Based on results from Richards et al. (2008a) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

The overall decline in abundance ("Percent Population Reduction") was estimated at 30 percent, and the decline in abundance before the 1998 bleaching event ("Back-cast Percent Population Reduction") was estimated at 14 percent. Given that *Acropora pharaonis* occurs in areas affected by broad changes in live coral cover trends and shifts in reef communities (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012) and has some susceptibility to both global and local threats, we conclude that it is likely the species has declined in abundance over the past 50 to 100 years, but the limited species-specific information does not make it possible to quantify changes in abundance.

Status

Acropora pharaonis is highly susceptible to ocean warming and associated bleaching, as are other acroporid corals. This is exacerbated by its restricted range. The species is also susceptible to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea level rise, and collection and trade. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms in the 21 countries where records confirming the presence of this species exist indicate the most common regulatory mechanisms are reef fishing regulations and area management for coral protection and conservation with coral protection laws being less prominent. *Acropora retusa*'s geographic distribution exacerbates its vulnerability to extinction because it is restricted to a portion of the Indian Ocean with a limited amount of island and offshore habitat and includes areas projected to experience the most rapid and severe impacts from climate change and localized human impacts. Its depth range of five to 25 m and occurrence in various habitats moderates its vulnerability to extinction over the foreseeable future. However, the combination of its limited geographic distribution and high susceptibility to ocean warming are likely to be more influential to the status of the species because of the protected severity of ocean warming in the foreseeable future.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Acropora pharaonis*.

Acropora retusa

Acropora retusa is distributed from the Indian Ocean, including the Red Sea, to the central Pacific (Figure 8). *Acropora retusa* has been reported to occupy upper reef slopes and tidal pools (Veron 2000; Veron and Wallace 1985). *Acropora retusa* has been reported in water depths ranging from 1 m to 5 m (3.3 to 16.4 ft; Carpenter et al. 2008).

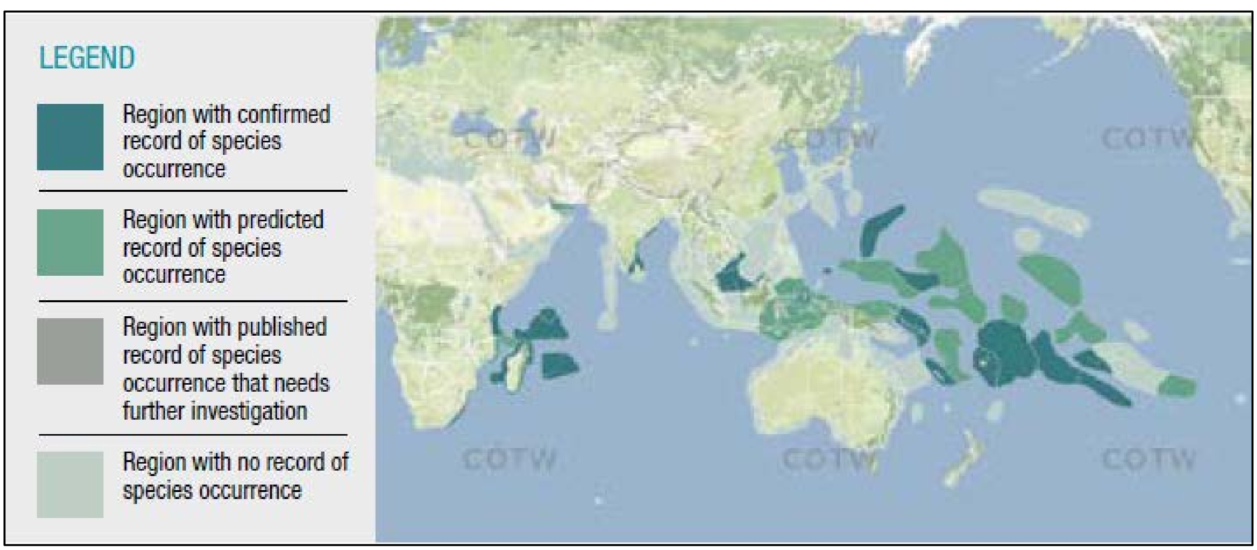

Figure 8. Map showing the range of confirmed, predicted, and historic distribution *of Acropora retusa* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Population dynamics

Veron (2014) reports that *Acropora retusa* occupied 0.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.21 on a one to five rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as “rare.” Overall abundance was described as “common in South Africa, rare elsewhere.” The absolute abundance of this species is likely at least millions of colonies (Richards et al. 2008b; Veron 2014).

The overall decline in abundance (“Percent Population Reduction”) was estimated at 49 percent, and the decline in abundance before the 1998 bleaching event (“Back-cast Percent Population Reduction”) was estimated at 18 percent. However, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *Acropora retusa* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited amount of species-specific information.

Status

Acropora retusa is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, predation, and nutrients. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms addressing global threats that contribute to extinction risk for this species are inadequate. *Acropora retusa* is restricted to shallow habitat (zero to five m), where many global and local threats may be more severe, especially near populated areas. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range also reduces the absolute area in which the species may occur throughout its geographic range, and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts. *Acropora retusa*'s abundance is considered rare overall. This level of abundance, combined with its restricted depth distribution where impacts are more severe, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events. The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Acropora retusa*.

Acropora speciosa

Acropora speciosa is distributed from Indonesia to French Polynesia (Figure 9). *Acropora speciosa* has been reported to occupy protected environments with clear water and high diversity of *Acropora* (Veron 2000) and steep slopes or deep, shaded waters (Richards et al. 2008a). *Acropora speciosa* has been reported in water depths ranging from 12 m to 30 m (39.4 to 98.4 ft; Carpenter et al. 2008) and 15 m to 40 m (49.2 to 131.2 ft; Richards 2009). It is found in mesophotic assemblages in American Samoa (Bare et al. 2010), suggesting the potential for deep refugia.

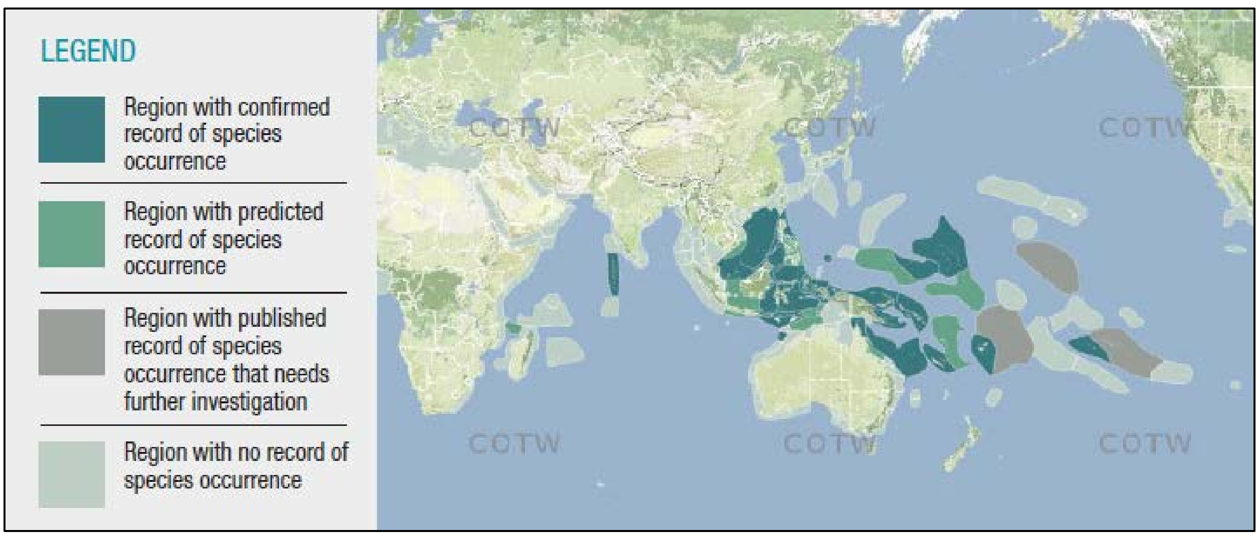

Figure 9. Map showing the range of confirmed, predicted, and historic distribution of *Acropora speciosa* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Population dynamics

The total world population of this species has been estimated at 10,942,000 colonies, with an effective population size of 1,204,000 colonies (Richards et al. 2008a; Veron 2014).

The overall decline in abundance ("Percent Population Reduction") was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event ("Back-cast Percent Population Reduction") was estimated at 14 percent (Carpenter et al. 2008). However, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *Acropora speciosa* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Status

Acropora speciosa is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, predation, and nutrient enrichment. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate. Although *Acropora speciosa*'s habitat includes mesophotic depths which may provide some buffering capacity against threats that are more severe in shallower reef environments such as warming, its habitat is quite specialized, which may limit buffering capacity if threats are more pronounced within the type of habitat where the species occurs within. *Acropora speciosa*'s effective population size of 1.2 million genetically distinct colonies could increase vulnerability to extinction if a high proportion of the effective population occurs within the parts of its range most affected by threats, potentially causing the species to decline to such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events. The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Acropora speciosa*.

5.2.3.2 Isopora crateriformis

Isopora crateriformis is distributed from Sumatra (Indonesia) to American Samoa, and there are reports of the species from the western and central Indian Ocean (Figure 10). *Isopora crateriformis* is found most commonly in shallow, high-wave energy environments. *Isopora craterformis* has been reported in water depths ranging from low tide commonly to at least 12 m (39.4 ft; Birkeland et al. 1987). The species was recently reported (as *Acropora crateriformis*) on mesophotic reefs (< 50 m [164 ft] depth) in American Samoa (Bare et al. 2010).

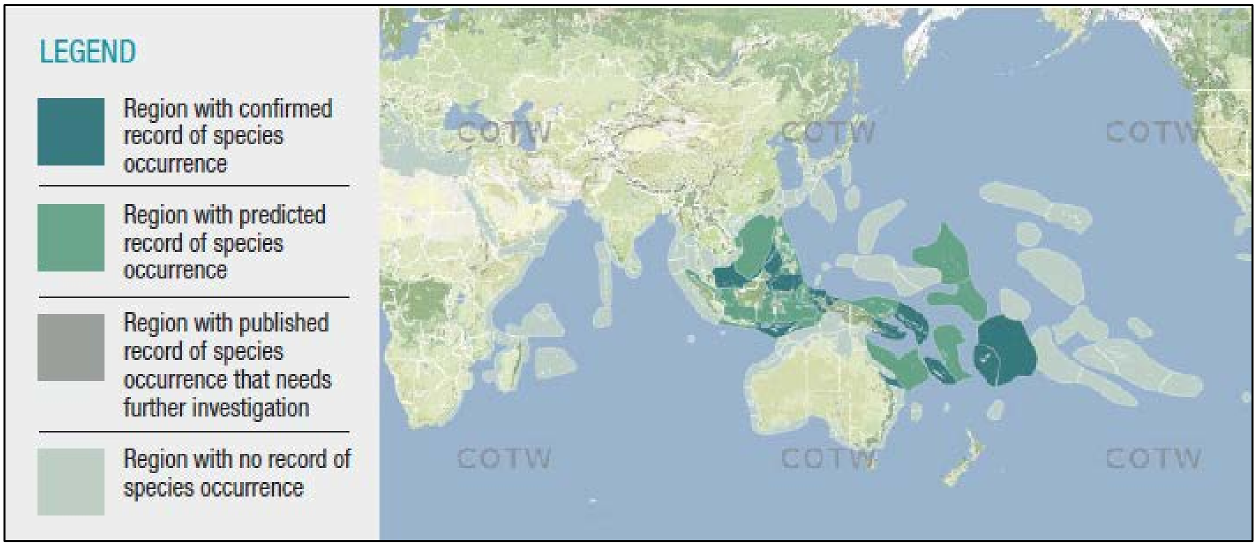

Figure 10. Map showing the range of confirmed, predicted, and historic distribution of *Isopora crateriformis* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Life history

Isopora crateriformis is most likely a simultaneous hermaphroditic (having both male and female gametes) brooder as is the closely related *Isopora cuneata* (Bothwell 1981). *Isopora cuneata* can undergo several seasonal cycles of larval production (Kojis 1986). Its brooding life history allows *Isopora* spp. to locally dominate recruitment at Lord Howe Island, Australia; colonies of this genus also dominate the adult population there, suggesting brooding may drive community structure in remote areas (Harriott 1992;1995). *Isopora cuneata* is not prone to asexual reproduction via fragmentation, based on its semi-encrusting morphology (Bothwell 1981). The species shows moderate gene flow (Mackenzie et al. 2004) but little potential for large-scale dispersal (Ayre and Hughes 2004).

Population dynamics

Veron (2014) reports that *Isopora crateriformis* occupied 0.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.4 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as “rare.” Overall abundance was described as “occasionally common on reef flats.” The absolute abundance of this species is likely at least millions of colonies (Richards et al. 2008e; Veron 2014).

The overall decline in abundance was estimated at 38 percent, and the decline in abundance before the 1998 bleaching event (“Back-cast Percent Population Reduction”) was estimated at 14 percent. However, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences of species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *Isopora crateriformis* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

The species shows moderate gene flow (Mackenzie et al. 2004) but little potential for large-scale dispersal (Ayre and Hughes 2004).

Status

Isopora crateriformis is highly susceptible to ocean warming, disease, acidification, trophic effects of fishing, and nutrients, and predation. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate. The majority of *Isopora crateriformis*' distribution is within the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future. *Isopora crateriformis*' qualitative abundance is rare overall. Considering that much of the range of this species includes areas where severe and increasing impacts are predicted, this level of abundance combined with its restricted depth distribution, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events. The combination of these biological and environmental characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Isopora crateriformis*.

5.2.3.3 Seriatopora aculeata

Seriatopora aculeata is distributed from Australia, Fiji, Indonesia, Japan, Papua New Guinea, and Madagascar to the Marshall Islands (Figure 11). *Seriatopora aculeata* has been reported to occupy shallow reef environments (Veron 2000) in water depths ranging from 3 m to 40 m (9.8 to 131.2 ft; Carpenter et al. 2008).

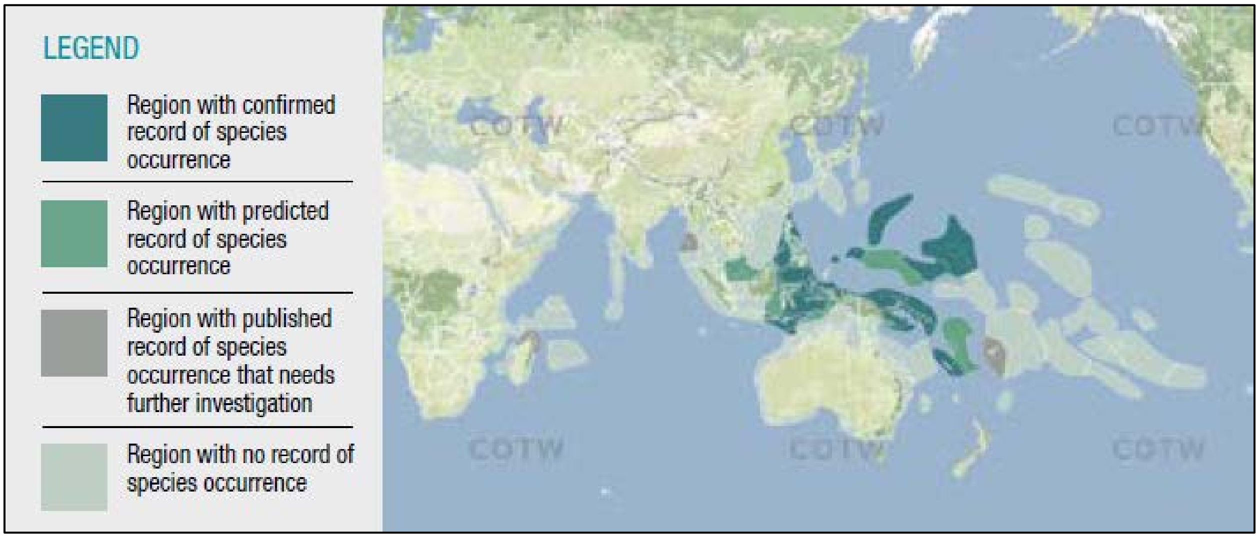

Figure 11. Map showing the range of confirmed, predicted, and historic distribution of *Seriatopora aculeata* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Life history

The reproductive characteristics of *Seriatopora aculeata* have not been determined, but its congeners are hermaphroditic brooders (Rinkevich and Loya 1979; Shlesinger and Loya 1985; Yamazato et al. 1991). The larvae of the other *Seriatopora* species studied contain zooxanthellae, leading to the development of autotrophic larvae that can supplement maternal provisioning with energy sources provided by their photosynthetic symbionts (Baird et al. 2009). The minimum size and estimated age at first reproduction have not been determined for *Seriatopora aculeata*. However, for the congener *Seriatopora hystrix*, the minimum diameter is 8 cm and the estimated age at first reproduction is 1–2 years (Stimson 1978). Larval longevity has not been determined in this genus. *Seriatopora hystrix* can undergo polyp bailout during environmentally stressful conditions and successfully reattach (though at low rates) to the substrate (Sammarco 1982); however, this potential mode of asexual reproduction has not been documented for *Seriatopora aculeata*.

Population dynamics

Veron (2014) reports that *Seriatopora aculeata* occupied 10.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.70 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as “common,” and overall abundance was described as “uncommon.” The absolute abundance of this species is likely at least millions of colonies (Hoeksema et al. 2014; Veron 2014).

The overall decline in abundance was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (“Back-cast Percent Population Reduction”) was estimated at 14 percent (Carpenter et al. 2008). However, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *S. aculeata* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but quantification is not possible based on the limited species-specific information.

There is little information available regarding the genetic diversity of this species.

Status

Seriatopora aculeata is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, and collection and trade. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate. *Seriatopora aculeata*'s distribution is constrained to the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future. The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Seriatopora aculeata*.

5.2.3.4 Montipora australiensis

The distribution of *Montipora australiensis* includes eastern Africa, the central Indo-Pacific, and the entire central Pacific (Figure 12). Its predominant habitat includes shallow reef environments with high wave action (upper reef slopes), lower reef crests, and reef flats, and likely mid-slopes. It has a depth range from two to 30 m (6.6 to 98.4 ft).

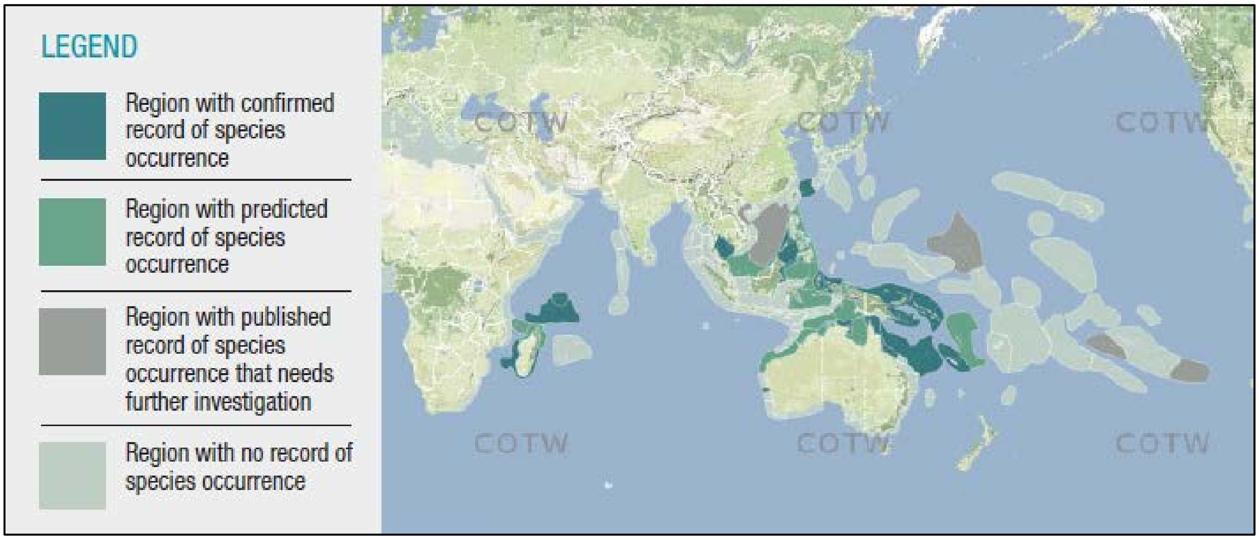

Figure 12. Map showing the range of confirmed, predicted, and historic distribution of *Montipora australiensis* (from Veron et al. http://www.coralsoftheworld.org/page/overview-of-coral-distributions/)

Life History

The reproductive characteristics of *Montipora australiensis* have not been determined. However, 35 other species of this genus are hermaphroditic broadcast spawners with external fertilization. Specific observations have not been published for *Montipora australiensis* but the larvae of all other studied *Montipora* species contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis, which likely occurs in this species as well.

Population Dynamics

Veron (2014) reports that *Montipora australiensis* occupied 0.40 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific. The species had a mean abundance rating of 1.50 on a one to five rating scale at sites where it was found (Veron 2014). Based on this semi-quantitative system, the species' abundance was characterized as "rare" with overall abundance described as "usually rare." Results from Richards et al. (2008d) and Veron (2014) indicate the absolute abundance of this species is likely at least millions of colonies.

Carpenter et al. (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. The overall decline in abundance ("Percent Population Reduction") was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event ("Back-cast Percent Population Reduction") was estimated at 14 percent. Given that *Montipora australiensis* occurs in areas affected by broad changes in live coral cover trends and shifts in reef communities (Birkeland 2004; Fenner 2012; Pandolfi et al. 2003; Sale and Szmant 2012) and has some susceptibility to both global and local threats, we conclude that it is likely the species has declined in abundance over the past 50 to 100 years, but the limited species-specific information does not make it possible to quantify changes in abundance.

Status

Montipora australiensis is highly vulnerable to ocean warming and moderately vulnerable to disease, acidification, trophic effects of fishing, nutrients, and predation. The species has been rates as moderately or highly susceptible to bleaching, but this is not based on species-specific data (Carpenter et al. 2008). The most common regulatory mechanisms for *Montipora australiensis* in the 13 countries where it occurs are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are somewhat common for the species, but 23 percent of pollution control laws are limited in scope and may not provide adequate protection. The geographic distribution of the species is mostly limited to parts of the Coral Triangle and the western Indian Ocean, which may exacerbate its vulnerability to extinction over the foreseeable future because it is in an area projected to have the most rapid and severe impacts from climate change and localized human impacts over the 21st century. Its depth range from two to 30 m moderates vulnerability to extinction as does its range in habitats where it is found. Overall, however, the combination of the species' characteristics and future projections of threats indicate the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not been designated for this species.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved for 15 Indo-Pacific corals, including *Montipora australiensis*.

6 ENVIRONMENTAL BASELINE

The "environmental baseline" has been recently revised to mean the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02; 84 FR 44976 published August 27, 2019).

The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of green (Southwest Indian Ocean DPS) and hawksbill sea turtles, and ESA-listed corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, and *Montipora australiensis*) in the action area.

