The Ocean Cleanup

Environmental Impact Assessment

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Background

The Ocean Cleanup has developed a prototype passive drifting system (The Ocean Cleanup System or OCS) to collect buoyant plastic debris from the Great Pacific Garbage Patch. There are multiple areas where the debris accumulates, and The Ocean Cleanup is focusing on the area known as the Eastern Pacific Garbage Patch (EPGP) which is located roughly midway between California and Hawaii within the North Pacific Subtropical Gyre.

The Ocean Cleanup is planning a year-long deployment in the EPGP in a location approximately 1,880 km (1,015 nmi) from San Francisco. Assembly of the OCS has begun on Alemeda Island in the San Francisco Bay and The Ocean Cleanup estimates that it will be completed in mid-2018. Prior to deployment, The Ocean Cleanup will conduct a Tow Test outside of the shipping channel and protected areas offshore San Francisco and a trial deployment at a currently undetermined location outside of the United States Exclusive Economic Zone (U.S. EEZ) (>370 km [200 nmi] from the California coast) that will last approximately two weeks. After the Tow Test and trial deployment, the OCS will be towed to the EPGP and it is estimated that this will require 22 days of towing to reach the designated location.

Purpose and Need

The Ocean Cleanup voluntarily chose to conduct an Environmental Impact Assessment (EIA) to properly assess potential impacts and ensure that mitigation measures could be implemented to reduce or eliminate any substantial identified impacts. The Tow Test will utilize a U.S. flagged vessel, while the vessel used for the Pacific Trial and deployment to the EPGP will not be U.S. flagged and will not be completed by U.S. citizens. All of the proposed activities (except the Tow Test) will occur in international waters outside of the U.S. EEZ. Because no permits are required, the proposed activities do not fall under regulatory oversight of the United States National Environmental Policy Act and no environmental impact assessment (EIA) is required. In the absence of regulatory requirements, this EIA was created to meet the 1999 International Association for Impact Assessment Principles of Environmental Impact Assessment Best Practices (IAIA, 1999).

EIA Summary

The various components of the activities being proposed by The Ocean Cleanup (including towing operations from San Francisco Bay and a year-long deployment in the EPGP) have been evaluated for potential impacts to the biological, physical, chemical and social environment. A total of 16 resource areas were considered, including:

- Air Quality
- Water Quality
- Sediment Quality
- Plankton
- Fish and Fishery Resources
- Benthic Communities
- Marine Mammals
- Sea Turtles
- Coastal and Oceanic Birds
- Protected Areas
- Biodiversity
- Archaeological Resources
- Commercial and Military Vessels
- Human Resources, Land Use, and Economics
- Recreational Resources and Tourism
- Physical ocean factors

A preliminary screening was conducted to identify the resources at risk from the towing and deployment of the OCS in the EPGP. In this preliminary analysis, the level of impact associated with each interaction was categorized as "potential impact for analysis" (e.g., a measurable impact to a resource is predicted) or "no impact expected" (i.e., no measurable impact to a resource is predicted). Several resources were identified as having no expected impacts from the proposed activities and were removed from further analysis. Resource areas that were screened out included air quality; sediment quality; water quality; benthic communities; biodiversity; human resources, land use and economics; recreational resources and tourism; and physical oceanography. The remaining resource areas were characterized based on review and summarization of pertinent data sources, including peer-reviewed literature, government publications, and applicable datasets. The impact assessment methodology was conducted from a risk-based perspective to determine the overall significance of each potential impact based on its consequence and likelihood (**Table ES-1**).

Table ES-1. Matrix combining impact consequence and likelihood to determine overall impact significance.

Likelihood vs. Consequence		Decreasing Impact Consequence (←)				
		Beneficial	Negligible	Minor	Moderate	Severe
Decreasing Impact Likelihood (↓)	Likely	Beneficial (no numeric rating applied)	1 – Negligible	2 – Low	3 – Medium	4 – High
	Occasional		1 – Negligible	2 – Low	3 – Medium	4 – High
	Rare		1 – Negligible	1 – Negligible	2 – Low	4 – High
	Remote		1 – Negligible	1 – Negligible	2 – Low	3 – Medium

Impacts from routine operations resulting from the proposed activities are expected to occur based on a series of impact producing factors, including:

- Towing Operations
- OCS – Entanglement/Entrapment
- OCS – Attraction/Ingestion of Plastics
- Vessel – Physical Presence/Strikes
- Noise and Lights
- Loss of Debris

The Environmental Impact Assessment also addressed potential impacts associated with an accidental fuel spill. Resources potentially affected by each impact producing factor were subsequently evaluated. The impact assessment process involved: 1) an initial determination of impact, without any mitigation; 2) an identification and application of appropriate mitigation measures; and 3) a determination of impact after mitigation was applied (i.e., residual impact). Impacts resulting from routine operations associated with the proposed activities were rated, in terms of overall impact significance using an alphanumeric and color code, as follows:

Beneficial
1 – Negligible
2 – Low
3 – Medium
4 – High

Impacts rated Medium or High were considered primary candidates for mitigation, while those rated Negligible or Low were of secondary importance from a mitigation perspective. In application, mitigation measures were considered for all impacts, regardless of impact level. The initial analysis of routine operations (i.e., prior to application of mitigation measures) produced impact determinations that were predominately in the Negligible or Low categories. No High level impacts were noted. A comprehensive discussion of the mitigation measures and corporate/subcontractor policies that The Ocean Cleanup will follow during their proposed activities is presented under separate cover in an Environmental Management Plan.

Impacts from an accidental fuel spill were identified based on the accidental release of diesel fuel. Diesel fuel released into the marine environment undergoes rapid weathering, including evaporation and dissolution. Given the relatively small potential spill volume and weathering factors, the impacts to various resources from a fuel spill release were routinely rated Negligible or Low. Impacts from an accidental diesel fuel spill are expected to be localized and relatively short-term (due to its high volatility and dispersibility). A tabular summary of impacts from routine operations and an accidental fuel spill is presented in **Table ES-2**. When proper mitigation measures, maritime regulations, and industry best practices are applied, the significance of potential impacts of the proposed activities will generally be Negligible or Low. Moreover, the long-term positive impacts as a result of removing large amounts of floating plastic from the EPGP will likely provide a beneficial impact to biological resources in the region.

Table ES-2. Summary of impacts from routine operations and an accidental fuel spill from the proposed activities.

Resource Affected	Description of Potential Impact	Impact Determination Prior to Mitigation	Mitigation Measure(s)	Residual Impact
Long-Term Impacts				
Plastic Removal by the Ocean Cleanup System (OCS)				
All Resources	Reduction in entanglements, ingestion, and contamination of every biological and social resource by means of plastic removal from the North Pacific	**Beneficial**	Not applicable.	**Beneficial**
Routine Operations				
Towing Operations				
Protected Areas	• Disturbance of wildlife in marine protected areas from towing activities	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• The towing vessel traveling the project area will travel at slow speeds (<3 knots).	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible
Commercial and Military Vessels	• Temporary disruption of vessel traffic within San Francisco Bay	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Issue a Notice to Mariners with information on timing and nature of proposed activities that may affect waterway closures.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
OCS – Entanglement/Entrapment				
Plankton	• Entrapment in the OCS • Ingestion of plastic particles	Likelihood: Likely Consequence: Negligible Significance: 1 – Negligible	• None recommended.	Likelihood: Likely Consequence: Negligible Significance: 1 – Negligible
Marine Mammals	• Entanglement in the OCS or accumulated debris resulting in injury or death	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS. • Rescue attempts of entangled marine mammals in distress may be attempted according to the Environmental Management Plan.	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
Sea Turtles	• Entanglement or entrapment with the OCS or accumulated debris	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS. • Rescue attempts of entangled sea turtles in distress may be attempted according to the Environmental Management Plan.	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
OCS – Attraction/Ingestion of Plastics				
Fish and Fishery Resources	• Attraction to vessel(s) and lights	Likelihood: Occasional Consequence: Minor Significance: 2 – Low	• None recommended.	Likelihood: Occasional Consequence: Minor Significance: 2 – Low
Marine Mammals	• Attraction to the OCS • Ingestion of congregated plastics resulting in injury or death	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Potential use of Acoustic Deterrent Devices or Acoustic Harassment Devices during plastic extraction activities to deter marine mammals from entering the vicinity of the OCS. • Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS.	Likelihood: Rare Consequence: Moderate Significance: 2 – Low

Table ES-2. (Continued).

Resource Affected	Description of Potential Impact	Impact Determination Prior to Mitigation	Mitigation Measure(s)	Residual Impact
Sea Turtles	• Attraction to the OCS • Ingestion of plastics collected by the OCS	Likelihood: Occasional Consequence: Moderate Significance: 3 – Medium	• Potential use of flashing green lights during plastic extraction activities to deter sea turtles from entering the vicinity of the OCS. • Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS.	Likelihood: Occasional Consequence: Moderate Significance: 3 – Medium
Coastal and Oceanic Birds	• Attraction to the OCS and ingestion of plastics collected by the OCS	Likelihood: Occasional Consequence: Minor Significance: 2 – Low	• None recommended.	Likelihood: Occasional Consequence: Minor Significance: 2 – Low
Vessel – Physical Presence/Strikes				
Fish and Fishery Resources	• Attraction to vessel(s) and lights	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• None recommended.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
Marine Mammals	• Exposure to routine discharges from vessel; vessel strike	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Visual monitoring during the project will identify marine mammals that may be near vessels. • Debris retrieval vessels will maintain a watch for marine mammals and when travelling to and from the East Pacific Garbage Patch. • Support vessel(s) traveling between the project area and shore will travel at slow speeds (<14 knots).	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
Sea Turtles	• Injury or mortality resulting from a vessel collision with a sea turtle	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Visual monitoring during the project will identify sea turtles that may be near vessels • Support vessel(s) traveling between the project area and shore will travel at slow speeds (<14 knots).	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
Coastal and Oceanic Birds	• Injury or mortality resulting from a vessel collision with a bird due to attraction from lights	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• None recommended.	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
Protected Areas	• Disturbance of wildlife in marine protected areas from towing activities	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• Support vessel(s) traveling between the project area and shore will travel at slow speeds (<14 knots).	Likelihood: Rare Consequence: Minor Significance: 1 - Negligible
Commercial and Military Vessels	• Temporary disruption of vessel traffic within San Francisco Bay	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Issue a Notice to Mariners with information on timing and nature of proposed activities that may affect waterway closures.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
Noise and Lights				
Fish and Fishery Resources	• Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Elimination of unnecessary acoustic energy: The levels of anthropogenic noise will be kept as low as reasonably practicable.	Likelihood: Likely Consequence: Minor Significance: 2 – Low

Table ES-2. (Continued).

Resource Affected	Description of Potential Impact	Impact Determination Prior to Mitigation	Mitigation Measure(s)	Residual Impact
Marine Mammals	• Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Elimination of unnecessary acoustic energy: The levels of anthropogenic noise will be kept as low as reasonably practicable.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
Sea Turtles	• Behavioral modification changes (e.g., diving, evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Elimination of unnecessary acoustic energy: The levels of anthropogenic noise will be kept as low as reasonably practicable.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
Coastal and Oceanic Birds	• Behavioral modification changes (e.g., disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Likelihood: Likely Consequence: Minor Significance: 2 – Low	• Elimination of unnecessary acoustic energy: The levels of anthropogenic noise will be kept as low as reasonably practicable.	Likelihood: Likely Consequence: Minor Significance: 2 – Low
Loss of Debris				
Marine Mammals	• Entanglement with, or ingestion of, debris accidentally lost	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• Verify compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible
Sea Turtles	• Entanglement with, or ingestion of, debris accidentally lost	Likelihood: Rare Consequence: Moderate Significance: 2 – Low	• Verify compliance with MARPOL restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	Likelihood: Rare Consequence: Moderate Significance: 2 – Low
Coastal and Oceanic Birds	• Entanglement with, or ingestion of, debris accidentally lost	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• Verify compliance with MARPOL restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible

Table ES-2. (Continued).

Resource Affected	Description of Potential Impact	Impact Determination Prior to Mitigation	Mitigation Measure(s)	Residual Impact
Accidental Fuel Spill				
Plankton	• Exposure to diesel fuel	Likelihood: Rare Consequence: Negligible Significance: 1 – Negligible	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under MARPOL 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels. • **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	Likelihood: Rare Consequence: Negligible Significance: 1 – Negligible
Fish and Fishery Resources	• Hydrocarbon contamination from an accidental fuel spill	Likelihood: Rare Consequence: Negligible Significance: 1 – Negligible	• **Same as above** – SOPEP, chemical storage, spill equipment on board, fuel transfer protocols, and reporting procedures.	Likelihood: Rare Consequence: Negligible Significance: 1 – Negligible
Marine Mammals	• Diesel fuel exposure, including inhalation of vapors, ingestion, fouling of baleen	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• **Same as above** – SOPEP, chemical storage, spill equipment on board, fuel transfer protocols, and reporting procedures.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible
Sea Turtles	• Diesel fuel exposure, including inhalation of vapors, ingestion	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• **Same as above** – SOPEP, chemical storage, spill equipment on board, fuel transfer protocols, and reporting procedures.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible
Coastal and Oceanic Birds	• Diesel fuel exposure, including inhalation of vapors, ingestion	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• **Same as above** – SOPEP, chemical storage, spill equipment on board, fuel transfer protocols, and reporting procedures.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible
Protected Areas	• Diesel fuel exposure, including inhalation of vapors, ingestion	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible	• **Same as above** – SOPEP, chemical storage, spill equipment on board, fuel transfer protocols, and reporting procedures.	Likelihood: Rare Consequence: Minor Significance: 1 – Negligible

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ADD	Acoustic Deterrent Device
AHS	Acoustic Harassment Device
AIS	Automatic Identification System
BOEM	Bureau of Ocean Energy Management
CCS	California Current System
CSA	CSA Ocean Sciences Inc.
dB	decibels
DPS	distinct population segment
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
EIA	Environmental Impact Assessment
EPGP	Eastern Pacific Garbage Patch
ESA	Endangered Species Act
FAD	fish aggregating device
GPS	global positioning system
HDPE	High density polyethylene
IHA	incidental harassment authorization
IMO	International Maritime Organization
IPF	Impact producing factor
ITA	incidental take authorization
IUCN	International Union for Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSFCMA	Magnuson-Steven's Fishery Conservation and Management Act
MWA	Military Warning Area
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NPP	Net primary production
NPSG	North Pacific Subtropical Gyre
NTM	Notice to Mariners
OCS	The Ocean Cleanup System
ONMS	Office of National Marine Sanctuaries
PAM	Passive Acoustic Monitoring
U.S. EEZ	United States Exclusive Economic Zone
U.S.	United States
USCG	U.S. Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

1.0 Introduction

The Ocean Cleanup has developed a prototype passive drifting system (the Ocean Cleanup System or OCS) to collect buoyant plastic debris from the Great Pacific Garbage Patch. The Great Pacific Garbage Patch refers to areas in the Pacific Ocean that act as natural gathering points where rotating currents, winds, and other ocean features converge to accumulate marine debris. There are multiple areas where the debris accumulates, and The Ocean Cleanup is focusing on the area known as the Eastern Pacific Garbage Patch (EPGP) which is located roughly midway between California and Hawaii within the North Pacific Subtropical Gyre (NPSG) (**Figure 1-1**).

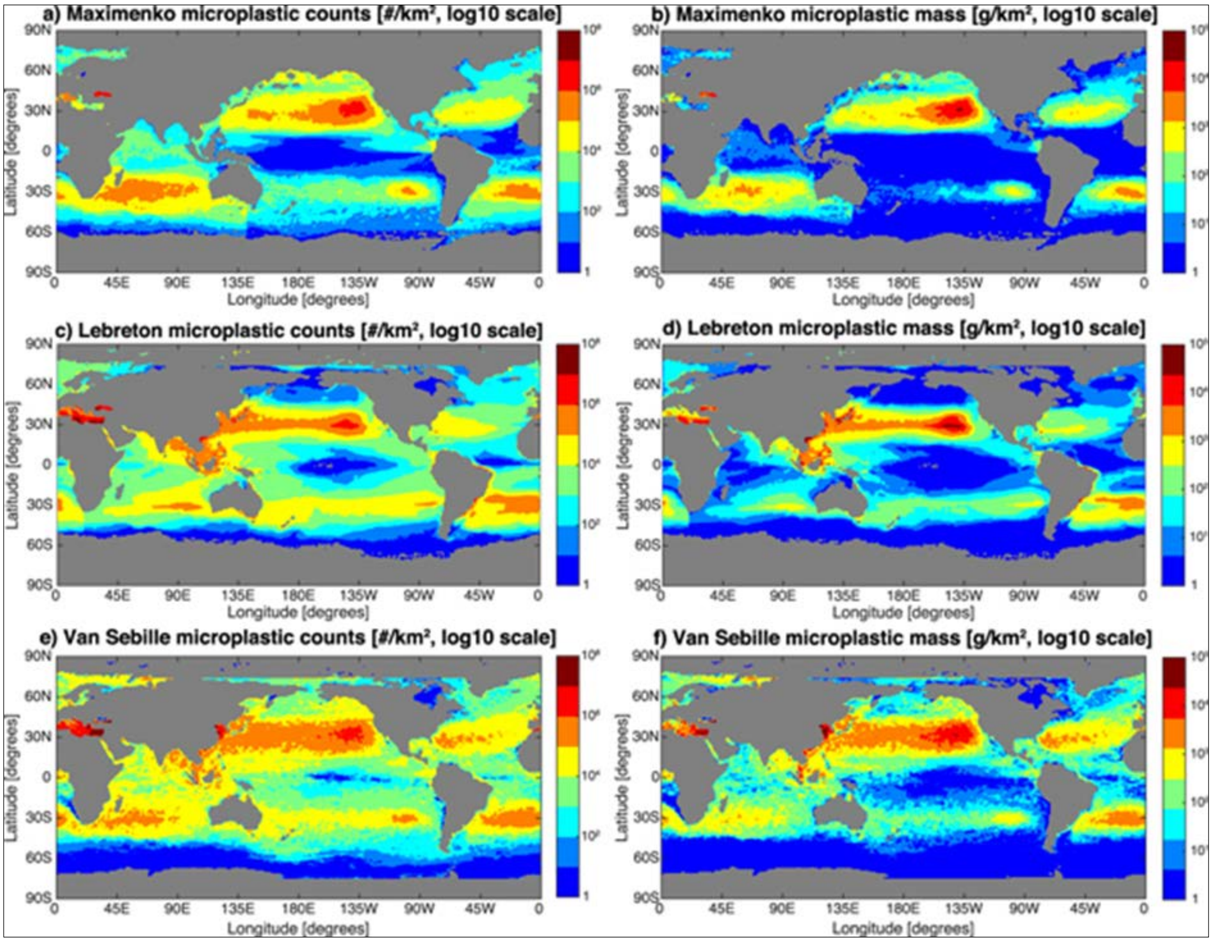

Figure 1-1. Results of computer modeling showing estimated density of microplastic contamination. Figure provided by The Ocean Cleanup.

The Ocean Cleanup is planning an approximately year-long deployment in the EPGP in a location approximately 1,880 km (1,015 nmi) from San Francisco. This Environmental Impact Assessment (EIA) presents the existing environmental conditions of the area that may be potentially impacted by the proposed project which includes a Tow Test, followed by towing operations from San Francisco Bay to the Pacific trial location outside the United States Exclusive Economic Zone (U.S. EEZ) and finally to a location within the EPGP. The EIA provides a description of the Tow Test, towing operations, and deployment of the OCS in the EPGP and an assessment of potential environmental impacts that may result from operations together with recommendations to manage, mitigate, and monitor those impacts. The EIA is organized as follows:

- The **Executive Summary** is a short, non-technical summary of the project that briefly describes the baseline environment, the risk assessment methodology, potentially significant impacts, and mitigation measures.
- **Chapter 1.0**, **Introduction**, presents the project, including objectives, location, and scheduling. This chapter discusses the purpose, scope, and organization of the EIA.
- **Chapter 2.0**, **Project Description**, provides a detailed narrative of the proposed activities, the waste and emissions that may be associated with such a project, and the purpose of the project. Planned activities that may affect the environment are described in sufficient detail to support impact assessment.
- **Chapter 3.0**, **Legislative and Regulatory Environment**, identifies and describes the national and international laws, regulations, guidelines, protocols and standards that were considered as potentially applicable to the proposed project. This chapter summarizes specific permitting requirements that were considered in relation to the proposed project.
- **Chapter 4.0**, **Description of the Existing Environment**, characterizes the conditions of the project area environment in terms of the physical, chemical, and biological components. This chapter presents key information needed to understand the environmental setting, identify valued ecosystem components, and assess impacts. This chapter also provides a preliminary screening of resources to eliminate resources with little or no potential for adverse or significant impact from the detailed analysis. The text is organized as follows:
    - Preliminary Screening of Activities and Affected Resources;
    - Data Sources;
    - Biological Environment; and
    - Social Environment.
- **Chapter 5.0**, **Potential Environmental Impacts**, identifies and assesses the potential environmental impacts from this proposed project, both beneficial and negative. The chapter includes the basis for impact designation, impacts from routine operations, and impacts from potential accidents or upsets. Cumulative impacts are also discussed.
- **Chapter 6.0, Conclusion,** summarizes the findings of the EIA.
- **Chapter 7.0**, **Literature Cited**, lists all published and unpublished data sources in this EIA.
- **Appendix**, presents technical data used in support of the EIA.

2.1 PROJECT OVERVIEW

Ocean Cleanup System Design and Operation

The Ocean Cleanup has designed the OCS a passive drifting system aimed at collecting floating plastics in the top 3 m (9.8 ft) of the ocean surface. Based on the current project design, the OCS is comprised of a high-density polyethylene (HDPE) pipe 600 m (1,969 ft) length and 1.2 m (4 ft) in diameter (**Table 2-1**). The assembled OCS will be concave shaped, which will be maintained with closing lines crossing the concave side of the OCS (**Figure 2-1**). An impermeable skirt, or screen will hang submerged below the pipe; the height of the screen will vary along the OCS between 0 m (0 ft) (approximately 72 m [236 ft] of the total length), 2 m (7 ft) screen (approximately 160 m [525 ft] of the total length), and 3 m (9.8 ft) screen (approximately 360 m of the total length). This screen will be weighted with ballast that is intended to keep it oriented straight under the pipe. A screen clamping bracket will be used to attach the screen to the pipe (**Figure 2-2**). A photograph of a section of the prototype impermeable screen is presented in **Figure 2-3**; a conceptual schematic of the OCS design is presented in **Appendix A**.