6.1 Status of Green and Hawksbill Sea Turtles and ESA-Listed Corals Within the Action Area

Green (Southwest Indian Ocean DPS) and Hawksbill sea turtles

Green sea turtles are the dominant nesters in the northern region where a sea turtle monitoring program looks at nesting in Quirimbas National Park and Vamizi Island (Fernandes et al. 2018), which are part of the Quirimbas Archipelago. At Vamizi Island during the 2017/2018 nesting season, 116 female green sea turtle tracks and 89 confirmed and 27 unconfirmed nests were recorded on nesting beaches with peak activity from May to July (Fernandes et al. 2018). During the 2018/2019 season, 220 green turtle tracks, with higher activity in July followed by March and April, were recorded and 191 nests were confirmed (Fernandes et al. 2020). Of the 191 nests, hatchling success was estimated as 96.3 percent based on the number of eggs laid versus the number of unhatched eggs. The number of live and dead hatchlings from these nests was reported as 15,688 and 171, respectively (Fernandes et al. 2020). Green turtles nest year-round in northern Mozambique with activity typically peaking from March to June on Vamizi Island and higher hatching success from Vamizi compared to that of other monitored beaches in the southern part of Mozambique (Fernandes et al. 2018).

At Vamizi Island during the 2017/2018 (June 2017 to May 2018) nesting season, a total of 35 green sea turtles were captured as part of tagging efforts of which seven were recaptures of animals tagged during the 2008/2009 and 2009/2010 nesting seasons (Fernandes et al. 2018). During the 2018/2019 (June 2018 to May 2019) season, 27 green turtles were tagged and three recaptured (Fernandes et al. 2020). It is estimated that the population of female green turtles nesting on Vamizi Island is 50 animals (Garnier et al. 2012). Strandings of eight adult and juvenile green sea turtles and one hawksbill (life stage unidentified) were reported during a five-month period over which strandings were monitored at the Quirimbas National Park (Pereira and Louro 2017), indicating that both adults and juveniles of the species are present in the action area, in addition to hatchlings during nesting season. Results of tagging and recapture indicate the northern portion of Mozambique may be an important feeding site for green and hawksbill sea turtles (Costa et al. 2007). Hawksbill nesting has also been reported on Vamizi Island (Louro et al. 2006). Between April 2004 and May 2007, nine hawksbill nests were confirmed on Vamizi

Island (Garnier et al. 2012). More than 85 immature hawksbill sea turtles were reported in waters around the island of Vamizi between October 2006 and July 2008 (Garnier et al. 2012).

The BA states that nesting by green and hawksbill sea turtles has been documented on Rongui and Tecomaji Islands, offshore of Tungue Bay, which are also part of the Quirimbas Archipelago, throughout the year based on surveys conducted from 2003 to 2017 (RINA 2019). Green sea turtles are the dominant nesters in this area. Green and hawksbill sea turtles also nest along the Afungi coastline, with nesting more common during southward winds (RINA 2019).

Palma Bay contains large expanses of seagrass on sandy substrates from the mid-tide level in the intertidal zone to depths up to 8 m. Coral reefs, comprised of Porites-dominated bommies are distributed among the seagrass beds mainly in the west and south of Palma Bay; in the bommie fields on the inshore side of Tecomaji, Rongui, and Queramimbi; and in the reefs at Cabo Delgado Peninsula and to the east of the islands. There are diverse reefs and fringing reefs in the area of Cabo Delgado Peninsula and around the islands off Palma Bay (Impacto & ERM 2014). These areas provide habitat for green and hawksbill sea turtles, likely both juveniles and adults.

Marine mammal and sea turtle surveys were conducted as part of seismic surveys in the action area. An aerial survey of Area 1 recorded 49 sea turtle sightings and another smaller survey in Area 1 recorded 51 sea turtles, but did not identify sea turtles to species. An aerial survey of the Quirimbas National Park recorded 114 unidentified sea turtles (RINA 2019).

Because we do not have estimates of all nesting activity by green and hawksbill sea turtles in the action area or estimates of the number of turtles of each species in the water, we are not able to estimate the potential population, both resident and transitory, of green and hawksbill sea turtles in the action area. However, based on nesting, tagging and recapture, in-water surveys, and aerial surveys, it appears that there could be tens to a hundred animals of one or both species in waters of the action area at any given time.

Acropora pharaonis, Acropora retusa, Acropora speciose, Isopora crateriformis, Seriatopora aculeata, Montipora australiensis

Live coral cover in the action area of Palma and the Quirimbas National Park is at least 35 percent with *Acropora* spp. dominating in reef habitats (Pereira et al. 2014). The northern Quirimbas islands, which include Rongui, Tecomaji, and Vamizi, support some of the healthiest coral reefs in the Western Indian Ocean and are thought to play a key role in the region due to their location where the south Equatorial Current splits into the south-flowing Mozambican Current and north-flowing East African Coastal Current (Garnier et al. 2012).

Many of the surveys conducted for the project did not identify coral to species level but did document the presence of *Acropora* spp. and *Montipora* spp. in both coral bommies in Palma Bay and reefs associated with the islands of Rongui and Tecomaji that were surveyed for the project. Monitoring of reefs as part of a Mozambique Coral Reef Management Program reported the presence of *Acropora*, *Montipor*a, and *Seriatopora* spp. in the Quirimbas Archipelago and

Acropora and *Montipora* spp. in a reef monitoring site off Pemba, Ponta Maunhane ((Motta et al. 2002). *Acropora pharaonis* was reported by Davidson et al. (2006) off Vamizi Island, but not by Sola et al. (2015b) from monitoring in 2012 and 2013. Similarly, Obura (2012) reported *Acropora retusa*, but Sola et al. (2015a) did not observe this species. These differences are likely due to differences in sampling sites and monitoring coverage and potentially errors in identification of corals as many species are difficult to identify to species due to their similarities. Similarly, *Isopora crateriformis* is very similar to *Isopora palifera*, which is present in the action area, so RINA (2019) determined that the listed *Isopora crateriformis* is likely present in and around Cabo Delgado. *Montipora* corals are also difficult to identify to species level, but at least 17 species of this genus have been recorded in northern Mozambique (Obura 2012), including at Vamizi Island, so RINA (2019) assumed that *Montipora australiensis* is present in the action area. *Seriatopora* corals have significant phenotypic plasticity that leads to difficulty in identification of species. Because four other *Seriatopora* spp. have been identified in Mozambique and Madagascar (Samoilys et al. 2015) and due to the difficulty in distinguishing species of this genus, RINA (2019) assumed *Seriatopora aculeata* is present in the action area.

Coral slicks are observed annually around Vamizi Island and gamete development in *Acropora* spp. was monitored from July 2012 to October 2013 and from August to September 2014 to document multi-specific spawning events each year (Sola et al. 2015a). Spawning of acroporid corals in this area generally occurs once a year for a few consecutive days between September and December based on analysis of eight years of observations of coral spawn slicks. Sola et al. (2016) found at least 50 percent of species (with a focus on *Acropora*) sampled had mature gametes and resampling after spawning events indicated almost 100 percent release of gametes from these colonies. Thus, while the study did not identify ESA-listed coral species as part of the monitoring, it is likely that ESA-listed acroporid corals in the action area are part of the multi-species spawning events in the fall of each year, similar to mass spawning events by Caribbean acroporid species. Acroporid corals were also found to be the dominant coral recruits (over 80 percent of all coral spat) at Vamizi Island with settlement occurring approximately 9-18 days after mass spawning events, mainly from August to October (Sola et al. 2015a). A total of 129 *Acropora* spp., two *Montipora* spp. (also Acroporidae), and 14 *Seriatopora* spp. juvenile corals were identified in sampling sites off Vamizi Island (Sola et al. 2015a), indicating that recruitment of various ESA-listed corals occurs in the action area.

Because of the overall lack of quantitative, comprehensive surveys of coral habitats in the action area, it is not possible to determine the potential number of colonies of ESA-listed species present in the action area.

6.2 Factors Affecting Green (Southwest Indian DPS) and Hawksbill Sea Turtles and ESA-Listed Corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, and *Montipora australiensis*) in the Action Area

6.2.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to affect ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered with greenhouse gas emissions and the potential variability in emissions serving as a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (USGCRP 2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The IPCC Special Report on the Impacts of Global Warming (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Hoegh-Guldberg et al. 2018). Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (Hoegh-Guldberg et al. 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with a calcium carbonate skeleton such as corals and mollusks as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals and mollusks in particular are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification; IPCC 2014). As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world’s oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100 (IPCC 2014).

From 2002-2008, the Indian Ocean experienced five plOD events (referring to a phase in the Indian Ocean with cold sea surface temperatures (SST) anomalies in the east and warm anomalies in the west), which contributed to an increase in frequency of these events from about four per 30 years in the early 20th century to approximately 10 over the last 30 years (Cai et al. 2009). Increases in these events would contribute to droughts in East Asia, Australia, and the Arabian Peninsula and flooding in parts of India and East Africa (Cai et al. 2009). However, Li et al. (2017) argue that results of studies such as that by Cai et al. (2009) are largely artifacts of model biases and errors.

The January-March seasonal SSTs averaged over the tropical Indian Ocean (15^{o}S-15^{o}N, 40^{o}E-110^{o}E) have increased approximately 0.6^{o}C since 1950, with most of the warming occurring in the last 30 years (Hoerling et al. 2004). Roxy et al. (2016) used datasets and modeling to demonstrate that the western tropical Indian Ocean has been warming for more than a century at a rate faster than any other region of the tropical oceans and appears to be the largest contributor to the overall trend in the global mean SST. During 1901-2012, the Indian Ocean warm pool experienced an increase of 0.7^{o}C, but the western Indian Ocean experienced anomalous warming of 1.2^{o}C in summer SSTs. The warming of the western Indian Ocean against the rest of the tropical warm pool region alters the zonal SST gradients and has the potential to change the Asian monsoon circulation and rainfall, as well as alter marine food webs (Roxy et al. 2016). The Roxy et al. (2016) study shows the long-term warming trend over the western Indian Ocean during summer is highly dependent on the asymmetry in the El Niño-Southern Oscillation (ENSO) teleconnection and the positive SST skewness associated with ENSO during recent decades. Roxy et al. (2016) also found a decrease of up to 20 percent in phytoplankton in the western Indian Ocean over the past six decades driven by enhanced ocean stratification due to rapid warming in the ocean.

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Macleod 2009; Robinson et al. 2008; Kintisch and Buckheit 2006; Learmonth et al. 2006; Mcmahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Eliott 2009), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). These impacts will be exacerbated by sea level rise. In Mozambique, coastal sea level trend patterns based on satellite altimetry from 1993-2009 show an increase in sea level of two to four mm per year (Pereira et al. 2014; Meyssignac et al. 2012). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

Genetic analyses and behavioral data suggest that sea turtle populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). Altered sex ratios have been observed in sea turtle populations worldwide (Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008; Fuentes et al. 2009). This does not yet appear to have affected population viabilities through reduced reproductive success, although average nesting and emergence dates have changed over the past several decades by days to weeks in some locations (Poloczanska et al. 2009). A fundamental shift in population demographics may lead to increased instability of populations that are already at risk from several other threats. In addition to altering sex ratios, increased temperatures in sea turtle nests can result in reduced incubation times (producing smaller hatchling), reduced clutch size, and reduced nesting success due to exceeded thermal tolerances (Fuentes et al. 2010; Fuentes et al. 2009; Fuentes et al. 2011; Azanza-Ricardo et al. 2017).

In the NMFS final rule to list 20 coral species as threatened (79 FR 53851), ocean warming and acidification, associated with climate change, were identified as two of the most important threats to the current or expected future extinction risk of reef building corals. Reef building organisms are predicted to decrease the rate at which they deposit $CaCO_3$ in response to increased ocean acidity and warmer water temperatures (Raymundo et al. 2008). Further, the most severe coral bleaching events observed to date have typically been accompanied by ocean warming events such as the ENSO (Glynn 2001). Bleaching episodes result in substantial loss of coral cover, and result in the loss of important habitat for associated reef fishes and other biota. Corals can typically withstand mild to moderate bleaching, but severe or prolonged bleaching events can lead to coral colony death (79 FR 53851). While the susceptibility to ocean warming and acidification associated with climate change is expected to vary by species and specific coral colony (based on latitude, depth, bathymetry, etc.; 79 FR 53851), climate change is expected to have major impacts on the coral species considered in this opinion. Monitoring of a reef site in the Sencar Channel of the Quirimbas Archipelago in 1999 and 2000 found that the reef was severely affected by the 1997-1998 El Niño bleaching event (Motta et al. 2002; Pereira et al. 2000).

Within the action area, coral bleaching from elevated SSTs has been documented and estimates of sea level rise and increases in storm surges are affecting sea turtle nesting beaches and in-water habitat for these animals as well as ESA-listed corals.

6.2.2 Fisheries

Pilot fishery programs are being facilitated by the LNG project and were due to start in 2019. These programs include mariculture of seaweed, mariculture of sea cucumbers, enhancements to the intertidal zone that provides habitat for fishery species, pelagic fish attracting devices, and diversification in the fisheries. The relocation of fishing villages and temporary and permanent safety zones that are part of the Area 1 and Area 4 projects may shift fishing effort within the bay. However, overfishing by local populations has significantly depleted fishery resources in bay, meaning that exclusion zones may serve as de facto reserves, assuming the environment recovers to a level that will support natural populations once construction has been completed and operation of the projects is underway. Any recovery of the natural marine community in the bay would have a positive effect on ESA-listed corals as the lack of herbivores, likely from overfishing, has led to an overgrowth of algae in some areas (Pulfrich et al. 2015). Similarly, the overfishing of predators of the horn drupe snail (*Drupella* spp.) is likely one of the reasons for outbreaks of the snail, including in waters of Palma Bay, which leads to partial mortality of coral, particularly the branching coral species preferred by the snail that include *Acropora* and *Montipora* spp. (Pulfrich et al. 2015).

Mozambique has commercial (industrial and semi-industrial) and artisanal fisheries with artisanal landings being responsible for almost 90 percent of the total national fisheries production (Pereira et al. 2014). In the action area, commercial fisheries target pelagic species such as tuna and sharks in deeper waters. Romanov (2002) looked at bycatch in the tuna purse-seine fisheries in the western Indian Ocean, which included some offshore portions of the action area. Romanov (2002) examined bycatch reports from observers aboard Russian vessels in 1987 and 1990-91 targeting free-swimming schools, whale-associated schools, and schools associated with floating objects such as logs ("log-associated schools"). The bycatch of one sea turtle was reported for a log-associated school.

There are fishing villages in the action area, including those within the footprint of the proposed Area 1 and Area 4 LNG facilities that will be relocated as part of the projects. Artisanal fishing is carried out from vessels or from the shoreline and intertidal areas. The gear used includes manual trawls, gillnets, handlines, traps, and harpoons. Fisheries management measures in Mozambique include minimum mesh sizes, closed seasons, and the designation of the three-mile zone from the coast exclusively for artisanal fishing. However, bycatch in fishing gear, particularly nets and trawls, is common and turtles are often kept regardless of whether they are still alive at the time of capture (Bourjea et al. 2008; Williams 2017; Fernandes et al. 2020; Fernandes et al. 2018; Williams et al. 2019; Garnier et al. 2012).

In addition to fisheries bycatch of sea turtles, sea turtle poaching is apparently common in the action area despite laws prohibiting this (Louro et al. 2006; Pereira and Louro 2017; Fernandes et al. 2018; Williams et al. 2019). Remains of carapaces and bones and even whole carapaces, as well as turtle meat used as bait in fishing traps have been reported by monitoring programs in Quirimbas National Park (Fernandes et al. 2018; Pereira and Louro 2017). Hawksbill carapaces are still used for the manufacture of tortoiseshell and eggs are collected for consumption (Costa et al. 2007; Louro et al. 2006).

Fishing gear can have a significant effect on ESA-listed corals and their habitat. Abandoned gear can become entangled in corals and cause breakage and abrasion of portions of colonies. Injured areas on corals are more susceptible to disease, which can result in further tissue damage and loss. The use of net gear in areas containing corals results in significant breakage of coral colonies. The use of nets in areas containing corals is no longer allowed under Mozambique regulations but damage to reefs from past fishing practices may mean that some coral areas are still recovering from damage caused by these practices. Abandoned gear is likely to be an on-going problem as the loss of gear is always a possibility, though it was not identified as a significant threat to sea turtles or their habitat using expert elicitation to study the condition of sea turtles in Mozambique (Williams et al. 2019).

6.2.2.1 Aquaculture

Pemba has a commercial shrimp aquaculture enterprise (Indian Ocean Aquaculture, 980 ha) that uses a semi-intensive farming system in earthen ponds with sizes ranging from 5-10 ha. This is one of three such operations in Mozambique. All fish farms use their effluent ponds and mangroves as biofilters. The government has been promoting aquaculture projects in recent years, including the building of ponds in mangroves, which is likely to affect nearshore habitats such as seagrass beds and corals used by ESA-listed species in the action area.

Palma Bay has been identified as a location with the potential for aquaculture in the form of fish farming and seaweed production. In December 2011, approximately 10 ha of the bay was declared a "Marine Reserve" by Decree No. 71/2011, but there are currently no known or proposed aquaculture farms in the bay (Impacto & ERM 2014). There are companies producing seaweed in the Cabo Delgado province but information regarding the environmental effects of these operations is lacking (Pereira et al. 2014). Aquaculture operations, depending on their siting, including the physical and oceanographic conditions where operations are established, can affect ESA-listed corals through water quality degradation associated with nutrient influxes from feed and defecation of caged fish and inputs of antibiotics and other chemicals. Aquaculture gear may pose an entanglement hazard to turtles if not properly designed and maintained.

6.2.3 Vessel Operation and Traffic

Pemba is the only large port in the Cabo Delgado Province in northern Mozambique. It is a container port, but has not seen the level of use projected as it was developed due in part to road improvements and associated increases in land-based cargo transport following the cessation of hostilities in the early 1990s in the country (Wood and Dibben 2005). Pemba has been used as the base for vessels associated with seismic surveys for oil and gas exploration in the action area, as well as for construction and other vessels associated with the development of the oil and gas industry in the action area. However, the development and use of the port is limited by a lack of capacity to maintain port facilities and vital links to rail and road networks (Wood and Dibben 2005).

Historically, there have been coastal navigation routes using dhows, which are now largely motorized (Wood and Dibben 2005). The increase in vessel traffic by marine construction and survey vessels represents an increase in the transit of larger, faster motorized vessels. There are no data regarding increases in vessel traffic and any corresponding increases in ship strikes, groundings, marine debris, and accidental spills at this time for the action area but maritime development in other locations indicates there is increased potential for vessel strikes to sea turtles, as well as increased the potential for accidental spills and groundings that can affect sea turtle refuge and foraging habitat, and ESA-listed Indo-Pacific corals and their habitat.

The increases in vessel traffic also mean an increase in the ensonification of areas where vessel traffic is concentrated, which can alter the behavior and use of these areas by ESA-listed sea turtles. At this time, increases in vessel traffic and associated increases in marine debris, noise, and vessel strikes are rated as low threats in the action area compared to fisheries bycatch and poaching (Williams et al. 2019).

6.2.4 Research Activities

The Mozambique Ministry began a National Coastal Zone Management Program for the Coordination of Environmental Affairs in conjunction with other institutions and donors. The program included the development of a management plan for coral reefs with monitoring started in 1999 (Motta et al. 2002). Sampling sites included the Quirimbas National Park. However, it does not appear that the program was continued. There has been other coral monitoring and research done in the Quirimbas Archipelago, particularly at Vamizi Island where work has included breakage of coral branches to look for mature oocytes (Sola et al. 2016), deployment of plates to quantify coral recruitment (Sola et al. 2015a), and the collection of specimens through fragmentation to assess species morphology in the laboratory (Sola et al. 2015b).

The Mozambique Marine Turtle Working Group began in April 2004 with the first phase of a national turtle monitoring and tagging program, but the working group is no longer in existence. A community-based monitoring program was begun on Vamizi Island in 2003 to track nesting and foraging sea turtles (Garnier et al. 2012) prior to creation of a sanctuary on the island. In 2006, the sanctuary was created and the Community Fishery Council manages it and report on sea turtle poaching (Fernandes et al. 2020; Williams et al. 2019). In 2006, the Quirimbas National Park sea turtle tagging and monitoring program began as part of the national effort to tag and monitor sea turtles in eight sites along the coast of Mozambique (Fernandes et al. 2020). As part of the program on Vamizi Island, sea turtle nests are monitored and excavated once there are signs that hatching has occurred, female turtles are tagged or existing tags are rechecked, and nests are marked and translocated if necessary. This same tagging and monitoring is supposed to be done at Quirimbas National Park, but data collection and recording is poor and the standard protocols that are supposed to be used in all eight sites within the Mozambique monitoring program are not always followed (Fernandes et al. 2020).

6.2.5 Coastal Development

Anthropogenic sources of marine pollution, associated with ongoing industrial development in the action area, may indirectly affect green and hawksbill sea turtles and ESA-listed corals in the action area. At least 40 percent of the population of Mozambique lives in coastal districts, including urban centers like Pemba (Pereira et al. 2014). Cabo Delgado province is part of the Mueda Corridor, a planned development corridor focusing largely on oil and gas development, ports, tourism, and aquaculture. Coastal development is likely to affect important coastal habitats such as mangroves, seagrass beds, and corals used by ESA-listed species in the action area.

As part of LNG development in the area, existing fishing communities are being relocated, Palma is developing to address the need for hotels and other infrastructure, and permanent housing is being constructed for workers who will be employed by the projects. The area around Pemba is also developing in part to respond to increases in tourism but also to try and expand the use of the port and service some of the natural gas development going on in the Cabo Delgado Province. The construction of these facilities requires filling of wetland areas, associated changes in hydrology, as well as likely increases in stormwater runoff, and associated land-based pollutants.

There are studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Caurant et al. 1999; Aguirre et al. 1994). Mckenzie et al. (1999) measured concentrations of chlorobiphenyls and organochlorine pesticides in sea turtles tissues collected from the Mediterranean (Cyprus, Greece) and European Atlantic waters (Scotland) between 1994 and 1996. Omnivorous loggerhead turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles (Storelli et al. 2008). It is thought that dietary preferences were likely to be the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age. Sakai et al. (1995) found the presence of metal residues occurring in loggerhead turtle organs and eggs. Storelli et al. (1998) analyzed tissues from twelve loggerhead sea turtles stranded along the Adriatic Sea (Italy) and found that characteristically, mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals and porpoises (Law et al. 1992). No information on detrimental threshold concentrations is available, and little is known about the consequences of exposure of organochlorine compounds to sea turtles. Research is needed on the short- and long-term health and fecundity effects of chlorobiphenyl, organochlorine, and heavy metal accumulation in sea turtles. Similarly, limited data are available for ESA-listed corals related to exposure and toxicity thresholds for things like heavy metals. Exposure data that are available, such as from studies using mountainous star coral indicate that chronic exposure to certain concentrations of copper result in effects to embryo development (Bielmyer et al. 2010).

Vamizi has a resident community dispersed in three settlements on the west of the island. The community has doubled in recent years due to immigration of itinerant fishers from Tanzania and other provinces in Mozambique (Garnier et al. 2012). There is a small tourism lodge on the northeast of the island. Leisure and recreational tourism in Mozambique is predominantly natural resource-based with coastal national parks, national reserves, and marine protected areas, including in the Quirimbas Archipelago, being destinations that are growing in popularity (Ministry of Tourism 2014). Tourism development is an area the government would like to target with Pemba being one of the primary investment nodes identified in an analysis of tourist destinations in the country, in part due to its location in relation to the Quirimbas Archipelago and access to an airport and port (Ministry of Tourism 2014). The construction of new hotels in the area of Palma has begun aimed at business travelers associated with the natural gas industry that is developing in the area. Tecomaji, Rongui, and Vamizi Islands are privately owned. Tecomaji Island is being developed as a tourist destination with small tourist villas built close to the beach. A luxury lodge is planned for Rongui Island. The hotel developments in Palma could affect the nearshore habitats of Palma Bay depending on the location of construction, as well as plans for management of stormwater. The tourism developments on the three offshore islands in the action area are smaller and, based on the existing designs of the lodges on Vamizi and Tecomaji, are not expected to cause significant declines in water quality around the islands. However, increased use of the coral reefs around the island by divers and snorkelers and potentially recreational boaters, could lead to impacts such as damage and breakage and declines in reef health in the most popular sites as has been seen in other areas (Barker and Roberts 2004; Lucrezi et al. 2013; Zakai and Chadwick-Furman 2002). Green and hawksbill sea turtles have also been seen to alter their use of refuge and foraging habitat to avoid peak times of day when recreational visitors are common (NMFS 2016a).

In addition to issues related to water quality, there are issues related to water quantity and availability. As noted previously, the action area is within a zone of Mozambique that is very dry. Therefore, the need for potable water as coastal development increases, whether for housing, tourism, or industrial purposes, means that groundwater resources will be used, potentially leading to saltwater intrusion and further alterations of coastal wetlands that affect their ability to filter land-based pollutants and reduce their transport to nearshore waters containing habitat for green and hawksbill sea turtles and ESA-listed corals. Desalination plants are also likely to be constructed to address the natural deficit in potable water in the action area. The construction of these plants often require the construction of water intakes (unless beach wells are used), which can lead to impingement of coral larvae, and outfalls that discharge super-heated brine. Both the temperature of the discharge and the high salt concentration can lead to declines in the quality of nearshore habitats such as seagrass beds and corals. Depending on the speed of discharge, there may also be declines in habitat condition due to scour. As these habitats are used by green and hawksbill sea turtles and ESA-listed corals, declines in habitat quality would affect the ability of sea turtles to find suitable shelter and foraging habitat and corals to find adequate settlement and growth habitat for sexual and asexual recruits, as well as affecting the health of existing colonies.

6.2.6 Natural Gas Activities

Hydrocarbon exploration in Cabo Delgado Province, including in Palma district, began in the 1980s. In 2008, Artumas conducted seismic acquisition and exploratory drilling to certify whether or not hydrocarbons exist in commercially viable quantities in the Rovuma Basin Onshore Block. The discovery of natural gas in the Rovuma Basin off the coast of northern Mozambique is characterized as the most significant discovery worldwide in the last 20 years (Impacto & ERM 2014).

6.2.6.1 Surveys

Offshore seismic surveys involve the use of high-energy sound sources operated in the water column to probe below the seafloor for oil and gas exploration. Deep seismic survey acoustic sources consist of air gun arrays while receiver arrays consist of hydrophones or geophones encased in plastic tubing called streamers. When an air gun array fires, an acoustic energy pulse is emitted and reflected or refracted back from the seafloor. These reflected/refracted acoustic signals create pressure fluctuations, which are detected and recorded by the streamers. Seismic air guns generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods. Most of the energy from air guns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from air guns usually reach 235 to 240 dB at dominant frequencies of five to 300 Hz (NMFS 2018a).

Exploration contracts to explore the offshore gas fields in the action area were signed with the government of Mozambique in 2007 (RINA 2019). Two (2-D) and three-dimensional (3-D) seismic surveys have been conducted in the offshore portion of the Rovuma Concession Block. The first survey was conducted in 2008 and was a 3-D survey. As additional 2-D survey was conducted in 2008. Two 2-D surveys were conducted in 2009 in water depths less than 50 m and greater than 50 m (164 ft), respectively (RINA 2019). 2-D surveys involve the use of a single streamer of hydrophones towed along a grid with spacing of approximately 3 km (1.86 miles). Escort vessels accompanied survey vessels and were responsible for identifying hazards such as shallow water or fishing equipment (RINA 2019). The MMOP (as described in Section 3.2.4) was implemented during seismic surveys. The 3-D survey data was used to fill gaps between the widely spaced 2-D data from surveys to provide a more accurate representation of subsurface geology in order to select optimum locations for exploratory drilling.

Marine mammal and sea turtle surveys were conducted as part of seismic surveys to determine the extent of potential impacts to these animals and identify conservation measures to avoid and minimize impacts. Aerial surveys of Area 1 recorded 293 marine mammal sightings and 100 unidentified sea turtles. An aerial survey of the Quirimbas National Park recorded a humpbacked dolphin and 114 unidentified sea turtles. None of the marine mammals observed in these surveys were ESA-listed species (RINA 2019).

ESA-listed sea turtles may exhibit a variety of different responses to sound fields associated with seismic air guns. Avoidance behavior and physiological responses from air gun exposure may affect the natural behaviors of sea turtles (McCauley et al. 2000). McCauley et al. (2000) conducted trials with caged sea turtles and an approaching-departing single air gun to gauge behavioral responses of green and loggerhead sea turtles. Their findings showed behavioral responses to an approaching air gun array at 166dB re: 1 µPa root mean square (rms) and avoidance around 175 dB re: 1 µPa rms. From measurements of a seismic vessel operating 3-D air gun arrays in 100 to 120 m (328.1 to 393.7 ft) water depths, this corresponds to behavioral changes at around two km (1.24 mile) and avoidance at around one km (0.62 mile; NMFS 2018a).

Given the results of the aerial surveys of Area 1, it is likely that green and hawksbill sea turtles were impacted by previous seismic surveys using airgun arrays, altering their behavior in response to the noise of airguns with a corresponding temporary expenditure of more energy to swim away from the noise.

6.2.6.2 Accidental Spills

In May 2014, Anadarko was conducting exploratory drilling in deep, offshore waters in Area 1 and approximately 7,900 gallons (29,904.75 liters) of drilling mud (Low Toxicity Synthetic Oil-Based Muds) was spilled.

The largest accidental spill from well drilling for which NMFS has detailed data regarding the effects to ESA-listed animals is the Deepwater Horizon spill in the Gulf of Mexico. A spill of 2,450 barrels (102,899 gallons or 389,515 liters) of synthetic-based drill fluid (SBF) occurred in May 2003 in an area referred to as Mississippi Canyon Block 778 in the Gulf of Mexico in a water depth of 6,040 ft as the dynamically positioned drilling rig was pulling out of the wellhole (Bolland et al. 2004). The riser parted in two places and SBF was released. SBFs are synthesized rather than refined from crude oil and do not contain PAHs, which are thought to contain the majority of the toxic content attributed to drilling fluids. The stock base fluid of SBFs is hydrophobic and emulsifiers and wetting agents are necessary to prepare the drilling fluid, which may contain lime, barite, and corrosion inhibitors (Bolland et al. 2004). The rate of potential biodegradation of spilled SBF is controlled by various factors. At the seafloor where DO is limited, as bacteria utilize available oxygen to metabolize SBF, sediments would become anaerobic and biodegradation would slow (Bolland et al. 2004). Visual evidence of sinking drilling mud was taken from an ROV about 10 minutes after the incident and showed rapid descent of the mud plume and a lateral movement away from the drill site. The drilling mud release likely affected the benthic community due to physical smothering and anoxic conditions but ROV surveys did not reveal accumulation of material, indicating dispersal into the water column (Bolland et al. 2004). A review of papers and technical reports on the effects of the discharge of drilling waste from oil and gas platforms found that the zone of influence for water-based fluids was larger than for SBF but the zone of biological effects on benthic community diversity and abundance ranged from 100 to 1,000 m (328 to 3,280.8 ft) for both (Ellis et al. 2012).

Water-based drilling muds, such as those the project proponent has used for exploratory drilling, tend to disperse further but the area of impact is still expected to remain small and muds are expected to disperse into the water column and settle on the seafloor. The depths in Area 1 mean there is a lack of refuge and foraging habitat for green and hawksbill sea turtles. These species transit through the portion of the action area where exploratory drilling has occurred so accidental spills of drilling mud probably had little to no effect on the animals, unless they were swimming in the immediate area of the plume at the time of the spill.

6.2.6.3 Palma Bay LNG Development

Area 4

Offshore production wells and the infrastructure necessary to develop the gas reserves in Area 4 are in development, including a piping system to carry gas from Area 4 to the shared onshore

LNG facilities. The development of the gas fields in Area 4 has been concentrated in the western part of the area, approximately 55 km (34 miles) offshore in water depths between 1,500 and 2,300 m (4,921.3 and 7,545.9 ft).

This development has similar impacts to green and hawksbill sea turtles as that for the development of the Area 1 gas field and the associated pipeline. Pipeline construction will also affect ESA-listed corals because the pipeline route is proposed between Rongui and Tecomaji Islands, although there may be additional changes made to the route to further reduce environmental impacts to important marine habitats. The use of TSHD will result in entrainment of green and hawksbill sea turtles and damage to habitat used by these species. The use of CSD in coral areas will also damage habitat used by green and hawksbill sea turtles.

Terrestrial and Nearshore Facilities

The terrestrial facilities for the Area 1 and Area 4 LNG projects are located on the southern shores of Tungue Bay in the Alfungi Peninsula (see Figure 1). The total land area allocated to the project is approximately 7,000 hectares (ha; 17,297 acres), but the footprint of the terrestrial facilities will be approximately 3,600 ha (8,895.8 acres). The footprint of the onshore component of the project was revised in order to reduce impacts to wetlands. There will still be impacts to 1,643 ha (4,059.9 acres) of wetlands, but the wetland areas determined to be the most sensitive and important for native fauna will not experience the level of disturbance originally proposed. The terrestrial footprint of the project was modified to avoid the wetland areas determined to be the most environmentally valuable as much as possible. Fill of estuarine areas will be from the upper reaches toward the bay where reasonably practicable to allow motile organisms to move downstream. Wetlands outside the project footprint will have a 150 m (492 ft) buffer maintained around them.

The construction of the Replacement Village commenced in January 2018. Roadways and camps began construction in October/November 2019.

Once onshore, the gas will be processed in the LNG facility to remove impurities, converted to liquid, and stored in LNG storage tanks. For export, LNG will be transported through insulated pipelines to an export jetty where it will be loaded into LNG carriers to be transported to international markets.

The structures constructed along the coastline adjacent to the LNG facility will be located to take advantage of existing deep water channels or proximity to deep water. The natural channels will be deepened and widened by dredging to accommodate project vessels during construction and operation of the project (Impacto & ERM 2014). Dredging is required to accommodate LNG vessel traffic and construction of the export terminal facilities such as the TBL and the MOF. Some areas will require dredging down to -10.5 m (-34.4 ft) Lowest Astronomical Tide (LAT). Estimated dredge volume for the MOF, including the TBL and MOF channel, is up to 6.3 Mm^3. Approximately 2.4 Mm^3 of this material may be used to construct the MOF and the rest of the dredged material will be disposed of in the offshore dredge material disposal site. Approximately 3.3 Mm^3 (116.5 million ft^3) will be dredged for the jetty berths and approximately 2.6 Mm^3 (91.8 million ft^3) will be dredged for the LNG vessel access channel and anchorage areas. The navigation channel will be created by widening an existing channel by dredging to 160 m (524.9 ft) wide while the turning basin and access to channel will be created by dredging new areas in order to create a 600 m (1,968.5 ft) turning circle for large vessels (Impacto & ERM 2014). It is anticipated that TSHD will be used for most of the dredging in the area of the access channel, turning basin, MOF, and jetty. Maintenance dredging may be required every three to five years but is expected to be minimal (Impacto & ERM 2014).

During peak pipeline and nearshore construction activities, up to 40 construction vessels could be present in the field at any one time. Construction vessels will not be dynamically positioned and will need to anchor in one of three shallow water sites (Figure 13) located in water depths of 5 to 8 m (16.4 to 26.2 ft) immediately west of Tecomaji Island (Anchorage A), off the northwest shoreline of Tecomaji Island in water depths from less than 2 (6.6 ft) to greater than 10 m (32.8 ft; Anchorage B), and in a larger channel complex in the west/center of Palma Bay (Anchorage C). Anchoring ships and other vessels such as pipe-lay barges will use their own single point anchoring system and weather vane to winds and sea conditions. The locations of anchorage areas have changed to encompass more areas of sand bottom. Anchorage A has seagrass and corals in its western portion. Anchorage B has coral reef in the northern section. Anchorage C has seagrass and corals in the west and four pockmarks (soft/spongy habitat with numerous wormholes) within its boundaries. Because of the presence of important benthic habitats, each anchorage area has been segmented into environmentally sensitive and less sensitive subareas with routine anchorage restricted to the use of less sensitive areas (Figure 13). The project proponent plans to transplant massive and sub-massive corals from within Anchorage A to coral habitat outside the anchorage area.

The nearshore and in-water construction activities are expected to take 18 months and have a 30-year service life. The nearshore, in-water and terrestrial facilities will service two LNG trains initially.

The piping system at the nearshore project facilities will be commissioned simultaneously with the LNG facility and will undergo hydrostatic, integrity, and systems control testing. The boil off gas system will also be tested as well as the venting and flaring components, which will result in the venting and flaring of some gas. Seawater and water from reverse osmosis will be used for hydrotesting of onshore pipelines and storage tanks. Hydrotest water will be discharged to the sea as for the pipeline and subsea production system.

A TBL will be constructed to allow for landing of equipment and materials onshore. Most building materials for project construction will be brought to the site by sea. The landing will be constructed in three phases, the first two phases of which are already under construction:

- A rapid deployment beach landing will be constructed first on Afungi Beach. This landing will provide an area for landing of vessels such as landing craft tanks and/or groundable barges to allow the transport of equipment and materials inshore to a designated laydown area over a temporary haul road. This landing will be marked with signs and markers. Locally sourced wooden mats will be laid on the shoreline for this landing.
- The early beach landing facility will be constructed next in order to provide greater flexibility for landing equipment and materials. The landing will allow for all tide access for specific marine transport vessels because it will have a short dredged channel to a constructed bulkhead or quay. The small bulkhead or quay to be constructed for this facility will allow the mooring of landing craft tanks and/or small barges. A small floating pontoon will also be installed on the northeast corner of the landing for passenger vessel loading and unloading. This pontoon may be relocated to the final temporary beach landing facility.

The final TBL facility will have four barge berths consisting of two lift-on/lift-off (LO-LO) berths and two roll-on/roll-off (RO-RO) berths with a causeway connecting to the onshore project site. One LO-LO berth will be capable of receiving liquids, specifically diesel and water. The TBL will be approximately 230 m (754.6 ft) wide and extent approximately 845 m (2,772.3 ft) from the shoreline. The early beach landing will require the driving of approximately 655 sheet piles and the final TBL will require the driving of an additional 2,070 sheet piles. Vibratory pile driving will be used to install the sheet piles associated with the TBL. Acoustic modeling by JASCO concluded that no sea turtles would be exposed to injurious sound levels from vibratory pile driving (Zeddies et al. 2019).

The MOF will be approximately 415 m (1,361.5 ft) wide and extend approximately 1,000 m (3,280.8 ft) from the shoreline. The MOF will include berths that will be dredged to between approximately -8.3 and -12 m (-27.2 and -39.4 ft) LAT. The design includes a 300 m (984.2 ft) wide dredged causeway. The MOF will incorporate the TBL when completed. Approximately 450 king piles and 800 sheet piles will be driven for the combi-wall structure of the MOF. Vibratory pile driving will be used to install the sheet piles at the MOF. Impact pile driving will be used to install other piles at the MOF. A vessel refueling facility will support vessels such as pilot boats and tugs.

The LNG export jetty will be a trestle structure divided into three main sections:

- A concrete abutment providing the transition between land and start of the trestle bridges
- An access trestle measuring approximately 2,700 m (8,858.3 ft) long and extending from the abutment northward
- A jetty head measuring approximately 1,900 m (6,233.6 ft) long connecting the berths to the trestle.

The jetty will also have a product water outfall from processing of gas at the onshore LNG facility.

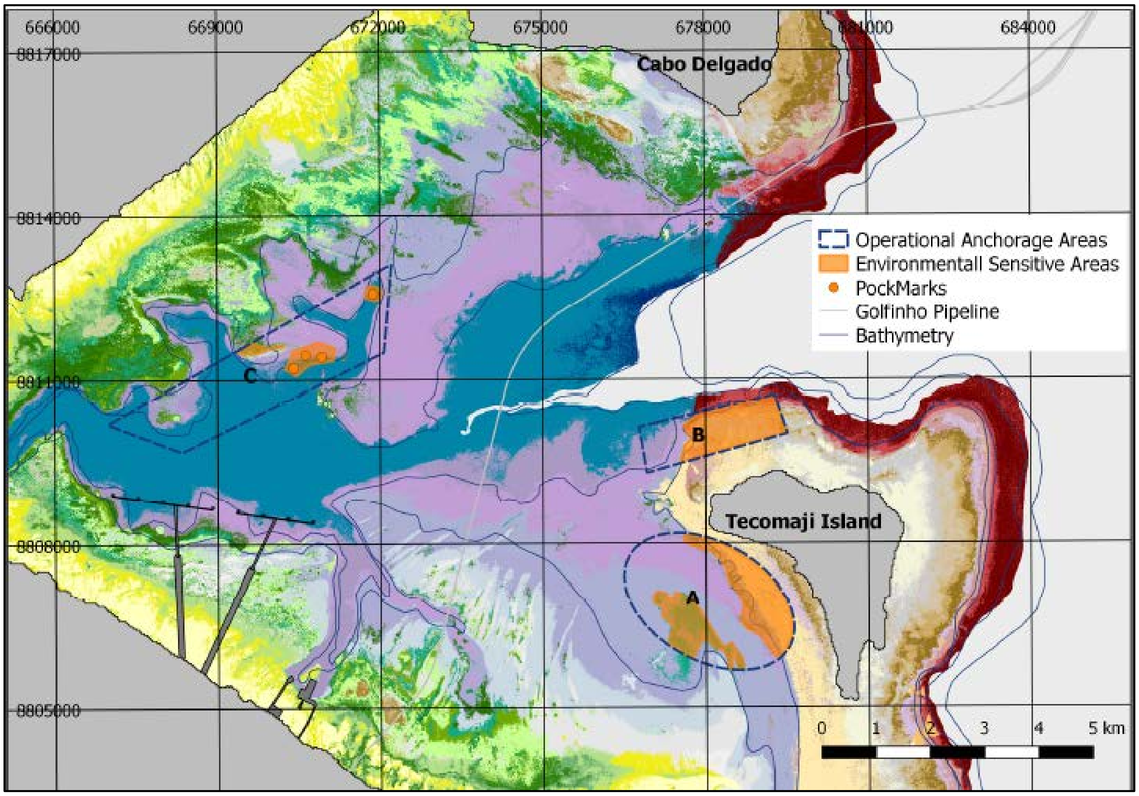

Figure 13. Designated anchorage areas to be used during project construction overlain on a benthic habitat map and showing the environmentally sensitive areas within each anchorage (from Impacto & SLR 2019)

The causeway will extend from the shoreline to the approximately 2 m (6.6 ft) LAT depth contour, at which point an elevated roadway/pipeway trestle structure will extend to a water depth of approximately 15 m (49.2 ft) LAT. The trestle is likely to be approximately 7 to 10 m (23 to 32.8 ft) above LAT and have a total width of approximately 14 m (45.9 ft) to accommodate a road and pipe rack, separated by concrete barriers. The jetty trestle will be a pile-supported structure extending to the LNG berthing area and including four LNG loading platforms. The loading platforms will each have four breasting dolphins, six mooring dolphins, and one condensate-loading platform with four breasting dolphins and four mooring dolphins. Approximately 1,400 steel piles spaced 15 to 30 m (49.2 to 98.4 ft) apart will be driven to a depth of 20 - 35 m (65.6 to 114.8 ft) below LAT using impact pile driving. Pile driving will move progressively seaward from the causeway with the surface of the trestle, which will consist of prefabricated sections connected to the tops of the piles. The sections will be lifted into place by barge-mounted cranes. The export berth will be built using the same methods.

Approximately seven hydraulic hammers will be used to drive the open-end steel piles for the MOF and jetty. An estimated four units will work on the jetty and three on the MOF. At the jetty, one unit will drive piles for the access trestle from the abutment to Loop 8 and three will work on the rest of the access trestle and the jetty head. Pile driving for the MOF and jetty will occur intermittently over a period of 2 to 3 years. Pile driving will occur intermittently, with piling cycles lasting 2 to 3 hours on average, although pile driving could last up to 10 hours depending on pile diameter and substrate, among other things. The rate of hammering will be approximately 45 per minute. Intermittent pile driving for completion of shoreline/in-water structures will occur over a two to three year period.

Hawksbill and Green Sea Turtles

The auditory system of sea turtles appears to work via water and bone conduction, with lower frequency sound conducted through skull and shell, and does not appear to function well for hearing in air (Lenhardt et al. 1985; Lenhardt et al. 1983). Sea turtles do not have external ears or ear canals to channel sound to the middle ear, nor do they have a specialized eardrum. Fibrous and fatty tissue layers on the side of the head may be the sound-receiving membrane in sea turtles, a function similar to that of the eardrum in mammals, or may serve to release energy received via bone conduction (Lenhardt et al. 1983). Sound is transmitted to the middle ear, where sound waves cause movement of cartilaginous and bony structures that interact with the inner ear (Ridgeway et al. 1969). Unlike mammals, the cochlea of sea turtles is not elongated and coiled, and likely does not respond well to high frequencies, a hypothesis supported by a limited amount of information on sea turtle auditory sensitivity (Bartol 2013; Ridgeway et al. 1969). Investigations suggest that sea turtle auditory sensitivity is limited to low-frequency bandwidths, such as the sound of waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as cues to identify their natal beaches (Lenhardt et al. 1983), but appear to rely on other non-acoustic cues for navigation, such as magnetic fields (Lohmann and Lohmann 1996) and light (Avens and Lohmann 2003).

Little is known about how sea turtles use sound in their environment. Based on knowledge of their sensory biology (Moein Bartol and Musick 2003; Bartol and Ketten 2006), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on their vision than auditory cues (Hazel 2009; Hazel et al. 2007). Additionally, they are not known to produce sounds underwater for communication.

Available information suggests that the auditory capabilities of sea turtles are centered in the low frequency range (<2 kHz; Bartol et al. 1999; Dow Piniak et al. 2012; Lenhardt et al. 1994; Lenhardt et al. 1983; Martin et al. 2012; O'hara and Wilcox 1990; Ridgeway et al. 1969), with greatest sensitivity below 1 kHz. A more recent review on sea turtle hearing and sound exposure indicated that sea turtles detect sounds at less than 1,000 Hz (Popper et al. 2014). Research on leatherback sea turtle hatchlings using auditory evoked potentials showed the turtles respond to tonal signals between 50 and 1,200 Hz in water (maximum sensitivity 100 to 400 Hz; 84 dB re: 1 µPa rms at 300 Hz; Piniak et al. 2012).

The U.S. Navy developed acoustic impacts criteria and thresholds in cooperation with NMFS for sea turtle exposures to various sound sources as part of ESA section 7 consultations for Navy training and testing activities (Navy 2018). In order to develop some of the hearing thresholds of received sound sources for sea turtles expected to produce TTS and PTS, the Navy compiled all sea turtle audiograms available in the literature to create a composite audiogram for sea turtles as a hearing group. Measures or predicted auditory threshold data, as well as measured equal latency contours, were used to influence the weighting function shape for sea turtles and the weighting function parameters were adjusted to provide the best fit to the experimental data (NMFS 2018a). Because data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the sea turtle hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fish, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage (Navy 2018; NMFS 2018a). Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on methods proposed by Southall et al. (2007); (NMFS 2018a). From these data and analyses, dual metric thresholds were established similar to those for marine mammals and fish, including a peak SPL metric (0-pk) that does not incorporate the auditory weighting function nor the duration of exposure, and another based on cumulative SEL (SEL_{cum}) that incorporates both the auditory weighting function and the exposure duration (Table 6).