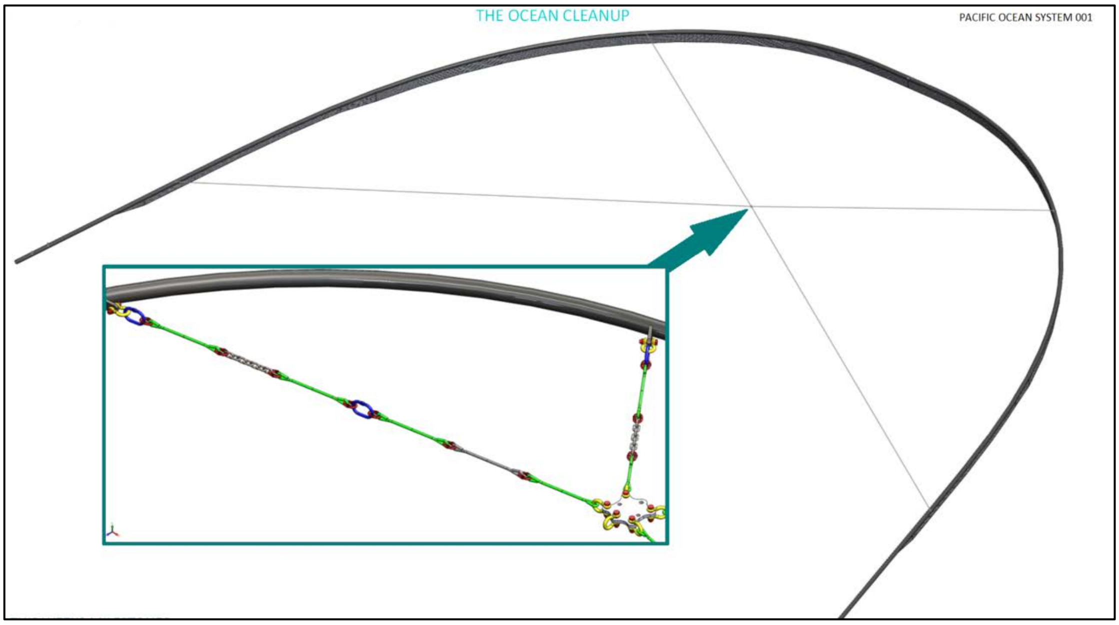

Figure 2-1. Isometric view of the Ocean Cleanup System showing the concave shape and the closing lines that will be used to obtain the U-shape.

Figure 2-2. Screen clamping bracket used to connect the screen to the Ocean Cleanup System.

Figure 2-3. Small section of the impermeable screen that is part of the Ocean Cleanup System.

Table 2-1. Summary of primary components, materials, and dimensions of the Ocean Cleanup System.

Ocean Cleanup System Component	Material	Estimated Dimensions
Pipe	HDPE	600 m (1,969 ft) in length; 1.2 m (4 ft) diameter; 0.076 m (0.25 ft) thick
Impermeable Screen	Woven polyester fibers	72 m (236 ft) = no screen; 168 m (551 ft) = 2 m (7 ft) screen; 360 m (1,181 ft) = 3 m (9.8 ft) screen
Tow head	Steel	n/a
Closing Line	Polyester, with sections of chain and Dyneema®	520 m (1,706 ft) permanently installed; additional 40-120 m (131-394 ft) depending on final design. Approximate diameter of 5 cm (1.9 in) with jacket.
Ballast Weight	Steel plates	528 m (1,732 ft)

ft = feet; HDPE = high density polyethylene; m = meters; n/a = not applicable.

The OCS is a passively drifting system driven by surface currents and wind; no engines or other propulsion systems are present. The OCS is designed to automatically orient itself with the convex side facing the wind, enabling it to drift downwind, thereby passively collecting plastics in the top 3 m (9.8 ft) of the water column within the concave side of the OCS. Polyester closing lines between the end points will be used to place the system in its convex shape; wind and currents will maintain the correct shape of the OCS. This design achieves a relative velocity to the surface current by means of having more exposure to the wind as compared with the plastics, in doing so, the system moves faster than the plastic. The OCS is designed so that it will orientate itself correctly if the wind direction changes. Due to a difference in the centre of drag between the submerged and emerged parts of the system, a stable system is created. **Figure 2-4** presents a conceptual diagram of the forces acting on the OCS.

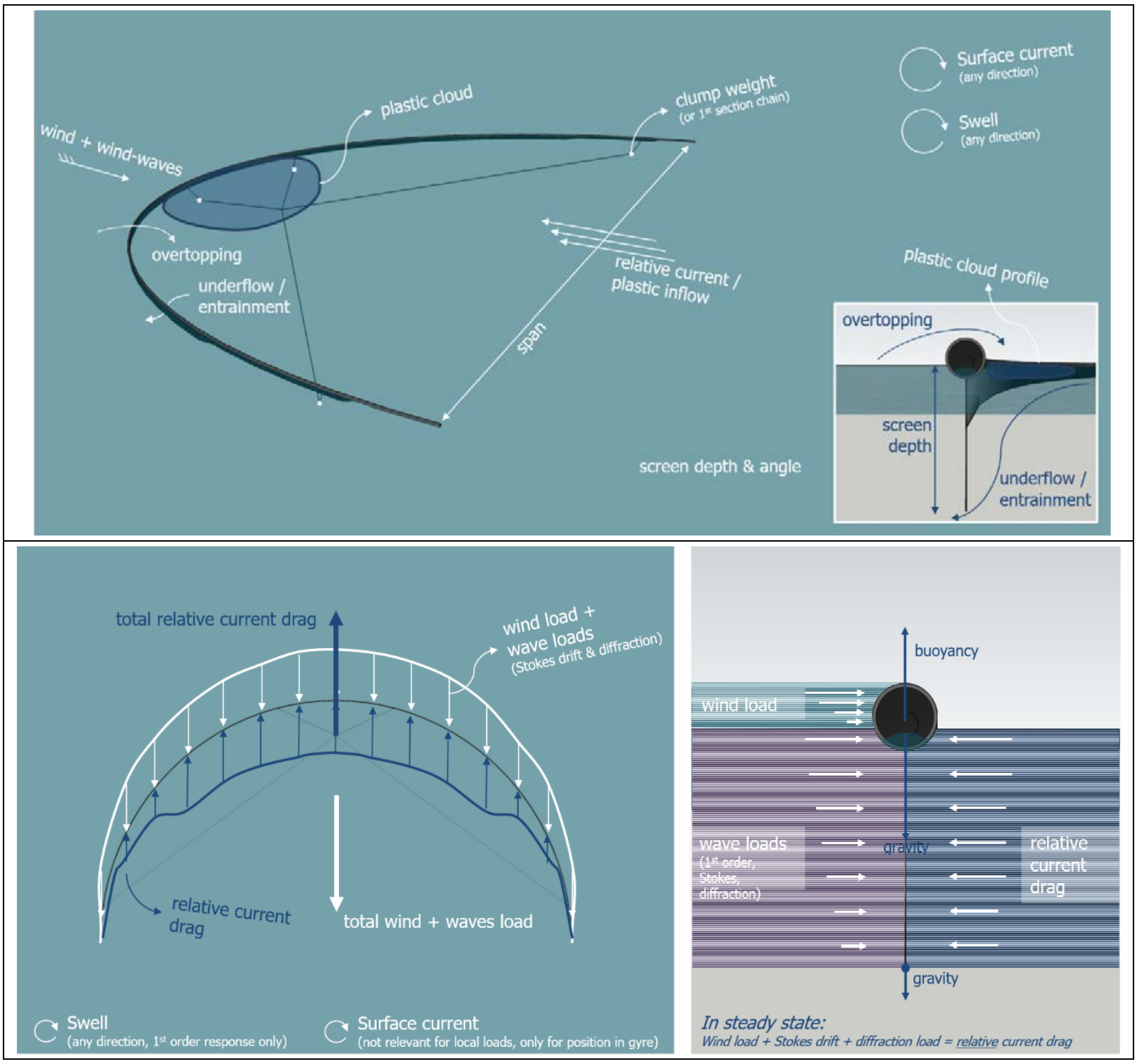

Figure 2-4. Conceptual diagram depicting the forces acting on the Ocean Cleanup System.

Plastic Extraction Operations

The plastic extraction vessel will travel from California to the location of the OCS within the EPGP. When the vessel arrives on location, it will maneuver close to the retention area of the OCS, preferably on the convex side of the system so as to not disturb the plastic accumulation area (located at the concave side). Extraction will only be performed during daylight hours and under favorable weather conditions.

Prior to the commencement of plastic extraction, the area will be inspected for potential presence of marine mammals or sea turtles. Observations will be performed both visually by a Marine Mammal Observer/Protected Species Observer and acoustically by the Passive Acoustic Monitoring (PAM) operator. Extraction operations will not commence unless the area is free of marine mammals and sea turtles and sharks. As soon as the area has been declared clear of marine mammals, sea turtles, and sharks, the extraction procedure will commence. During the process of extraction, an Acoustic Deterrent Device (ADD) or Acoustic Harassment Device (AHD) may be deployed to temporarily keep marine life out of the extraction area.

A conceptual model of The Ocean Cleanup extraction system is provided in **Figure 2-5**. The Ocean Cleanup is planning to use of a modified purse seine net designed to extract accumlulated plastic without marine life by-catch. The customized, modified purse seine net will be deployed, encircling the area in front of the OCS where the plastic debris has accumulated. The purse-seine net floater will have enough buoyancy to achieve a freeboard of 50 cm (20 in) during the extraction operations to avoid plastic debris lost by overtopping. Square shaped mesh will be utilized to reduce by-catch relative to diamond shaped mesh (Ordines et al., 2006). The customized 200-m long purse seine net will have a 10 mm square mesh; a 10-m section of one side of the net will have a finer mesh (3 mm) and be able to elongate to perform the purse seine bottom closing once the net is beside the vessel. This procedure may have the additional benefit of collecting some microplastics that accumulate in the OCS. The customized purse seine net may be equipped with ADD or AHD pingers to deter marine mammals and green flashing lights to deter sea turtles, and is designed to sustain a maximum load of 8 tons.

Beyond the potential use of an ADD or AHD, the area will also be scanned for marine life (large fish and sharks) with an underwater camera deployed from an auxiliary vessel. As soon as the area encircled by the net is cleared of marine mammals, sea turtles, and sharks, the net will be towed away by the main vessel from the OCS, closed slowly, and the catch will be transferred on board the vessel with both the use of a brailer (**Figure 2-6**) equipped with fine mesh net optimized for the collection of macro and microplastics, and later on with direct extraction of the purse seine net on the vessel.

Once the plastic is transferred to the vessel, living small fish (and other organisms) will be manually separated to the extent possible, documented, and released back into the ocean (where feasible). This will be done in part to understand the amount and type of by-catch which will assist in identifying additional mitigation measures for future use. Any marine mammal and sea turtle carcasses that may have been trapped in derelict netting will be reported to the appropriate agency. If a living marine mammal or sea turtle is unexpectedly found entangled in a derelict net or other debris, a disentanglement procedure may be initiated considering human safety, weather conditions and the species involved.

Unsorted extracted plastic will be deposited in open top containers onboard the extraction vessel. The containers will be fitted with drainage holes equipped with commercial grade filters to avoid drainage of microplastics. Any remaining water will be pumped off. The extracted plastic will be transported to shore where it will be unloaded from the vessel at a drop off point in the San Francisco Bay area. The plastic will be packaged in wind and weather tight containers and labeled according to classification and transferred to a recycling location.

At the recycling location, the plastic will be pretreated to remove leftover biomass and inorganic fractions to be recycled with separate methods. Non-plastic components contained in the recovered debris along with plastics that are not suited for mechanical recycling (e.g., wood) will be subject to thermal recycling with the objective of recovering a maximum amount of useful products, such as wax. Mechanical recycling provides plastic granulates to be directly used in products and thermal recycling produces, depending on process choice, fuels and chemicals or synthesis gas. The Ocean Cleanup will perform responsible mechanical and thermal recycling of the collected plastic.

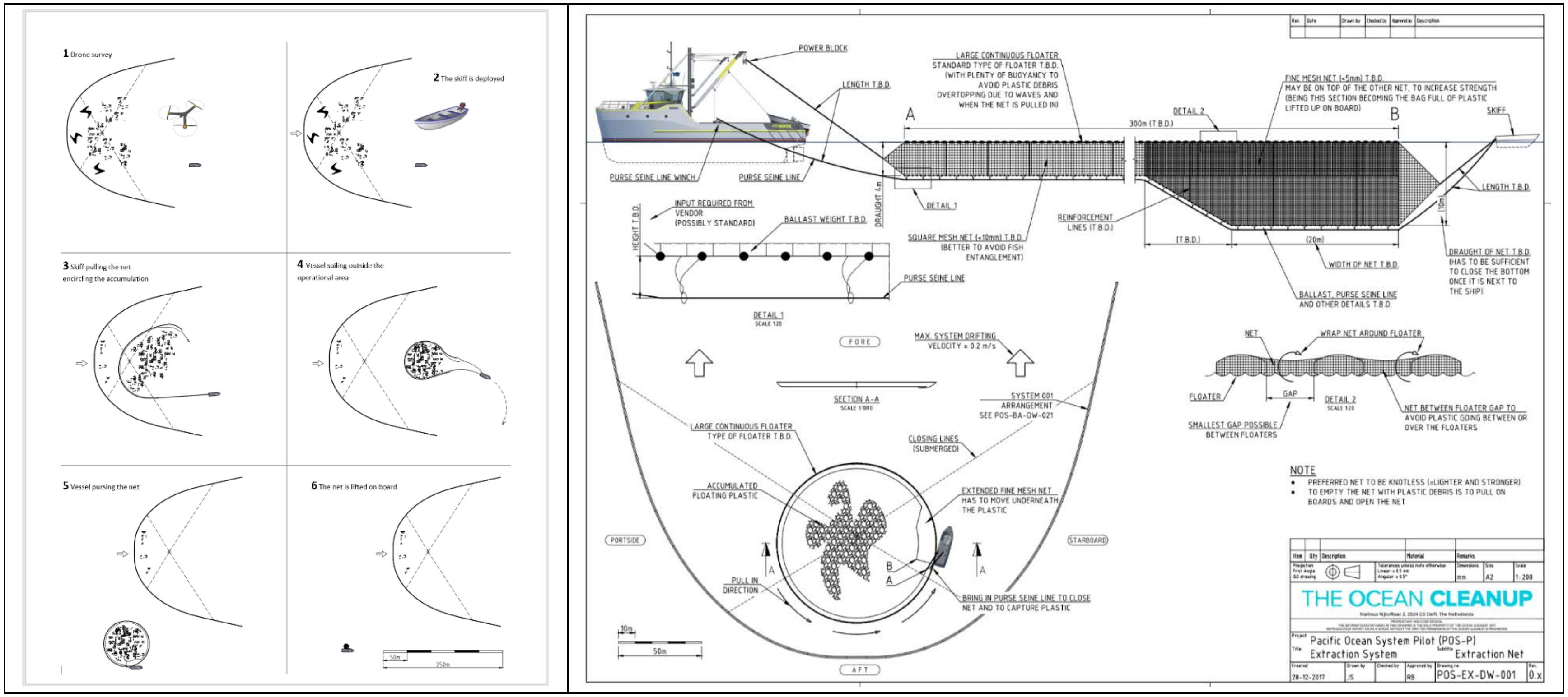

Figure 2-5. Conceptual model of The Ocean Cleanup System extraction system.

Figure 2-6. Example of a brailer to transfer plastic onto the plastic extraction vessel.

2.1.1 Tow Test

Prior to the deployment of the OCS in the EPGP, a shorter section (120 m [394 ft]) will be launched and towed behind a tugboat outside of San Francisco Bay into the Pacific Ocean as a sea trial for towing operations. The objectives of the Tow Test are to:

- Perform a test run of the assembly, launch, and retrieval of a cleanup system in Alameda
- Analyze and monitor behavior of floater-screen in tow configuration;
- Determine towing forces at different speeds and wave directions; and
- Test durability of the screen and screen-floater connection during tow.

The 120 m (394 ft) section will be pulled by a tugboat at the front end of the pipe and a smaller auxiliary steering tug at the stern. A pilot will be onboard the main tug to assist with navigation through the Bay. Upon exiting the Bay and navigation traffic channels, the steering tug will no longer be required. **Figure 2-7** provides a map of the Tow Test route from Alameda Island.

During the Tow Test, the system will be run through a variety of scenarios including towing with the wind/waves coming from the bow, stern, and perpendicular to the system; vessel heading alterations; various towing speeds, and variable tow-line length.

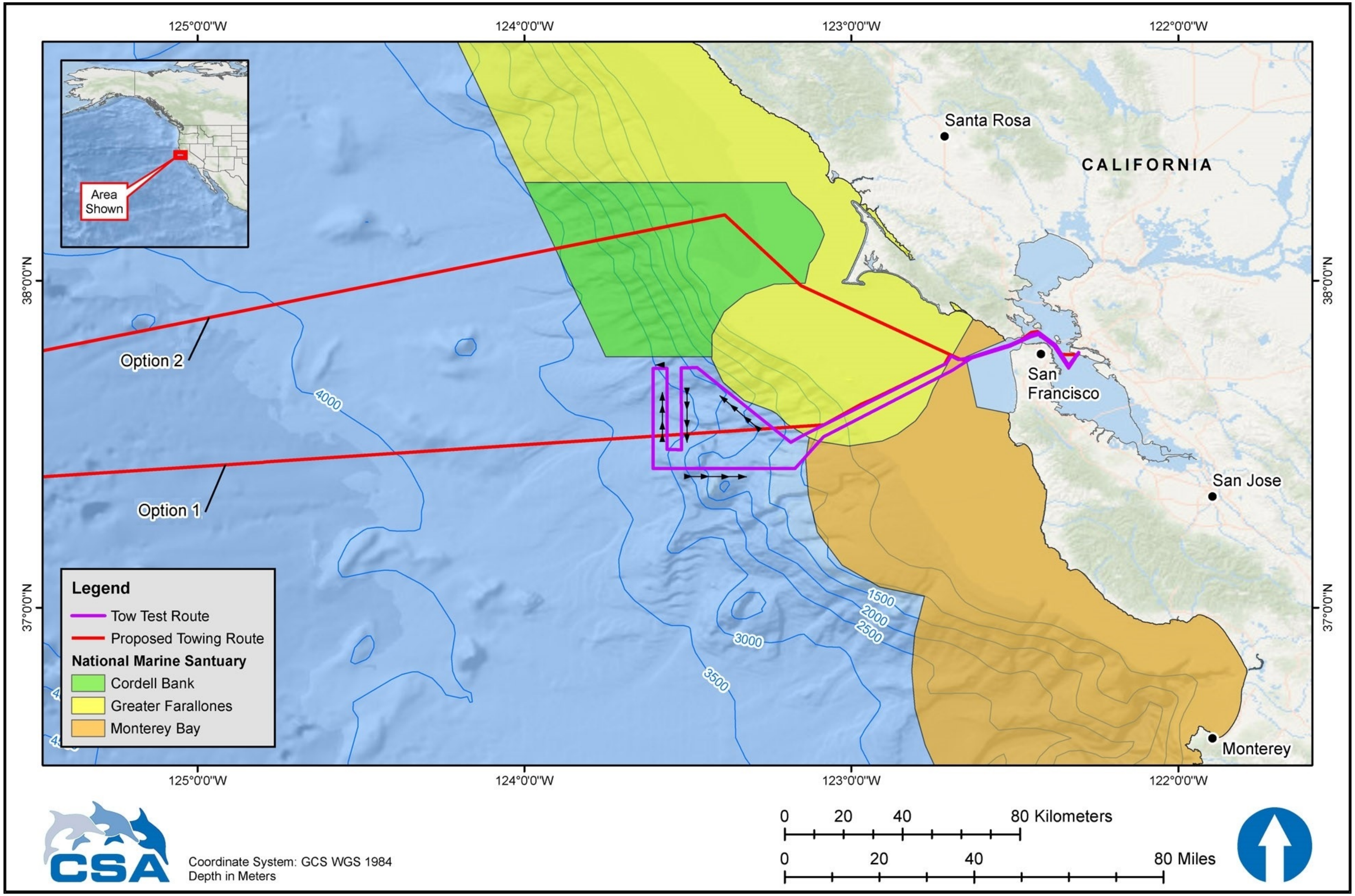

Figure 2-7. Tow Test route for the 120 m (394 ft) section of the Ocean Cleanup System.

Equipment used to monitor the 120 m (394 ft) section includes an airborne drone to supply top view of the OCS, an air/water drone to get close to water surface and possibly film underwater, a global positioning system (GPS) tracker, load shackles, a current meter an anemometer and subsea camera(s). Upon completion of the Tow Test, which is anticipated to take two to three weeks, the test piece will be towed back to San Francisco Bay to be recovered to shore. The OCS will be stored at The Ocean Cleanup shorebase on Alameda Island until the Pacific Trial commences (**Section 2.1.2**).

2.1.2 Pacific Trial

A trial deployment is anticipated to occur with the fully assembled 600 m (1,969 ft) OCS approximately five weeks after completion of the Tow Test (mid-summer 2018). This trial will occur at a currently undetermined location outside of the U.S. EEZ, greater than 370 km (200 nmi) from the California coast and will last approximately two weeks. The trial will involve towing the OCS from San Francisco to the test location, testing the closing lines connection procedure, observing the OCS behavior in offshore, open-ocean conditions, testing attached sensors, and testing environmental monitoring equipment. During the trial, two marine mammal observers will be on board the monitoring vessel at all times. Additionally, PAM will be utilized to monitor for marine mammals.

After completion and inspection, if no damage is found, the OCS will be towed directly to the EPGP without returning to San Francisco Bay. If damage is found, the closing lines of the OCS will be disconnected and the entire system will be towed back to The Ocean Cleanup shorebase on Alameda Island for repair.