Table 6. Acoustic thresholds identifying the onset of PTS and TTS for sea turtles exposed to impulsive sounds (Navy 2018)

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset (weighted)	Temporary Threshold Shift Onset (weighted)
Sea Turtles	30 Hz to 2 kHz	204 dB re 1 μPa^2-s SEL_{cum} 232 dB re: 1 µPa SPL (0-pk)	189 dB re 1 μPa^2-s SEL_{cum} 226 dB re: 1 µPa SPL (0-pk)

Sea turtles may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the immediate area around a source based on studies examining sea turtle behavioral responses to sound from impulsive sources. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In nesting season, near nesting beaches, behavioral disturbances may interfere with nesting beach approach. In most cases, acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence (NMFS 2018a).

Three piles driven per day at four locations over seven days were used to calculate the potential effects of pile driving noise on sea turtles. Zeddies et al. (2019) calculated sea turtle injury using the NMFS criterion of 180 dB re 1 µPa SPL, and the Navy criteria of 204 dB re 1 μPa^2-s SEL_{cum} and 232 dB re: 1 µPa SPL (0-pk) and found the 180 dB re 1 µPa SPL was the most conservative and so was the only threshold reported for this modeling. Zeddies et al. (2019) calculated impact hammer pile driving associated with the construction of the MOF and LNG jetty could cause injurious effects to sea turtles at 202 m (662.7 ft) from the pile driving activities for 46-in diameter steel piles, 495 m (1,624 ft) for 60-in diameter piles, and 879 m (2,883.9 ft) for 72-in diameter piles. However, because the threshold used by Zeddies et al. (2019) is closer to that for TTS (Table 6), it is not possible to separate the ranges to injurious effects they calculated into PTS and TTS. Zeddies et al. (2019) calculated single strike SPLs for impact hammer pile driving could cause behavioral effects at 545 m (1,788 ft) for 46-in piles, 1,201 m (3,940.3 ft) for 60-in piles, and 2,311 m (7,582 ft) for 72-in diameter piles using a threshold of 175 dB for sea turtles. Zeddies et al. (2019) estimated that, given the sightings of hawksbill sea turtles in the bay, two hawksbills every seven days could suffer injury from the acoustic impacts of pile driving. However, RINA (2019) determined that the turtles could be green or hawksbill because both are common in the bay. Depending on the time of year and based on the data available regarding green and hawksbill nesting in the action area and sightings of turtles in the water (Section 6.1), NMFS believes adult, sub-adult, or juvenile green or hawksbill sea turtles could suffer injury or behavioral changes as a result of impact pile driving, potentially in greater numbers than estimated by Zeddies et al. (2019) and RINA (2019).

Vibratory pile driving to install sheet pile for the construction of the TBL and MOF is not expected to have significant effects on sea turtles unless animals are within 20 m of pile driving activity. This is not likely to occur because the project will have observers looking for marine mammals and sea turtles and will implement measures such as ceasing pile driving activity depending on where animals are sighted near pile driving activity. In addition, animals are expected to move away from construction activity.

ESA-Listed Indo-Pacific Corals

While there have been some recent studies indicating that coral planulae (larvae) respond to acoustic cues in order to find suitable substrate for settlement, the sound levels, types of sound, and other factors driving settlement habitat selection are not well-understood. Noise from pile driving would result in changes in the soundscape for a short period, but the physical disturbance from in-water construction in areas containing listed coral colonies is likely to be the more significant stressor.

Conservation Measures for LNG Project:

The following conservation measures are part of the project and are incorporated in the Marine Terminal Environmental Management Plan, which is reviewed by EXIM:

Shoreline Construction:

Mitigation measures to ensure that some longshore sediment and water exchange is maintained, prevent the isolation of pocket beaches, and facilitate particulate organic material (POM) supply; enhance biodiversity in affected subtidal areas; and manage potential water quality impacts from corroding hard structures include:

- Development of an active shoreline management and monitoring program that includes:
    - Beach monitoring
    - Use of land-based construction equipment to move sand from the areas of accretion to areas where erosion is evident.
- Monitor hard structures for signs of excessive corrosion and undertake maintenance where required.

Pile Driving:

- Where feasible, the MMOP should allow for a "soft start" procedure when megafauna are present in the bay, for approximately 20 minutes prior to operating at the full cycle rate for impact pile driving in Palma Bay. In the event that pile driving has been stopped for more than 10 minutes, ensure that soft-start protocol is repeated.
- Establish an exclusion zone with a radius of at least 600 m (1,968.5 ft) from the pile locations before each pile-driving activity.
- Take all reasonable steps to ensure no marine mammals are present within the exclusion zone 30 minutes prior to pile driving activity commencing.
- Pile driving should not commence if marine mammals are detected within the exclusion zone or until 20 minutes after the last visual or acoustic detection.

The construction of the nearshore facilities will affect hard and soft corals, including some patch reefs, and seagrass (Table 7). This construction includes the footprint of the structures and the dredging footprints associated with each structure. The footprint of these facilities is shared with the neighboring Area 4 project. The extent of impacts to habitats in the nearshore portion of the project are preliminary estimates based on a worst-case scenario. The project proponent anticipates that the final construction footprints will have a smaller impact on benthic habitats as more site-specific survey work is completed prior to different construction activities.

Table 7. Estimate of the Areas of Habitat Affected by the Footprint of the Nearshore Facilities (from RINA 2019)

MOF and TBL		
Biotope and Substrate Type	**Habitat Area (ha)**	**Habitat in Acres (ac)**
Total Area	90.0	222.4
Soft and hard coral	4.2	10.38
Seagrass	6.5	16.06
Mixed (including seagrass and corals)	0.21	0.52
Jetty		
Total Area	14.3	35.34
Soft and hard corals	1.8	4.4
Seagrass	4.7	11.6
Mixed (seagrass with macroalgae and corals)	1.5	3.7

As shown in Figure 13, the use of designated anchorage areas in the bay by construction vessels will also affect seagrass and coral habitats. Green and hawksbill sea turtles use these habitats in the action area as refuge and foraging habitat. There will also be direct and indirect impacts to ESA-listed corals from nearshore construction, as well as terrestrial construction and associated changes in hydrology and land-based pollutant transport to nearshore waters in Palma Bay due to extensive fill placement in wetlands, as well as the construction of process and wastewater outfalls for use during construction and operational phases of the Area 1 and Area 4 projects.

6.2.7 Natural Disturbance

Mozambique has been hit by 13 documented intense tropical cyclones during the period 1956-2008 (Neumann et al. 2013). In November 1988, March 1994, January 1998, November 2003, and March 2008, tropical storms and Category 4 storms have made landfall in northern Mozambique. Fitchett and Grab (2014) investigated the frequency and timing of tropical cyclone landfalls over the southwest Indian Ocean from 1850-1899 (based primarily on ship logs), 1900-1943 (based on ship logs, land-based records, and air-based observations), and 1944-2011 (based on aircraft reconnaissance and satellite imagery, Figure 14). They found no statistically significant trends in the frequency of landfalls over the past six decades but did find an increase in the number of tropical cyclones tracking to the south of Madagascar before making landfall over Mozambique. Some of these storms have led to significant flooding from rainfall and storm surge (Bié et al. 2017). Because of tropical cyclones that lead to breakage and abrasion of corals, flooding, and associated transport of pulses of freshwater and sediment to nearshore waters containing coral habitats, coral communities have experienced significant effects, including mortality (Perry 2003; Pereira and Gonçalves 2004). Storms and associated direct and indirect impacts to sea turtle habitat, both nesting beaches and in-water habitats, can affect nesting and hatching success, growth of resident juveniles that use affected in-water habitats, and foraging success of adult turtles. Tropical storms and cyclones also affect ESA-listed Indo-Pacific corals through breakage, overturning, and other physical damage caused by swells, although in the case of many of the branching corals, if damage is not severe, these impacts may serve to propagate the species.

Extreme weather events are associated with the ENSO and the Indian Ocean Dipole Mode (IODM, also called the Indian Ocean Zonal Mode). Strong IODM events that reverse the zonal SST gradient for several months trigger high rainfall, but this usually affects more southern portions of Mozambique with the action area being the driest part of the country (Pereira et al. 2014). However, when large rainfall events do occur, pulses of freshwater and land-based pollutants can affect sea turtle refuge and foraging habitat in nearshore waters, as well as ESA-listed Indo-Pacific coral colonies and their habitat.

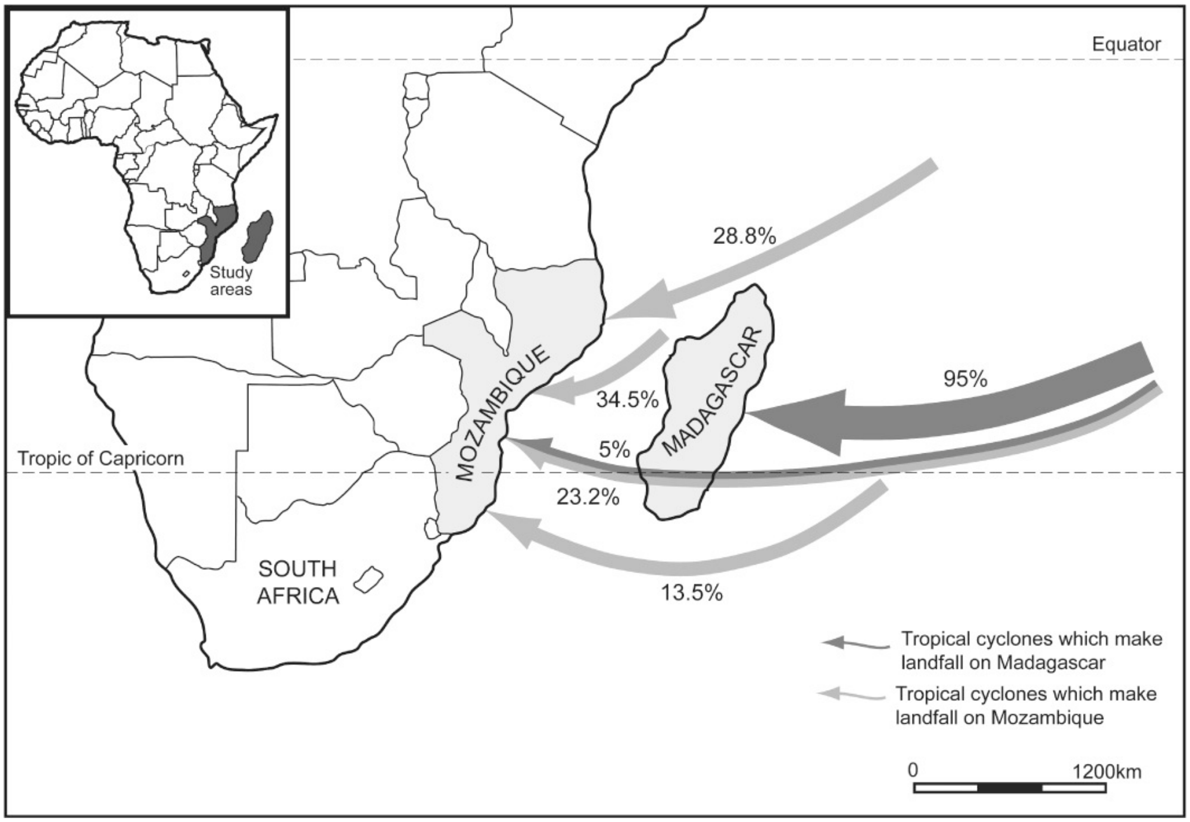

Figure 14. Percentages of tropical storms making landfall in Madagascar and Mozambique from 1944-2011 (from Fitchett and Grab 2014)

Crown-of-thorns (COT) starfish preys on coral polyps and has been implicated in coral reef degradation. In addition, some studies indicate that coral reefs that have experienced stressors such as bleaching that have led to decreases in coral cover may be more susceptible to COTs outbreaks (Obura et al. 2000). However, research by Vogler et al. (2008) demonstrated that *Acanthaster planci* is actually a species complex based on molecular data collected across its distribution. Specifically, Vogler et al. (2008) found that COT consists of four strongly differentiated mitochondrial clades from the Red Sea, the Pacific, the Northern Indian Ocean, and the Southern Indian Ocean (which includes the action area). The Northern and Southern Indian Ocean are closely related sister groups. The majority of research has been performed on the Pacific species under the assumption that this was representative of the entire group. However, because outbreaks do not appear to be as massive or as widespread as in the Pacific, there may be key biological or ecological differences between these clades (Vogler et al. 2008). A COT starfish was observed during a survey at north of Tecomaji (Impacto & ERM 2014), but there are no reports of large numbers of these animals or outbreaks in the action area. COT is a threat to corals as it feeds directly on polyps so, if even localized outbreaks were to occur, there would be impacts to ESA-listed Indo-Pacific corals in the action area.

6.3 Synthesis of Baseline Impacts

Collectively, the stressors described above have had, and are likely to continue to have, lasting impacts on green (Southwest Indian DPS) and hawksbill sea turtles; and ESA-listed corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*) within the action area. Some of these stressors, such as fishing, result in mortality or serious injury to individual animals, whereas others result in more indirect (e.g., water quality degradation) or non-lethal (e.g., research permits involving only surveys) impacts.

We consider the best indicator of the environmental baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 5.2, some of the species considered in this consultation appear to have stable populations, others are declining, and for others, their population trends remain unknown. Taken together, this indicates the environmental baseline is affecting species in different ways. The species with stable populations are not declining despite the potential negative impacts of the environmental baseline. Therefore, while the baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in this Environmental Baseline section is limiting their recovery. However, it is also possible that their populations are at such low levels that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species for which NMFS has found the action is likely to cause adverse effects is discussed in the Status of Species Likely to be Adversely Affected (Section 5.2) of this Opinion.

7 EFFECTS OF THE ACTION

"Effects of the action" has been recently revised to mean all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.02; 84 FR 44976 published August 27, 2019).

This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

7.1 Discountable and Insignificant Effects

We have determined that green (Southwest Indian DPS) and hawksbill sea turtles and ESA-listed Indo-Pacific corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*) may be adversely affected by the proposed action and its consequences. However, some of the effects of stressors from the proposed action (Section 4) to these species will be discountable or insignificant and therefore not likely to result in adverse effects. These stressors are discussed below.

7.1.1 Noise

As discussed in Section 6.2.6.3, while there have been some recent studies indicating that coral planulae (larvae) respond to acoustic cues in order to find suitable substrate for settlement, the sound levels, types of sound, and other factors driving settlement habitat selection are not well-understood. Noise associated with in-water construction activities as part of the proposed action and its consequences would result in changes in the soundscape for a short period, but are not expected to result in effects to ESA-listed corals.

Helicopters: Helicopters produce low-frequency sound and vibration (Pepper et al. 2003; Richardson et al. 1995). Noise generated from helicopters is transient in nature and variable in intensity. Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. For a MH-60 helicopter, noise levels at the helicopter average approximately 136 dB re: 20 μPa in air with frequencies between 20 Hz and 5 kHz. More low frequency components (<1 kHz) are contained in this broadband signal primarily from rotor noise (i.e., helicopter blade rotation). Helicopters often radiate more sound forward than aft.

Most of the acoustic energy from an aircraft arrives through a relatively narrow cone extending vertically downward from the aircraft (Cavanagh and Eller 2000; Richardson et al. 1995). This cone creates a "footprint" directly beneath the flight path, with the width of the footprint (at the water's surface) being a function of aircraft altitude. Furthermore, in air noise decreases with distance, with a decrease in sound level from any single noise source following the "inverse-square law." In other words, the SPL changes in inverse proportion to the square of the distance from the sound source. Therefore, aircraft sound levels actually at the air-water interface (i.e., sea surface) is a function of how high above the surface the aircraft is flying or hovering. Thus, the higher the aircraft, the less sound reaches the sea surface (Cavanagh and Eller 2000; Richardson et al. 1995).

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors and has been addressed Urick (1983), Young (1973), Richardson et al. (1995), and Cavanagh and Eller (2000). Sound is transmitted from an airborne source to a receptor underwater by four principal means: (1) a direct path, refracted upon passing through the air-water interface; (2) direct refracted paths reflected from the bottom in shallow water; (3)

evanescent transmission in which sound travels laterally close to the water surface; and (4) scattering from interface roughness due to wave motion (USCG 2017).

Aircraft sound is refracted upon transmission into water because sound waves move faster through water than through air (a ratio of about 0.23:1). Based on this difference, the direct sound path is reflected if the sound reaches the surface at an angle more than 13 degrees from vertical. As a result, most of the acoustic energy transmitted into the water from an aircraft arrives through a relatively narrow cone extending vertically downward from the aircraft. Traveling beyond the sea surface, the sound values in air and in water are not directly comparable due to the reference units used, and must be converted. The result is that sound waves with the same intensities in water and air have relative intensities that differ. The difference in the relative sound pressures between air and water is not as simple as adding or subtracting 26 dB from a measured sound in air or water to convert to the other medium. Because water is much denser than air, water has higher impedance. The impedance of water is about 3600 times (10 log 3600 = 36) times that of air because sound travels faster in water than in air. Thus, sounds of equal measured pressure will be measured at 36 dB higher in water than in air. Therefore, the difference is between not only the air and water pressures, but also the impedance of water. This means it is actually a difference of 62 dB higher in water than in air.

Helicopter sounds are generally below 500 Hz and the range of best hearing for ESA-listed sea turtles appears to be 100 to 400 Hz so turtles in the immediate area below a helicopter may detect sound from the aircraft. If we use the MH-60 example, which has a noise level of approximately 136 dB re: 20 µPa in air, we would expect a louder noise level in the water (up to 62 dB higher as explained above). However, because helicopters will be transiting to and from the MODU on supply runs and other service runs and are not expected to hover over the water, any sea turtles offshore would not be exposed to sound from the helicopter for long periods of time. Thus, while sea turtles might exhibit behavioral responses such as swimming away from the noise of the aircraft, these responses are not expected to be of long duration. In addition, given that Hazel (2009) found sea turtles responded more to the visual stressor of vessel presence rather than vessel noise, it is possible that sea turtles will not react to noise from helicopters transiting to and from the MODU. Therefore, we believe the effects to green and hawksbill sea turtles from noise generated by helicopters used to service the MODU are likely to be insignificant and thus not likely to adversely affect the animals.

In-Water Construction: In terms of the potential effects of noise from dredging and MODU operation on various life stages of sea turtles, Zeddies et al. (2019) concluded that dredging using the TSHD and CSD could result in injurious or behavioral acoustic effects to sea turtles within 20 m (65.6 ft) of dredging activity in Palma Bay. As noted in Section 5.1, the CSD was modeled as having the greater effects than the TSHD with a SEL at the source of up to 200 dB re 1 μPa^2/Hz/m. Vibrodensification was modeled as having a SEL at the source of up to 180 dB re 1 μPa^2/Hz/m (Zeddies et al. 2019). Dredging operations in Palma Bay will take place in some areas where juveniles, sub-adults, and adult green and hawksbill sea turtles are likely to be present, specifically coral and seagrass habitats. However, the bay is very large with numerous areas containing suitable refuge and foraging habitat for green and hawksbill sea turtles and large portions of the pipeline construction footprint are uncolonized sand bottom , which is not a preffered habitat of green and hawksbills. Based on the analysis by Zeddies et al. (2019), turtles would have to be within 20 m (65.6 ft) of the dredge in order to experience injurious or behavioral effects from sound generated by dredging. Given the size of the bay and the availability of large areas of refuge and foraging habitat away from the dredging footprint, we believe turtles will avoid areas with in-water construction activity. In addition, the work by Garnier et al. (2012) and surveys for the project indicate that approximately up to four turtles of either species may be present at any one time in Palma Bay. Therefore, we believe it is extremely unlikely that green and hawksbill sea turtles would be within the range of injurious and behavioral effects associated with noise from dredging operations.

Offshore, Zeddies et al. (2019) concluded that noise from the MODU could result in injurious effects to sea turtles up to 27 m (88.6 ft) from the drilling rig and behavioral effects up to 80 m away. Aerial surveys conducted as part of seismic work associated with assessment of the gas field indicated that there are sea turtles in the waters of Area 1 at any given time. However, because the surveys did not identify any turtles to species, it is not clear whether the animals observed included green and hawksbill. Given the frequency with which these two species are sighted in the action area as part of nesting and other monitoring, it is likely that a significant portion of the sightings were green and hawksbill sea turtles, particularly green sea turtles, which seem to be the dominant sea turtle species in the action area. Green and hawksbill sea turtles in offshore waters are likely to be transiting through these waters to and from refuge and foraging sites along the east coast of Africa and beyond based on some satellite tracking data. Because juveniles and sub-adults prefer more shallow, coastal waters, sea turtles in Area 1 are more likely to be adults because of the water depths and distance from shore. Given the size of Area 1, it is extremely unlikely sea turtles would remain within the range of injurious effects from noise, 27 m (88.6 ft), of where the MODU is operating rather than moving away.

Therefore, we believe the effects of noise from dredging and MODU operation on green and hawksbill sea turtles are extremely unlikely to occur, will be discountable, and thus are not likely to adversely affect these species.

7.1.2 Marine Debris and Accidental Spills

Vessels generate marine debris such as lost equipment and trash that falls into the water. Marine debris is also generated during in-water construction activities by construction materials that fall into the water along with trash. Divers will not be used as part of in-water construction so it is unlikely that any equipment, gear, or construction materials that fall into the water will be retrieved, unless the ROVs that will be used to survey along in-water construction footprints will also have the capacity to collect debris. In-water construction activities will be conducted 24/7, making it more likely that items will fall into the water without being noticed. Based on previous consultations for in-water construction, the offshore and pipeline construction activities are not expected to generate significant amounts of debris.

There was a drilling mud spill during exploratory well drilling in the action area, as described in Section 6.2.6.2, but, based on Ellis et al. (2012), these spills dissipate in the water column and result in effects to benthic communities within 1,000 m (3,280.4 ft). Because any drilling mud spill would occur in deep, offshore waters, we do not expect these spills to affect ESA-listed corals. Green and hawksbill sea turtles are also not expected to be affected by accidental spills of drilling mud because areas likely to be impacted by spills are in the immediate area of offshore wells and are not likely to contain refuge and foraging habitat used by these species.

We believe the effects to green and hawksbill sea turtles and ESA-listed corals from marine debris and accidental spills of drilling mud are extremely unlikely to occur, will be discountable, and thus are not likely to adversely affect these species.

7.1.3 Strikes/Collisions

ROVs will be used to survey for sea turtles prior to activities such as dredging in Tungue Bay and offshore disposal of dredged material. ROVs will also be used to survey the reef area prior to CSD use to confirm the pipeline route through the reef. ROVs could collide with sea turtles and ESA-listed corals but, because the operator is monitoring the ROV throughout its operation and can adjust where it is in the water, collisions are unlikely. Similarly, other towed equipment, such as barges that will not be operated on their own power, and pipe sections, will be monitored during towing and move at very low speeds, making collisions with sea turtles unlikely. Equipment and vessels could accidentally ground in areas containing ESA-listed corals and coral habitat used by green and hawksbill sea turtles. However, much of the action area contains deeper water and even in Palma Bay, there are natural deep water channels. In addition, different sections of the pipeline will be dredged using different equipment in part to address vessel draft versus water depth. The exception is the dredging through the coral reef where a larger dredge corridor is needed to accommodate the size of the CSD. There are no reports of accidental groundings by construction vessels operating in the action area or from seismic surveys and exploratory drilling completed in the action area. We believe the effects of collisions with ROVs and other equipment and accidental groundings to green and hawksbill sea turtles and ESA-listed corals are extremely unlikely, discountable, and therefore not likely to adversely affect these species.