2.1.3 Deployment

The Ocean Cleanup plans to assemble the OCS on the former United States Naval base on Alameda Island, which provides a sheltered area for operations in San Francisco Bay. The OCS will be towed to the EPGP immediately following the completion of the Pacific trial and any necessary repairs. The pre-selected location for deployment is located approximately 1,880 km (1,015 nmi) offshore (**Figure 2-8**). Once released, the OCS will move passively with the wind and surface currents.

The OCS will be equipped with a solar powered monitoring system including two Automatic Identifictation Systems (AIS), several GPS transmitters, seven equally spaced lights for navigational safety, a weather station, bilge sensors, static and dome cameras, three strain gauges to monitor OCS integrity, and satellite communication equipment. During the approximately year-long deployment, a monitoring vessel will be on standby to monitor the OCS for the majority of the deployment, monitoring will be performed according to the Environmental Management Plan (under separate cover). When the monitoring vessel returns to port for supplies, a remotly operated automonous monitoring vessel will be deployed. A passive acoustic system (hydrophone) to detect marine mammals will be present on the monitoring vessel. If the OCS drifts towards shipping lanes outside of the NPSG, or towards another undesired location, it will be towed back to the high plastic concentration zones in the center of the EPGP by the service vessel.

The Ocean Cleanup estimates that a plastic extraction vessel will travel to the OCS every six weeks to collect marine plastics from within the retention system as it is currently assumed, based on an internal study (by The Ocean Cleanup) using computational modelling, that in optimal conditions, every week one ton of plastic debris will accumulate in front of the system. After the first several months of deployment in the EPGP, The Ocean Cleanup will review the rate of plastic accumulation and adjust the interval of the debris retrieval vessel trips as needed. After collection, the plastics will be returned to shore and sorted/recycled as discussed in **Section 2.1**.

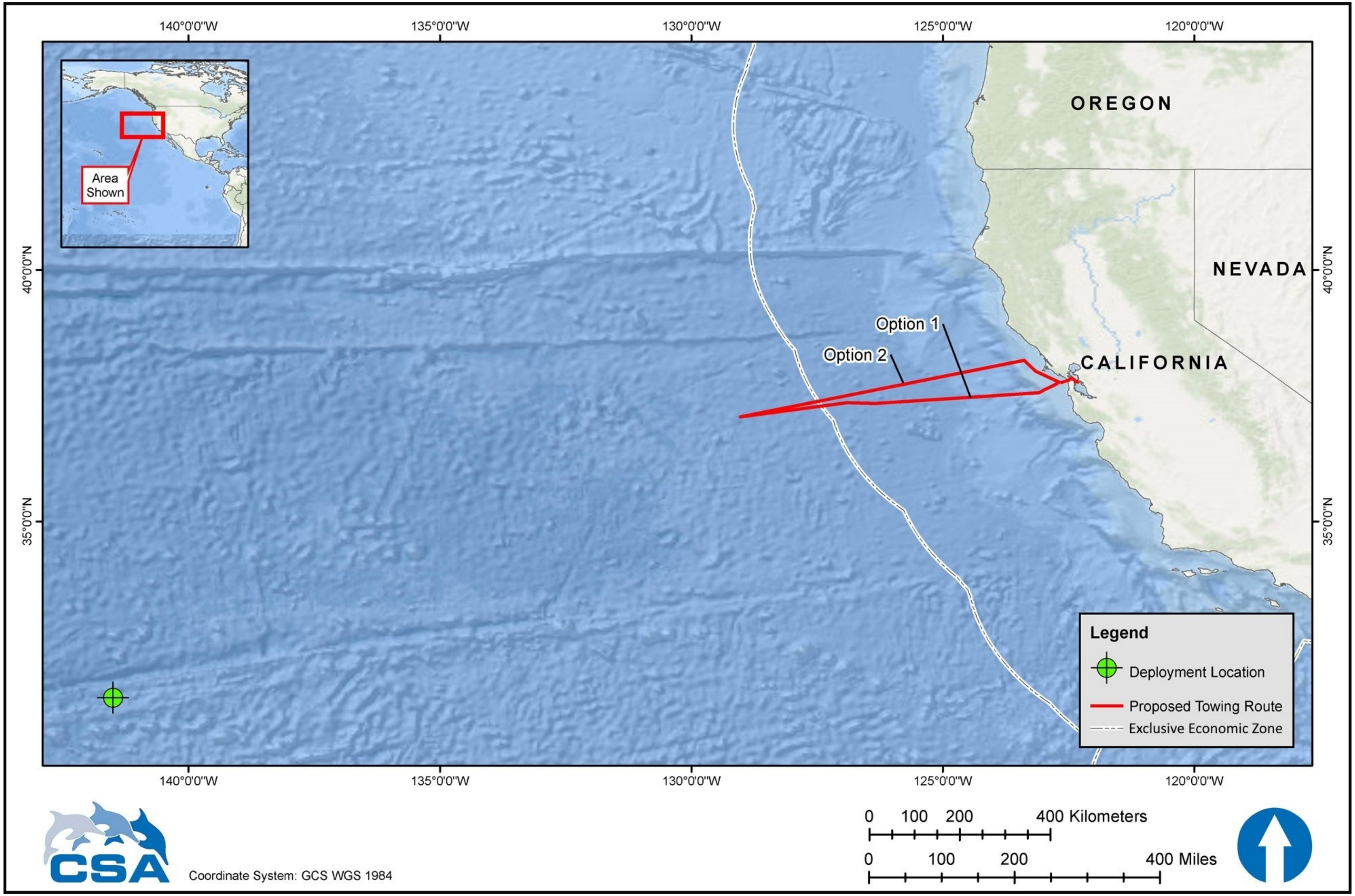

Figure 2-8. Proposed tow routes and deployment location for the Ocean Cleanup System in the East Pacific Garbage Patch.

2.2 LOCATION AND SCHEDULE

2.2.1 Location

The Tow Test area is located approximately 93 km (50 nmi) from San Francisco (**Figure 2-7**). The location for the Pacific trial will be located outside of the U.S. EEZ (>370 km [200 nmi] offshore) and between 407 and 500 km (220 to 270 nmi) offshore with respect to Alameda Island. The proposed location for deployment in the EPGP is located approximately 1,880 km (1,015 nmi) from the Alameda Island in San Francisco Bay. The locations for assembly and operations for the EPGP deployment were selected after a careful analysis of alternative locations, proximity to land, shipping lanes, suitable onshore work space, sensitive marine habitats and marine protected areas (MPAs). The exact towing route will be confirmed with the USCG before each departure. The approximate deployment coordinates are provided in **Table 2-2**.

Table 2-2. Approximate deployment locations and distance from San Francisco.

Deployment	Proposed Deployment Location		
	Latitude (°N)	Longitude (°W)	Distance from Alameda Island, San Francisco
Tow Test Location	37.5	-124.5	93 km (50 nmi)
Pacific Trial	Undetermined		>407 km (220 nmi)
Eastern Pacific Garbage Patch	31.5	-141.5	1,880 km (1,015 nmi)

km = kilometers; nmi = nautical miles.

2.2.2 Schedule

The Tow Test was completed in May 2018. Following the Tow Test, the system is being stored on Alameda Island for full assembly to its full length before the Pacific Trial, currently tentatively scheduled for mid-summer 2018. Following the trial, the OCS will be towed directly to the EPGP (unless repairs are necessary). It is estimated that 22 days of towing (based on departure from San Francisco Bay) will be necessary to reach the deployment location in the EPGP.

2.3 PROJECT VESSELS AND EQUIPMENT

The OCS will be towed to the EPGP using an offshore supply vessel. The Ocean Cleanup has not yet contracted a towing vessel, but has projected that the vessel will be a suitable, certified offshore anchor handling tug or similar vessel. The selected ship will be equipped with VHF Radio with digital selective calling, single side band radio, Global Maritime Distress and Safety System, Iridium Satellite phone, NavTex, radar with aft station display, Chart Navigation Computer, GPS, depth sounder, automatic identification system, magnetic compass, autopilot, and dynamic positioning system gyro compasses.

The monitoring vessel will be on location within the EPGP for the majority of the deployment, with intermittent times away from the OCS for supply trips to San Francisco. During the time in between supply trips, the OCS will be monitored using a remotely operated vehicle and the monitoring equipment installed on the OCS itself, both of which will be continuously connected by satellite to The Ocean Cleanup mission control. The vessel to be utilized to retrieve plastic debris from the OCS is expected to be a purse seiner fishing vessel. The Ocean Cleanup has estimated that the debris retrieval vessel will visit the OCS approximately every six weeks to retrieve plastic debris. Approximately nine round-trip visits from San Francisco to the OCS will be required based on a one-year deployment. These time frames will be adjusted according to the data collected and findings that will occur during the EPGP deployment.

2.4 EMISSIONS AND DISCHARGES

2.4.1 Emissions

Activities from the proposed towing and deployment will produce emissions from internal combustion engines, including greenhouse gases, and varying amounts of other pollutants such as carbon monoxide, oxides of nitrogen, and sulfur, volatile organic compounds, and particulate matter. The geographic location of operations ranges from Alameda Island in San Francisco Bay to the proposed deployment location approximately 1,880 km (1,015 nmi) from shore in the EPGP. The amount of air pollutants and greenhouse gases generated during The Ocean Cleanup activities will depend primarily on the number, design, and size of the vessels; the size of engines and generators on the vessels; the distance traversed under power; and overall duration of the activities, however, due to the limited extent and duration of activities, the amount of pollutants is expected to be nominal.

2.4.2 Discharges

Discharges from project vessels may include sanitary and domestic wastes, deck drainage, cooling water, bilge water, and food wastes. All sanitary waste will be treated using a marine sanitation device, producing an effluent with low residual chlorine concentrations (i.e., 1.0 mg/L or less), with no visible floating solids or oil and grease. Treated black water discharges will comply with International Convention for the Prevention of Pollution from Ships (MARPOL) requirements.

Domestic waste (also known as gray water) consists of the water generated from showers, sinks, laundries, and galleys, safety showers, and eye wash stations. Domestic wastewater is typically screened to remove any floating solids then discharged; domestic waste does not require treatment before discharge under MARPOL requirements.

Table 2-3 provides a summary of effluent discharges expected during the proposed project and **Table 2-4** provides estimated maximum volumes/weights for sanitary waste, domestic waste, and food waste expected to be generated during the proposed project.

Table 2-3. Summary of effluent discharges expected during The Ocean Cleanup proposed year-long deployment in the Eastern Pacific Garbage Patch.

Effluent	Expected Volumes; Treatment or Processing
Sanitary and Domestic Wastes	Sanitary wastes: 132.5 L/person/d (35 gal/person/d) – macerate, chlorinate, discharge. Domestic wastes: 378.5 to 567.8 L/person/d (100 to 150 gal/ person/d) – remove floating solids, discharge. Sanitary wastes will be collected and treated, and domestic wastes will be collected prior to discharge in compliance with MARPOL 73/78, Annex IV. Total volumes of sanitary and domestic waste dependent upon number of personnel.
Deck Drainage	Deck drainage to be monitored and treated to remove oil and grease; discharge not to exceed 29 mg/L monthly average, or 42 mg/L daily maximum for hydrocarbons. All discharges will be in compliance with MARPOL 73/78, Annex I. Total volume depends on rainfall.
Cooling Water	Effluent should result in a temperature increase of no more than 3°C (5.4°F) at edge of the zone where initial mixing and dilution take place. Where the dilution zone is not defined, the dilution zone will be 100 m (328 ft) from point of discharge.

Table 2-3. (Continued).

Effluent	Expected Volumes; Treatment or Processing
Bilge Water	Processed through an oil-water separator. Discharged in compliance with MARPOL 73/78, Annex I. Variable volumes, depending on vessels used.
Food Wastes	Food waste will be ground and passed through 25-mm (1-in) mesh screen prior to disposal overboard outside 22-km (12-nmi) zone as required by the MARPOL Convention (i.e., compliance with MARPOL 73/78, Annex V). Total weight dependent upon number of personnel.

Notes: A monitoring vessel to remain on site for the duration of the deployment; debris retrieval vessel to transit to the survey area only once every six weeks. Source of effluents: Towing vessel, monitoring vessel, and debris retrieval vessel. Abbreviations: d = day; ft = feet; gal = gallon(s); in = inches; km = kilometers; L = liter(s); MARPOL = International Convention for the Prevention of Pollution from Ships; mg/L = milligram(s) per liter; mm = millimeter(s); nmi = nautical miles(s); ppm = part(s) per million. Generation rates: Per BOEM (2012), a typical offshore facility will discharge 132.5 L (35 gallons) per person per day of treated sanitary wastes and 378.5 to 567.8 L (50-100 gallons) per person per day of domestic wastes, based on U.S. Environmental Protection Agency (USEPA, 1993) estimates. These estimates are considered conservative for sanitary and domestic waste discharges from oil and gas industry support operations, including seismic, guard, and supply vessels.

Table 2-4. Summary of estimated project discharges, reflecting maximum volumes/weights for sanitary waste, domestic waste, and food waste.

Vessel	Persons (max)	Days (max)	Sanitary Waste (L)	Domestic Waste (L)	Food Waste (kg)
Offshore Anchor Handling Tug (Towing)	36	44[1]	209,880	599,544	1,584
Offshore Anchor Handling Tug (Monitoring)	36	365[2]	1,741,050	4,973,490	13,140
Purse Seiner (Debris Retrieval)	10[3]	90[4]	119,250	340,650	900
		Total	**2,070,180**	**5,913,684**	**15,624**

1 Based on round trip towing of 22 days each way.
2 Based on estimates that a monitoring vessel will be on location for 12 months.
3 Max persons for purse seiner estimated.
4 Based on nine vessel transits at 10 days each.
kg = kilograms; L = liters.
Generation rates: Per BOEM (2012), a typical offshore facility will discharge 132.5 L (35 gallons) per person per day of treated sanitary wastes and 378.5 to 567.8 L (50-100 gallons) per person per day of domestic wastes, based on U.S. Environmental Protection Agency (USEPA, 1993) estimates. These estimates are considered conservative for sanitary and domestic waste discharges from offshore support operations. Estimated metric rates include: Sanitary waste (black water): 132.5 L/person/day (35 gallons/person/day); Domestic waste (gray water): 378.5 L/person/day (50 gallons/person/day); and Food waste: 1 kg/person/day (2.2 pounds/person/day).

2.4.3 Waste

Waste will be managed in accordance with the vessels' Garbage Management Plans and associated Bridging documentation/contractual conditions with The Ocean Cleanup, as well as all applicable laws and regulations. The Ocean Cleanup will review the Garbage Management Plan and will conduct due diligence on any waste disposal subcontractors that may be hired for the project.

3.0 Legislative and Regulatory Environment

Usually, the primary U.S. law requiring an assessment of potential environmental impacts associated with discretionary projects is the National Environmental Policy Act (NEPA) of 1970. NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making discretionary decisions such as the issuance of permits or other approvals. The proposed deployment location in the EPGP is located in international waters, outside the permitting jurisdiction of U.S. agencies. Further, the activities being proposed by The Ocean Cleanup will not utilize U.S.-flagged vessels (other than the Tow Test), and will not be completed by U.S. citizens. Consequently, U.S. permits that might otherwise be required for a project of this nature are not required, and therefore NEPA review is not triggered. Nevertheless, in the interest of transparency, and to assess the proposed activities for potential environmental impacts and identify potential mitigation measures, this EIA was prepared to meet the 1999 International Association for Impact Assessment Principles of Environmental Impact Assessment Best Practices (IAIA, 1999).

The Ocean Cleanup will comply with relevant federal and local regulations when towing nearshore and within the U.S. EEZ. The Ocean Cleanup will submit information to the local U.S. Coast Guard (USCG) office and the local Harbormaster for issuance of a Local Notice to Mariners (NTM) as necessary, which would specify the towing dates and locations and the recommended avoidance requirements. Preparation and coordination of the NTM typically takes 30 days. All vessel operations will be in compliance with MARPOL. Brief descriptions of MARPOL and other relevant U.S. environmental laws are presented below.

3.1 INTERNATIONAL CONVENTION OF THE PREVENTION OF POLLUTION FROM SHIPS, 1973/1978 (MARPOL)

MARPOL (1973) was developed by the International Maritime Organization (IMO) in an effort to reduce marine pollution from vessels. In 1978, MARPOL was updated to include five annexes on ocean dumping. By signing MARPOL, countries agree to enforce Annexes I and II (oil and noxious liquid substances) of the treaty. Annexes III (harmful substances), IV (sewage), and V (prevention of pollution by garbage from ships) are optional. The U.S. is signatory to two of the optional MARPOL Annexes, III and V. Annex V is of particular importance to the maritime community including shippers, oil platform personnel, fishers, and recreational boaters because it prohibits the disposal of plastic at sea and regulates the disposal of other types of garbage at sea. The USCG is the enforcement agency for MARPOL Annex V within the U.S. EEZ, within 370 km (200 nmi) of the U.S. shore.

The Marine Plastic Pollution Research and Control Act is the U.S. federal law implementing MARPOL Annex V in all U.S. waters. Under the Marine Plastic Pollution Research and Control Act, it is illegal to throw plastic trash off any vessel within the EEZ. It is also illegal to throw any other garbage (e.g., orange peels, paper plates, glass jars, monofilament fishing line) overboard while navigating in inland waters or within 5 km (3 nmi) offshore. The greater the distance from shore, the fewer restrictions apply to non-plastic garbage. However, in general, dumping plastics overboard in any waters anywhere is illegal at any time. Garbage must be brought ashore and properly disposed of in a trash can, dumpster, or recycling container. Docks and marinas are required to provide facilities to handle normal amounts of garbage from their paying customers.

3.2 ENDANGERED SPECIES ACT

The Endangered Species Act (ESA), enacted in 1973 (16 U.S.C. 1531), provides for conservation of threatened and endangered plants and animals, and the ecosystems on which they depend. The ESA was designed to protect and recover critically imperiled species as a "consequence of economic growth and development untempered by adequate concern and conservation" and is administered by the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS).

The deployment of the OCS will occur in international waters by non-U.S. citizens using a non U.S.-flagged vessel and is not subject to ESA rules and regulations except while completing routine towing operations nearshore and within the U.S. EEZ. When operating within the U.S. EEZ, it is highly unlikely that towing operations will result in the take of any ESA-listed species due to the extremely slow towing speed.

3.3 MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371, 50 CFR part 1) was enacted on October 21, 1972 based on the following findings: marine mammals are resources of great international significance; certain species or stocks are, or may be, in danger of extinction or depletion as a result of man's activities; such species or stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part; and the primary objective of their management should be to maintain the health and stability of the marine ecosystem. This statement clearly speaks to the need to maintain a broad scope that considers species- and ecosystem-level impacts.

The deployment of the OCS will occur in international waters by non-U.S. citizens using a non U.S.-flagged vessel and is not subject to MMPA rules and regulations except while conducting routine towing nearshore and within the U.S. EEZ. When towing within the U.S. EEZ, it is highly unlikely that towing operations will result in the take of any marine mammal due to the extremely slow towing speed.

3.4 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (P.L. 94-265) was enacted to address impacts to fisheries on the U.S. Continental Shelf. It established U.S. fishery management over fishes within the fishery conservation zone from the seaward boundary of the coastal states out to 370 km (200 nmi) (i.e., boundary of the U.S. Exclusive Economic Zone or EEZ).

The Sustainable Fisheries Act requires that BOEM and other agencies consult with NMFS concerning actions that may adversely impact essential fish habitat (EFH). EFH is defined as the waters and substrate necessary to fishes or invertebrates for spawning, breeding, feeding, or growth to maturity. Areas designated as EFH contain habitat essential to the long-term survival and health of U.S. fisheries. EFHs for managed fisheries are described in the Fishery Management Plans.

The deployment of the OCS will occur in international waters by non-U.S. citizens using a non U.S.-flagged vessel and is not subject to MSFCMA rules and regulations except while towing nearshore and within the U.S. EEZ. When towing within the U.S. EEZ, it highly unlikely that towing operations will result in any negative impacts to EFH due to the routine nature of the towing activities.

3.5 NATIONAL MARINE SANCTUARIES ACT

The National Marine Sanctuaries Act (NMSA) (16 U.S.C. § 1431 *et seq.*) was enacted in 1972 and is the legislative mandate that governs the Office of National Marine Sanctuaries (ONMS) and the National Marine Sanctuary (NMS) System. Under the NMSA, the Secretary of Commerce is authorized to designate and manage areas of the marine environment as NMSs. Such designation is based on attributes of special national significance, including conservation, recreational, ecological, historical, scientific, cultural, archaeological, educational, or aesthetic qualities. Day-to-day management of NMSs has been delegated by the Secretary of Commerce to the ONMS.

The Ocean Cleanup is not proposing any activities to occur in any NMS other a routine towing operation (the same that must be undertaken by any vessel leaving the San Francisco Bay) throughh the Monterrey Bay NMS, Greater Farallones NMS, and/or Cordell Bank NMS). The Ocean Cleanup has notified the Greater Farallones National Marine Sanctuary and the Monterey Bay Marine Sanctuary of their plans, and no consultation with ONMS is expected to be required due to the routine nature of the towing activities in the NMS areas.

3.6 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act (MBTA) of 1918 (16 U.S.C. 703-712) is the primary legislation in the U.S. for the conservation of migratory birds. It implements the U.S. commitment to four bilateral treaties, or conventions, for the protection of a shared migratory bird resource. The MBTA prohibits the taking, killing, or possession of migratory birds and the nests or eggs of any such bird unless permitted by regulation.

The deployment of the OCS will occur in international waters by non-U.S. citizens using a non U.S.-flagged vessel and is not subject to MBTA rules and regulations except while towing nearshore and within the U.S. EEZ. When towing within the U.S. EEZ, it highly unlikely that towing operations will result in the take of any migratory birds due to the extremely slow towing speed. Furthermore, a 2017 U.S. Department of Interior Legal Opinion (U.S. Department of Interior, 2017) concluded that the MBTA applied only to direct or affirmative take of migratory birds, and not to incidental takes.