The effects of vessel strikes on green and hawksbill sea turtles are discussed in Section 7.2.

7.1.4 Entanglement/Entrapment

Activities resulting in lines in the water can pose an entanglement risk for green and hawksbill sea turtles. In-water structures can also pose a risk for entrapment depending on the design of the structure. In the case of the pipeline, it is possible that sea turtles could be trapped between pipes and barges. Entanglement and entrapment in lines, in-water structures, and construction equipment other than TSHD is unlikely given the use of observers and the probability that sea turtles will move away from in-water construction to refuge and foraging habitats in other portions of the action area. We believe these effects are extremely unlikely, discountable, and therefore not likely to be adversely affected.

The effects of entrainment of sea turtles in the TSHD, entrainment/entrapment of sea turtles in water intakes, and entrainment and entrapment of coral larvae in water intakes are discussed in Section 7.2

7.1.5 Water Quality

Sea turtles breathe air, but they also drink water and excrete solute to regulate their internal ion balance. Sea turtle exposures to chemical constituents such as those in hydrotest waters, discharges of treated wastewater, and stormwater discharges, are less than those of marine fish because turtles do not drink continuously or have gills that serve as another route for toxicants to enter the body. Allometric differences (e.g., body size, membrane area, organ size) are factors to be considered when evaluating toxicity data. A smaller individual generally succumbs to toxic effects more rapidly than a larger individual because it takes a longer time for exposures to reach critical concentrations within the tissues of the larger individual. Therefore, higher exposure concentrations would be needed to elicit the same response over a similar exposure period.

The above information is helpful when addressing data gaps for species like sea turtles. There are no data for the actual effects of aquatic toxicants on survival, growth, or fitness that can be used to evaluate water quality criteria for these species, such as the IFC standards for hydrotest waters or the Mozambique water quality standards for discharges of treated wastewater. A majority of the marine fish and invertebrates inhabiting the same waters as sea turtles are allometrically disadvantaged because they are smaller and have more intense exposures because they respire through gills. For these reasons, they are more likely to respond to toxicants in water than sea turtles. The exception to this are those toxicants that accumulate in organisms and those that biomagnify through the food web. In poorly flushed marine systems, legacy inorganic and persistent organic toxicants can become incorporated into the biogeochemical cycle, with contaminants recycling between sediment and organism tissues through the trophic web, resulting in generational exposures. This is not expected to be a factor in the action area, as Palma Bay is relatively open to ocean mixing and subject to tropical storms that seasonally flush and redistribute sediment. Body burdens in sea turtles primarily result from diet. The presence of a contaminant in the tissues of an organism only confirms exposure and does not provide useful information about effects. The impact of this uncertainty on evaluating location-specific discharges is attenuated when the action area comprises a very small portion of a species foraging area and exposure to pollutants in seawater is expected to be minimal. Green and hawksbill sea turtles are likely to forage in waters affected by discharges of hydrotest waters, stormwater, and treated water, but adverse effects are not expected for forage species/habitats. Therefore, we believe the effects to green and hawksbill sea turtles from the discharge of hydrotest waters, stormwater, and treated wastewater will be extremely unlikely to occur, discountable, and thus not likely to adversely affect these species.

Hydrotest waters will have concentrations of constituents such as heavy metals that are allowable under the IFC standards, but are much higher than criteria such as the U.S. Environmental Protection Agency's (EPA) National Aquatic Life Criteria, which were developed based on toxicity studies using saltwater species. The IFC allowed concentration of all heavy metals in the hydrotest waters is 5 mg/L. The EPA criterion continuous concentration (CCC, which is the highest concentration of a chemical in water that aquatic organisms can be exposed to indefinitely without resulting in an adverse effect) is intended to protect against effects on survival, growth, and reproduction over longer exposures (Table 8). Similarly, the general guideline value of 0.5 mg/L for phenols is likely to be greater than toxicity values for invertebrate species that are reasonable surrogate species for ESA-listed corals. The lack of specificity in defining the phenols makes it difficult to assess because the response of organisms varies depending on the toxicant. Therefore, we would expect the discharge of hydrotest waters to affect ESA-listed corals in particular as the animals cannot move away from the discharge. However, because the discharge of hydrotest water is expected to be irregular over an approximately two-week period, we believe the effects of the discharge on ESA-listed corals will be insignificant and therefore not likely to adversely affect these species.

Table 8. Comparison of IFC Standard with EPA National Recommended Aquatic Life Criteria

Metal	IFC Standard (mg/L)	Saltwater Total CCC (mg/L)
Arsenic	5	0.036
Cadmium	5	0.0078526
Chromium (VI)	5	0.04965
Copper	5	0.002573
Lead	5	0.0053256
Mercury	5	0.000799
Nickel	5	0.008118
Silver	5	N/A acute criterion is 0.0019
Zinc	5	0.076626

Note that there is no CCC for silver, instead the acute criterion, which is the criterion maximum concentration (CMC, the highest concentration of a chemical in water that aquatic organisms can be exposed to acutely without causing an adverse effect) that is intended to protect against severe acute effects during short-term exposure is reported. A CCC or CMC is not available for Vanadium.

The discharge of drilling muds and cuttings, dredged material from the pipeline construction at the offshore disposal site, as well as associated sediment resuspension and transport in the area of the wellfield and dredge material disposal site will result in sediment effects on the seafloor and temporary plumes in the water column. The water-based drilling mud that will be used, and any SBF that might be used as part of well drilling is not expected to present a toxic effect to ESA-listed corals and sea turtles. In addition, ESA-listed corals are not present in the area where well drilling will occur and modeling of the sediment plume that may be generated by drilling activities indicates that it will not travel toward shallower waters where these species may be present. ESA-listed corals are also not present in the offshore disposal site but studies indicate that there are reef areas near the landward boundary of the site, which could result in the transport of sediment to ESA-listed corals during disposal of dredged material. The use of ROV surveys to assess whether specific disposal sites are adequate will include an evaluation of the distance from coral resources (both deepwater corals and shallow water corals). Green and hawksbill sea turtles, though reported to be present in Area 1, are most likely to be transiting through the area as availability of refuge and foraging habitat preferred by these species is limited in the deep waters of Area 1. Turtles could use habitats close to the offshore disposal site and would thus have the potential to be exposed to sediment plumes during disposal activities. However, any effects are expected to be short-term because sediments in the bay are largely sand, which has a larger grain size and settles faster. Dredging of the reef area will result in the creation of finer sediments from grinding up of the limestone content of the reef but this would also be temporary and sediments are expected to remain in the deeper waters of the disposal area. The discharge of materials from drilling, sediment resuspension from drilling, and disposal of dredged material and associated sediment resuspension is expected to result in effects to ESA-listed corals and green and hawksbill sea turtles that are insignificant and thus not likely to adversely affect these species.

Vessels regularly discharge into marine waters as part of normal operations. Discharges include deck runoff, leaching of antifouling products, bilgewater, and other waste streams, which vary depending on the size and type of vessel. Some of the vessels used by the project contractor as part of the proposed action may have toilets, kitchens, showers, or other sources of discharges. Vessel motors often discharge a small amount of petroleum products during normal operation as well. There are regulations (MARPOL 73/78) governing the location of certain discharges, such as sanitary wastewater, and requiring controls for some discharges that contain contaminants to minimize their release into nearshore marine waters. The project will comply with all of these regulations and will also require that, until the nearshore facilities are constructed, which will include disposal facilities for shipboard wastes, contractor vessels transit to Pemba to appropriately dispose of wastes. We have completed consultations with EPA and the U.S. Department of Defense for discharges from military vessels, including discharges from regular vessel operations, and found these to be not likely to adversely affect ESA-listed species and their designated critical habitat (OPR-2018-00159, FPR-2016-9174). Therefore, we believe the discharges from vessels as part of normal operations will have insignificant effects on ESA-listed corals and green and hawksbill sea turtles in the action area. Thus, these discharges are not likely to adversely affect these species.

The effects of changes in water quality from outfalls on ESA-listed corals are discussed in Section 7.2.

7.1.6 Introduction of Non-Native Species

The introduction of non-native aquatic species (NAS) is considered one of the primary threats to at-risk species, including ESA-listed species (Wilcove et al. 1998; Anttila et al. 1998; Pimentel et al. 2004). Clavero and García-Berthou (2005) found that invasive species were a contributing cause to over half of the extinct species in the IUCN database; and invasive species were the only cited cause in 20 percent of those cases. Invasive species consistently rank as one of the top threats to the world's oceans (Wambiji et al. 2007; Terdalkar et al. 2005; Raaymakers and Hilliard 2002; Raaymakers 2003; Pughiuc 2010).

When non-native plants and animals are introduced into habitats where they do not naturally occur, they can have significant impacts on ecosystems and native fauna and flora. Non-native aquatic species can be introduced through infested stock for aquaculture and fishery enhancement, ballast water discharge, and from the pet and recreational fishing industries. Non-native species can reduce native species abundance and distribution, and reduce local biodiversity by out-competing native species for food and habitat. They may also displace food items preferred by native predators.

For example, invertebrates can have major impacts on the ecosystems they invade. Benthic invertebrates, such as mussels, polychaetes, and hydroids can become dominant filter feeders, greatly reducing the amount of organic energy that is available to native taxa in the water column (NMFS 2012). This transfer of energy from the water column into the benthos fundamentally alters the ecology of the host habitat, resulting in less prey available for other filter feeders. Adverse effects of this include reduced body condition, growth, survival, and/or reproduction of native pelagic organisms at the same or similar trophic level as the invader if the native competitor cannot adapt to another food source. These changes would be manifested up the food chain to higher trophic level organisms in the habitat.

Globally, 39 percent of marine NAS invasions were linked to hull fouling, whereas 31 percent of marine NAS invasions were likely to have been transported via ballast water (Molnar et al. 2008). Bax et al. (2003) identified hull fouling as the source of 36 percent of the nonnative coastal marine species established in continental North America (Molnar et al. 2008), whereas ballast water only accounted for 20 percent (Bax et al. 2003).

There are a total of 333 non-native species, and another 130 cryptogenic species (i.e., unknown origin), documented as part of the marine and estuarine biota of the six largest Hawaiian islands from Kauai to Hawaii (Carlton and Eldredge 2015). The greatest proportion of non-native and cryptogenic species are found in the majors harbors of Oahu, which receive the large majority of all vessel traffic in the Hawaiian Islands (Coles and Eldredge 2002). Approximately 20 percent of the benthic algae, fishes, and macroinvertebrate species found these harbors are either non-native or cryptogenic. Algal species have become nuisance invaders of many Hawaiian reefs (Smith et al. 2002). With the exception of Kaneohe Bay, the largest embayment in Hawaii with a history of urban impact, few nonindigenous fishes or invertebrates have been detected on Hawaiian reefs (Coles and Eldredge 2002).

Coles and Eldredge (2002) reviewed scientific literature for information regarding the occurrence and impacts of nonindigenous species from harbors, embayments, and coral reef surveys in the tropical Pacific. Coles and Eldredge (2002) found, for U.S. waters of Apra Harbor, Guam, and Pearl Harbor and other harbors in O'ahu, Hawaii, that low percentages of nonnative species or species that could not be confirmed to be native were present with larger numbers in the most-used harbor areas. They found Inner Apra Harbor, which is dedicated to military use, had 27 nonindigenous species and 29 cryptogenic species (i.e., of unknown origin these species are not demonstrably native but information does not exist to confirm they were introduced), making up 6.7 percent of the total species in the harbor. In Outer Apra Harbor and island-wide, nonindigenous and cryptogenic species made up only 1.7 percent of the total species. In Hawaii, the nonindigenous and cryptogenic species in Pearl Harbor comprised 23 percent of the total number of species and 17 percent in harbors on the south and west shores of O'ahu, while Midway and Kaho'olawe had only 1.5 and 1 percent, respectively. With the exception of some invasive algae in Hawaii, results of studies indicate that the nonindigenous and cryptogenic species in tropical areas are relatively rare on coral reefs and do not appear to cause substantial negative effects (Coles and Eldredge 2002).

While NAS can become aquatic nuisance species and threaten the condition of species such as corals in an area, much of the vessel traffic associated with the proposed action will be vessels that operate within the Indian Ocean and are therefore less likely to transport species that are not already found in the action area. In addition, the contractor will be required to comply with IMO's 2017 *International Convention for the Control and Management of Ships' Ballast Water and Sediments* (Ballast Water Management Convention) and ship hull management requirements of MARPOL. Based on studies such as Carlton and Eldredge (2015) and Coles and Eldredge (2002), NAS tend to remain concentrated in the port and harbor areas where they are released and appear to rarely colonize coral reefs. The greatest number of vessels will be used during nearshore construction when up to 40 vessels might be used at one time. Vessels used in the action area are likely to have been ported there for some time and have been used in the Indian Sea over the recent past, and the results of studies in the Pacific indicate NAS do not appear to have measurable effects to coral reefs. We believe the effects of the introduction of NAS in ballast water or from fouled hulls to green and hawksbill sea turtles and ESA-listed corals will be extremely unlikely, discountable, and therefore not likely to adversely affect these species.

7.2 Exposure, Response, and Risk Analyses

In Section 4, we described the stressors resulting from the proposed action and its consequences and determined that the following stressors are likely to adversely affect green (Southwest Indian DPS) and hawksbill sea turtles: vessel strikes; entrainment in TSHD and entrapment/entrainment in water intakes; lighting of vessels; and habitat loss and/or damage from in-water construction and vessel anchoring and propeller wash. The following stressors are likely to adversely affect ESA-listed Indo-Pacific corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*): larval impingement in water intakes; changes in water quality from outfalls, stormwater discharge, turbidity from dredging; and habitat loss and/or damage from dredging, vessel anchoring and propeller wash.

In the following section, we consider the exposures that could cause an effect on ESA-listed species that are likely to co-occur in space and time with the effects of the stressors identified in the previous paragraph, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on ESA-listed species and, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent. We also consider the responses of ESA-listed species to exposures and the potential reduction in fitness associated with these responses.

7.2.1 Exposure to Stressors

As discussed in Section 6.1, green sea turtles are the most common turtles in the action area dominating both nesting and in-water activity. Hawksbill sea turtles do not nest in large numbers in the action area, but are also common in waters of the action area. In recent years, approximately 200 green sea turtle nests have been reported on Vamizi Island from approximately 50 adult females (Fernandes et al. 2018; Fernandes et al. 2020; Garnier et al. 2012). Hatchling success is estimated as at least 75 percent for Vamizi with approximately 15,688 live green sea turtle hatchlings produced from nests in the 2018/2019 season (Fernandes et al. 2020). Nine hawksbill nests were reported on Vamizi Island between 2004 and 2007 (Garnier et al. 2012). Green and hawksbill nesting is also reported on Rongui and Tecomaji Islands (RINA 2019), but no quantification of nests was provided. Tagging and recapture, as well as stranding data, indicate that juvenile, sub-adult, and adult green and hawksbill sea turtles likely use the area (Costa et al. 2007; Garnier et al. 2012). Aerial surveys of Area 1 reported 100 sea turtle sightings and a survey in Quirimbas National Park recorded 114 unidentified sea turtles (RINA 2019). Thus, while we are unable to quantify the number of sea turtles that will be exposed to stressors as a result of the proposed action and its associated consequences, we know that hatchlings, adults, sub-adults, and juveniles in waters of the action area could be exposed to stressors. These stressors are associated with vessel strikes; entrapment/entrainment; lighting of vessels; and habitat loss and/or damage from in-water construction and vessel anchoring and propeller wash.

Live coral cover in the action area is at least 35 percent acroporid corals, but we have no data that could be used to estimate the number of each listed coral species. *Acropora* spp., *Montipora* spp., and *Seriatopora* spp. have been recorded in the action area, as have two species of *Isopora* so RINA (2019) concluded that *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*, *Acropora pharaonis*, *Acropora retusa*, and *Acropora speciosa* are present in the action area. *Acropora*, *Montipora*, and *Seriatopora* spp. have also been confirmed as recruits at Vamizi Island and these species, particularly *Acropora*, were identified during mass spawning (Sola et al. 2015a). Thus, while we are unable to quantify the number of ESA-listed Indo-Pacific coral colonies in waters of the action area could be exposed to stressors from larval impingement; changes in water quality; and habitat loss and/or damage and loss of individuals from dredging, we know that there could be sexually mature and immature colonies and recruits.

If we use habitat area as an indicator of the number of species that may be present in areas of Palma Bay where pipeline dredging will occur, 9 ha (22.24 ac) of *Acropora* fore reef and 2.2 ha (5.44 ac) of reef flat will be impacted, in addition to 15.1 ha (37.3 ac) of mixed corals and seagrass. Thus, a total area of 26.3 ha (64.98 ac), of which 11.2 ha (27.68 ac) are likely to contain greater coverage of corals, with ESA-listed coral colonies will be impacted. The fore reef and reef flat are within the CSD footprint. These coral habitats also provide refuge and foraging habitat for adult, sub-adult, and juvenile hawksbill sea turtles and refuge habitat for the same life stages of green sea turtles. Similarly, 2.7 ha (6.67 ac) of high density seagrass and 11.5 ha (28.42 ac) of low/moderate density seagrass, in addition to the 15.1 ha (37.3 ac) of mixed seagrass and coral habitat that will be impacted by the pipeline construction serve as refuge and foraging habitat for various life stages of sea turtles.

7.2.2 Response

Given the exposure discussed above, in this section we describe the range of responses among green (Southwest Indian DPS) and hawksbill sea turtles and ESA-listed corals, as applicable, due to activities that will be implemented as part of the proposed action and its associated consequences. For the purposes of this consultation, our assessment tries to detect potential lethal, sub-lethal (or physiological), and behavioral responses that might reduce the fitness of individuals.

7.2.2.1 Green (Southwest Indian DPS) and Hawksbill Sea Turtles

<u>Vessel Operation:</u> Hazel (2009) found, based on a review of sea turtle stranding data, that vessel collision along the east coast of Queensland between 1999 and 2002 resulted in the mortality of at least 65 sea turtles annually, mainly green sea turtles but also some loggerheads, and that 72 percent of the animals were sub-adult and adult turtles. Vessel traffic included a limited number of large ships and a large number of commercial vessels consisting of ferries, dredges, fishing vessels, tourist and charter vessels, and government vessels (used for activities such as research and defense), as well as recreational vessels. Hazel (2009) also found that green sea turtles seemed to rely on visual cues rather than sound cues when fleeing from vessels, meaning that

turtles responded when vessels were within 12 m (39.4 ft) of the animals. Animals fled frequently from vessels operating at four km per hour (km/hr or 2.5 mph; 60 percent of the time) but infrequently in encounters with a vessel traveling at speeds of 11 km/hr (6.8 mph; 22 percent of the time) and only four percent of the time in encounters with a vessel traveling at speeds of 19 km/hr (11.8 mph; Hazel 2009; Hazel et al. 2007), possibly because animals do not see vessels quickly enough to move away. The response of turtles to vessels was often to launch upward and then begin swimming with 74 percent of animals moving away from a vessels track and approximately 20 percent of animals crossing in front of the vessel before moving away (Hazel 2009; Hazel et al. 2007). Security vessels will operate at high speeds, faster than speeds at which sea turtles are able to avoid vessels, and will not have observers on board. Additionally, construction vessels will operate at variable speeds in the bay and at speeds of nine to 11 knots in offshore waters while in transit. While these speeds are protective of marine mammals, they are faster than the speed above which Hazel (2009) observed significant increases in collision risk to green sea turtles. Therefore, the expected increase in vessel traffic and the speeds at which these vessels will operate will increase the possibility of collisions with green and hawksbill sea turtles. Depending on the severity of the collision, animals could suffer minor injuries, serious injuries, or die.

Vessel traffic associated with well drilling and pipeline installation, particularly of larger vessels used during construction versus the smaller local vessels used by fishers in the Palma Bay portion of the action area, will increase during in-water construction activities associated with the proposed action and its consequences.

Underwater sound from vessels is generally at relatively low frequencies, usually between 5 and 500 Hz (Hildebrand 2009; NRC 2003; Southall et al. 2017; Urick 1983; Wenz 1962). Low frequency ship noise sources include propeller noise (cavitation, cavitation modulation at blade passage frequency and harmonics, unsteady propeller blade passage forces), propulsion machinery such as diesel engines, gears, and major auxiliaries such as diesel generators (Ross 1976). High levels of vessel traffic are known to elevate background levels of noise in the marine environment (Andrew et al. 2011; Chapman and Price 2011; Frisk 2012; Miksis-Olds et al. 2013; Redfern et al. 2017; Southall 2005). Commercial ships radiate noise underwater with peak spectral power at 20–200 Hz (Ross 1976). The dominant noise source is usually propeller cavitation which has peak power near 50–150 Hz (at blade rates and their harmonics), but also radiates broadband power at higher frequencies, at least up to 100,000 Hz (Arveson and Vendittis 2000; Gray and Greeley 1980; Ross 1976). While propeller singing is caused by blades resonating at vortex shedding frequencies and emits strong tones between 100 and 1,000 Hz, propulsion noise is caused by shafts, gears, engines, and other machinery and has peak power below 50 Hz (Richardson et al. 1995). Overall, larger vessels generate more noise at low frequencies (<1,000 Hz) because of their relatively high power, deep draft, and slower-turning engines (<250 rotations per minute) and propellers (Richardson et al. 1995).

One potential effect from vessel noise is auditory masking that can lead animals to miss biologically relevant sounds that species may rely on, as well as eliciting behavioral responses such as an alert, avoidance, or other behavioral reaction (NRC 2005;2003; Williams et al. 2015). There can also be physiological stress from changes to ambient and background noise. The effects of masking can vary depending on the ambient noise level within the environment, the received level, frequency of the vessel noise, and the received level and frequency of the sound of biological interest (Clark et al. 2009; Foote et al. 2004; Parks et al. 2010; Southall et al. 2000). In the open ocean, ambient noise levels are between about 60 and 80 dB re: 1 μPa, especially at lower frequencies (below 100 Hz; NRC 2003). When the noise level is above the sound of interest, and in a similar frequency band, auditory masking could occur (Clark et al. 2009). Any sound that is above ambient noise levels and within an animal's hearing range needs to be considered in the analysis. The degree of masking increases with the increasing noise levels; a noise that is just detectable over ambient levels is unlikely to actually cause any substantial masking above that which is already caused by ambient noise levels (NRC 2005;2003). However, if changes to ambient levels occur over a long period, animals are more likely to experience stress or leave the area long enough to have an adverse effect such as energetic consequences of having to look for other refuge and foraging habitats or becoming more exposed to predators.

Given that the range of best hearing for ESA-listed sea turtles appears to be 100 to 400 Hz, green and hawksbill sea turtles in the action area are not expected to detect signals emitted by the navigation equipment used by vessels while underway. The frequency range for operation of small vessels is also outside the hearing range of sea turtles so noise from operation of small vessels is not expected to affect green and hawksbill sea turtles in the action area.

Green and hawksbill sea turtles are expected to detect low frequency noise associated with large vessel operation based on their hearing ranges. Based on the work of Hazel (Hazel 2009; Hazel et al. 2007) in Queensland, sea turtles may be more likely to respond to visual rather than sound stressors from vessels that are very close to the animals, but are expected to continue current behavior (feeding, swimming, breeding, etc.) most of the time despite vessel operations. Closer interactions with vessels and sea turtles may elicit avoidance behavior such as diving and fast swimming, which may result in short interruptions in feeding and other behaviors (Hazel 2009).