3.7 SHORE PROTECTION ACT

The Shore Protection Act of 1988 (33 U.S.C. § 2601 et seq.) regulates the transportation of waste within coastal waters. In general, regulated vessels are required to have a permit from the U.S. Secretary of Transportation to transport municipal or commercial waste. Ministerial permits to transport waste are issued by the USCG in consultation with the USEPA. The Ocean Cleanup is currently consulting with the USCG and the USEPA as to whether its operations require a permit under the Shore Protection Act.

3.8 COASTAL ZONE MANAGEMENT ACT

The Coastal Zone Management Act (CZMA) requires that all federal discretionary agency activities affecting the coastal zone (e.g., permits and licenses) include a determination that the proposed activity is consistent with the enforceable policies of the relevant state's certified program ("Consistency Determination"). Aside from routine towing and other operations, the nature and scope of The Ocean Cleanup's operations are such that there are no discretionary federal approvals required; accordingly, a CZMA determination is not applicable. Similarly, because The Ocean Cleanup's operations will take place primarily outside the U.S. EEZ, its operations are unlikely to substantially affect the coastal zone, making a CZMA determination unnecessary.

3.9 INTERNATIONAL UNION FOR CONSERVATION OF NATURE

The International Union for Conservation of Nature (IUCN) is a membership union composed of both government and civil society organizations. Created in 1948, IUCN has evolved into the world's largest and most diverse environmental network. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

The IUCN Red List of Threatened Species™ (Red List) provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The Red List is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. The introduction in 1994 of a scientifically rigorous approach to determine risks of extinction that is applicable to all species, has become a world standard. Far more than a list of species and their status, the IUCN is a powerful tool to inform and catalyze action for biodiversity conservation and policy change (IUCN, 2018).

The IUCN status of many of the resources that may be impacted from the deployment of The Ocean Cleanup system are included in **Section 5.3**. Although most of the regulatory acts discussed only apply while towing nearshore and within the U.S. EEZ, the Red List provides an internationally recognized conservation status of these biological resources. The Ocean Cleanup's towing and deployment activities have been designed to minimize impacts to marine species, and by removing plastic from the EPGP, will result in an overall beneficial impact.

4.1 PRELIMINARY SCREENING OF ACTIVITIES AND AFFECTED RESOURCES

A preliminary screening was conducted to identify the resources at risk from the tow test, Pacific Trial, towing, and deployment in the EPGP. Screening allows for completion of a focused impact analysis by eliminating (from detailed analysis) resources with little or no potential for adverse or significant impact. This approach focuses the analysis on the resources at greatest impact risk. A matrix was developed to list environmental resources in the area of the tow test, Pacific Trial, towing, and deployment off the coast of San Francisco and project activities that may impact resources (**Table 4-1**). In this preliminary analysis, the level of impact associated with each interaction was categorized as "potential impact for analysis" (i.e., a measurable impact to a resource is predicted) or "no impact expected" (i.e., no measurable impact to a resource is evident).

Table 4-1. Preliminary screening of potential impacts (Leopold matrix).

Resource	Project Activity/ Impact Producing Factor						
	Towing Operations	OCS – Entanglement /Entrapment	OCS – Attraction/ Ingestion of Plastics	Vessel – Physical Presence/ Strikes	Noise and Lights	Loss of Debris	Accidental Small Fuel Spill
Air Quality	--	--	--	--	--	--	--
Sediment Quality	--	--	--	--	--	--	--
Water Quality	--	--	--	--	--	--	--
Fish/Fishery Resources	--	--	●	●	--	●	●
Plankton	●	●	--	--	--	--	●
Benthic Communities	--	--	--	--	--	--	--
Marine Mammals	●	●	●	●	●	●	●
Sea Turtles	●	●	●	●	●	●	●
Coastal and Oceanic Birds	--	--	●	●	--	--	●
Protected Areas	●	--	--	●	--	--	●
Biodiversity	--	--	--	--	--	--	--
Commercial and Military Vessels	●	--	--	●	--	--	--
Archaeological Resources	--	--	--	--	--	--	--
Human Resources, Land Use, and Economics	--	--	--	--	--	--	--
Recreational Resources and Tourism	--	--	--	--	--	--	--
Physical Oceanography	--	--	--	--	--	--	--

● indicates a potential impact; - indicates no impact expected. OCS = Ocean Cleanup System.

Several resources were identified as having no expected impacts from the proposed activities. Rationale for exclusion of these resources from further analysis are detailed in the following subsections.

4.1.1 Air Quality

Potential impacts from emissions on air quality are expected to be negligible. Vessels (towing, monitoring, and debris retrieval), machinery, and equipment involved in The Ocean Cleanup activities will emit a variety of air pollutants, including nitrogen oxides, sulfur oxides, particulate matter, volatile organic compounds, and carbon monoxide, as well as greenhouse gases (e.g., carbon dioxide) primarily from combustion of fossil fuels for propulsion and power generation. The amount of air pollutants and greenhouse gases generated during The Ocean Cleanup activities will depend primarily on the number, design, and size of the vessels; the size of engines and generators on the vessels; the distance traversed under power; and overall duration of the activities, however, due to the limited extent and duration of activities, the amount of pollutants is expected to be nominal. The Ocean Cleanup is currently performing a Life Cycle Assessment to full estimate greenhouse gas emissions from the towing and deployment. Due to the novelty of the project, the Assessment will last the full year of the deployment and will help The Ocean Cleanup to quantify actual impacts to air quality from project emissions and to identify possible mitigation measures for future activities.

Air emissions from The Ocean Cleanup vessels will contribute nominal amounts of pollutants to the emissions inventories for vessels in the waters offshore San Francisco. Air quality could be temporarily affected by an accidental fuel spill in the immediate vicinity of the spill, but due to the small volume of a potential spill and the high volatility of refined fuels, any impacts on air quality are expected to be negligible. For these reasons, a more extensive analysis of air quality emissions associated with anticipated operations will not be performed as part of this EIA.

4.1.2 Sediment Quality

There are no activities proposed by The Ocean Cleanup that could have substantial impacts on sediment quality. No anchors or other bottom disturbing activities will occur during the OCS towing or deployment and consequently a more detailed analysis of potential impacts to sediment quality will not be performed as part of this EIA.

4.1.3 Water Quality

Potential impacts from vessel discharges on water quality are expected to be negligible. The towing vessel, monitoring vessel, and debris retrieval vessels will discharge treated sanitary and domestic wastes from USCG-approved marine sanitation devices along with miscellaneous discharges (e.g., deck drainage, bilge water, machinery space drainage). The volume of treated discharges generated during The Ocean Cleanup activities will depend primarily on the design and size of the vessels, the onboard crew compliment, the distance traversed, and the overall duration of activities. Most discharges will occur outside the U.S. EEZ in international waters and will quickly become diluted in seawater.

Furthermore, all vessels are subject to the regulations of MARPOL 73/78, as modified by the Protocol of 1978 (**Section 3.1**). MARPOL includes six annexes that cover discharge of oil, noxious liquid substances, harmful packaged substances, sewage, garbage, and air pollution (IMO, 2017). Annex V specifically prohibits plastic disposal anywhere at sea and severely restricts discharge of other garbage (IMO, 2017). Adherence to these regulations minimizes or negates the likelihood of discharges of potentially harmful substances into the marine environment.

Water quality could be temporarily affected by an accidental fuel spill in the immediate vicinity of the spill. The extent and persistence of water quality impacts from a small diesel fuel spill would depend on the meteorological and oceanographic conditions at the time and the effectiveness of spill response measures, but diesel fuel rapidly evaporates and is completely degraded for naturally occurring microbes (NOAA, 2006). It is not expected that the impacts to water quality from an accidental fuel spill will be significant. For these reasons, more detailed analysis of water quality impacts associated with anticipated The Ocean Cleanup activities will not be performed as part of this EIA.

4.1.4 Benthic Communities

There are no activities proposed by The Ocean Cleanup that could have substantial impacts on benthic communities. However, the water depth at the OCS assembly location on Alameda Island is sufficiently shallow that the system will not be able to hang vertically down without touching the bottom. Care will be taken to ensure that disturbance of the seafloor is minimized. No anchors or other bottom disturbing activities will occur during the OCS towing or deployment, consequently a more detailed analysis of impacts to benthic communities will not be performed as part of this EIA.

4.1.5 Biodiversity

No impacts to biodiversity are expected from The Ocean Cleanup activities. While The Ocean Cleanup activities may have impacts on individuals of a variety of species (see impacts discussion in **Chapter 5**), it is not expected that any detrimental impacts will occur on a species level that would result in harm to biodiversity.

4.1.6 Archaeological Resources

No impacts to archaeological resources are anticipated from The Ocean Cleanup activities. No seafloor disturbing activities are proposed that would have the potential to impact shipwrecks or other submerged archaeological resources. Mobilization of the OCS is expected to occur on Alameda Island in a developed, industrial area with no known archaeological resources nearby. The Ocean Cleanup project does not involve any new land-based development. Consequently, a more detailed analysis of archaeological resources will not be performed as part of this EIA.

4.1.7 Human Resources, Land Use, and Economics

No substantial impacts to human resources, land use, or economics are expected from The Ocean Cleanup activities. The Ocean Cleanup activities will result in a minor positive economic benefit due to payments to federal, state, and/or local authorities and private parties for port fees, fuel, other miscellaneous purchases, potential employment opportunities during OCS assembly, and other incidental expenses incurred while in Alameda and elsewhere in the San Francisco Bay area. No alteration to land use is proposed and no new ports or other infrastructure will be built. Consequently, a more detailed analysis of human resources, land use, and economics will not be performed for this EIA.

4.1.8 Recreational Resources and Tourism

Impacts to recreational resources and tourism from The Ocean Cleanup activities are expected to be negligible. There are no known recreational or tourism resources in the EPGP as it is located in a remote area of open ocean more than 1,800 km (1,000 nmi) from land. Recreation or tourism boating activities may be briefly interrupted during the towing of the OCS out of San Francisco Bay; The Ocean Cleanup will coordinate with the USCG and issue a NTM to mitigate potential impacts. As a result of the temporary and negligible impacts expected, more detailed analysis of potential impacts to recreation resources and tourism will not be performed as part of this EIA.

4.1.9 Physical Ocean Factors

Physical oceanographic resources will not be affected by The Ocean Cleanup activities and associated discharges; impacts to physical oceanography are expected to be negligible. Ocean current characteristics, water column density stratification, wave height, directional spectra, and vertical current structure, among other factors, will be considered during planning, deployment, and debris recovery operations.

4.2 DATA SOURCES

Utilizing information provided by The Ocean Cleanup and the CSA Ocean Sciences Inc. (CSA) Research Library facility, CSA conducted a comprehensive review based on literature, previously completed environmental studies, and EIAs concerning projects in the region. Project area-specific information is limited; as such, regional data was utilized to preliminarily characterize the marine environment in the project area.

4.3 BIOLOGICAL ENVIRONMENT

4.3.1 Plankton

4.3.1.1 Plankton in the North Pacific Subtropical Gyre

The NPSG is a large system of circulating currents covering an area that extends from approximately 15°N to 35°N latitude and 135°E to 135°W longitude (Karl, 1999). With a surface area of approximately $2x10^7$ km^2, the NPGS is the largest circulation feature on the planet (Karl, 1999). The NPSG includes a broad range of habitats that are both temporally and spatially variable (Karl, 1999; Karl and Church, 2017).

Within the NPSG, picoplankton is the dominant group (more than 50% of the total) in terms of abundance, while relative abundance of diatoms and dinoflagellates is less than 15% (Uitz et al., 2006, 2010) of the total. *Prochlorococcus*, a cyanobacteria, accounts for >75% of the photoautotrophic biomass in the upper portion of the water column (Karl et al., 2001).

Seasonally, zooplankton biomass peaks are observed during the summer months of highest primary productivity. Increased sea surface temperature, stratification, and nitrogen fixation happen during summer, which is reflected in maxima of primary production and zooplankton biomass. Many species of zooplankton undergo diel vertical migration where they move up to the epipelagic zone in the water column at night and return to the mesopelagic zone during the day.

Seasonality in phytoplankton has also been observed. During summer, surface species are found in the upper 75 m (246 ft) whereas deep species found from 75 to 150 m (246 to 492 ft) bloomed in winter (Campbell et al., 1997; Batten and Freeland, 2007). Other studies show low plankton abundance in winter by the north pacific current (Batten and Freeland 2007). Studies related to other plankton groups, like diatoms, show low concentrations of diatom cells throughout the year, although distinct assemblages were observed in the mixed-layer and in the deep chlorophyll maximum layer. However, a conspicuous increase in diatom concentration particularly in the mixed-layer in July was observed, mainly by *Hemiaulus hauckii* and *Mastogloia woodiana* (Scharek et al., 1999). Summer plankton blooms are a common seasonal phenomenon in the NPSG. A high-frequency area of bloom occurrences in the NPSG is generally centered along 30°N, about 130 to 160°W (Dore et al., 2008). The largest historical blooms have covered more than 350,000 km^2 (102,044 nmi^2) and lasted as long as four months (Wilson, 2003). Blooms occur annually between the months of June and October and are generally observed coincident with sea surface temperatures >25°C (77°F) and mixed layer depth <70 m (230 ft). Some of blooms are dominated by *Richelia*-diatom symbioses, while others by *Trichodesmium*, a filamentous cyanobacteria (White et al., 2007).

4.3.1.2 Gelatinous Macrozooplankton

Gelatinous macrozooplankton (e.g., jellyfish, ctenophores) belong to the phyla Cnidaria. Little is known about the population abundance or dynamics of most species of jellyfish as many live in open ocean environments far from land. **Table 4-2** lists species that have been found in or nearby the deployment area for the OCS in the EPGP.

Table 4-2. Cnidarian species that have been reported in the vicinity of the OCS deployment in the Eastern Pacific Garbage Patch. Data from: Wrobel and Mills (1998).

Class	Species	Climate Region	Dominant Occurrence	Buoyancy (Positive/Neutral)	Feeding
Hydrozoa	*Algantha digitale*	North Pacific Water 40°N to Artic waters	Artic water and open ocean	Neutral	At night at surface
	Velella velella	Tropical and temperate waters	Open ocean	Positive	At surface
	Pegantha spp.	40°N to 40°S	Open ocean	Neutral	--
	Liriope tetraphylla	40°N to 40°S	Open ocean and near coast	Neutral	--
	Physalia utriculus	North Pacific and Hawaiian waters	Open ocean	Positive	At surface
	Physophora hydrostatica	Tropical and temperate waters	Deep midwaters	Neutral	Deep waters
	Porpita porpita	Tropical and sub-tropical waters	Open ocean and near coast	Positive	At surface
Scyphozoa	*Aurelia aurita*	70°N to 40°S	Mostly inshore; can be found in open water	Neutral	Water column
	Aurelia labiata	North Pacific from California to Japan	Mostly inshore can be found in open water	Neutral	Water column
	Phacellophora camtschatica	Temperate waters from Gulf of Alaska to Chile	Open ocean	Neutral	Water column

OCS = The Ocean Cleanup System. -- = Feeding method unknown.

4.3.1.3 Ichthyoplankton

Data regarding ichthyoplankton in the project area are sparse, but it is likely that many of the pelagic fish species discussed in **Section 5.3.2** may be present in larval form as well. Loeb (1979) described larval fish assemblages in the NPSG. Ichthyoplankton collected from six cruises resulted in approximately 30,000 individual larvae from over 150 species. However, it should be noted that Loeb (1979) reported that fish larvae constituted <2% of the total macrozooplankton collected in the NPSG. Overall fish larvae abundance was not found to differ by season, but the species composition of ichthyoplankton did differ by season (Loeb, 1979).

4.3.1.4 Plankton in the California Current

The California Current is a Pacific Ocean current that flows southward from approximately 50° N latitude to offshore Baja California, approximately 15 to 25° N latitude. The current is largely driven by atmospheric pressure gradients and winds offshore the west coast of North America (Checkley and Barth, 2009).

The California Current System (CCS) upwelling is generally lowest during the winter and increases to peak levels during the late spring and summer months (Black et al., 2011). From October to March, conditions in the eastern coast of the Pacific are predominantly downwelling: the water column is well-stratified, the standing stock of primary producers is low, and productivity is generally light or nutrient limited (White et al., 2014).

In the CCS, abrupt changes in zooplankton biomass and community structure on inter-annual scales are strongly linked to fluctuations of El Niño (Valencia et al., 2016). During El Niño a deepening of the nutricline (a zone within which nutrient levels decline rapidly with depth of water) is expected, consequently primary productivity decreases, as well as macrozooplankton biomass. However, individual taxa responses can vary for example the biomass of copepods and euphausiids (krill) underwent only a minor decrease during the El Niño of 1958-1959 (Lavaniegos et al., 2002).

Studies related to zooplankton variations during El Niño/La Niña events show that monthly-averaged copepod species richness was anomalously high throughout most of 1996-1998 and low from winter 1999 to autumn 2002. The proportion of euphausiids was similar during the period analyzed, but the proportions of copepods and salps changed. Copepods were more abundant during the El Niño Southern Oscillation peak, and salps more abundant in the transition phases between peaks (Lavaniegos et al., 2002).

Seasonality in regional coastal phytoplankton offshore California has also been reported, with concentrations of nano- and microphytoplankton lower during the winter and reach their maximum density in the summer (Trujillo et al., 2001). A study shows that the phytoplankton net primary production (NPP) in the CCS has a strong annual periodicity correlated with El Niño/La Niña events. During El Niño events, NPP had been reported to have a 30% reduction at a location 100 to 300 km (54 to 162 nmi) off southern California, meanwhile a 40% increase was observed off Baja California. During its peak, NPP decreased during El Niño by 10 to 15% in the 1,000-km band off Southern California but increased by 20 to 30% off Northern and Southern Baja. The total annual NPP was lowest during the El Niño years of 1997-1998 and peaked in 2000. Trends of increasing NPP and zooplankton volume were observed off Central and Southern California with the onset of La Niña (Kahru and Mitchell, 2002). The current El Niño/La Niña forecast for mid to late 2018 according to NOAA (2018) indicates a 50% chance for El Niño conditions in the fall of 2018 and a 65% chance of El Niño conditions in the winter of 2018.

Shifts in phytoplankton community composition are observed over the upwelling/downwelling seasonal progression. During upwelling events, diatoms numbers increase due to high nutrient levels, whereas dinoflagellate concentrations increase during the nutrient-depleted, stratified summer periods and during the phases that interrupt upwelling events.

Blooms of the dinoflagellate, *Akashiwo sanguinea*, have been reported in the U.S Pacific Northwest, off the California coast. In 2004, a large *A. sanguinea* (also known as *Gymnodinium splendens* or *Gymnodinium sanguineum*) bloom was observed in San Francisco Bay and attributed to an upper-atmosphere high-pressure anomaly following a summer of weak coastal upwelling. At some locations, *A. sanguinea* persisted well into November and December of 2009, when sea surface temperature was anomalously warm (White et al., 2014).

4.3.2 Fish/Fishery Resources

4.3.2.1 Coastal and Estuarine Species

The San Francisco Bay Estuary contains more than 100 species of fish, many of which complete all stages of life in the Estuary, while some anadromous fish migrate from ocean waters, through the Estuary, and into a series of freshwater streams where they spawn (URS Group, Inc. [URS], 2015). Sharks and Rays (Elasmobranchii) are found in the Estuary, in addition to various fish species that spawn offshore and are carried into the Estuary by currents. **Table 4-3** describes some of the common species found in the coastal and estuarine habitat of the San Francisco Bay Estuary.

Table 4-3. Example of species found within the San Francisco Bay Estuary (San Francisco Bay Conservation and Development Commission [BCDC], 2002; URS Group, Inc., 2015).

Common Name	Scientific Name	Species Details
Chinook Salmon	*Oncorhynchus tshawytscha*	• Migratory species. • Distributed in North America from the Monterey Bay area of California to the Chukchi Sea area of Alaska. • After a few years feeding in the ocean, they return to the streams or rivers to spawn, generally in summer or early fall. • Hatch in freshwater streams and rivers and migrate to the open ocean to feed.
Chum Salmon	*Oncorhynchus keta*	• Migratory species. • Distributed in the North Pacific (i.e., Korea, Japan, Okhotsk, Arctic Alaska, south to San Diego, California). • Spawns from late summer to March, with peak spawning in early winter when the river flows are high. • Hatch in freshwater streams and rivers and migrate to the open ocean.
Coho Salmon	*Oncorhynchus kisutch*	• Migratory species. • Occurs in the North Pacific Ocean and in most coastal streams and rivers from Alaska to central California. • Spends 1 to 2 years feeding in the ocean, then returns to their natal streams or rivers to spawn, generally in fall or early winter.
Denver Sole	*Microstomus pacificus*	• Found in the Pacific Ocean from the Bering Sea and western Aleutian Islands to southern Baja, California. • Dover sole live near the ocean floor and prefer soft bottom habitat in waters up to 1,400 m (4,593 ft) deep. • Spawning seasons vary by location and larvae usually settle to the bottom after a year of living in the upper water column.
English Sole	*Parophrys vetulus*	• Spawn from winter to early spring over soft muddy ocean floors in water 50 to 70 m (164 to 230 ft) deep. • After spawning, this species travels north to summer feeding grounds and returns south in the fall.
Flathead Sole	*Hippoglossoides elassodon*	• Migrate in winter along the outer continental shelf to feeding grounds in shallower water in the spring. • Spawning occurs from February to April in deeper waters.
Pacific Mackerel	*Scomber japonicus*	• Found from South Eastern Alaska to Mexico. • Mackerel perform inshore/offshore migration, with numbers increasing near the California coast from July to November. • Spawning timing varies depending on location, but often occurs from late April to September off California. Spawning is year-round off central Baja, California, peaking from June through October. • Commercial valuable species.
Pacific Sardine	*Sardinops sagax*	• Juvenile sardines perform a northward return migration, taking advantage of the surface manifestation of the poleward flowing California Undercurrent to assist migration (Weber et al., 2015).

Table 4-3. (Continued).