Similar to other consultations involving the use of vessels and based on available information, we conclude that green and hawksbill sea turtles in the action area are likely to either not react or to exhibit avoidance behavior associated with the noise of vessel operation. Most avoidance responses would consist of movements away from vessels, perhaps accompanied by slightly longer dives (Hazel 2009). Most of the temporary changes in behavior would consist of a shift from behavioral states with low energy requirements like resting, to states with higher energy requirements like active swimming, with the animals then returning to the lower energy behavior. Behavioral responses could result in energetic costs that result in long-term harm because disturbance from activities such as dredging will be sustained over a period of approximately 24 months. Individuals are expected to be able to find alternate habitat for refuge and feeding but there will be energetic costs associated with the need to expand home ranges in the case of non-transitory juveniles and sub-adults in particular.

Entrainment in TSHD: In addition to the potential for vessel strikes of sea turtles discussed previously, sea turtles can be entrained in the TSHD draghead where they are taken by the force of the suction or entrapped beneath the draghead as it moves across the seabed. Entrainment usually results in severe injury and/or mortality of the animals (Ramirez et al. 2017). Based on documented sea turtle entrainment from the U.S. beginning in the 1980s, dredging in coastal waters generally poses greater risks of entrainment because of the higher density of animals in areas being dredged (Ramirez et al. 2017). Almost 800 incidental sea turtle entrainments by TSHDs were reported by the U.S. Army Corps of Engineers from 1980 to 2015 within the southeastern coastal waters of the U.S. with more occurring in the South Atlantic compared to the North Atlantic and Gulf of Mexico where 401 reported sea turtle entrainments occurred from 1995 to 2008 (Ramirez et al. 2017). It is likely that these are underestimates because evidence of sea turtle interactions with the TSHD can be missed due to things like sinking and burial of sea turtle parts, unscreened overflow in parts of the hopper dredge, or impingement of sea turtles underwater that are not observed (Ramirez et al. 2017). Protection measures were implemented in 1992 in the U.S. after it was discovered that TSHD use resulted in sea turtle entrainment, which resulted in some decrease in annual sea turtle takes.

Hazel (2009) found that green turtles were not visible at the sea surface longer than two seconds but spent more than 80 percent of their time in depths of three m or less during the day. This suggests green sea turtles are likely to be foraging in shallow areas containing seagrass beds where the TSHD will be used but will not be present frequently at the water surface, meaning observers may not see these animals in order to minimize potential entrainment in the dredge. At night, green turtles moved to slightly deeper water and often spent more time submerged (Hazel 2009). Given that continuous dredging (24 hours) will take place daily until all dredging work is complete, the potential for entrainment of sea turtles in the dredge may be greater at night. Dredging, pipeline installation, and backfill activities will take place over a period of up to 24 months, meaning that for almost two years sea turtles will be at risk of entrainment in the hopper dredge.

The project proponent has developed conservation measures, including an observer program, to avoid and minimize the effects of things like TSHD on sea turtles. However, because sea turtles are often not at the surface for long periods, they may be missed by observers. Similarly, while the project will use ROVs to look for sea turtles in the area to be dredged, animals may respond to the presence of ROVs by swimming away and later return to the dredging area. In addition, the turbidity plume generated from dredging will also affect the ability to find sea turtles in the area to be dredged. While we do not have estimates of the number of green and hawksbill sea turtles that may be in Palma Bay during dredging operations using the TSHD, monitoring of nesting and turtles in the water (see Section 6.1) indicate that green and hawksbill sea turtles are present in the action area year-round with nesting documented on Rongui and Tecomaji Islands year-round by both species. Therefore, it is likely that adult, sub-adult, and juvenile green and hawksbill sea turtles will be entrained in the TSHD, which will operate continuously for at least a year in the bay. The project proponent has agreed to incorporate screening of dredged material to look for evidence of sea turtle entrainment as part of the conservation measures to be employed during the project and, if there is evidence of entrainment, measures such as the use of sea turtle excluder devices on the cutter head will be employed. However, these measures are not 100 percent effective in preventing entrainment and entrainment will first have to occur in order for further protective measures to be employed. Entrained sea turtles typically die or suffer such severe injuries that survival in the wild is not possible.

Entrainment/Entrapment in Water Intakes: Sea turtle hatchlings from nests on Rongui and Tecomaji Islands that are attracted to lights on vessels could be entrained or entrapped in vessel water intakes depending on the design, water depth, and location of the intake on a particular vessel. Both green and hawksbill hatchlings could be affected. Depending on the structure of the intake, sea turtles may be able to free themselves, but the concentration of hatchlings is likely to attract predators and the turtles may not be able to escape predation. If the suction rate is high, turtles could be injured if they are sucked into a screen over the intake, causing damage to body parts such as flippers. If the intake is not screened or the screen mesh is large or broken, hatchlings could be sucked all the way in to the intake, which would increase the chance for animals to suffer injury or mortality. Hatchlings could also drown if they are entrapped or entrained for any length of time under water. Similarly, smaller juvenile sea turtles could be entrained or entrapped in water intakes associated with the treatment plants that will be constructed to serve the onshore facilities. Depending on the design of the intake, juveniles could drown if they are unable to free themselves or if the structure does not have a warning system that notifies someone of the need to check the intake. Juveniles could also be injured, either during an attempt to free themselves or due to suction against the intake. It is not expected that intakes would be large enough to suck juveniles all the way in to the intake.

Lighting: Lighting of vessels and in-water structures is not expected to affect ESA-listed corals. Lighting could affect the movement of sea turtles, particularly nesting females and hatchlings. During construction, which will take place 24 hours a day particularly for the pipeline, lighting will be required to ensure worker safety during nighttime operations. Lighting of the construction operation would allow observers to spot turtles that come to the surface, although animals are often more likely to be resting on the seafloor at night (Hazel 2009). Nighttime lighting could result in disorientation of green and hawksbill hatchlings from nests on Rongui and Tecomaji Islands, particularly if construction vessels are using the anchorage area near the islands during nesting season. The MODU requires lighting at all times to ensure vessels can see it, enable operations to take place continuously, and to ensure worker safety. Hatchlings attracted to vessel lights would be more susceptible to predators, as well as the potential for entrainment or entrapment in seawater intakes of larger vessels. This is more likely to affect green sea turtles given the larger number of documented nests by this species as opposed to hawksbill sea turtles. In addition, if sea turtle nesting beaches are facing oceanward rather than toward the bay, hatchlings are unlikely to end up in the bay where the vessels are anchored. The potential effects of disorientation due to lighting are expected to occur over the up to 24 months of pipeline construction and so would affect at least two peak nesting seasons, depending on the timing when pipeline construction occurs.

Habitat Loss and/or Damage: In-water construction activities, particularly pipeline dredging, anchorage of construction vessels, and propeller wash from anchorage and start up in shallow waters, will result in direct impacts to coral and seagrass habitats used by green and hawksbill sea turtle adults, sub-adults, and juveniles and sediment resuspension and transport. A total of 40.5 ha (100.07 ac) of seagrass and coral habitat will be within the temporary and permanent footprint of pipeline dredging. Once the pipeline trench is backfilled, some natural recovery of seagrass is expected, though the extent to which natural recovery occurs will depend on the frequency and severity of storms, whether replanting is done to stimulate recovery, and the level of continued disturbance in Palma Bay associated with continued construction activities and transit of vessels from the offshore area to the nearshore facilities. Coral habitats, particularly the coral reef that will be dredged to allow for pipeline installation, are not expected to recover without some level of restoration. Therefore, there will be an overall loss of and decline in the quality of a measurable area of refuge and foraging habitat that is currently used mainly by juvenile and sub-adult green and hawksbill sea turtles. During pipeline construction, sea turtles are likely to move away from construction operations, which will have an energetic cost due to the need to swim further. These effects are likely to continue once construction of the pipeline has been completed because natural recovery of seagrass and restoration and recovery of coral areas will take time. The use of anchorages and potential propeller wash from large vessels, tugs, and barges powering up in shallow waters, are expected to result in further loss of and declines in seagrass and coral habitats from effects such as sediment burial and scouring of the bottom and benthic organisms.

In addition, dredging activities associated with pipeline construction will result in turbidity plumes that will result in at least temporary impacts to habitats used by green and hawksbill sea turtles in the action area. Modeling of turbidity plumes from dredging concluded that turbidity plume concentrations of 10 to 15 and 15 to 20 mg/L would be generated for both TSHD and CSD. Maximum sedimentation above 4 cm (1.57 in) will occur mainly within the ZOMI, which is up to 500 m (1,640.4 ft) beyond the full construction footprint (with temporary and permanent construction areas). Depending on the seagrass species, this could lead to a temporary decline in growth, resulting in further temporary losses of refuge and foraging habitat for various life stages of green sea turtles. The conservation measures include controls and TSS levels above which additional protective measures will be taken to try to minimize effects to marine habitats. However, the levels proposed are significantly higher than natural levels recorded in most portions of the bay where the seagrass and coral habitats that will be impacted by pipeline construction are located.

There is no information on adult home range densities in the nearshore waters of the action area, though we would expect a much lower density of adult sea turtles compared to juveniles. It is known that reproductively mature hawksbill sea turtles (Proietti et al. 2012; Rincon-Diaz et al. 2011) and green turtles (Bresette et al. 2010) tend to establish foraging home ranges in waters further offshore and deeper than do juveniles, so the impact of habitat disruption or degradation from the pipeline construction is likely to have a lesser effect on mature turtles than juveniles and sub-adults. Based on the habitat preferences of sea turtles according to their life stage, and the reduced importance of the potentially impacted nearshore waters for adult foraging habitat, we conclude that the impact of habitat loss will be significant for juvenile and sub-adult turtles, but not for adults.

7.2.2.2 ESA-Listed Indo-Pacific Corals (Acropora pharaonis, Acropora retusa, Acropora speciosa, Isopora crateriformis, Seriatopora aculeata, Montipora australiensis)

<u>Larval Impingement in Intakes:</u> Depending on the location in relation to spawning coral colonies and current patterns, time of year at which intakes are operating, and intake design properties, ESA-listed coral larvae could suffer impingement in seawater intakes of vessels, the MODU, and shoreline-based facilities such as the desalination plants that will be used during construction. Studies of coral spawning in the action area indicate that acroporid corals and species of *Montipora* and *Seriatopora* participate in a mass spawning event typically any time from September to December (Sola et al. 2015a). The intake for the desalination plant will be located in the bay and will have a screen with a mesh size that would not preclude intake of coral larvae. While the intake velocity is slow (0.49 ft per second, which is just below the upper velocity threshold of 0.5 ft per second recommended by the EPA to minimize impingement of aquatic organisms), it will likely still be enough to impinge coral larvae.

We do not have details of the seawater intakes that will be on the MODU and construction vessels but, if they have screens, the mesh size is likely to be too large to prevent the entrance of coral larvae or may be large enough to cause larvae to be mashed against the screen. The intake velocity of the vessels may also be greater than that recommended to reduce the potential for impingement.

Coral larvae are only viable for about three weeks, although some studies suggest much longer lifespans for some species on the Great Barrier Reef (Graham et al. 2008). Therefore, even if larvae are not sucked into the intake, they will die after a few weeks trapped on the intake screens, although this is less likely because the mesh is too large to prevent the entry of coral larvae (assuming all intakes use the 100 mm by 100 mm screen rather than a 100 micrometer mesh that would reduce intake of aquatic organisms). The study by Sola et al. (2015a) did not quantify the amount of coral larvae in spawning slicks. Sampling for a proposed LNG project in Puerto Rico in an area containing well-developed coral reefs with ESA-listed corals, including acroporid corals, found higher coral larval densities at night than during the day with peak densities over a seven to 11 day period following the full moon, which meant a peak a night in September 2015 of 6,532 larvae per 26,400 gallons (FERC 2016). Larval mortality is often 90 percent or more from predation and other factors prior to settlement and metamorphosis (Wilson and Harrison 2005; Heyward et al. 2002) so the loss of viable larvae to impingement represents a small loss in future recruits of the different ESA-listed coral species in the action area.

Changes in Water Quality: ESA-listed coral colonies in Palma Bay may be chronically exposed to discharges from outfalls associated with the desalination plant, wastewater treatment plant, and cement plant that will discharge to the bay throughout the construction period. The discharges are required to meet Mozambique water quality standards (see Table 3). However, many of the criteria are not protective of ESA-listed corals so exposure to discharges over the five-year period of construction will result in chronic effects to corals such as tissue loss, disease, and a cessation of sexual reproduction over some or all of the years during which construction of the pipeline and discharges from terrestrial facility construction are ongoing. Declines in growth are also likely to occur.

The temperature standard of 35^{o}C is past the upper tolerance limits of corals beyond which they are expected to suffer heat stress. Reef corals tend to thrive in areas with mean temperatures within a narrow range (typically 25-30^{o}C). Short-term exposures (days) to temperature increases of a few degrees (i.e., 3-4^{o}C increase above climatological mean maximum summer temperature) or long-term exposures (several weeks) to minor temperature increases (i.e., 1-2^{o}C above mean maximum summer temperature) can cause significant thermal stress in the form of bleaching and mortality in most coral species (Berkelmans and Willis 1999; Jokiel and Coles 1990; Fitt and Warner 1995). Such temperature thresholds are variable in time (e.g., season) and geographic location and may be nonlinear. Even in areas where corals have adapted to extremely high summer (and low winter) temperatures such as in the Arabian Gulf and Northwestern Hawaiian Islands, corals bleach when their normal maximum and minimum temperature tolerances are exceeded (Riegl 2002; Hoeke et al. 2006; Brainard et al. 2011). High temperatures are a significant cause of coral bleaching. Coral can withstand mild to moderate bleaching but severe, repeated, or prolonged bleaching can lead to colony mortality.

The pH standard, particularly the lower range, is outside the tolerance of coral species. As pH declines, the linear extension rate and skeletal density of corals decrease (Hoegh-Guldberg et al. 2007), leading not only to impacts to individual colonies but to the value of coral areas as habitat for other species. Decreasing pH also leads to bleaching as corals experience stress and increasing acidification can override any acclimatization to thermal stress (Anthony et al. 2008). Studies in both the Caribbean (Crook et al. 2012) and the Pacific (Fabricius et al. 2011) have found that very few hard corals can survive and grow below a pH of 7.7 and aragonite saturation of 2.9. Corals from the genus *Porites* were still found in these conditions and *Siderastrea radians* (Caribbean), but at low abundance and typically only when nutrient concentrations were high (Crook et al. 2012). Major reef-building corals did not tolerate these conditions regardless of nutrient input. The size of coral colonies, even in tolerant species, declined as pH became more acidic, likely because growth slowed under more acidic conditions. Similar to corals, research has shown that the percent cover of several sponge species declines significantly with increases in acidification and that the community composition of sponges shifts as these bioerode under acidic conditions and other species become more common (Goodwin et al. 2014). Thus, if outfalls are compliant with the lower range of the pH standard, the exposure of ESA-listed corals to these discharges will lead to bleaching and effects on growth associated with increases in acidity.

The TSS standard of 50 mg/L is high and does not correspond with values reported for areas of Palma Bay containing corals (Impacto & ERM 2014). Studies have found that survival of coral recruits in warmer waters (water temperatures of 30^{o}C) is better if fine sediments are less than 6.55 NTU (Fourney and Figueiredo 2017); coral disease increases by orders of magnitude in reefs exposed to sediment plumes (Pollock et al. 2014); undisturbed reefs consistently have turbidity values less than 1 NTU (Fourney and Figueiredo 2017); and high sediment concentrations affect reproduction (Jones et al. 2015). High TSS leads to smothering of coral polyps. Some coral species dedicate energy to the production of mucous to slough off sediment. This has a cost on reproduction because energy spent in mucous production means coral colonies will not have the energy to produce mature gametes. It is not clear whether the water treatment plants will discharge solids, particularly the wastewater treatment plant, because information regarding the level of treatment was not provided.

It has been suggested that enterococci bacteria may not be reliable indicators in tropical and subtropical environments, including coastal waters, because of the ability of these bacteria to replicate in water and sediment and be held in sediment reservoirs (Bonkosky et al. 2009; Lee et al. 2006; Phillips et al. 2011). In addition, other animals also contribute to fecal contamination of coastal waters, meaning that high concentrations of these bacteria may not be due to human sewage contamination. In some areas with large seabird colonies, for example, high concentrations of fecal indicator bacteria are due to the rookeries, as indicated by tests that use microbial source tracking (MST) methods. MST is being used to identify the source of fecal contamination with molecular markers that can amplify DNA sequences from potential microbial fecal indicators (Bonkosky et al. 2009). Human sewage has been identified as the likely source for the strain of *Serratia marcescens* which caused outbreaks of white pox disease in threatened elkhorn coral in the Caribbean (Sutherland et al. 2010). Diseases such as white pox are listed as major contributors to the decline of elkhorn coral. Discharges represent more direct and undiluted exposure “pulses”, expose elkhorn to *Serratia marcescens*, and cause an outbreak of whitepox disease. At this time, NMFS does not have a good understanding of the potential impact of human sewage indicator pathogens on the population health of ESA-listed corals but, based on available information, we expect the allowable standard for total coliform bacteria may result in adverse effects to corals.

Nitrogen (N) and phosphorous (P) are indirect stressors because they stimulate eutrophication and stressors associated with excessive plant and algal growth: extremes in DO, reduced light penetration, smothering, and algal toxins when present in high concentrations. Under natural conditions, essential nutrients contribute to the proper structure and function of ecosystems. However, in excessive quantities, nutrients can have adverse effects on ecosystems and rank as one of the top causes of water resource impairment (Bricker et al. 2008; USEPA 2014).

Eutrophication alters the composition and species diversity of aquatic communities through intensifying competition by those species, native or invasive, that are better adapted to eutrophic environments (Nordin 1985; Welch et al. 1988; Carpenter et al. 1998; Smith 1998; Smith et al. 1999). Eutrophication can have cascading effects that change ecosystem structure at numerous trophic levels. Nuisance levels of algae and other aquatic vegetation (macrophytes) can develop rapidly in freshwater and marine habitats in response to nutrient enrichment when other factors (e.g., light, temperature) are not limiting. The relationship between nuisance algal growth and nutrient enrichment is well-documented (Welch et al. 1992; Dodds et al. 1997; Chetelat et al. 1999; Vannieuwenhuyse and Jones 1996). Increases in nutrient loading to nearshore waters that increase algal and phytoplankton growth, affect coral habitat function related to coral settlement and growth.

In addition to outcompeting native aquatic plants and sessile organisms such as corals for space and light, the proliferation of nuisance algae can lead to harmful algal blooms (e.g., brown tides, toxic *Pfiesteria piscida* outbreaks, some types of red tides) that contain potent toxins from microalgae. In marine systems, algal toxins have caused massive fish kills, along with deaths of whales, sea lions, dolphins, manatees, sea turtles, birds, and wild and cultured fish and invertebrates (Landsberg 2002; Shumway et al. 2003). Eutrophication is believed to be a likely contributor to the increased occurrence of harmful algal blooms (Heisler et al. 2008). Eutrophication has also been linked to increases in bacteria biomass (Carr et al. 2005). Bacteria have been associated with mortality of fish, turtles, and alligators (Shotts et al. 1972). Harmful algal blooms are not common in the USVI but there may be a relationship between pulses of nutrients and blooms of other algal species and cyanobacteria in coral and seagrass habitats in summer months. Van Houtan et al. (2014) found that green sea turtles were more likely to develop fibropapilloma (FP) tumors due to the concentrations of arginine nitrogen the animals were consuming in macroalgae from eutrophied waters. In areas with chronic high nutrient inputs in the Florida Keys, reef coral die-off occurred and was attributed to microbial diseases responding to high nutrient inputs (Lapointe et al. 2004).

The accumulation of algal biomass through excessive productivity can reduce available habitat, and the decay of this organic matter may lead to reductions in DO in the water column, which in turn can cause problems such as fish kills and the release of toxic substances or phosphates that were previously bound to oxidized sediments (Chorus and Bartram 1999). Because hypoxia, defined as concentrations below 0.2 ml/L (Kamykowski and Zentara 1990), often occurs in estuaries or nearshore areas where the water is poorly mixed, nursery habitat for fish and shellfish is often affected. Without nursery grounds, the young animals cannot find the food or habitat they need to reach adulthood. This causes years of weak recruitment to adult populations and can result in an overall reduction or destabilization of important stocks. High biomass blooms can also directly inhibit growth of beneficial vegetation by blocking sunlight penetration into the water column (Onuf 1996). Macroalgal blooms reduce sunlight penetration and can overgrow or displace seagrasses and corals as well as foul beaches (Valiela et al. 1997). Bloom-inflicted mortalities can degrade habitat quality indirectly through altered food webs or hypoxic events caused by the decay of dead animals (Lopez et al. 2008). Tew et al. (2013) found a 16:1 ratio of N:P to be ideal in allowing for the development of adequate phytoplankton to then nourish the zooplankton community that served as prey for larval and early stage juvenile grouper.

In addition, direct toxic effects can occur in waters with elevated nitrogen in the form of ammonia, with the more toxic form, ammonium, more prevalent at high pH. In addition to the potential for ammonia toxicity under high nutrient loadings, toxins may be produced by some algae that thrive in eutrophic conditions. Accumulation and increased turnover of algal and plant biomass (i.e., death, decay, nutrient release) generates suspended solids in the form of organic particulates and phytoplankton, contributing to turbidity from natural and human-caused erosion and sediment resuspension. Increased turbidity affects light penetration into the water column and the ability of aquatic plants to photosynthesize and survive and the effectiveness of sight-dependent behaviors such as foraging, reproductive displays, and predator evasion. Decreased light penetration affects the degree of coverage of the substrate by plants and benthic organisms that are reliant on plants. Suspended organic matter can eventually accumulate on and smother plants, animals, and benthic habitats. Increases in plant and microbial biomass or productivity may result in negative ecological effects by:

- altering food resources: the amount and type of food resources or their palatability (e.g., changes in algal cell size affects filter-feeding animals);
- increased microbial infection of invertebrates or fish;
- altering habitat: light penetration, diurnal DO cycle, changes in benthic interstitial space, availability of macrophytes as habitat;
- stimulating generation of toxins: some algae that thrive in eutrophic conditions can be toxic to fish and invertebrates;
- increasing mortality through favoring nitrogen pathways increasing the formation of toxic unionized ammonia; and
- changes in community structure, even without overall increases in primary producers, due to alterations to nutrient availability ratios.

The Mozambique water quality standards criteria of 10 mg/L Total P and 15 mg/L Total N are high compared to areas in the Pacific and Caribbean where corals are present. For instance, the criteria for TP and TN in the Florida Keys are 7-11 micrograms per liter (µg/L) and 170-150 µg/L, respectively, annual average values not to be exceeded more than once every three years. In Hawai'i, embayments have a wet criteria (geometric mean) of 200 µg/L TN and 25 µg/L TP, a dry criteria (geometric mean) of 150 µg/L TN and 20 µg/L TP, as well as not to exceed (NTE) wet and dry criteria that cannot be exceeded more than 10 percent and two percent of the time. The wet and dry criteria for the NTE two percent TN wet is 500 µg/L and 350 µg/L dry and for TP is 75 µg/L wet and 60 µg/L dry. Therefore, the permitted nutrient levels are likely to result in eutrophication and associated increases in algal biomass, which would affect the growth and health of ESA-listed coral colonies.