Common Name	Scientific Name	Species Details
White Seabass	*Atractoscion nobilis*	• Occurs primarily in southern California but in years of warmer sea surface temperatures, the spatial distribution shifts northward, up to San Francisco Bay. • Juvenile and adult white seabass are associated with kelp beds, which are affected by anomalously warm water. • During El Niño events anchovies and market squid (i.e., key prey items) are greatly reduced or absent in the Southern California Bight, however other prey items such as sardines increase in abundance during this event (Valero and Waterhouse, 2016). • Commercially important species.
Market Squid	*Doryteuthis opalescens*	• Spawning occurs April through October in central California and October through the end of April or May in southern California. • Spawning squid congregate in large schools near their spawning grounds, usually over sandy habitats. • The California market squid fishery is strongly affected by environmental and atmospheric conditions of the California Current System as well as El Niño/La Niña events. • Overall catches can be decreased during El Niño but then rebound with the increased upwelling of cooler La Niña phases (Pacific Fishery Management Council 2017; Jackson and Domeier, 2003).

4.3.2.2 Oceanic Species

Oceanic fish species include both pelagic and highly migratory species. Relevant groups that are present in oceanic waters from the California coast to the EPGP include tunas; billfish (i.e., marlin, swordfish, sailfish); dolphinfish; sharks and rays; salmon; sole; mackerels; sardines; seabass; and squid (**Table 4-4**). In general, highly migratory species are species with a wide geographic distribution and undertake migrations of significant and variable distances for reproduction and feeding purposes. They can spend part of their life cycle near coasts, however most are pelagic and live predominantly in open ocean habitats. Several species have their migratory routes in vicinity to the NPSG and the CCS. The NPSG is considered a large interconnected biome, however, the abundances of large fishes such as marlins, sharks, and tunas had been reduced from historical levels and populations of small mesopelagic fish species are now more abundant than in the past. These small mesopelagic fish species mostly feed on zooplankton and are consumed by bigger fishes, squids, seabirds and marine mammals (Choy et al., 2015; Davison and Asch, 2011). **Table 4-4** presents distribution, migration pattern, and spawning details for some of the common species found near the NPSG and the CCS.

Table 4-4. Distribution, migration pattern, and spawning details for some of the common species found near the North Pacific Subtropical Gyre and the California Current System.

Common Name	Scientific Name	Species Details
Yellowfin Tuna	*Thunnus albacares*	• Highly migratory species. • Does not spawn near California, but can be found when ocean temperatures are warm. • Spawning occurs in the southeastern Pacific, near Central America, during January and February. • Commercially important.

Table 4-4. (Continued).

Common Name	Scientific Name	Species Details
Skipjack Tuna	*Katsuwonus pelamis Euthynnus pelamis*	• Found off the coast of California in the fall when the water is warm and when currents are from either the south or southwest. • Does not spawn in California, but spawning occurs in the eastern Pacific in the summer months. • Commercially important.
Bigeye Tuna	*Thunnus obesus*	• Highly migratory species. • Distributed across Pacific, but the bulk of the catch is made toward eastern and western ends of the basin. • Spawns in Equatorial South Pacific between April and September. • Commercially important.
Albacore Tuna	*Thunnus alalunga*	• Typically conducts an expansive annual migration that begins in spring or early summer waters off Japan, continues throughout late summer into inshore waters off the United States Pacific coast, and ends late in the year in the Western Pacific Ocean. • Spawning takes place in the mid-Pacific. • Large specimens caught North West of the Hawaiian Islands in late summer carry nearly ripe eggs in their ovaries. • Fishing for Albacore takes place in waters 37 to 185 km (20 to 100 nmi) offshore central and southern California.
Pacific Bluefin	*Thunnus orientalis*	• Juveniles migrate to Eastern Pacific waters late in the first or second year of life. • Seasonal visitors to California waters from May to October. • Most of the U.S. catch is within 185 km (100 nmi) of the California coast. • Commercially important.
Wahoo	*Acanthocybium solandri*	• Found worldwide in tropical and subtropical waters • Popular game fish
Striped Marlin	*Kajikia audax Tetrapturus audax*	• Highly migratory species. • Abundant off the coast of California during summer from July to October.
Swordfish	*Xiphias gladius*	• Highly migratory species. • Occur worldwide in tropical and temperate seas. • Most encountered between the mainland and the Channel Islands off Southern California. • Spawning occurs offshore Hawaii from April until July.
Yellowtail Amberjack	*Seriola lalandi*	• Distributed from Chile to Canada and are also found in the Gulf of California at depths up to 70 m (230 ft). • Spawning occurs from June through October. • In California, most are caught between Point Conception and the Coronado Islands, Baja.
Dolphinfish	*Coryphaena hippurus Coryphaena equiselis*	• Highly migratory species. • Distributed widely in all oceanic waters, including coastal and open ocean areas. • Commercially important species that are usually caught by tuna troll lines and occasionally by purse-seines and driftnets.
Great White Shark	*Carcharodon carcharias*	• Found along the Pacific coast for most of the year. • In the spring, a migration pattern occurs, and the sharks move west into the open ocean and congregate approximately halfway between Hawaii and California (Jorgenson et al., 2009) at an area called *white shark café* possibly for reproduction or feeding. White sharks stay at the *café* from April to July.
Spiny Dogfish	*Squalus acanthias*	• Non-migratory species. • Found off Chile and Central Baja California to Alaska and Japan. • Common in nearshore waters and is long-lived.
Spinetail Devil Ray	*Mobula japanica*	• The southern Gulf of California serves as an important spring and summer mating/feeding ground for adults. • Pupping takes place offshore around offshore islands or seamounts.

Table 4-4. (Continued).

Common Name	Scientific Name	Species Details
Shortfin Mako Shark	*Isurus oxyrinchus*	• One of the larger sharks to inhabit California waters and tends to follow movements of warm water poleward in the summer.
Oceanic Whitetip	*Carcharhinus longimanus*	• Common by-catch of longline, purse-seine, and hand line fisheries worldwide.
Silky Shark	*Carcharhinus falciformis*	
Blue Shark	*Prionace glauca*	• Caught in the North Pacific as by-catch in the giant flying squid fishery by becoming entangled while preying on squids. • Commonly caught with hook and lines, pelagic trawls, and bottom trawls.

Numerous fish species that could occur in the area of deployment in the EPGP are classified by the IUCN as either Vulnerable or Endangered. **Table 4-5** summarizes the Vulnerable or Endangered species that may be found in the open ocean in the vicinity of the OCS deployment.

Table 4-5. Species of pelagic fish that are classified as Vulnerable or Endangered that may be found in the vicinity of the OCS Eastern Pacific Garbage Patch deployment location. Source: IUCN Red List, 2017.

Family	Common Name	Scientific Name	IUCN Red List Status	Depth Range	Reference
Sphrynidae	Great hammerhead shark	*Sphyrna mokarran*	Endangered	Surface to 80 m (263 ft)	Compagno, 2007
	Scalloped hammerhead shark	*Sphyrna lewini*	Endangered	Surface to 275 m (902 ft)	Compagno, 2007
	Smooth hammerhead shark	*Sphyrna zygaena*	Vulnerable	Surface to 200 m (656 ft)	Ebert, 2003
Rhincodontidae	Whale shark	*Rhincodon typus*	Endangered	Surface to >1,900 m (>6,234)	Tyminski et al., 2015
Lamnidae	Short fin mako shark	*Isurus oxyrinchus*	Vulnerable	Surface to 500 m (1,640 ft)	Compagno, 2001
	Great white shark	*Carcharodon carcharias*	Vulnerable	Surface to 250 m (820 ft)	Compagno, 2001
Molidae	Ocean sunfish	*Mola mola*	Vulnerable	Surface to 400 m (1,312 ft)	Cartamil and Lowe, 2004
Alophiidae	Pelagic thresher shark	*Alopias pelagicus*	Vulnerable	Surface to 150 m (492 ft)	Compagno, 2001
	Big eye thresher shark	*Alopias superciliosus*	Vulnerable	Surface to 725 m (2,379 ft), mostly below 100 m (328 ft)	Compagno, 2001
	Common thresher shark	*Alopias vulpinus*	Vulnerable	Surface to 366 m (1,200 ft)	Compagno, 1984
Carcharhinidae	Oceanic whitetip shark	*Carcharhinus longimanus*	Vulnerable	Surface to 150 m (492 ft)	Froese and Daniel, 2013
Cetorhinidae	Basking Shark	*Cetorhinus maximus*	Vulnerable	Surface to 1,000 m (3,300 ft)	Shepard et al., 2006
Mobulidae	Giant manta ray	*Manta birostris*	Vulnerable	Surface to 120 m (394 ft)	Mundy, 2005
Squalidae	Spiny dogfish	*Squalus acanthias*	Vulnerable	20 to 800 m (66 to 2,625 ft)	Fordham et al., 2016
Scombridae	Bigeye tuna	*Thunnus obesus*	Vulnerable	Surface to 1,500 m (4,921 ft)	Collette et al., 2011
	Pacific bluefin tuna	*Thunnus orientalis*	Vulnerable	Surface to 550 m (1,804 ft)	Collette and Nauen, 1983

IUCN = International Union for Conservation of Nature; OCS = The Ocean Cleanup System.

4.3.3 Marine Mammals

In the north-eastern Pacific Ocean region, there are 42 species of marine mammals representing two taxonomic orders: Cetacea (baleen whales, toothed whales, dolphins, and porpoises) and Carnivora (true seals and eared seals) (Jefferson et al., 2008).

All marine mammals within waters under the jurisdiction of the United States are protected under the MMPA of 1972. Some species are further protected under the ESA of 1973. Under the ESA, a species is considered *endangered* if it is "in danger of extinction throughout all or a significant portion of its range." A species is considered *threatened* if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The MMPA prohibits, with certain exceptions, the 'take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. Some marine mammal species or specific *stocks* (defined as a group of nonspecific individuals that are managed separately [Wang, 2002]) may be designated as *strategic* under the MMPA, which requires the jurisdictional agency (NMFS or USFWS) to impose additional protection measures. A stock is considered strategic if:

- direct human-caused mortality exceeds its *Potential Biological Removal* level (defined as the maximum number of animals, not including natural mortality, that can be removed from the stock while allowing the stock to reach or maintain its optimum sustainable population level);
- it is listed under the ESA;
- it is declining and likely to be listed under the ESA; or
- it is designated as depleted under the MMPA.

The IUCN Red List provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e., those listed as *Critically Endangered*, *Endangered*, and *Vulnerable*). The current MMPA, ESA, and IUCN status of each marine mammal species that may occur within the project area are provided in the following sections.

4.3.3.1 Whales, Dolphins, and Porpoises (Order Cetacea)

Baleen Whales (Suborder Mysticeti)

Eight species of baleen (mysticete) whales are known to occur in the waters of the North Pacific Ocean (**Table 4-6**). These include four species classified as 'Endangered', three as 'Least Concern' and one as 'Data Deficient' in the IUCN Red List (**Table 4-6**; IUCN, 2017). Data deficient means that there is not sufficient information to assess their status. The sei, blue, fin, and North Pacific right whales are the endangered species, while the minke, gray, and humpback are species of least concern. The Bryde's whale is data deficient. All species are listed as 'migratory'. While the minke and fin are migratory, they can also be present year-round in some locations.

Table 4-6. Mysticete whales present from California coast to the North Pacific Ocean.

Common Name	Scientific Name	Migratory	IUCN Red List Status[1]	ESA Status[2]	NOAA Stock and Status[3]	Entanglement Known	Reference
Common Minke Whale (North Pacific subspecies)	*Balaenoptera acutorostrata scammoni*	Yes, but some are present year-round	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	Yes	Reilly et al., 2008a

Table 4-6. (Continued).

Common Name	Scientific Name	Migratory	IUCN Red List Status[1]	ESA Status[2]	NOAA Stock and Status[3]	Entanglement Known	Reference
Sei Whale (Northern Hemisphere subspecies)	*Balaenoptera b. borealis*	Yes	Endangered	Endangered	Eastern North Pacific Stock, Strategic	Yes	Reilly et al., 2008b
Bryde's whale	*Balaenoptera edeni*	Yes	Data Deficient	Not Listed	Eastern Tropical Pacific Stock, Not Strategic	No	Reilly et al. 2008c
Blue Whale (Northern Hemisphere subspecies)	*Balaenoptera m. musculus*	Yes	Endangered	Endangered	Eastern North Pacific Stock, Strategic	No	Reilly et al., 2008d
Fin Whale (Northern Hemisphere subspecies)	*Balaenoptera p. physalus*	Yes, but some have year-round residency	Endangered	Endangered	California/Oregon/ Washington Stock, Strategic	No	Reilly et al., 20013
Gray Whale	*Eschrichtius robustus*	Yes	Least Concern	Not Listed	Eastern North Pacific Stock, Not Strategic	No	Reilly et al., 2008e
North Pacific Right Whale	*Eubalaena japonica*	Yes	Endangered	Endangered	Eastern North Pacific, Strategic	No	Reilly et al., 2008f
Humpback Whale (North Pacific subspecies)	*Megaptera novaeangliae kuzira*	Yes	Least Concern	Endangered	California/Oregon/ Washington, Strategic	Yes	Reilly et al., 2008g

ESA = Endangered Species Act; IUCN = International Union for the Conservation of Nature; NOAA = National Oceanic and Atmospheric Administration.

Common Minke Whale (Balaenoptera acutorostrata)

The common minke whale is a small mysticete whale that is divided into three subspecies. The subspecies *B. a. scammoni* occurs within the North Pacific (Committee on Taxonomy, 2017). Adult common minke whales reach a length of up to 10.7 m (35 ft) (Jefferson et al., 2008).

Distribution

The minke whale has a cosmopolitan distribution and occurs in polar, temperate, and tropical waters. In the Pacific, minke whales are usually seen over continental shelves (Brueggeman et al., 1990). The distribution of common minke whales in the northern Pacific Ocean is shown in North Pacific animals within the extreme northern part of their range are believed to be migratory, but in inland waters of Washington and in central California they appear to establish home ranges (Dorsey et al., 1990). Minke whales occur year-round in California (Dohl et al., 1983; Forney et al., 1995; Barlow, 1997). Although minke whales are relatively common within their northern range (Bering and Chukchi seas and in the Gulf of Alaska), they are not considered abundant in any other part of the eastern Pacific (Leatherwood et al., 1982; Brueggeman et al., 1990).

Auditory and Vocalization Range

Minke whale vocalizations are low-frequency, ranging from 80 Hz to 20 kHz range (Winn and Perkins, 1976; Frankel, 2002). It is classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz22 kHz) (Southall et al., 2007).

Status

Minke whales off the coasts of Washington, Oregon, and California are included within the California/Oregon/Washington stock. Minke whales are not listed as Endangered under the ESA and are not considered Depleted or Strategic under the MMPA. The IUCN Red List classifies them as a species of **Least Concern**.

Sei Whale (Balaenoptera borealis)

The sei whale is a large mysticete whale that is divided into two subspecies. The subspecies *B. b. borealis* occurs within the Northern Hemisphere (Committee on Taxonomy, 2017). Adult sei whales reach length of 12 to 18 m (40 to 60 ft) (Jefferson et al., 2008).

Distribution

Sei whales have a cosmopolitan distribution and occur in subtropical, temperate, and subpolar waters around the world but appear to prefer temperate waters in the mid-latitudes. The entire distribution and movement patterns of this species is not well known. Sei whales are distributed in oceanic waters and do not appear to be associated with coastal features. This species may unpredictably and randomly occur in a specific area, sometimes in large numbers. Sei whales' summer distribution is known to be mainly north of 40° latitude. While little is known about the species' winter distribution (Reilly et al., 2008b), animals migrate southward to lower latitudes. Blue whales in the north pacific range from the eastern region to the California coastline (Reilly et al., 2008d), and are reported as relatively common off California (Calambokidis and Barlow, 2004). Similar to sei whales, blue whales migrate from high latitude winter grounds to low latitude breeding grounds. The extent of their distribution in low to mid latitudes is uncertain.

Auditory and Vocalization Range

Recorded vocalizations of sei whales range from 432 Hz to 3.5 kHz (Thompson et al., 1979; Knowlton et al., 1991; McDonald et al., 2005). While there are no direct hearing data available (Ketten, 2000), sei whales are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

Status

Sei whales within the eastern North Pacific are included within the Eastern North Pacific Stock. Sei whales are listed as **Endangered** under the ESA, and the Eastern North Pacific stock is considered as a **Depleted** and **Strategic** stock under the MMPA. The IUCN Red List also classifies them as **Endangered**.

Bryde's Whale (Balaenoptera edeni)

The IUCN regards the Bryde's whale as a species "complex" - meaning its classification remains unclear; there are at least two and maybe three Bryde's whale species (Reilly et al., 2008c). Currently, there are two recognized subspecies. The subspecies *B. e. brydei* occurs within the North Pacific (Committee on Taxonomy, 2017). Bryde's whales can reach lengths of about 13 to 16.5 m (40 to 55 ft).

Distribution

Bryde's whales have a circumglobal distribution in tropical and subtropical waters and are distributed widely across the tropical and warm-temperate Pacific (Leatherwood et al., 1982). They are also the most common baleen whale in the central Gulf of California (Tershy et al., 1990). Sightings and acoustic recordings of Bryde's whales in southern California waters have increased in the past decade (Kerosky et al., 2012, Smultea et al., 2012), possibly signaling a northward range expansion (Kerosky et al., 2012).

Auditory and Vocalization Range

Bryde’s whale vocalizations are low-frequency, ranging from 20 to 900 Hz (Cummings, 1985; Oleson et al., 2003). The species is classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

Status

Bryde's whales are not listed as Threatened or Endangered under the ESA. Bryde's whales in the eastern tropical Pacific would not be considered a Strategic stock under the MMPA. The IUCN Red List also classifies them as a **Data Deficient** species.

Blue Whale (Balaenoptera musculus)

The blue whale is the largest whale species and is divided into five subspecies. The subspecies *B. m. musculus* occurs within the Northern Hemisphere (Committee on Taxonomy, 2017). North Pacific blue whales were once thought to comprise five separate populations (Reeves et al., 1998). Recent acoustic evidence suggests only two populations, in the eastern and western north Pacific, respectively (Stafford et al., 2001, Stafford, 2003, McDonald et al., 2006, Monnahan et al., 2014). Adult blue whales reach length of up to about 33 m (110 ft) (Jefferson et al., 2008).

Distribution

The blue whale is a cosmopolitan species, found in all oceans except the Arctic and some regional seas such as the Mediterranean, Okhotsk, and Bering Seas (Reilly et al., 2008d).

Blue whales commonly occur within offshore waters (Rice, 1998); however, individuals are occasionally sighted in relatively shallow water. In particular, there are a few locations in the world where blue whales are known to migrate through near-coastal relatively shallow areas Jefferson et al., 2008).

Auditory and Vocalization Range

Blue whales produce a variety of low-frequency sounds in the 10 to 200 Hz band (Stafford et al., 1998, 1999a,b, 2001; Frankel, 2002). Short sequences of rapid frequency modulated calls below 90 Hz are associated with animals in social groups (Moore and DeMaster, 1999; Mellinger and Clark, 2003). Most blue whale vocalizations are low-frequency, ranging from 17 to 20 Hz. Sound intensity of blue whale vocalizations are the loudest of any animal (188 dB) (Sears, 2002). While there are no direct hearing data available (Ketten, 2000), blue whales are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

Status

The northern hemisphere subspecies of the blue whale is listed as an **Endangered** species and consequently the Eastern North Pacific stock is automatically considered a **Depleted** and **Strategic** stock under the MMPA. The IUCN Red List also classifies the blue whale as an **Endangered** species.

Fin Whale (Balaenoptera physalus)

The fin whale is a large baleen whale species and is divided into three subspecies. The subspecies *B. p. physalus* occurs within the Northern Hemisphere (Committee on Taxonomy, 2017). Fin whales attain a maximum length of about 22 m (75 ft) in the Northern Hemisphere.

Distribution

The Northern Hemisphere fin whale likely includes both distinct Pacific and Atlantic subspecies (Archer et al., 2013). Fin whales occur year-round off the central and southern California coast (Reilly et al., 2013). In summer, they occur off the entire coast of western North America from California into the Gulf of Alaska. While there appears to be some migration of fin whales, acoustic data suggests that overall there is no marked seasonality in distribution in the North Pacific (Watkins et al., 2000).

Fin whales have a similar known distribution as sei and blue whales. However, this species is known to be distributed further north than the latter species. Fin whales occur year-round off south and central California (Reilly et al., 2013), in the Gulf of California (Urbán et al*.,* 2005), and in Hawaiian waters (Angliss and Outlaw, 2005). Fin whales in the Gulf of California constitute a genetically isolated subpopulation (Bérubé et al., 2002). In summer, their distribution extends north up to the region around the Gulf of Alaska and the Okhotsk Sea (Reilly et al., 2013; Angliss and Outlaw, 2005).

Auditory and Vocalization Range

Fin whale vocalizations are low-frequency, generally below 70 Hz but ranging up to 750 Hz (Clark et al., 2002). While there are no direct hearing data available (Ketten, 2000), fin whales are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

Status

The fin whale is formally listed as **Endangered** under the ESA, and consequently the California to Washington stock is automatically considered as a **Depleted** and **Strategic** stock under the MMPA. The IUCN Red List also classifies the fin whale as an **Endangered** species (Reilly et al., 2013).

Gray Whale (Eschrichtius robustus)

The gray whale includes one species, although genetic comparisons indicate there are distinct Eastern North Pacific and Western North Pacific population stocks (LeDuc et al*.,* 2002; Lang et al., 2011; Weller et al., 2013). Gray whales mostly feed on tube-dwelling amphipods, and polychaete tube worms on the seabed, but can also prey on crabs, baitfish, crab larvae, amphipods, eggs and larvae, and cephalopods).

Distribution

Most gray whales in the Eastern North Pacific population feed in the Chukchi, Beaufort and northwestern Bering Seas during summer and fall; however, there is a relatively small number of whales (approximately 200) that summer and feed along the Pacific coast between Kodiak Island, Alaska and northern California (Darling, 1984, Gosho et al., 2011, Calambokidis et al., 2012) and are referred to as the Pacific Coast Feeding Group. During winter, there are three primary wintering lagoons in Baja California, Mexico (Jones, 1990). While gray whales were once more widely distributed, they now only occur in North Pacific and adjacent waters. The eastern North Pacific population migrates from summer foraging grounds in the Chukchi, Beaufort, and Bering Seas to winter breeding grounds off Baja California. Some (presumably a small number) also summer and forage between coastal Vancouver Island to central California.

Auditory and Vocalization Range

Gray whales have a limited call repertoire (six distinct calls) and produce low frequency calls – generally ranging between 100 to 2,000 Hz. They are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

In 1994, the Eastern North Pacific stock of gray whales was removed from the List of Endangered and Threatened Wildlife, as it was no longer considered endangered or threatened under the ESA. Pacific Coast Feeding Group gray whales do not currently have a formal status under the MMPA, though the population size appears to have been stable since 2003, based on photo-ID studies (Calambokidis et al. 2014, IWC 2012). The IUCN Red List classifies the gray whale as a species of **Least Concern** (Reilly et al., 2008e).

North Pacific Right Whale (Eubalaena japonica)

Right whales are large baleen whales. The North Pacific right whale is the largest of the three right whale species (Jefferson et al., 2008). Adults are generally 13.7 to 16.7 m (45 to 55 ft) in length.

<u>Distribution</u>

North Pacific right whales inhabit waters of the Pacific Ocean, particularly between 20° and 60° latitude. Few sightings of right whales occur in the central North Pacific and Bering Sea. Sightings have been reported as far south as central Baja California and Hawaii, and as far north as the sub-Arctic waters of the Bering Sea and sea of Okhotsk in the summer. They are considered vagrant in California, Oregon, and Washington (Reilly et al., 2008f). They primarily occur in coastal or shelf waters, although movements over deep waters are known. For much of the year, their distribution is strongly correlated to the distribution of their prey. Two areas within the Gulf of Alaska and within the Bering Sea are designated as critical habitat for the North Pacific right whale (73 FR 19000).

<u>Auditory and Vocalization Range</u>

Morphometric analyses of inner ears from stranded North Atlantic right whales (*Eubalaena glacialis*) were used for development of a preliminary model of the frequency range of hearing. From these results, the estimated hearing range of right whales is 10 Hz to 22 kHz (Parks et al., 2007). They are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

<u>Status</u>

The right whale is listed as **Endangered** under the ESA, and therefore designated as **Depleted** under the MMPA. In 2008, NMFS relisted the North Pacific right whale as **Endangered** as a separate species from the North Atlantic congener, *Eubalaena glacialis* (73 FR 12024). Therefore, the stock (Eastern North Pacific stock) is classified as **Strategic**. The IUCN Red List classifies the North Pacific right whale as **Endangered** (Reilly et al., 2008f).

Humpback Whale (Megaptera novaeangliae)

The humpback whale is a large baleen whale species and is divided into three subspecies. The subspecies *M. novaeangliae kuzira* occurs within the North Pacific Ocean (Committee on Taxonomy, 2017). Fin whales attain a length of 18 to 22 m (60 to 75 ft) in the Northern Hemisphere.

<u>Distribution</u>

Humpback whales live in all major oceans from the equator to sub-polar latitudes, including the project area. Nearly all populations undertake seasonal migrations between tropical and sub-tropical winter calving and breeding grounds and high-latitude summer feeding grounds.

NMFS convened the Humpback Whale Biological Review Team to conduct a comprehensive review of the status of humpback whales as the basis for considering revisions to this species' listing status. The Biological Review Team evaluated available data sets (e.g., genetic data, tagging data, photographic-ID data), and determined that there are at least 14 distinct population segments (DPSs) of humpback whales (81 FR 62260). It is likely or certain that there is some mixing between these populations, though the DPSs are still considered distinct.

Humpback whales are also a cosmopolitan species (Clapham and Mead, 1999). In the North Pacific, humpback whales migrate from high latitude summer grounds to low latitude winter grounds where they breed (Clapham, 2002). Calving and mating generally occur in coastal waters. In summer, humpback whales range in their distribution from southern California to the roughly the region around Alaska, the Bering Sea and over to northeastern Japan. In winter, these humpback whales occur off islands from Hawaii to northern Philippines and off the coast of Mexico and Central America. In areas off California, humpback whales have been reported to feed on euphausids and sardines (Clapham et al., 1997).

The northeastern Pacific Ocean, including the project area, includes three humpback whale DPSs: Hawaii, Central America, and Mexico (NMFS, 2017).

Auditory and Vocalization Range

Humpback song is known to range from at least 20 Hz to at least 8 kHz. They are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al., 2007).

Status

Currently, the ESA lists the Central America DPS as **Endangered**, the Mexico DPS is listed as **Threatened**, and the Hawaii DPS as **Not at Risk** (81 FR 62260). The IUCN Red List classifies the North Pacific right whale as a species of **Least Concern** (Reilly et al., 2008g).

Odontocete (Toothed) Whales, Dolphins, and Porpoises

Twenty-five species of toothed (odontocete) whales and dolphins are known to occur in the waters of the North Pacific Ocean (**Table 4-7**). These include one species (sperm whale) classified as "Vulnerable" under the IUCN Red List (and 'Endangered' under the ESA). All other odontocete species are listed as "Least Concern" or "Data Deficient" under the IUCN Red List and are not listed under the ESA.

Table 4-7. Toothed whales (Family Odontoceti) present between the California coast and the North Pacific Ocean.

Scientific Name	Common Name	IUCN Red List Status	ESA Status[2]	NOAA Stock and Status[3]	Entanglement Known	Reference
Berardius bairdii	Baird's beaked whale	Data deficient	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Taylor et al., 2008a
Delphinus capensis	Long-beaked common dolphin	Data deficient	Not Listed	California Stock, Not Strategic	No	Hammond et al., 2008a
Delphinus delphis	Short-beaked common dolphin	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	Yes	Hammond et al., 2008b
Feresa attenuata	Pygmy killer whale	Data deficient	Not Listed	n/a	No	Taylor et al., 2008b
Globicephala macrorhynchus	Short-finned pilot whale	Data deficient	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Taylor et al., 2011

Table 4-7. (Continued).

Scientific Name	Common Name	IUCN Red List Status	ESA Status[2]	NOAA Stock and Status[3]	Entanglement Known	Reference
Grampus griseus	Risso's dolphin	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Taylor et al., 2012a
Kogia breviceps	Pygmy sperm whale	Data Deficient	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Taylor et al., 2012b
Kogia sima	Dwarf sperm whale	Data Deficient	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Taylor et al., 2012c
Lagenorhynchus obliquidens	Pacific white-sided dolphin	Least Concern	Not Listed	California/Oregon/ Washington, Northern and Southern Stocks, Not Strategic	No	Hammond et al., 2012a
Lissodelphis borealis	Northern-right whale dolphin	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Hammond et al., 2012b
Mesoplodon carlhubbsi	Hubbs' beaked whale	Data deficient	Not Listed	n/a	No	Taylor et al., 2008c
Mesoplodon densirostris	Blainville's beaked whale	Data deficient	Not Listed	n/a	No	Taylor et al., 2008d
Mesoplodon ginkgodens	Ginko-toothed beaked whale	Data deficient	Not Listed	n/a	No	Taylor et al., 2008e
Indopacetus pacificus	Indo-Pacific beaked whale, or Longman's beaked whale	Data deficient	Not Listed	n/a	No	Taylor et al., 2008f
Orcinus orca	Killer whale, or Orca	Data Deficient	Southern Resident Stock (Endangered); Other Stocks (Not Listed)	Southern Resident Stock (Strategic); West Coast Transient (Not Strategic); Offshore Stock (Not Strategic)	No	Reeves et al., 2017
Phocoena phocoena	Harbor porpoise	Least Concern	Not Listed	San Francisco-Russian River Stock, Not Strategic	No	Hammond et al., 2008c
Phocoenoides dalli	Dall's porpoise	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Hammond et al., 2012c
Physeter macrocephalus	Sperm whale	Vulnerabl e	Endangered	California/Oregon/ Washington Stock, Strategic	No	Taylor et al., 2008g
Pseudorca crassidens	False killer whale	Data Deficient	Endangered	n/a	No	Taylor et al., 2008h
Stenella attenuata	Pantropical spotted dolphin	Least Concern	Not Listed	n/a	No	Hammond et al., 2012d
Stenella coeruleoalba	Striped dolphin	Least Concern	Not Listed	California/Oregon/ Washington Stock, Not Strategic	No	Hammond et al., 2008d
Stenella longirostris	Spinner dolphin	Data Deficient	Not Listed	n/a	No	Bearzi et al., 2012
Steno bredanensis	Rough-toothed dolphin	Least Concern	Not Listed	n/a	No	Hammond et al., 2012e
Tursiops truncatus	Common bottlenose dolphin	Least Concern	Not Listed	Coastal California Stock, Not Strategic	Yes	Hammond et al., 2012f
Ziphius cavirostris	Cuvier's beaked whale	Least Concern	Not Listed	California/Oregon/ Washington Stock, Strategic	No	Taylor et al., 2008i

ESA = Endangered Species Act; IUCN = International Union for the Conservation of Nature; NOAA = National Oceanic and Atmospheric Administration.

Baird's Beaked Whale (*Berardius bairdii*)

The Baird's beaked whale is the largest member of the beaked whale family (Ziphiidae). Females reach lengths of about 13 m (40 ft) and can weigh approximately 12,000 kg (26,400 lb) (Jefferson et al., 2008). They feed on pelagic fish and gadiform fishes, cephalopods, and crustaceans living near the seabed (Balcomb, 1989; Kasuya, 2002), as well as some pelagic fish, such as mackerel, sardines, and saury.

Observations of Baird's beaked whales along the U.S. west coast have been primarily along the continental slope from late spring to early fall. Observations of this species are less frequently during the colder water months of November through April, when animals are presumed to be farther offshore (Carretta et al., 2017). Animals off the U.S. west coast (and within the project area belong to the California/Oregon/Washington management stock.

Distribution

The Baird's beaked whale is distributed in the North Pacific Ocean and adjacent seas, and are known to occur from the southern range of the Gulf of California to Honshu (Japan), however the limits of their range in oceanic waters are not well known (Balcomb, 1989; Kasuya, 2002). There are an estimated 1,100 Baird's beaked whales in the eastern North Pacific, and no information on trends for the species. Baird's beaked whales occur in deep oceanic waters, and sometimes in waters closer to shore where deep water occur near the coast. Baird's beaked whales have generally been sighted near the continental slope and oceanic seamounts (Kasuya, 2002) at depths of 1,000 to 3,000 m (3,281 to 9,843 ft).

Status

Currently, the Baird's beaked whale is not listed under the ESA. The California/Oregon/Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the North Pacific right whale as a **Data Deficient** species (IUCN, 2017).

Long-beaked Common Dolphin (*Delphinus capensis*)

Long-beaked common dolphins are relatively small dolphins that may reach lengths of 1.9 to 2.6 m (6 to 8.5 ft) and may weigh between 80 to 235 kg (160 and 500 lb) (Jefferson et al., 2008). They are commonly found within about 93 km (50 nmi) of the coast, primarily inshore of the 250-m (820-ft) isobaths, with very few sightings (<15%) in waters deeper than 500 m (1,640 ft) (Carretta et al., 2017). Animals off the coast of California belong to the California management stock (Carretta et al., 2017).

Distribution

The distribution of long-beaked common dolphins is not well in many locations, but not known in many others. Generally, this species if found in nearshore water within approximately 180 km of coastlines (Heyning and Perrin, 1994). Long-beaked common dolphins between California and Mexico are part of large populations estimated at 55,000 within Pacific coast waters of the Mexican EEZ and 69,000 in the Gulf of California (Gerrodette and Palacios, 1996).

Status

Currently, the long-beaked common dolphin is not listed under the ESA. The California stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the long-beaked common dolphin as a **Data Deficient** species (IUCN, 2017).

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is a small dolphin that may reach approximately 2.7 m (9 ft) in length and may weigh about 200 kg (440 lb) (Jefferson et al., 2008). They prefer oceanic and offshore waters that are warm tropical to cool temperate (10 to 28 °C or 52 to 88°F). They also prefer waters altered by underwater geologic features where upwelling occurs (Hammond et al., 2008b). Animals off the U.S. west coast belong to the California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

The short-beaked common dolphin is widely distributed in tropical and temperate waters, including within the Pacific Ocean (Perrin, 2002). Almost 3 million have been estimated for the eastern tropical Pacific and around 352,000 for the U.S. west coast (Gerrodette and Forcada, 2002). This species occurs in offshore and near coastal waters. In some locations, common dolphins show seasonal changes in abundance (Forney and Barlow, 1998). Short beaked common dolphins in the Eastern Tropical Pacific have been sighted in association with yellowfin tuna, and prey on schooling fish and squid (Perrin, 2002) and have been found to interact with tuna purse-seine fishing operations (Gerrodette, 2002). They often forage in upwelling areas with steep sea floor gradients (Reilly, 1990; Fiedler and Reilly, 1994).

Status

Currently, the short-beaked common dolphin is not listed under the ESA. The California stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the long-beaked common dolphin as a species of **Least Concern** (IUCN, 2017).

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is a small member of the dolphin group. They can reach a length of 2.6 m (8.5 ft) and may weigh up to 170 kg (380 lb) (Jefferson et al., 2008). The pygmy killer whales forage on fish and squid (Perryman and Foster, 1980). However, little is known about their diet. Animals that may occur within the project area are currently not included in any management stock.

Distribution

The pygmy killer whale occurs in tropical and subtropical offshore oceanic waters around the world, and close to the coast where there are deep waters. There appears to be uncommon with 38,900 of these whales estimated in the eastern tropical Pacific (Wade and Gerrodette, 1993).

Status

Currently, the pygmy killer whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Short-finned pilot whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is a larger member of the dolphin group reaching average lengths of 5.5 m (18 ft) and weights of 1,000 to 3,000 kg (2,200 to 6,600 lb) Jefferson et al., 2008). The species are thought to mainly target squid, but also take fish in deep waters over the outer continental shelf or continental slope. Animals that may occur within the project area are members of the California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

Short-finned pilot whales are distributed in warm temperate to tropical waters around the world. The species generally has been sighted in deep offshore waters (Reilly and Shane, 1986, Olson and Reilly, 2002). The estimated abundance of the species in the eastern tropical Pacific is around 590,000 (Gerrodette and Forcada, 2002), off the west coast of North America is approximately 300, and off Hawaiian waters is around 8,800 (Barlow, 2006). The Gulf of Mexico contains over 2,300 short-finned pilot whales (Mullin and Fulling, 2004).

Status

Currently, the short-finned pilot whale is not listed under the ESA. The California/Oregon/ Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Risso's Dolphin (*Grampus griseus*)

The Risso's dolphin is a medium-sized cetacean that can reach lengths of approximately 2.6 to 4 m (8.5 to 13 ft) and weigh 300 to 500 kg (660 to 1,100 lb). It is found in temperate, subtropical and tropical waters of 10 to 30°C (50 to 86°F) with depths generally greater than 1,000 m (3,300 ft) (Jefferson et al., 2008). Prey targeted by Risso's dolphin include squid and crustaceans. Risso's dolphins within the project area are members of the MMPA California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

Risso's dolphins are widely distributed from the tropical to temperate waters (Kruse et al., 1999). The species occurs mostly in deep waters of the continental slope, outer shelf, and in oceanic areas beyond the shelf slope in the eastern tropical Pacific. Among many other locations, it also occurs in the Gulf of California. While no global estimates are available, estimated abundance of Risso's Dolphins off California ranged from almost 4,000 in summer to 32,000 in winter (Forney and Barlow, 1998). Abundance estimates of populations off California, Oregon, and Washington has been estimated at approximately 16,000 (Barlow, 2003). In Hawaiian waters, estimates are around 2,000. In the eastern tropical Pacific, around 175,000 animals have been estimated (Wade and Gerrodette, 1993).

Status

Currently, the Risso's dolphin is not listed under the ESA. The California/Oregon/Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the Risso's dolphin as a species of **Least Concern** (IUCN, 2017).

Pygmy sperm whale (*Kogia breviceps*)

The pygmy sperm whale is a small cetacean that may reach lengths of up to about 3.5 m (11.5 ft) and weigh between 315 to 450 kg (700-1,000 lb) (Jefferson et al., 2008). It prefers tropical, subtropical, and temperate waters in oceans and seas worldwide. They are most common along the waters seaward of the continental shelf edge and the slope; and in most areas, are thought to be more "oceanic" and "anti-tropical" than dwarf sperm whales (see below) (Jefferson et al., 2008). Pygmy sperm whales are known to feed on cephalopods, deep sea fishes and shrimp (Aguiar-Dos Santos and Haimovici, 2001; McAlpine et al., 1997). Pygmy sperm whales within the project area are members of the MMPA California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

Pygmy sperm whales are distributed in all tropical to warm temperate oceans (McAlpine, 2002). The species' range is poorly known, and no global abundance estimates available, however estimates off California, Oregon, and Washington are around 250 (Barlow, 2003). Estimates off Hawaii are higher, around 7,000 (Barlow, 2006). Pygmy sperm whales are reported to occur in oceanic waters beyond the edge of the continental shelf.

Status

Currently, the pygmy sperm whale is not listed under the ESA. The California/Oregon/Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the pygmy sperm whale as a **Data Deficient** species (IUCN, 2017).

Dwarf Sperm Whale (*Kogia sima*)

The dwarf sperm whale is a small cetacean that can reach lengths of up to about 2.7 m (9 ft) and weigh between 135 to 270 kg (300 to 600 lb). It prefers warm tropical, subtropical, and temperate waters worldwide, and is most common along the waters of the continental shelf edge and the slope. Dwarf sperm whales are thought to occur in shallower depths than pygmy sperm whales (Jefferson et al., 2008). Like pygmy sperm whales, dwarf sperm whales appear to feed on cephalopods in deep water, among other prey species (Aguiar-Dos Santos and Haimovici, 2001). Pygmy sperm whales within the project area are members of the MMPA California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

The dwarf sperm whale appears to be distributed widely in offshore waters of tropical and warm temperate areas (Caldwell and Caldwell, 1989). Like the pygmy sperm whale, no global estimates of the population are available. Off Hawaii, estimates are around 19,000, and in the eastern tropical Pacific around 11,200 (Wade and Gerrodette, 1993). Off Hawaii, site fidelity has been recorded (Baird et al., 2006).

Status

Currently, the dwarf sperm whale is not listed under the ESA. The California/Oregon/Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the dwarf sperm whale as a **Data Deficient** species (IUCN, 2017).

Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

The Pacific white-sided dolphin reaches a length of 1.7 to 2.5 m (5.5 to 8.0 ft) and may weigh between 135 to 180 kg (300 to 400 lb). They are extremely playful and highly social animals. Schools of thousands of Pacific white-sided dolphins are occasionally observed, but group size generally ranges from 10 to 100 animals. They inhabit waters from the continental shelf to the deep open ocean (Jefferson et al., 2008). The species feed on cephalopods and small pelagic schooling fish such as lanternfish, anchovies, saury, horse mackerel, and hake (Brownell et al., 1999).

Pacific white-sided dolphins within the project area are members of the MMPA California/Oregon/Washington Northern management stock (Carretta et al., 2017).

Distribution

Pacific white-sided dolphins occur in temperate waters of the North Pacific and adjacent seas (Brownell et al., 1999, Van Waerebeek and Würsig, 2002). In the central North Pacific, abundance estimates range from 900,000 to 1 million (Buckland et al., 1993, Miyashita, 1993a), however these are considered to likely be overestimated (Buckland et al., 1993). Abundance estimates off the U.S. West Coast are between 13,000 and 122,000 individuals (Forney et al., 1995). Pacific white-sided dolphins occur in shelf and slope waters of continental margins (Carretta et al., 2006), and in some inland waterways such as off British Columbia (Heise, 1997).

Status

Currently, the Pacific white-sided dolphin is not listed under the ESA. The California/Oregon/ Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the dwarf sperm whale as a species of **Least Concern** (IUCN, 2017).

Northern Right Whale Dolphin (*Lissodelphis borealis*)

The northern right whale dolphin may reach lengths of approximately 2 to 3 m (6.5 to 10 ft) and may weigh between 60 to 115 kg (130 and 250 lb). They are generally found in waters over the continental shelf and slope that are colder than 19°C (66°F) (Jefferson et al., 2008). Northern right whale dolphins feed on cephalopods and mid-water fishes, among other species (such as market squid and lanternfish off southern California). Northern right whale dolphins within the project area are members of the MMPA California/Oregon/Washington Northern management stock (Carretta et al., 2017).

Distribution

The northern right whale dolphin has been sighted in the North Pacific Ocean in deep, temperate waters. Estimates of abundance are available for some geographical regions. In the oceanic North Pacific, between 307,000 and 400,000 animals have been estimated (Buckland et al., 1993; Miyashita, 1993a; Hiramatsu, 1993). The distribution in the eastern North Pacific appears to vary seasonally (Forney and Barlow, 1998), with abundance estimates along the U.S. West Coast ranging between around 9,000 to 21,000 dolphins (Forney et al., 1995). This species occurs in deep oceanic off the outer continental shelf, and sometimes closer to the coast in deep water areas (including in the California Current system; Jefferson et al., 1994).

Status

Currently, the northern right whale dolphin is not listed under the ESA. The California/Oregon/ Washington stock is not classified as Depleted or Strategic (Carretta et al., 2017). The IUCN Red List classifies the dwarf sperm whale as a species of **Least Concern** (IUCN, 2017).

Hubb's Beaked Whale (*Mesoplodon carlhubbsi*)

The Hubb's beaked whale is a poorly known species, and few specimens (less than 60 records) have been examined. These specimens were up to 5.32 m in length. They are not constituents of a MMPA management stock. The species is oceanic, feeding on squid and deepwater fishes. There are no abundance estimates.

Distribution

Hubbs' beaked whale is only known to occur off central British Columbia down to southern California, and off Japan (Mead, 1989; MacLeod et al., 2006), and is thought to occur across the North Pacific (MacLeod et al., 2006). Nothing is known about movements within either parts of their range and nothing is known from the high seas.