In addition to chronic effects of discharges, modeling of turbidity plumes from dredging associated with pipeline construction in Palma Bay concluded that turbidity plume concentrations of 10 to 15 and 15 to 20 mg/L will be generated for CSD in the reef area and for TSHD, which will take place in areas containing seagrass, sand, and coral habitats in Palma Bay. Maximum sedimentation above 4 cm (1.57 in) will occur mainly within the ZOMI, including in the reef area. As described above regarding TSS, sediment plumes can lead to smothering of corals. The conservation measures include controls and TSS levels above which additional protective measures will be taken to minimize effects to marine habitats. However, the levels proposed are significantly higher than natural levels recorded in most portions of the bay where corals occur and higher than levels reported as leading to chronic effects to corals. Areas in the ZOMI are likely not to recover reef structure and function due to the settlement of sediment on coral areas, as well as the potential for resuspension of this sediment with waves and storms and associated continued abrasion of corals during sediment resuspension. The decline in habitat quality associated with sedimentation from dredging the reef will result in a decrease in the amount of available substrate for settlement and growth of coral recruits in addition to effects to ESA-listed coral colonies in the footprint of temporary dredge impacts that remain in the area around the pipeline corridor.

<u>Habitat Loss and/or Damage</u>: The dredging of the pipeline route through the coral reef will result in the loss of ESA-listed coral colonies that are not removed from the dredging footprint. In addition, we expect some mortality of transplanted coral colonies. There are no estimates of transplant success for Mozambique but coral transplant work in Puerto Rico and the U.S. Virgin Islands, including of ESA-listed acroporid corals, indicate that transplantation often results in the mortality of approximately 10 percent of transplanted colonies. Transplanted corals could also suffer temporary declines in health due to the stress of transplantation. Temporary declines in the health of coral colonies that survive transplantation would be evidenced by bleaching and/or partial tissue mortality, and a lack of sexual reproduction within the first spawning season following transplantation.

Dredging using CSD through a portion of reef will result in the loss of nine ha (22.24 ac) of *Acropora* fore reef and 2.2 ha (5.44 ac) reef flat, or a total of 11.2 ha (27.68 ac) of reef habitat. While the placement of quarry stone is anticipated in order to attempt to restore some of the pre-construction rugosity of the reef area, previous consultations that assessed the time required to restore coral habitat function estimated decades were needed to allow for the establishment of adequate structure and function to compensate for the loss of existing, natural coral habitats. In addition, depending on the source and composition of the stone, natural colonization may be delayed. Overall, there will be a loss of habitat for settlement and recruitment of ESA-listed corals, some of which will be permanent loss, and some temporary loss on the scale of a decade or more based on previous work.

7.2.3 Risk Analysis

As discussed in previous sections, we believe several of the activities that are part of the proposed action and its consequence are likely to result in potential injury, behavioral responses and/or mortality of hatchling, juvenile, sub-adult, and adult green and hawksbill sea turtles; and potential injury and mortality of sexually mature and immature, and recruits of *Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*. The consequences of these responses are discussed further below.

7.2.3.1 Green (Southwest Indian DPS) and Hawksbill Sea Turtles

Increases in vessel traffic and operating speeds proposed for construction vessels at the offshore wellfield and in the bay are likely to lead to interactions between juvenile, sub-adult, and adult green and hawksbill sea turtles including injury, mortality, and behavioral responses. Juvenile, sub-adult, and adult green and hawksbill sea turtles may also suffer severe injury or mortality because of entrainment in the TSHD. Green and hawksbill hatchlings could suffer various degrees of injury or mortality associated with entrainment/entrapment in the water intakes of vessels, particularly those anchored near Tecomaji and Rongui Islands during peak nesting season. Similarly, hatchling green and hawksbill sea turtles could also become disoriented from lights on vessels, particularly those anchored near the offshore islands where these turtles nest. The congregation of disoriented hatchlings at vessels would increase the risk of predation of hatchlings and have fitness consequences associated with energy expenditures to swim to the vessels instead of out to sea. Small juvenile green and hawksbill sea turtles entrained/entrapped in water intakes associated with water treatment plants for construction of terrestrial facilities could also suffer various degrees of injury or mortality. There may also be fitness consequences, particularly to juvenile and sub-adult green and hawksbill sea turtles that are more likely to use nearshore habitats for refuge and foraging than adult animals. Seagrass and coral habitats will suffer temporary and permanent impacts due to pipeline construction, resulting in sea turtles having to leave their resident habitat in some cases or travel further to forage. Behavioral responses to equipment used during the 24 months of pipeline construction and the energetic expenditures associated with having to range further to feed or relocate.

The number and life stage of animals of each species that suffer fitness consequences will depend on the locations of vessel and TSHD operations; suction rates, sizes, and design of seawater intakes; type, orientation, and location of lighted vessels; and location and extent of habitat impacts in relation to resident and transitory animals and their habitat use. Fitness effects include injury; significant behavioral changes that lead to energetic costs and associated effects on development, growth, and sexual reproduction; and mortality. In terms of potential fitness consequences to green and hawksbill sea turtles because of significant disturbance, injury, or mortality, we consider the population effects to these sea turtle species in the context of total annual mortality associated with human activities in the action area. We also calculate the potential minimum number of different life stages of green and hawksbill sea turtles that may be present annually from studies done in the action area.

As stated previously, while we do not have a population estimate for these species in the action area, based on monitoring in the action area we estimate there could be:

- A minimum of 50 nesting green female sea turtles and at least one adult female hawksbill sea turtle (based on an estimate of three nests per year from data in Garnier et al. 2012) in the action area annually
- A minimum of 15,688 live green sea turtle hatchlings (from data in Fernandes et al. 2020) and 315 hawksbill sea turtles hatchlings (assuming a clutch size of 140 and the same emergent success as for green sea turtles) in the action area annually
- At least five juvenile, sub-adult or adult green sea turtles and four juvenile, sub-adult or adult hawksbill sea turtles (Costa et al. 2007; Garnier et al. 2012; Fernandes et al. 2018; Fernandes et al. 2020) in the action area annually.

We use these estimates as the best available data in order to calculate the potential numbers of animals of different life stages that will suffer lethal or sub-lethal (injury, significant behavioral changes) effects. However, in the case of hatchlings, studies have shown that sea turtle hatchling mortality rates range from 30 to 60 percent as the animals leave the beach and swim toward open water and only 2.5 in 1,000 reach adulthood (Pilcher and Ali 1999; Frazer et al. 1992). Thus, we estimate that between 4,706 and 9,413 green sea turtle hatchlings and between 95 and 189 hawksbill sea turtle hatchlings could survive to swim toward open water adjacent to nesting beaches on Tecomaji and Rongui Islands. This assumes that the number of hatchlings for these islands is the same as recorded on Vamizi Island.

In our risk analysis we determined that hatchling green and hawksbill sea turtles could be injured or killed by entrainment/entrapment in seawater intakes of vessels and be disoriented by vessel lighting, particularly vessels anchored near the offshore islands outside the bay; juvenile, sub-adult, and adult sea turtles could experience injury or mortality due to entrainment in TSHD and vessel strikes; juvenile green and hawksbill sea turtles could suffer injury or mortality due to entrainment/entrapment in water intakes associated with terrestrial water treatment plants in the bay; and juvenile, sub-adult, and adult green and hawksbill sea turtles could exhibit significant behavioral changes due to the loss of refuge and foraging habitat associated with pipeline construction. Based on the estimates of minimum numbers of these life stages that may be in the action area, we conclude that up to 50 adult female green sea turtles and one adult female hawksbill sea turtle could be subject to these lethal and sub-lethal effects during the peak nesting season, and five adult green sea turtles and four adult hawksbill sea turtle outside peak nesting season; up to 9,413 green and 189 hawksbill sea turtle hatchlings; and five juvenile or sub-adult green and four juvenile or sub-adult hawksbill sea turtles. These estimates are based largely on nesting data from Vamizi Island, although some of the in-water data encompass portions of Tungue Bay. The estimated numbers of animals of each life stage that could be in the action area annually based on previous studies are likely a significant underestimate of the population of these species in the action area, of which the actual footprint of activities expected to result in adverse effects to green and hawksbill sea turtles is only a small portion. Thus, we conclude the fitness effects to different life stages of green and hawksbill sea turtles will not have a measurable effect on the populations of these species and are not likely to reduce the population viability of the Southwest Indian DPS of green sea turtles, and hawksbill sea turtles.

7.2.3.2 ESA-Listed Indo-Pacific Corals (Acropora pharaonis, Acropora retusa, Acropora speciosa, Isopora crateriformis, Seriatopora aculeata, Montipora australiensis)

Impingement of coral larvae in seawater intakes of vessels and terrestrial water treatment facilities will result in a reduction in the number of future recruits of ESA-listed coral species associated with the loss of larvae. Changes in water quality associated with outfalls of treated water will result in fitness consequences to sexually mature and immature coral colonies associated with the chronic effects of high temperature, low pH, high sediment concentration in the water column, and high nutrient content. Fitness consequences include tissue mortality, decreases in growth, weakened skeletal structure, and declines in or the stoppage of sexual reproduction and recruitment. CSD dredging will result in the elimination of ESA-listed coral colonies from the action area and the loss of future recruits from sexually mature colonies, as well as mortality of a portion of any corals transplanted and the lack of sexual reproduction by transplanted colonies for a year or two following transplant. CSD will also result in the permanent loss of settlement and recruitment habitat in the reef area, as well as a temporary loss in habitat structure and function for years following dredging and any restoration of the impacted coral habitat.

We have no population estimates of ESA-listed Indo-Pacific corals in the action area, but acroporid corals dominate many of the reefs in the area and the lowest percent cover of these species is 35 percent (Pereira et al. 2014). The populations of all of the ESA-listed coral species in the action area are estimated as at least millions of colonies with information for *Acropora pharaonis* being the most precise, identifying a world population of 10,942,000 and an effective population of 1,204,000 (Richards et al. 2008a; Veron 2014). Some of these species are naturally rare, but species of *Acropora*, *Seriatopora*, and to a lesser extent *Montipora*, appear to be relatively common in the action area based on surveys by various researchers. Based on known depth ranges for these species, *Acropora retusa* and *Isopora crateriformis* have the shallowest depth ranges. *Acropora pharaonis, Seriatopora aculeata*, and *Montipora australiensis* are also found in shallow waters, but have a larger depth range, including depths at which no dredging will occur. *Acropora speciosa* may be the least likely to be affected because the shallowest depth at which it has been reported is 12 m (39.4 ft). A measurable number of ESA-listed coral colonies of each species could be lost in the 11.2 ha (27.68 ac) of reef habitat that will be lost due to CSD in order to create the pipeline corridor. Information from surveys in the action area indicate that acroporid corals make up approximately 50 percent of reef species so it is likely that a large number of colonies of the listed acroporid corals will be lost. Using the minimum 35 percent cover estimate for reefs in the area and habitat area as a surrogate, we could assume that 3.92 ha (9.69 ac) of ESA-listed coral colonies will be impacted by pipeline construction. Because populations of these species are thought to be in the millions and given that the habitat area that will be most affected is a small portion of a large reef system, we believe the fitness consequences associated with the proposed action will represent a small subset of the ESA-listed corals in the action area. Effects to this subset will not have a measurable effect on the population of ESA-listed corals in the action area and is not likely to reduce the population viability of ESA-listed corals in the action area.

8 Cumulative Effects

"Cumulative effects" are those effects of future state (in this case, Mozambique) or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal (U.S.) actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

For this consultation, cumulative effects include climate change, fisheries, vessel operation and traffic, research activities, coastal development, natural gas activities, and natural disturbance.

Climate change has already affected the action area based on measured changes in sea level rise and is expected to continue into the foreseeable future. The BA prepared for the project calculated that the project, which is for the production of a fossil fuel, would not make a measurable contribution to greenhouse gas emissions influencing climate change (RINA 2019). However, should oil and gas development continue in the action area and beyond, the continued use of fossil fuels and loss of natural areas such as coastal forests and wetlands would contribute to emissions. On the other hand, continued sea level rise because of climate change could affect the viability of the LNG facilities in the future given their location on the coast. Ongoing climate change could exacerbate the effects of any increases in coastal and natural gas development and result in significant declines in water quality associated with runoff and the transport of land-based pollutants to nearshore waters, as well as discharges of process water, wastewater, and brine from desalination plants.

Fisheries are expected to continue in the action area, though habitat areas used will have to shift due to exclusion zones and operation of vessels associated with the offshore gas field and nearshore LNG facilities. Should planned fishery projects proposed by the project proponent such as the development of fish attracting devices be implemented, target species and gear use could change, potentially reducing some of the bycatch of sea turtles. Improvements in enforcement could also occur in the future as tourism development continues and/or economic improvements occur because of successful natural gas and other development projects, providing the government with funds to dedicate to compliance with existing laws for species protection. The continued education of local communities and an improvement in enforcement to implement the use of required sea turtle excluder devices on some gear and to prevent poaching is expected to continue into the foreseeable future.

Vessel operation and traffic will continue to shift from small local vessels to larger commercial vessels associated with natural gas activities, but also with tourism operations as facilities on offshore islands continue to be developed. LNG vessels will be approximately 350 m (1,148.3 ft) long with a 50 m (164 ft) beam width, a draft of approximately 12 m (39.4 ft), and transit speeds up to 21 knots. It is anticipated that one LNG vessel per week on average will transit to/from the first LNG train, once ready for operation. Train two would support two vessels per week. Two trains will be constructed initially. The construction of additional trains could occur if gas production increases. During the initial phases of project operation, it is expected that the new facilities will service four to five LNG carriers and one to two tankers (for condensate export) per month. Condensate will be offloaded to marine tankers through either a berth on the MOF or the LNG export jetty. Support vessels, including a pilot boat, tugboats, and general support vessels (line handlers, security and response boats), will be active during normal operations to assist with the safe navigation and maneuvering of LNG carriers.

Research activities associated with coral surveys, collection, and recruitment studies may increase depending on mitigation projects and offsets that may be required as part of the financing agreements of on-going natural gas development projects in the action area. The influx of new residents and funding may also lead to the availability of more government funding to study corals in the action area. The sea turtle monitoring and tagging programs in the action area are expected to continue both with government support and with continued support of local communities. The programs may grow as new residents move into the action area and tourism increases.

As already discussed, coastal development is expected to continue in the action area into the foreseeable future as the government continues to promote tourism and industrial development. This development will also mean a continued influx of residents from other areas of Mozambique and other countries. Because the action area will continue to be in a relatively arid location, the demand for water is likely to have the greatest effect on natural systems as the use of groundwater to support a growing population will lead to drawdown of aquifers and saltwater intrusion and the use of desalination plants will result in effects to ESA-listed corals when intakes are in areas with coral larvae and to corals and sea turtles from outfalls. Outfalls and non-point sources of land-based pollutants and human waste associated with coastal development and industrial growth are likely to have increasing effects to nearshore water quality, particularly given that the Mozambique water quality standards are not protective of aquatic life based on comparisons of the standards with toxicity studies using marine organisms.

Natural gas development is expected to continue in both Area 1, where there may be an additional 37 production wells drilled based on information in the Environmental Impact Assessment (EIA) prepared for the overall project. There may also be additional well drilling in Area 4. A floating production unit may also be constructed to boost production once reservoir pressure declines (Impacto & ERM 2014). This development would result in effects to green and hawksbill sea turtles similar to those discussed in other sections of this Opinion.

MEG will be used as an inhibitor to avoid the risk of hydrate formation in the subsea production system, requiring the inclusion of a chemical injection and recovery system in the subsea production system. The use of MEG in this case is part of a closed-loop system and MEG will be reused as much as possible. The primary wastes from the MEG recovery system are salt and water. The EIA prepared for the project notes that 2,200 kilograms (kg) of salt per day and 1,600 barrels of process water per day for each LNG train that is constructed and put into operation will be generated as wastes from the use of MEG as an inhibitor. The saline fluid will be comingled and discharged from the plant outfall that will be located at the end of the jetty. There will be two kinds of salt in the discharge one of which is highly soluble and the other less soluble. The discharge must comply with Mozambique water quality standards. The brine discharge rate is expected to be 62 to 93 m^3/hr once the onshore facilities are in operation and will be superheated. There will be other discharges of treated/produced water during operation of the Area 1 and Area 4 projects.

Future expansion of production could also lead to the construction of additional nearshore facilities to receive more LNG vessels and the addition of LNG trains in the onshore facilities. Elements of the potential future expansion are described in the EIA prepared for the Area 1 and Area 4 projects. Construction of additional nearshore facilities would result in effects to green and hawksbill sea turtles and ESA-listed corals similar to those discussed in other sections of this Opinion. Expansion of processing capacity would also result in additional volume of process water discharge and increases in potential water quality impacts.

The following conservation measures are part of the operational phase of the project and are included in the environmental management plans developed for the project:

<u>Stormwater Management:</u>

- Stormwater runoff from process areas should be treated through an oil/water separation system able to achieve the maximum oil and grease retention.

- All surface water runoff from areas other than the LNG processing area will be collected by a stormsewer system. This system will drain directly to a stormwater retention basin and will undergo subsequent treatment.
- LNG processing areas will have a perimeter barrier and the contained area will be sloped to move water to one or more internal collection sumps.
- Potentially contaminated stormwater from the LNG processing areas that exhibit evidence of an oil sheen will be directed to a stormwater retention basin. The basin will be lined with suitable materials to prevent groundwater impacts. Runoff collected in the stormwater retention basin from LNG processing and non-processing areas will be pumped at a low rate to an oil/water separator for treatment prior to discharge to the bay.

Brine and Wastewater Effluent:

- The project's process water (e.g., brine and treated sewage effluence) for operational discharges into Palma Bay will operate at optimum efficiency in line with the Water Resources and Wastewater Management Plan, through auditable maintenance schedules, and meet all water quality-related effluent parameters (see Table 3).
- Treated sewage will comply with all the applicable standards (see Table 3), regulations and/or approvals or authorizations.

Cooling Water:

- The effluent should result in a temperature increase of no more than 3^{o}C at the edge of the zone where initial mixing and dilution takes place in accordance with IFC guidelines for LNG facilities. Where the zone is not defined, 100 m (328 ft) from the point of discharge will be used.
- Free chlorine (total residual oxidant in estuarine/marine water) concentration in cooling/ cold water discharges (to be sampled at point of discharge) should be maintained at 0.2 parts per million (ppm).

While some of these conservation measures will reduce potential impacts to green and hawksbill sea turtles and ESA-listed corals, others, such as those related to water quality standards and temperatures of discharges, are likely not sufficiently protective of corals. Given rising SST and the low tolerance of corals to prolonged exposure to higher temperatures, the allowance of a 3^{o}C increase could result in more periods of water temperatures that exceed the thermal tolerance of corals. Similarly, many of the allowed water quality criteria exceed toxicity levels found to result in acute and/or chronic effects to marine organisms so continued discharge of treated waters from developed areas along the coast are likely to result in degradation of nearshore habitats. Coupled with the effects of continued fishing pressure, increasing tourism/recreational use, and continued climate change and the potential for increases in storms and COT outbreaks with increasing SST, the status of ESA-listed corals and habitat used by the corals and green and hawksbill sea turtles could suffer measurable declines in the action area due to future non-federal (U.S.) activities.

9 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the proposed action. In this section, we consider the Effects of the Action (Section 7), the Environmental Baseline (Section 6), and the Cumulative Effects (Section 8) to formulate the agency's biological opinion as to whether the proposed action is likely to: reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the Status of the Species Likely to be Adversely Affected (Section 5.2).

Some ESA-listed species are located within the action area but are not expected to be affected by the action or the effects of the action on these ESA resources were determined to be insignificant or discountable (Section 5.1). Because the proposed action will not adversely affect these species, there will be no loss of any individuals of these species. Therefore, there can be no adverse population viability consequence and thus no jeopardy. Some activities evaluated individually were determined to have insignificant or discountable effects and thus to be not likely to adversely affect some ESA-listed species (7.1).

The following discussions separately summarize the probable risks to survival and recovery the proposed action poses to green (Southwest Indian DPS) and hawksbill sea turtles, and ESA-listed Indo-Pacific corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*). These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the stressors considered further in this opinion; specifically vessel operation and use of the dredgers, water intakes, vessel lighting, declines in water quality, and habitat loss.

9.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the proposed action. The following discussions summarize the probable risks that vessel operation and the use of TSHD, water intakes, vessel lighting, declines in water quality, and habitat loss pose to threatened and endangered species that are likely to be exposed over the lifetime of this consultation. These summaries integrate our exposure, response, and risk analyses from Section 7.2.

9.1.1 Green (Southwest Indian DPS) Sea Turtle

We anticipate that up to 50 adult female green and five juvenile, sub-adult, and adult green sea turtles (Southwest Indian DPS) will experience lethal and sub-lethal effects associated with vessel strikes, particularly in the Palma Bay area, entrainment in TSHD, and having to expand their ranges due to the loss of refuge and foraging habitat associated with pipeline construction. We also anticipate that up to 9,413 green hatchling sea turtles will be disoriented by vessel lighting, making them more vulnerable to predation and lethal and sub-lethal effects from entrainment/entrapment in seawater intakes of vessels. We further anticipate that juvenile green sea turtles will experience lethal and sub-lethal effects of entrainment/entrapment in seawater intakes for water treatment plants, potentially the same up to five animals affected by other stressors. The severity of an individual animal's response to stressors from vessel operation, dredging, lighting, and water intakes will depend on the location of the stressor and life stage of the animal, which may depend on time of year.

No reduction in the distribution or current geographic range of green sea turtles from the Southwest Indian DPS is expected.

Whether the potential reduction in numbers due to lethal and sub-lethal effects, or due to impacts to reproductive output would appreciably reduce the likelihood of survival of green sea turtles from the Southwest Indian DPS depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

Abundance estimates are not available for the Southwest Indian DPS. There are thirty-seven nesting sites for the Southwest Indian DPS, with an estimated nester abundance of 91,059 (Seminoff et al. 2015). Trend data is lacking for a number of nesting sites in the Southwest Indian DPS, and it is not possible to determine the population growth rate for the DPS. At several protected nesting sites with long-term data available, nesting is stable or shows signs of increase.

We believe the action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of green sea turtles from the Southwest Indian DPS in the wild. The potential mortality of various life stages of green sea turtles may occur because of the action and would result in a reduction in absolute population numbers, but the population of green sea turtles in the DPS would not be appreciably affected. Likewise, the reduction in reproduction that could occur because of mortality of individuals or decreased growth rates of earlier life stages would not appreciably affect reproductive output in the Southwest Indian Ocean. For a population to remain stable sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives and at least one offspring must survive to reproduce itself. If the hatchling survival rate to maturity were greater than the mortality rate of the population, the loss of breeding individuals would be exceeded through recruitment of new breeding individuals from successful reproduction of sea turtles that are not removed from the potential pool of reproductive individuals because of the action. Abundance trend information for green sea turtles in the Southwest Atlantic DPS is not available, but some nesting data indicate increases or at least stable nesting. Therefore, we believe the anticipated lethal and sub-lethal effects attributed to the action will not have any measurable effect on the trend for this DPS.

The Recovery Plan for U.S. Pacific Populations of the Green Turtle (USFWS and NMFS 1998) lists the following recovery goals that are relevant to the impacts of the proposed action:

- Existing foraging areas are maintained as healthy environments.
- A management plan to maintain sustained populations of turtles is in place.
- International agreements are in place to protect shared stocks.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of eastern Africa. Sea turtle monitoring in the action area indicate that nesting by this species on Vamizi Island remains stable, while information from the project (RINA 2019) noted that nesting is also occurring on Rongui and Tecomaji Islands. The species is also the most frequently reported in waters of the action area and stranding data indicate that juveniles and adults are present in the action area (Costa et al. 2007).

The potential lethal and sub-lethal effects to green hatchlings, juveniles, sub-adults, and adults each year of stressors from activities such as pipeline construction and water intakes is not likely to reduce population numbers over time given likely population sizes based on observations in the action area and in other portions of the species’ range along the eastern coast of Africa, and expected recruitment. Thus, the action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of green sea turtles’ recovery in the wild. We conclude that the proposed action is not likely to jeopardize the continued existence of green sea turtles in the Southwest Indian DPS.

9.1.2 Hawksbill Sea Turtle

We anticipate that one adult female hawksbill sea turtle and four juvenile, sub-adult, and adult hawksbill sea turtles will experience lethal and sub-lethal effects associated with vessel strikes, particularly in the Palma Bay area, entrainment in TSHD, and having to expand their ranges due to the loss of refuge and foraging habitat associated with pipeline construction. We also anticipate that up to 189 hatchling sea turtles will be disoriented by vessel lighting, making them more vulnerable to predation and lethal and sub-lethal effects from entrainment/entrapment in seawater intakes of vessels. We further anticipate that juvenile hawksbill sea turtles will experience lethal and sub-lethal effects of entrainment/entrapment in seawater intakes for water treatment plants, likely the same up to four animals affected by other stressors. The severity of an individual animal’s response to stressors from vessel operation, dredging, lighting, and water intakes will depend on the location of the stressor and life stage of the animal, which may depend on time of year.

No reductions in the distribution or current geographic range of hawksbill sea turtles is expected.

Whether the potential reduction in numbers due to lethal effects or due to impacts to reproductive output would appreciably reduce the likelihood of survival of hawksbill sea turtles depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. There are currently no reliable estimates of population abundance and trends for non-nesting hawksbills. Therefore, nesting beach data are currently the primary information source for evaluating trends in abundance. Surveys at 88 nesting sites worldwide indicate that 22,004 – 29,035 females nest annually (NMFS and USFWS 2013). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce the survival of hawksbill sea turtles in the wild.

The Recovery Plan for the population of hawksbill sea turtle (NMFS and USFWS 1993) does not have any recovery objectives that are relevant to this consultation because the recovery criteria target the U.S. populations of hawksbill sea turtles, particularly those in Puerto Rico, U.S. Virgin Islands, and Florida.

The potential lethal and sub-lethal effects to hawksbill hatchlings, juveniles, sub-adults, and adult sea turtles annually associated with stressors from activities such as pipeline construction and water intakes is not likely to reduce population numbers over time given current population sizes and expected recruitment. Similarly, while we cannot estimate the exact numbers of take of adult, sub-adult, juvenile, and hatchling hawksbill sea turtles that may occur because of the proposed action and its consequences, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. Thus, the action is not likely to impede the recovery of hawksbill sea turtles and will not result in an appreciable reduction in the likelihood of hawksbill sea turtles' recovery in the wild. We conclude that the proposed action is not likely to jeopardize the continued existence of hawksbill sea turtles.

9.1.3 ESA-Listed Indo-Pacific Corals

Approximately 11.2 ha (27.68 ac) of reef habitat and an additional 15.1 ha (37.3 ac) of mixed seagrass and coral habitat will be affected by pipeline construction, including dredging, vessel anchoring, and sediment resuspension and transport. The reef habitats are dominated by acroporid corals, likely ESA-listed corals, large numbers of which will be lost due to the use of CSD to create the pipeline corridor in the reef. Future recruits of ESA-listed corals will be lost due to larval impingement in seawater intakes and the loss of recruitment and settlement habitat. Some of the ESA-listed coral colonies within the dredging footprint may be transplanted out of the impact area, 10 percent of which would be expected to suffer mortality due to transplant. The rest of the transplanted colonies would not be expected to reproduce at least for the first year following transplant.

We use the reef area as a surrogate to estimate that 3.92 ha (9.69 ac) of ESA-listed coral colonies will be adversely affected during the pipeline construction. The extent of land or marine area that may be affected by an action may be used as a surrogate if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953). In the case of ESA-listed corals, as has been discussed in this Opinion, there are no quantitative data indicting the number of colonies of each species that may be within the temporary and permanent construction footprint of the dredgers or estimates of the density of each species for the action area. Therefore, specifying the extent of effects in numbers of ESA-listed coral colonies is not practicable and we instead use habitat area as a surrogate. Additional coral colonies within the 15.1 ha (37.3 ac) of mixed seagrass and coral habitat in Palma Bay will experience chronic effects of water quality declines caused by outfalls resulting in full and partial tissue loss due to bleaching and declines in growth and skeletal formation, as well as declines in reproduction. There will also be a loss of future recruits due to the impingement of coral larvae in seawater intakes.

We estimate that 3.92 ha of ESA-listed corals will be lost as a result of CSD operations over 24 months in the action area; additional coral colonies will suffer full or partial tissue mortality in Palma Bay due to chronic effects of water outfalls; and future recruits will be lost due to impingement in seawater intakes.

We do not have precise population estimates for these species. The listing rule (79 FR 53852, September 10, 2014) notes that there are likely millions of colonies through the range of each species. For *Acropora speciosa*, the world population is estimated as 10,942,000 and the effective population is estimated as 1,204,000 (Richards et al. 2008c; Veron 2014). The overall abundance of *Acropora pharaonis* is characterized as common in the Red Sea, uncommon elsewhere. The species is distributed in portions of the western/northern Indian Ocean, including the Red Sea, and areas in the Pacific Ocean in depths from five to 25 m (16.4 to 82 ft). Overall abundance of *Acropora retusa* is common in South Africa, rare elsewhere. The species is distributed from the Indian Ocean, including the Red Sea, to the central Pacific in water depths from one to 5 m (3.3 to 16.4 ft). *Acropora speciosa* is considered common. The species is distributed from Indonesia to French Polynesia in water depths from 12 to 30 m (39.4 to 98.4 ft; Carpenter et al. 2008) and 15 to 40 m (49.2 to 131.2 ft; Richards 2009). Overall abundance of *Isopora crateriformis* is described as occasionally common on reef flats. The species is distributed from Sumatra (Indonesia) to American Samoa in water depths from low tide to at least 12 m (39.4 ft), and there are reports of the species from the western and central Indian Ocean. *Seriatopora aculeata* has an overall abundance described as uncommon. The species is distributed from Australia, Fiji, Indonesia, Japan, Papua New Guinea, and Madagascar to the Marshall Islands in water depths from three to 40 m (9.8 to 131.2 ft). *Montipora australiensis* has an overall abundance described as usually rare. The species' distribution includes eastern

Africa, the central Indo-Pacific, and the entire central Pacific in water depths from two to 30 m (6.6 to 98.4 ft).

No reductions in the distribution or geographic range of any ESA-listed Indo-Pacific coral species is expected to occur because of the proposed action.

We find that the anticipated lethal and non-lethal effects to ESA-listed Indo-Pacific coral species associated with the action will result in a reduction in numbers of these species. ESA-listed species are likely to be affected by vessel operation in the nearshore portion of the action area, entrainment in the TSHD, entrainment/entrapment in seawater intakes, and habitat loss and damage from pipeline construction. ESA-listed coral colonies, approximately 3.92 ac, will be lost due to CSD dredging through a portion of reef. Some colonies will be transplanted out of the pipeline construction footprint prior to construction. Transplanted corals are likely to suffer partial tissue mortality and bleaching and 10 percent of them are likely to die because of the stress of transplantation. The coral colonies affected by the action are expected to be a fraction of those present in the action area.

The reduction in numbers of ESA-listed Indo-Pacific corals in the action area is expected to result in a loss of reproductive potential over the lifetime of the consultation. Despite the potential loss of reproductive potential, the action area represents a very small portion of the range of all six species in the action area and, based on information from coral surveys in the action area, some of the species, particularly acroporids and potentially *Montipora* and *Seriatopora* spp. may be common in portions of the action area. Despite the reduction in reproductive potential, we do not believe there will be long-term damage to the ability of any of the species to sexually reproduce because of the action. Therefore, although we believe the project will lead to a loss of reproductive potential related to mortality of colonies that are sexually mature and the temporary loss of reproductive potential due to stressors such as transplantation, as well as the loss of future recruits due to impingement in seawater intakes and loss of habitat for settlement and recruitment, we do not anticipate that this would represent a detectable reduction in the long-term reproduction of ESA-listed Indo-Pacific corals in the action area. We believe the lethal and non-lethal effects to these colonies in the action area over the period covered by this consultation will not have any measurable effect on the overall populations of the species and will not appreciably reduce the species' likelihood of survival in the wild.

A recovery plan is not available for these coral species but NMFS has developed a recovery outline for these species (available at https://www.fisheries.noaa.gov/resource/document/15-indo-pacific-coral-species-recovery-outline). The outline serves as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved. The Summary Assessment in the recovery outline concludes that population trends for the listed Indo-Pacific corals are unknown. Therefore, recovery will depend on protection of coral reef habitat in areas where these species occur, reducing mortality of extant populations, and increasing resilience to global threats. The key challenges will be moderating the impacts of ocean warming associated with climate change and decreasing susceptibility to disease, which may be achieved through reduction of local stressors. Additional key challenges include species identification issues, which inhibit the ability to find and collect reliable species-specific data to inform recovery actions, and the widespread and international nature of the vast majority of the species' ranges. The recovery of the species will require an ecosystem approach including habitat protection measures, a reduction in threats caused by human activity, additional research, and time. The recovery vision for these species concludes that they should be present across their historic range and may expand their ranges into new locations with more favorable habitat conditions in the future.

To determine if the proposed action will appreciably reduce the likelihood of recovery for ESA-listed Indo-Pacific corals, we assess the effects of the proposed action in the context of our knowledge of the status of these species, their environmental baselines, the extinction risk analyses in the listing rule, and the information in the recovery outline. The final listing rule identified the species' abundance, life history characteristics, depth distributions, and threat vulnerabilities as characteristics that increase extinction risk. The low abundance of most of these species, combined with their geographic locations largely in shallow waters, exacerbate their vulnerability to extinction. The action will not affect the species' life history characteristics or increase the magnitude of the species' vulnerability to climate change threats such as ocean warming. The action will cause a small decrease in reproductive potential of each species and will affect habitat for the species through pipeline construction. The area affected is a small portion of the species' range and the number of colonies that may be affected by the action is likely a small portion of the ESA-listed Indo-Pacific coral colonies present in the action area based on the limited survey data available for corals in the action area. Therefore, we believe that the impacts to ESA-listed Indo-Pacific corals resulting from the action will not increase the magnitude of the threats that led to the listing of the species as threatened to levels that will appreciably reduce these species' likelihood of recovery in the wild. We conclude the proposed action is not likely to jeopardize the continued existence of *Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, and *Montipora australiensis* corals in the wild.

10 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action and cumulative effects, it is NMFS' biological opinion that the proposed action and its associated consequences is not likely to jeopardize the continued existence of green (Southwest Indian DPS) and hawksbill sea turtles, and ESA-listed Indo-Pacific corals (*Acropora pharaonis*, *Acropora retusa*, *Acropora speciosa*, *Isopora crateriformis*, *Seriatopora aculeata*, *Montipora australiensis*).

It is also NMFS biological opinion that the action is not likely to adversely affect the following ESA-listed species: blue, fin, Southern right, sei, and sperm whales; leatherback, loggerhead (Southwest Indian Ocean DPS), and olive ridley (non-Mexico Pacific breeding populations) sea turtles; African coelacanth (Tanzanian DPS); green and largetooth sawfish; oceanic whitetip and scalloped hammerhead (Indo-West Pacific DPS) sharks; and giant manta ray.

11 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

11.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

We anticipate the action associated with the financing of eligible U.S. goods and services to be used in the development, financing, construction, and start-up operations of the project on the high seas, namely the infrastructure necessary to produce the offshore gas reserves, and construction of the pipeline to transport gas from the gas field to the terrestrial LNG facilities, which is a consequence of the proposed action, will result in adverse effects to ESA-listed Indo-Pacific corals, green sea turtles (Southwest Indian DPS), and hawksbill sea turtles. The extent of these effects is described in Section 7.2.

In the case of this consultation, lethal and non-lethal effects to ESA-listed species in the territorial waters of Mozambique are not considered prohibited take because ESA prohibitions on take only apply to take occurring on the high seas. In our effects analysis (Section 7), NMFS determined that there would be no take of ESA-listed species on the high seas because of the project and thus no amount or extent of take is specified and no RPMs are necessary or appropriate for these species. NMFS has no authority to specify RPMs and associated terms and conditions in the territorial waters of Mozambique; therefore, none are included in the ITS, nor does the ITS specify the amount or extent of lethal and non-lethal effects to species in territorial waters. Acknowledging that the ITS provides a mechanism for assuring reinitiation of consultation, NMFS will receive monitoring reports on the effects to ESA-listed species in the territorial waters of Mozambique from EXIM (see Section 3.2.4), including effects that cause injury or mortality, and reinitiation of consultation would be triggered if new information reveals effects of the action that may affect listed species in a manner or to an extent not previously considered (Section 13).

12 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore may be considered by EXIM in relation to their section 7(a)(1) responsibilities:

1. We recommend that the Marine Mammal Protection Plan developed by the applicant be renamed the Marine Species Protection Plan and be expanded to encompass all marine mammals, particularly ESA-listed whales, sea turtles, and large, ESA-listed, fish. The plan should include observer requirements, particularly the ability to identify animals to species, changes to the templates to include space for reporting animals other than whales, as well as recording sea conditions and other details. EXIM should identify reporting to ensure NMFS receives copies of sighting reports and reports of any collisions, injuries, or stranded animals at least annually during the consultation timeframe.

2. We recommend that an environmental monitoring plan be developed and implemented prior to the commencement of in-water construction activities associated with pipeline construction. The plan should include pre- and post-construction determinations of the condition of benthic habitat utilized by ESA-listed corals and sea turtles, including coral habitats and seagrass beds, and colonies of ESA-listed corals (that will not be transplanted) within the established footprints of temporary and permanent impacts associated with construction of the pipeline. Pre-construction monitoring, including monitoring of sedimentation rates, shall begin at least two months prior to any in-water construction activities. Sedimentation rates should be measured to the nearest mm using fixed sediment samplers placed in the project footprint and in control stations where

turbidity plumes from dredging are not expected to travel. Permanent transects of quadrats should be established to determine whether benthic habitats within the temporary construction footprint and the permanent footprint in seagrass habitats recover naturally following pipeline installation and backfill. ESA-listed corals within the transects or quadrats in the temporary construction footprint that will not be transplanted will be identified and their GPS location logged. These corals will be photographed using methods to ensure that photos taken during each monitoring event are at the same location and distance from the coral to ensure any use of photos to measure colony size is accurate. Coral condition (including percent mortality, percent recent mortality, and recruitment tiles/plates as part of monitoring quadrat deployment) will be recorded. EXIM should identify reporting to ensure NMFS receives a copy of the plan and completed monitoring reports.

3. We recommend that coral and seagrass translocation plans be developed for areas within the permanent pipeline corridor to offset dredging effects to the reef and any lack of natural recovery of seagrass. Coral and seagrass translocation plans should include detailed procedures and measures for coral colony and seagrass removal and transplant, as well as monitoring requirements. Monitoring of transplants should cover a minimum of two years post-transplant. Relocation procedures should be based on industry standard protocols. The final number of ESA-listed coral colonies (or colonies thought to be ESA-listed species) and acreage of seagrass to be transplanted should be determined based on pre-construction surveys. The recipient site or sites for translocated corals and seagrass will be included in the plans and should be selected to ensure the same oceanographic and depth conditions as the areas from which corals and seagrass will be removed. All ESA-listed coral colonies (or colonies thought to be ESA-listed species) with a diameter of 4 cm or greater should be transplanted outside of the direct impact footprint of the pipeline prior to commencement of in-water construction activities. A subset of transplanted corals and seagrass at each recipient site should be monitored to determine transplant success such that a minimum of 50 percent of transplants at each recipient site are monitored. Seagrass along portions of the pipeline that will be buried and backfilled may also be stockpiled as sod blocks or plugs or rolled mats (depending on the species for replanting once pipeline burial is complete). EXIM should identify reporting to ensure NMFS receives a copy of the plan and completed monitoring reports.

4. We recommend that coral farms be designed and implemented in coordination with a local conservation group in the action area prior to commencement of in-water construction in coral habitats. The farms should be used to collect and grow fragments of coral colonies within the footprint of the CSD. Fragments can later be outplanted from the farms into areas within the reef following regrading and restoration of rugosity using suitable, clean, limestone substrate cemented into the affected reef. A maintenance and monitoring plan should be developed and implemented for coral farms and monitoring of

outplant success. EXIM should identify reporting to ensure NMFS receives a copy of the plan and completed monitoring reports.

5. We recommend the monitoring of in-water structures and equipment during in-water construction activities. If accumulation of marine debris associated with vessel operation and construction activities is observed, then strategies for debris control and appropriate disposal should be developed and implemented. This monitoring should also look for any sea turtle hatchlings that may become entrapped or entrained in debris. Live hatchlings that are found in debris should be freed from the debris, transported via boat to an offshore area without obstructions, and carefully released into the water in coordination with the appropriate government agency or stranding coordinator for the area. EXIM should identify reporting to ensure NMFS receives information regarding any strandings of sea turtle hatchlings in debris.

6. We recommend that light-emitting diode (LEDs) or other bulbs in sea turtle safe bandwidth (greater than 560 nanometers) be used on any in-water structures requiring lights and on vessels, particularly when anchored near Rongui and Tecomaji Islands during peak nesting season.

7. We recommend mitigation measures for entrainment and impingement of ESA-listed species due to seawater intakes associated with construction, including intakes on vessels and for terrestrial facilities, be specified. We also recommend that a plan for monitoring coral larvae during mass spawning of ESA-listed corals and associated entrainment and impingement be developed and implemented each year of construction when seawater intakes are operating. EXIM should identify reporting to ensure NMFS receives a copy of the plan and completed monitoring reports.

8. NMFS recommends that a water quality monitoring plan be developed to assess natural concentrations of constituents that may be released in outfalls associated with the proposed action and its consequences such as wastewater discharges used during construction. The plan should include pre- and post- monitoring for these constituents and monitoring of seagrass and coral communities in the area of the outfalls to determine whether there are acute or chronic impacts to these communities from the discharges. EXIM should identify reporting to ensure NMFS receives a copy of the plan and completed monitoring reports.

9. NMFS recommends that a partnership be developed with existing sea turtle nesting, tagging, and in-water monitoring programs in the action area to expand sea turtle monitoring efforts in order to quantify habitat use by sea turtles in the action area, including nesting and in-water habitats. NMFS requests that a copy of the results of any monitoring be provided to us.

10. NMFS recommends that anchorage areas be reconfigured to avoid the anchoring of vessels in any areas containing coral habitats and encourage anchoring in uncolonized sand bottom. If anchoring in areas containing coral habitats cannot be avoided, mooring buoys for large vessels with a design that minimizes the potential for chain scouring and other impacts to coral habitat should be installed in these areas.

In order for NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, EXIM should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement.

13 Reinitiation Notice

This concludes formal consultation for EXIM for the provision of funding of eligible goods and services to be used in the Mozambique LNG project. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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15 APPENDICES

15.1 Appendix A – Marine Mammal Observer Forms from MMOP

MARINE MAMMAL RECORDING FORM - COVER PAGE

Report Number (One for each sighting) ____/2019	**Country**	**Ship/ platform name**
Client	**Contractor**	**Survey type** ☐ site ☐ 2D ☐ 3D ☐ 4D ☐ OBC ☐ 4C ☐ VSP ☐ WAZ ☐ other
Start date	**End date**	

Number of source vessels	**Type of source** (e.g. airguns)	**Number of airguns** (only if airguns used)	**Source volume** (cu. in.)
Source depth (metres)	**Frequency** (Hz)	**Intensity** (dB re. 1μPa or bar metres)	**Shot point interval** (seconds)
Method of soft start ☐ increase number of guns ☐ increase pressure (where permitted) ☐ increase frequency (where permitted) ☐ other			

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	**Magnification of optical equipment** (e.g. binoculars)	**Height of eye** (metres)	**How was distance of animals estimated?** ☐ by eye ☐ with laser rangefinder ☐ with rangefinder stick/ calipers ☐ with reticle binoculars ☐ by relating to object at known distance ☐ other
Number of dedicated MMOs	**Training of MMOs** ☐ JNCC approved MMO induction course for UK waters ☐ PSO training course for the Gulf of Mexico ☐ MMO training course for Irish waters ☐ other ☐ none		

Was PAM used? ☐ yes ☐ no	**Number of PAM operators**	
Description of PAM equipment		
Range of PAM hydrophones from airguns (metres)	**Bearing of PAM hydrophones from airguns** (relative to direction of travel)	**Depth of PAM hydrophones** (metres)

MARINE MAMMAL RECORDING FORM - EFFORT

Report number ___ / 2019 | **Ship/ platform name** ....

Please record the following for all watches, even if no marine mammals are seen.

									Start a new line on form if any one of these changes							
Date	**Visual watch or PAM** v = visual watch p = PAM	**Observer's/ operator's name(s)**	**Time of start of watch** (UTC, 24hr clock)	**Time of end of watch** (UTC, 24hr clock)	**Start position** (latitude and longitude)	**Depth at start** (m)	**End position** (latitude and longitude)	**Depth at end** (m)	**Speed of vessel** (knots)	**Source activity** f = full power s = soft start r = reduced power (not soft start) n = not active	**Wind direction**	**Wind force** (Beaufort scale)	**Sea state** g = glassy (like mirror) s = slight (no or few white caps) c = choppy (many white caps) r = rough (big waves, foam, spray) or Beaufort sea states (0 - 7+)	**Swell** o = low (< 2 m) m = medium (2-4 m) l = large (> 4 m)	**Visibility** (visual watch only) p = poor (< 1 km) m = moderate (1-5 km) g = good (> 5 km)	**Sunglare** (visual watch only) n = no glare w = weak glare s = strong glare v = variable

MARINE MAMMAL RECORDING FORM - SIGHTINGS

Report Number (One for each sighting) ____/2020	**8.1.1 Ship/ platform name**	**8.1.2 Sighting number (start at 1 for first sighting of survey)**	**8.1.3 Acoustic detection number (start at 500 for first detection of survey)**
8.1.4 Date	**8.1.5 Activity Occurring at the moment**	**Time at start of encounter** (UTC, 24hr clock)	**Time at end of encounter** (UTC, 24hr clock)

Were animals detected visually and/ or acoustically?

- ☐ visual
- ☐ acoustic
- ☐ both

How were the animals first detected?

- ☐ visually detected by observer keeping a continuous watch
- ☐ visually spotted incidentally by observer or someone else
- ☐ acoustically detected by PAM
- ☐ both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	**Position** (latitude and longitude)	**8.1.6 Water depth (metres)**

8.1.7 Species/ species group		**Description** (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow)
8.1.8 Bearing to animal (when first seen or heard)	**Range to animal** (when first seen or heard) (metres)	

8.1.9 Total number	**Number of adults** (visual sightings only)	**Number of calves** (visual sightings only)

Behaviour (visual sightings only)

Direction of travel (relative to ship)

- ☐ towards ship
- ☐ away from ship
- ☐ parallel to ship in same direction as ship
- ☐ travelling in opposite direction to ship
- ☐ crossing ahead of ship
- ☐ variable
- ☐ milling
- ☐ other

Direction of travel (compass points)

- ☐ N
- ☐ NE
- ☐ E
- ☐ SE
- ☐ S
- ☐ SW
- ☐ W
- ☐ NW
- ☐ variable