Status

Currently, the Hubb's beaked whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Blainville's beaked whale (*Mesoplodon densirostris*)

The Blainville's beaked whale can reach lengths of approximately 4.5 to 6 m (15 to 20 ft) and may weigh 820 to 1,030 kg (1,800 to 2,300 lb). They are generally found in deep, offshore waters of the continental shelf. This species is often associated with steep underwater geologic structures such as banks, submarine canyons, seamounts, and continental slopes (Jefferson et al., 2008). Blainville's beaked whale feeds on squid and some deepwater fish (Heyning and Mead, 1996). Animals that may occur within the project area are currently not included in any MMPA management stock.

Distribution

The distribution of Blainville's beaked whales is considered the most extensive of the *Mesoplodon* genus. They have a cosmopolitan distribution throughout the world's oceans and range from the Mediterranean, England, Iceland, Nova Scotia (Canada), Brazil and South Africa in the Atlantic; to California, Chile, Japan, New Zealand and Australia in the Pacific. It appears to be relatively common in tropical waters (Reeves et al., 2003). This species appears to occur mostly in deep offshore waters, but can occur closer to shore in deep waters (MacLeod and Zuur, 2005).

Status

Currently, the Blainville's beaked whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

Ginkgo-toothed beaked whales are more robust than most *Mesoplodon* species, reaching lengths of 4.9 m (16 ft). The species does not appear to be very common anywhere. This species is thought to primarily feed on squid and some fish. Animals that may occur within the project area are currently not included in any MMPA management stock.

Distribution

The ginkgo-toothed beaked whale has been sighted in deep, oceanic temperate and tropical waters of the Indo-Pacific Ocean, among other locations (Mead, 1989; Pitman, 2002), and is thought to occur across the Pacific and into the eastern Indian Ocean (MacLeod et al., 2006).

Status

Currently, the Ginkgo-toothed beaked whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Longman's Beaked Whale (*Indopacetus pacificus*)

The Longman's beaked whale is considered one of the least known cetacean species. Compared to other *Mesoplodon* species, it is relatively large, reaching lengths of about 6 to 9 m _20 to 30 ft). Their weight is unknown (Jefferson et al., 2008). They live in generally warm (21 to 31°C [69.8 to 87.8°F]) and deep (greater than 1,000 m [3,300 ft]) waters. The species appears to primarily feed on cephalopods (Yamada, 2003). Animals that may occur within the project area are currently not included in any MMPA management stock.

<u>Distribution</u>

Longman's beaked whales do not appear to be common. Sightings have been from the tropical and subtropical Indo-Pacific, with abundance estimates off Hawaii of 1,007 individuals and 291 in the eastern North Pacific (Ferguson and Barlow, 2001; Barlow, 2006).

<u>Status</u>

Currently, the Longman's beaked whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Killer Whale (*Orcinus orca*)

The killer whale is a large cetacean, with males reaching up to 10 m (32 ft) in length and 10,000 kg (22,000 lb) in weight. Genetic studies and morphological evidence suggest the existence of multiple species or subspecies of killer whales worldwide. Killer whales are most abundant in colder waters, but may be fairly abundant in temperate waters. Killer whales also occur, though at lower densities, in tropical, subtropical, and offshore waters. Their diet is often geographic or population specific, and may include fishes, marine mammals, and sea birds (Jefferson et al., 2008).

Killer whales within the project area may be members of three MMPA management stocks: 1) the Southern Resident Stock (occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California; 2) the West Coast Transient Stock (occurring from California through southeastern Alaska); and 3) the Offshore Stock (occurring from California through Alaska) (Carretta et al., 2017).

<u>Distribution</u>

Killer whales are a cosmopolitan species, occurring worldwide (Forney and Wade, 2006). Killer whales tend to be more common along continental margins and in temperate and polar waters than tropical waters. Global abundance estimates have resulted in 50,000 killer whales, however more accurate population-specific estimates have been made. Estimates of killer whales in the eastern tropical Pacific are at around 8,500 (Wade and Gerrodette, 1993). The killer whale population in Baja California in Mexico has been estimated at 86 individuals (Guerrero-Ruiz et al., 1998); off Hawaii 430 individuals (Barlow 2003); 90 individual in inland waters off Washington and southern British Columbia (Ford et al., 2000, Krahn et al., 2004); the resident subpopulation of British Columbia estimated at 216 individuals (Ford et al. 2000; Angliss and Outlaw 2005); the west coast transient subpopulation includes 314 individuals (Ford and Ellis, 1999; Angliss and Outlaw, 2005); 211 individuals of the offshore type killer whales off British Columbia to California (Ford et al., 2000; Black et al., 1997), 251 individuals from the Aleutian Islands to the Gulf of Alaska (Zerbini et al., 2007); and 700-800 individuals in the western North Pacific (Miranova et al., 2002). These animals occur in a diversity of habitats ranging from the surf zones, to river mouths, enclosed seas and open oceans. Overall, killer whales are reported as being most common within continental margins (Forney and Wade, 2006).

Status

The Southern Resident killer whale stock is listed as **Endangered** under the ESA and **Strategic** under the MMPA. Other stocks present within the project area are not listed under the ESA or Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies the killer whale as a **Data Deficient** species (IUCN, 2017).

Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise is a small cetacean, reaching lengths of 1.5 to 1.7 m (5 to 5.5 ft) and weighing from 61 to 77 kg (135 to 170 lb). They are commonly found in bays, estuaries, harbors, and fjords less than 200 m (650 ft) deep (Jefferson et al., 2008). Harbor porpoises target a wide variety of fish and cephalopods (Smith and Gaskin, 1974; Recchia and Read, 1989; Fontaine et al., 1994; Gonzales et al., 1994; Aarefjord et al., 1995; Gannon et al., 1998; Read, 1999; Börjesson et al., 2003; Santos et al., 2004; Reeves and Notarbartolo di Sciara, 2006). Harbor porpoises within the project area are members of the MMPA San Francisco-Russian River management stock (Carretta et al., 2017).

Distribution

Harbor porpoises occur in cold temperate and sub-polar waters in the Northern Hemisphere (Gaskin, 1992, Read, 1999) in continental shelf waters and sometimes in deeper offshore waters. In the eastern North Pacific, they range from central California to the Chukchi Seas.

Status

Harbor porpoise in California are not listed as Threatened or Endangered under the ESA or as Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Dall’s Porpoise (*Phocoenoides dalli*)

The Dall’s porpoise can reach a maximum length of approximately 2.4 m (8 ft) and may weigh up to 220 kg (480 lb)). They can be found in offshore, inshore, and nearshore oceanic waters (Jefferson et al., 2008). Dall's Porpoise forage on a wide range of fish and squid, among other prey (e.g., krill, shrimps) (Houck and Jefferson, 1999; Jefferson, 2002a). Dall’s porpoises within the project area are members of the MMPA California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

Dall's porpoises occur only in the northern North Pacific Ocean and adjacent seas in deep waters (Jefferson, 1988; Houck and Jefferson, 1999), from the west coast of North America to Japan. Dall’s porpoise occurs in offshore deep waters and in fjords and channels (Miyashita and Kasuya, 1988; Jefferson, 1988; Rice, 1998).

Status

The Dall’s porpoise is not listed as Threatened or Endangered under the ESA or as Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is a large cetacean, with adult males reaching approximately 16 m (52 ft) and 40,823 kg (45 tons) in weight. Sperm whales commonly inhabit areas with a water depth of 600 m (1,968 ft) or more, and are uncommon in waters less than 300 m (984 ft) deep. Sperm whales forage on cephalopods and fish, among other species (Jefferson et al., 2008). Sperm whales within the project area are members of the California/Oregon/Washington management stock (Carretta et al., 2017).

Distribution

The sperm whale is widely distributed around the world (Rice, 1989). It generally occurs along the continental slope and in deeper waters. Sperm whales are distributed across the entire North Pacific and into the southern Bering Sea in summer, but the majority are thought to be south of 40°N in winter. They are found year-round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November (Carretta et al., 2015). Sperm whale population trend estimates indicate that a pre-whaling global population may have been around 1,100,000 and have been reduced by approximately 67% (Whitehead, 2002).

Status

Sperm whales are formally listed as **Endangered** under the ESA, and consequently the California/Oregon/Washington stock is automatically considered as a **Depleted** and **Strategic** stock under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a **Vulnerable** species (IUCN, 2017).

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is a large member of the dolphin family. Males reach lengths of almost 6 m (20 ft) and weigh approximately 700 kg (1,500 lb)). False killer whales mostly occur in relatively deep offshore waters (Stacey et al., 1994; Odell and McClune, 1999), but also occur in some partially enclosed seas and bays. False killer whales mostly forage on fish and cephalopods, but can attack small cetaceans (Baird et al., 2008). False killer whales within the project area are not included within a separate MMPA management stock.

Distribution

False killer whales are found in tropical to warm temperate waters in all oceans. Abundance off Hawaii has been estimated to be 268 (Barlow, 2006). In the eastern tropical Pacific, abundance has been estimated at 39,800 (Wade and Gerrodette, 1993). However, no global estimates are available.

Status

Currently, the false killer whale is not listed under the ESA. The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin is a relatively small dolphin species, reaching lengths of 2 m (7 ft) and weighing approximately 114 kg (250 lb) at adulthood. They spend the majority of daylight hours in shallower water (usually between 90 to 300 m [300 and 1,000 ft] deep). At night, they dive into deeper waters to search for prey. Spotted dolphins prey on fishes, squids, and crustaceans

(Robertson and Chivers, 1997). Pantropical spotted dolphins within the project area are not included within a separate MMPA management stock.

Distribution

The spotted dolphin occurs in all oceans between around 40°N and 40°S. It is more abundant in lower latitudes. In the eastern Pacific, over 220,000 coastal animals were estimated in 2000 (Gerrodette and Forcada, 2002), and offshore in the eastern North Pacific estimates were 737,000 in 2003 (CV=15%; Gerrodette et al., 2005), 24% of what they were estimated to be approximately 45 years earlier (Reilly et al., 2005). Within the eastern Pacific, spotted dolphins occur in greatest numbers in the region north of the Equator (the "Inner Tropical" waters).

Status

Currently, the pantropical spotted dolphin is not listed under the ESA. The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin can reach lengths of approximately 2.7 m (9 ft) and may weigh up to 160 kg (350 lb) for males. They prefer highly productive tropical to warm temperate oceanic waters (10 to 26°C or 52 to 84°F), and are often linked to upwelling areas and convergence zones (Jefferson et al., 2008). Striped dolphins forage on a wide variety of fish and squids in continental slope or oceanic regions (Wurtz and Marrale, 1993; Hassani et al., 1997; Archer, 2002). Striped dolphins that occur within the project area are members of the California/Oregon/Washington management stock.

Distribution

Striped dolphins are widely distributed in tropical and warm temperate oceans and seas. They are commonly encountered in warm offshore waters of California (Carretta et al., 2017). The striped dolphin abundance in the western North Pacific was estimated as 570,000 (Miyashita, 1993b). In the eastern tropical Pacific, population estimates were over 1,400,000 (Gerrodette et al., 2005). Off Hawaii, numbers are estimated at above 13,000 (Barlow, 2006). Striped dolphins in the North Pacific occur in oligotrophic waters of the central North Pacific gyre and in upwelling areas in the eastern tropical Pacific (Miyazaki et al., 1974; Reilly, 1990; Archer and Perrin, 1999; Balance et al., 2006).

Status

The striped dolphin is not listed as Threatened or Endangered under the ESA or as Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Spinner Dolphin (*Stenella longirostris*)

The spinner dolphin is relatively small, reaching lengths of 2 m (7 ft) and weighing approximately 59 to 77 kg (130 to 170 lb) at adulthood. In most places, spinner dolphins are found in the deep ocean where they likely track prey (Jefferson et al., 2008). Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and warm-temperate waters (Perrin et al., 2009). The Gray's (or pantropical) spinner dolphin (*Stenella longirostris longirostris*) is the most widely distributed subspecies and is found in the Atlantic, Indian, central and western Pacific Oceans, including the project area (Perrin et al., 1991). Spinner dolphins forage on a variety of fishes, squids, and shrimps (Perrin et al., 1973; Dolar et al., 2003). Spinner dolphins within the project area are not included within a separate MMPA management stock.

Distribution

Spinner dolphins occur in tropical and subtropical zones in both hemispheres, mainly around oceanic islands (Rice, 1998). Spinner dolphins occur in pelagic waters over the continental shelf in the eastern tropical Pacific and off Baja California (Perrin, 1990). Abundance estimates was around 801,000 individuals in the Eastern Tropical Pacific in 2000 (Gerrodette et al., 2005). In the Eastern Tropical Pacific, spinner dolphins can occur in very large numbers offshore from the coast.

Status

The spinner dolphin is not listed as Threatened or Endangered under the ESA (Carretta et al., 2017). The IUCN Red List classifies it as a **Data Deficient** species (IUCN, 2017).

Rough-toothed Dolphin (*Steno bredanensis*)

The Rough-toothed dolphin is a small member of the dolphin group that can grow up to 2.6 m (8.5 ft) long and about 160 kg (350 lb). They prefer deeper areas of tropical and warmer temperate waters where their prey is concentrated (Jefferson et al., 2008). Rough-toothed dolphins feed on cephalopods and fish (Pitman and Stinchcomb, 2002). Rough-toothed dolphins within the project area are not included within a separate MMPA management stock.

Distribution

The Rough-toothed dolphin occurs in deep tropical and subtropical waters (Jefferson, 2002b). Around 145,000 rough-toothed dolphins have been estimated to occur in the eastern tropical Pacific (Wade and Gerrodette, 1993), and almost 20,000 off Hawaii (Carretta et al., 2006). The rough-toothed dolphin mainly in waters beyond the continental shelf (Maigret, 1994), but can be seen closer to the coast in deep areas with a steep seabed gradient (Ritter, 2002).

Status

The rough-toothed dolphin is not listed as Threatened or Endangered under the ESA or as Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Common Bottlenose Dolphin (*Tursiops truncatus*)

The common bottlenose dolphin ranges in lengths from 1.8 to 3.8 m (6.0 to 12.5 ft), and may weigh from 136 to 635 kg (300 to 1400 lb). It is found in temperate and tropical waters around the world. There are both coastal populations that inhabit bays, estuaries and river mouths as well as offshore populations that inhabit pelagic waters along the continental shelf and slope. Common bottlenose dolphins prey on a wide range of fish and squid (Barros and Odell, 1990, Barros and Wells, 1998, Blanco et al., 2001, Santos et al., 2001), and can prey on shrimps and other crustaceans.

Bottlenose dolphins within the project area are members of two management stocks: 1) California coastal stock; and 2) California, Oregon and Washington offshore stock (Carretta et al., 2017). California coastal stock bottlenose dolphins are found within about one kilometer of shore, and from central California south into Mexican waters, at least as far south as San Quintin, Mexico.

Distribution

Common bottlenose dolphins are distributed worldwide in tropical and temperate waters. This species occurs inshore, shelf, and oceanic waters (Leatherwood and Reeves, 1990, Wells and Scott, 1999, Reynolds et al., 2000). A minimum global estimate may be on the order of 600,000. In the east tropical Pacific around 240,000 common bottlenose dolphins have been estimated (Wade and Gerrodette, 1993), off Hawaii, over 3,000 (Barlow, 2006), in inshore waters off California around 300 (Dudzik et al., 2006), and offshore of California, Oregon, and Washington around 2,000 animals have been estimated (Taylor et al., 2008j).

Status

The common bottlenose dolphin is not listed as Threatened or Endangered under the ESA, and the California coastal stock and California/Oregon/Washington offshore stock are not Depleted under the MMPA (Carretta et al., 2017). The IUCN Red List classifies it as a species of **Least Concern** (IUCN, 2017).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

The Cuvier's beaked whale can reach lengths of about 4.5 to 7 m (15 to 23 ft) and weigh 1,845 to 3,090 kg (4,000 to 6,800 lb). It may be found in temperate, subtropical, and tropical waters of the continental slope and edge (usually where water depth is greater than 1,000 m [3,300 ft]), as well as around steep underwater geologic features like banks, seamounts and submarine canyons. It feeds mostly on squid, fish, and crustaceans (MacLeod et al., 2003). Cuvier's beaked whales that occur within the project area are members of the California/Oregon/Washington management stock.

Distribution

Cuvier's beaked whales are distributed in offshore waters from tropical waters to Polar Regions in both hemispheres (Heyning, 1989, 2002), and in some enclosed seas such as the Gulf of California. Cuvier's beaked whales appear to be common with a possible worldwide abundance around 100,000. In the eastern tropical Pacific, abundance estimated have been around 80,000 animals (Ferguson and Barlow, 2001). Off the United States west coast, estimated abundance was around 1,800 (Barlow, 2003). Off Hawaii, abundance estimates were around 15,000 (Barlow, 2006).

Status

The Cuvier's beaked whale is not listed under the ESA or as Depleted under the MMPA. However, evidence suggests a substantial likelihood of population decline of Cuvier's beaked whales in the California Current since the early 1990s. Given the long-term decline in Cuvier's beaked whale abundance in the region, the California/Oregon/Washington stock is considered **Strategic**. The degree of decline also suggests that this stock is likely below its carrying capacity and may be Depleted (Carretta et al., 2017).

4.3.3.2 Seals and Sea Lions

The unranked taxon Pinnipedia includes seals, sea lions, and walrus. Four eared seals (Family Otariidae) and three true seals (Family Phocidae) are known to occur in the waters between the Californian coast and the deployment area in the EPGP. These include five species classified by the IUCN as 'Least Concern', one 'Vulnerable', and one 'Near Threatened' (**Table 4-8**; IUCN, 2017). The Steller sea lion is near threatened, and the northern fur seal is vulnerable. Species of least concern include the Guadalupe fur seal, California sea lion, Northern elephant seal, and Pacific Harbor seal.

Seals and sea lions have specific core areas of distribution, however vagrants are commonly sighted outside of these core areas. Two species are listed as 'migratory', including the Northern fur seal and the Northern elephant seal. 'Migratory' species generally migrate during particular seasons or life stages.

Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion is the largest otariid seal, with adult males reaching a length of about 3.3 m (11 ft) and average weight of 1,000 kg (2,205 lb) (Jefferson et al., 2008). Bickham et al. (1996) provided evidence of a discrete genetic discontinuity of Steller sea lions at 144°W (based on mitochondrial DNA) control region sequences. Based on this information, two separate stocks of Steller sea lions were recognized within U.S. waters: an Eastern U.S. stock, which includes animals born east of Cape Suckling, Alaska (144°W), and a Western U.S. stock, which includes animals born at and west of Cape Suckling (Carretta et al., 2017). The U.S. population is divided into the Western and the Eastern DPSs at 144° West longitude (Cape Suckling, Alaska). Subsequent studies confirmed this genetic subdivision and recognized a third population, the Asian stock, also using the maternally inherited mitochondrial DNA genome (Phillips et al., 2009). Individuals from the eastern stock (and perhaps few western stock animals that may cross into the range of the eastern stock) are likely to be present within the project area.

<u>Distribution</u>

The Steller sea lion is distributed as far south as central California north to the Gulf of Alaska, through the Aleutian Islands, the Kamchatka Peninsula, across to the Japan and the Sea of Japan (Loughlin, 2009). Vagrants have been reported in China and Herschel Island (Rice, 1998).

Core habitat used by Steller sea lions mainly includes coastal and continental shelf waters. However, Steller sea lions occur in deep ocean waters in some areas. Offshore waters are accessed during regular foraging trips where adult sea lions target pelagic fish and invertebrates may dive to over 400 m (1,312 ft) in depth (Merrick and Loughlin, 1997; Fadely and Lander, 2012; Fadely et al., 2013; Gelatt and Sweeny, 2016). Steller sea lions can often be found in high numbers in areas of high prey concentrations and around fishing vessels (Gelatt and Sweeny, 2016). Steller sea lions breed in late spring and summer, with pupping occurring between May and July. During the non-breeding season (winter) females may engage in longer foraging trips (Merrick and Loughlin, 1997; Fadely and Lander, 2012; Fadely et al., 2013).

<u>Status</u>

The eastern DPS of the Steller sea lion is not listed under the ESA; however, the western DPS is listed as **Endangered** (NMFS, 2017). The species is classified as **Near Threatened** by the IUCN (IUCN, 2017).

Northern Fur Seal (*Callorhinus ursinus*)

The northern fur seal is an otariid seal that may attain lengths of 2.1 m (7 ft) and a weight of 270 kg (595 lb). They primarily use two types of habitat, including open ocean for foraging and rocky beaches for reproduction (NMFS, 2017).

Adult fur seals spend over 300 days per year foraging at sea, and often concentrate around major oceanographic features such as seamounts, canyons, valleys, and along the continental shelf break, based on the availability of prey. Breeding seals normally haul-out on rocky beaches, but colonies can also use broad sandy beaches. Animals that may occur within the project area are members of the California management stock.

Table 4-8. Seals and sea lions present from the California coast to the offshore area of the East Pacific Garbage Patch.

Scientific Name	Common Name	Migratory	IUCN Red List Status[1]	ESA Status[2]	NOAA Stock and Status[3]	Entanglement Known	Reference
Eared Seals (Family Otariidae)							
Arctocephalus philippii townsendi	Guadalupe fur seal	No	Least concern	Threatened	Mexico/ Strategic	Likely	Aurioles-Gamboa, 2015
Callorhinus ursinus	Northern fur seal	Yes	Vulnerable	Not Listed	California/ Not Strategic	Yes	Gelatt et al., 2015
Eumetopias jubatus jubatus	Steller sea lion	No	Near Threatened	Not Listed	Eastern/ Not Strategic	Yes	Committee on Taxonomy, 2017; Gelatt and Sweeney, 2016
Zalophus californianus	California sea lion	Yes	Least Concern	Not Listed	United States/ Not Strategic	Yes	Aurioles-Gamboa and Hernández-Camacho, 2015
True Seals (Family Phocidae)							
Mirounga angustirostris	Northern elephant seal	Yes	Least Concern	Not Listed	California Breeding/ Not Strategic	Yes	Hückstädt, 2015
Phoca vitulina richardii	Pacific harbor seal	No	Least Concern	Not Listed	California/ Not Strategic	Yes	Harvey, 2016.

ESA = Endangered Species Act; IUCN = International Union for the Conservation of Nature; NOAA = National Oceanic and Atmospheric Administration.

1. http://www.iucnredlist.org/search
2. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/esa.html
3. http://www.nmfs.noaa.gov/pr/sars/species.htm#phocids

Distribution

The Northern fur seal is distributed between the Bering Sea and California (Sterling et al., 2014). These seals spend most time during non-breeding periods in pelagic waters foraging in offshore areas and the edge of the continental shelf. Many migrate between the Bering Sea and California during non-breeding periods. During the breeding season, around June to August, Northern fur seals spend around 1 to 1.5 months on land.

Status

The California stock of the northern fur seal is currently not listed under the ESA and not classified as Depleted or Strategic, under the MMPA (Carretta et al., 2017). The IUCN classifies the species as **Vulnerable** (IUCN, 2017).

Guadalupe Fur Seal (*Arctocephalus townsendi*)

The Guadalupe fur seal is an otariid seal that may attain lengths of 2 m (7 ft) and a weight of 160 to 170 kg (353 to 375 lb) (Jefferson et al., 2008). They primarily use two types of habitat, including open ocean for foraging and rocky beaches for reproduction (NMFS, 2017). Guadalupe fur seals are solitary, non-social animals. Animals that may occur within the project area are members of the Mexico to California management stock (Carretta et al., 2017).

Distribution

Guadalupe fur seals are distributed mainly on islands along the coast of California, with vagrants reported as far as Washington State (Moss et al., 2006). Little is known about the breadth of their foraging activities and offshore distribution when at sea. However, evidence indicates that Guadalupe fur seals forage as far off the coast as several hundred kilometers. The breeding season is in summer, with the greatest number of pups being born on Guadalupe Island (around June; Wickens and York, 1997; IUCN, 2017).

Status

The Mexico to California stock of the Guadalupe fur seal is currently listed as **Threatened** under the ESA. The stock is also classified as **Strategic** under the MMPA (Carretta et al., 2017). The IUCN classifies the species as **Least Concern** (IUCN, 2017).

California Sea Lion (*Zalophus californianus*)

The California sea lion is an otariid seal that may attain lengths of 2.4 m (8 ft) and a weight of greater than 390 kg (860 lb) (Jefferson et al., 2008).

California sea lions occur in shallow coastal and estuarine waters. Sandy beaches are preferred for haul out sites. In California, they haul out on marina docks as well as jetties and buoys. California sea lions are social animals and form groups of several hundred individuals onshore (NMFS, 2017).

Distribution

California sea lions are distributed from the coast of Baja California to the Gulf of Alaska and the Aleutian Islands (Maniscalco et al., 2004; Aurioles-Gamboa and Hernández-Camacho, 2015). These sea lions forage on the continental shelf and slopes on fish and cephalopods on the benthos as well as within the pelagic region of the water column (García-Rodriquez and Aurioles-Gamboa, 2004;

Weise et al., 2010; Villegas-Amtmann et al., 2011). Pups are born in the northern summary between May and July (García-Aguilar and Aurioles-Gamboa, 2003).

Status

The U.S. stock of the California sea lion is currently not listed under the ESA. The stock is not classified as Depleted or Strategic under the MMPA (Carretta et al., 2017). The IUCN classifies the species as **Least Concern** (IUCN, 2017).

Northern Elephant Seal (*Mirounga angustirostris*)

The northern elephant seal is the largest phocid seal in the Northern Hemisphere. Males can reach lengths of over 4 m (13 ft) and can weigh nearly 2,000 kg (4,400 lb). They spend about 9 months each year in the ocean (NMFS, 2017). Northern elephant seals in the northern Pacific Ocean are included in the California management stock.

Distribution

Northern elephant seals are distributed throughout a large area of the eastern Pacific Ocean, from Baja California north of 27° latitude to the Gulf of Alaska and the Aleutian Islands (Le Boeuf et al., 2000, Robinson et al., 2012). Vagrants have been reported from the Midway Islands and Japan. Northern elephant seals forage as far offshore as 8,000 km (4,320 nmi), and can dive to depths greater than 1,700 m (5,577 ft) (Robinson et al., 2012). Pups are born on offshore islands off Baja California and California, with some born as far north as British Columbia (Lowry et al., 2014).

Status

The California stock of the northern elephant seal is currently not listed under the ESA. The stock is not classified as Depleted or Strategic under the MMPA (Carretta et al., 2017). The IUCN classifies the species as **Least Concern** (IUCN, 2017).

Harbor Seal (*Phoca vitulina richardii*)

The harbor seal is a phocid seal that may reach lengths of 1.9 m (6.2 ft) and weigh 70 to 150 kg (154 to 330 lb) (Jefferson et al., 2008). Two subspecies of the harbor seal exist in the Pacific: *P. v. stejnegeri* in the western North Pacific, near Japan, and *P. v. richardii* in the eastern North Pacific (Carretta et al., 2017). NOAA recognizes three stocks along the west coast of the continental U.S.: 1) California, 2) Oregon and Washington outer coast waters, and 3) inland waters of Washington (Carretta et al., 2017). Animals within the project area belong to the California stock. Harbor seals live in temperate coastal habitats and use rocks, reefs, beach, and drifting glacial ice as haul out and pupping sites.

Distribution

Pacific Harbor seals are distributed from temperate to polar regions in the North Pacific. Eastern Pacific Harbor seals range from Baja California to the Aleutian Islands (Rice, 1998). These seals forage on a range of species of fish, cephalopods and crustaceans in bays and estuaries, and coastal waters out to the continental shelf slope (Pitcher, 1980; Olesiuk et al., 1990; Lowry, 2016).

Status

The California stock of the harbor seal is currently not listed under the ESA. The stock is not classified as Depleted or Strategic under the MMPA (Carretta et al., 2017). The IUCN classifies the species as **Least Concern** (IUCN, 2017).

4.3.4 Sea Turtles

Five species of sea turtles may occur in the NPSG close to where the OCS will be deployed (**Table 4-9**). These five species of turtle are all categorized as vulnerable or endangered by the IUCN. All marine turtles that occur in the North Pacific are part of a specific subpopulation as defined by the IUCN (**Table 4-9**). These subpopulations differ genetically from other populations but also show different trends in occurrence and have separate status designations on the IUCN Red List.

Table 4-9. Sea turtle species in the Pacific Ocean.

Common Name	Scientific Name	Population	Habitat and Diet	IUCN Red List Status for the Population and (Subpopulation)
Loggerhead sea turtle	*Caretta caretta*	North Pacific Subpopulation	Occupies three different habitats – oceanic, neritic, and terrestrial (nesting only), depending upon life stage; omnivorous	Vulnerable (Least Concern)
Olive ridley sea turtle	*Lepidochelys oliviacea*	Pacific Subpopulation	Primarily pelagic, but may inhabit coastal areas, including bays and estuaries; most breed annually, with annual migration (pelagic foraging, to coastal breeding/nesting grounds, back to pelagic foraging); omnivorous, benthic feeder	Vulnerable (Vulnerable)
Leatherback sea turtle	*Dermochelys coriacea*	East Pacific Subpopulation	Pelagic, living in the open ocean and occasionally entering shallower water (bays, estuaries); omnivorous (jellyfish; other invertebrates, vertebrates, kelp, algae)	Vulnerable (Critically Endangered)
Green sea turtle	*Chelonia mydas*	Central North/Hawaiian subpopulation	Aquatic, but known to bask onshore; juvenile distribution unknown; omnivorous	Endangered (Least Concern)
Hawksbill sea turtle	*Eretmochelys imbricata*	Indo-Pacific/ East Pacific subpopulation	Pelagic; feeding changes from pelagic surface feeding to benthic, reef-associated feeding mode; opportunistic diet	Critically Endangered (Critically Endangered)

Extensive research is performed on bycatch of turtles (Wallace et al., 2013). Loggerheads, leatherbacks, and green turtles are especially susceptible to impacts from bycatch during fishery activities. While exact numbers on entanglement by discarded fishing gear (e.g., ghost nets, marine debris) are not available, a report by the NOAA Marine Debris Program (NOAA, 2014a) suggests that the percentage of entanglements of all sea turtles as 5%, and Macfadyen et al. (2009) suggests that the threat to marine turtles posed by fishing debris is comparable to the threat posed by active fishing efforts prior to the introduction of turtle exclusion devices. A study by Wilcox et al. (2014) estimated that the total number of turtles caught by the 8,690 ghost nets they sampled was between 4,866 and 14,600, assuming nets drift for 1 year. Research considered plastic ingestion, a phenomenon widely observed in all marine turtles. It is known that all turtle species interact with marine plastic, with ingestion and entanglement being the two main types of interaction (Gall and Thompson, 2015).

4.3.4.1 *Migration and Nesting*

All marine turtle species have their nesting season starting around June through October/November. During nesting, the species are found close to the nesting areas or are migrating back to these areas. From November to May, marine turtles are migrating and can be found in their migration area (**Table 4-10**). **Table 4-10** shows that all presented sea turtles may occur within the project area for nesting, foraging/migration purposes, or for both nesting and foraging/migration.

Table 4-10. Sea turtle species, their nesting and foraging areas, and feeding behavior for turtles found in the North Pacific Ocean (IUCN, 2017; NOAA 2014b,c, 2016a,b, 2017a).

Common Name	Primary Pacific Ocean Nesting Area	Nesting Season	Foraging/Migration Area	Feeding Behavior
Loggerhead sea turtle	Japanese Coast	June to November	North Pacific to Baja California.	Carnivorous, juveniles are omnivorous. Feed on bottom dwelling invertebrates such as horseshoe crabs, clams, mussels, and other invertebrates. During migration, they feed on floating mollusks, jellyfish, sponges, and flying fish.
Olive ridley sea turtle	Mexican west Coast	June to November	Along the west coast from Mexico to as far as Oregon. Within 1,931 km (1,043 nmi) offshore but spotted in the center of the subtropical gyre (140°W)	Omnivorous, shallow prey feeders (crabs, jellyfish, eggs, mollusks).
Leatherback sea turtle	Coast of Indonesia, Papua, Solomon Islands	June to November	Indonesia to California, Mexico	Gelatinivorous, only soft animals like jellyfish. Deep diving species.
Green sea turtle	Mexico, Hawaii, South Pacific islands	June to October	Pacific areas with seagrass	Herbivorous (sea grass, algae).
Hawksbill sea turtle	Hawaii and Pacific Islands	June to October	Tropical, found in mainly in areas with coral reefs. Migration area extents to the North Pacific.	Spongivorous (preferably sponges and animals in coral reefs).

4.3.4.2 *Loggerhead Sea Turtles*

Adult loggerhead sea turtles are primarily found in tropical and subtropical coastal waters, but they may be found in the open ocean during migration. Satellite tracking and modeling studies have shown that juvenile loggerhead sea turtles may use The Ocean Cleanup project area during migration (Kobayashi et al., 2008; Abecassis et al., 2013; Briscoe et al., 2016a,b). However, most juvenile loggerheads tracked by satellite tags were more commonly found in the northwest Pacific and not in The Ocean Cleanup project area (Abecassic et al., 2013).

Loggerheads do not nest in coastal California and are unlikely to be found in coastal areas. After the breeding season, females go to feeding areas on the continental shelf off the coast of Mexico. Mating occurs during migration. Adults feed on a wide variety of benthic fauna such as clams, crabs, sea urchins, sponges, and fish. Young turtles feed on jellyfish, *Sargassum*, gastropods, and crustaceans. The major threat to adult loggerheads is interactions with fisheries, including entanglement with longlines (Lewison et al., 2004).

4.3.4.3 *Olive Ridley Sea Turtle*

The Olive ridley turtle is a pantropical species that lives mainly in pelagic areas, but has been sighted in coastal areas. Olive ridley turtles do not nest in coastal California and are not normally seen in coastal areas surrounding San Francisco Bay. This species nests on the West coast of Mexico, but has been sighted as far north as Oregon. This turtle is omnivorous and feeds mainly on algae, lobster, crabs, tunicates, mollusks, shrimp, and fish (NOAA, 2014b).

4.3.4.4 Leatherback Sea Turtle

The leatherback turtle is better suited to cold waters than other sea turtles. This turtle is a highly pelagic species, which approaches the coastal waters during the breeding periods. Leatherback turtle migration pathways are poorly understood, but several recent studies employing satellite tags indicate that leatherbacks routinely migrate along a trans-Pacific route in search of food (Benson et al., 2006, 2011). Consequently, it is likely that leatherbacks will be present in the project area during the OCS deployment as well as during the towing between San Francisco and the project area.

The leatherback turtle does not nest in coastal California, but is routinely spotted in nearshore areas as the western Pacific subpopulation forages in the neritic zone off the western U.S. coast (Benson et al., 2006) and may be encountered in the tow test area in the nearshore area off the coast of California. The eastern Pacific subpopulation nests in Central America from Mexico to Ecuador (NOAA, 2016a). Leatherback turtles feed mainly on jellyfish, tunicates, and other epipelagic soft-bodied invertebrates.

4.3.4.5 Green Sea Turtles

Green turtles are widely distributed in tropical and subtropical waters near continental coasts and islands. Green turtles do not nest in coastal California, but have been identified in coastal areas from Baja California to southern Alaska, though they are most common south of San Diego (NOAA, 2016b). The primary nesting areas in the Pacific are in Mexico, the Hawaiian Islands, and many of the small islands in the south Pacific. Green sea turtles are entirely herbivorous, feeding mainly on algae and seagrasses (NOAA, 2016b).

4.3.5.6 Hawksbill Turtle

The hawksbill turtle is the most tropical of all sea turtles and does not nest in coastal California. Pacific nesting beaches are mainly on the Hawaiian Islands and south Pacific islands. The hawksbill turtle is carnivorous and feeds on a variety of organisms such as sponges and various invertebrates (NOAA, 2014c). It is possible that individuals from both the East Pacific and the Indo Pacific subpopulations may occur in the central Pacific near the deployment of the OCS.

4.3.5 Coastal and Oceanic Birds

4.3.5.1 Coastal Birds

The San Francisco Bay Estuary provides essential habitat for millions of birds on the Pacific Flyway; a bird migration corridor along the Pacific Coast that stretches as far north as northern Canada and Alaska, and as far south as the southern tip of South America (**Figure 4-1**). The Estuary is comprised of a wide variety of habitats such as tidal flats; ponds; tidal marshes; subtidal areas with eel grass and oyster beds; and open ocean areas that support a wide variety of waterbirds. Species present in the Estuary are a subset of waterbirds in the families Gaviidae (loons), Podicipedidae (grebes), Pelecanidae (pelicans), Phalacrocoracidae (cormorants), Ardeidae (herons, bitterns, and allies), Threskiornithidae (ibises and spoonbills), Rallidae (rails, gallinules, and coots), Gruidae (cranes), and Laridae (skuas, gulls, terns, and skimmers). Roughly 120 waterbird species occur in the San Francisco Bay Estuary (URS, 2015).

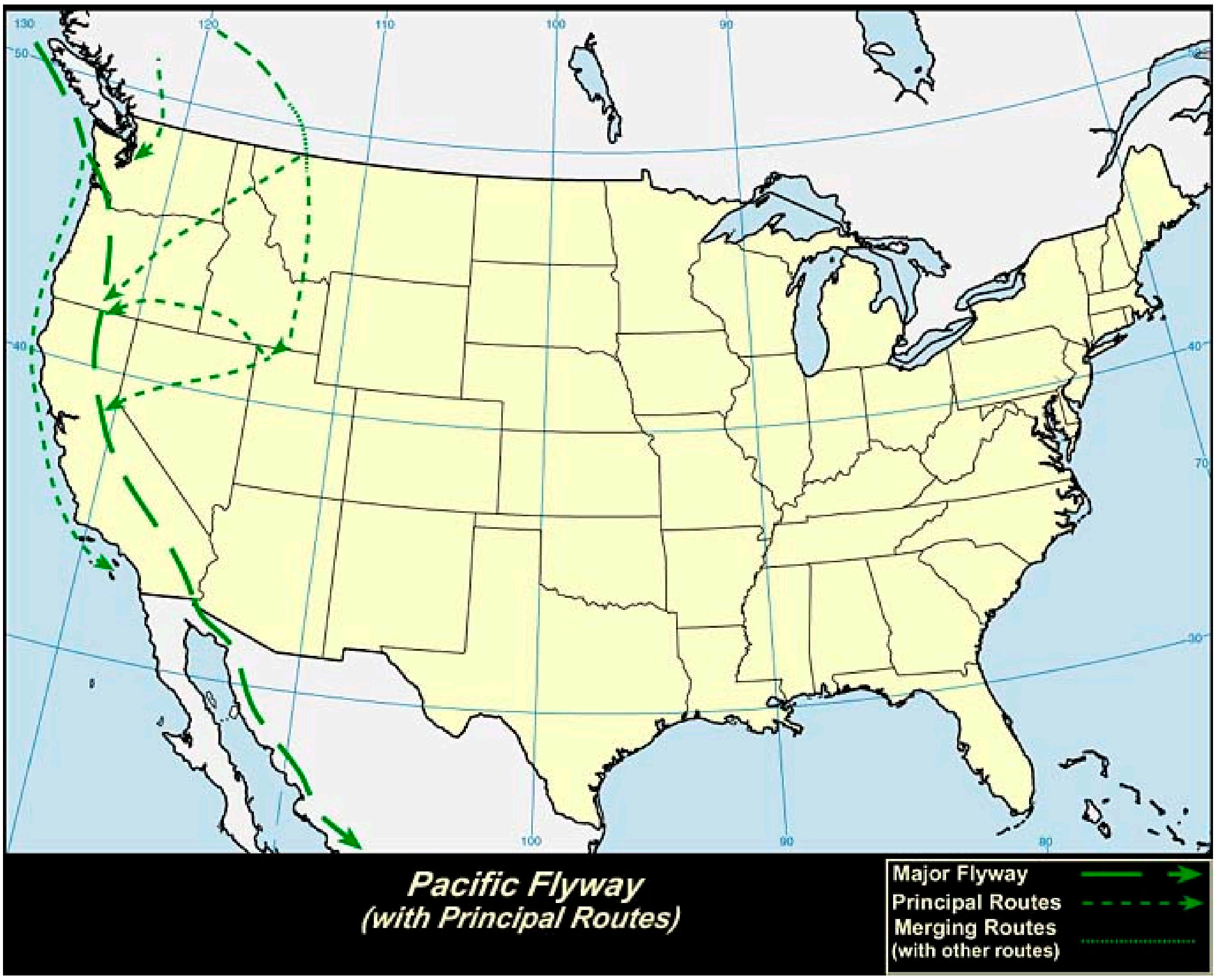

Figure 4-1. The Pacific flyway migration route (Image from: Songbirdgarden, 2017).

The Estuary is a major North American refuge for many species of waterfowl and shorebirds during their migration and wintering (August through April) periods, and provides breeding habitat during the summer for other species (e.g., mallard [*Anas platyrhynchos*], black-necked stilt [*Himantopus mexicanus*], snowy plover [*Charadrius nivosus*]). Furthermore, the Estuary is recognized as a Western Hemisphere Shorebird Reserve Network site of international importance for millions of shorebirds in migration and as the winter home for more than 50% of the diving ducks in the Pacific Flyway with one of the largest wintering populations of canvasbacks (*Aythya valisineria*) (Shuford, 2014; Western Hemisphere Shorebird Reserve Network [WHSNR], 2009). The Estuary functions as a refuge for gulls, terns, grebes, pelicans, egrets, raptors, rails, and many species of songbirds as well. Of the birds utilizing the Estuary area, approximately two-thirds are represented by three families: Anatidae (waterfowl), Laridae (gulls and terns), and Scolopacidae (sandpipers and phalaropes).

Some of the more common birds in the open waters of the Estuary are diving ducks, including canvasback, scoters, and scaup. Coastal waters near San Francisco Bay could be used for foraging by brown pelicans (*Pelecanus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), Forester's tern (*Sterna forsteri*), and other fish-eating birds, such as osprey (*Pandion haliaetus*) and belted kingfisher (*Megaceryle alcyon*).

Tidal flats within the Estuary are a primary foraging habitat for shorebirds such as Western sandpipers (*Calidris mauri*) and dunlins (*Calidris alpina*); dowitchers (*Limnodromus griseus* and *Limnodromus scolopaceus*); marbled godwits (*Limosa fedoa*); willets (*Tringa semipalmata*); and American avocets (*Recurvirostra americana*). Tidal marsh habitats of California, such as those of the

Bay Estuary, are extremely important to rails, holding the entire world and U.S. populations of the state and federally endangered Ridgway's Rail (formerly the California Clapper Rail [*Rallus longirostris obsoletus*]) and Light-footed Clapper Rail (*R. l. levipes*), respectively, and >90% of that of the California Black Rail (*Laterallus jamaicensis coturniculus*) (Shuford, 2014). **Table 4-11** lists the threatened and endangered birds found the San Francisco Bay Estuary.

Table 4-11. Threatened and endangered birds in the San Francisco Bay Estuary. Data compiled from the International Union for Conservation of Nature (IUCN, 2017) and the California Department of Fish and Wildlife (CDFW, 2017).

Common Name	Scientific Name	Foraging/ Migration Season	Foraging/ Migration Area	State/ Federal Status	IUCN Red List Status
Ridgway's Rail	*Rallus longirostris obsoletus*	Year Round	Tidal Marsh	SE, FE	Near Threatened (as *R. longirostris*)
Light-footed Clapper Rail	*Rallus longirostris levipes*	Year Round	Tidal Marsh	SE, FE	Least Concern (as *R. longirostris*)
California Black Rail	*Laterallus jamaicensis coturniculus*	Year Round	Tidal Marsh	ST	Near Threatened (as *L. jamaicensis*)
California Least Tern	*Sternula antillarum brownii*	September-May	Shallow estuary, Lagoons	SE, FE	Least Concern (as *S. antillarum*)
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Year Round	Intertidal zone, salt pans on marsh edges	FT	Least Concern (as *C. alexandrines*)

FE = Federally Listed as Endangered; FT = Federally Listed as Threatened; SE = State Listed as Endangered; ST = State Listed as Threatened.

Some waterbird species utilize both coastal and oceanic environments offshore of San Francisco Bay such as California brown pelicans which roost on the Farallon Islands during summer and autumn. Peregrine falcons (*Falco peregrinus*) are known to winter on the islands and species breeding on the islands include the American coot (*Fulica americana*), cinnamon teal (*Anas cyanoptera*), gadwall (*Anas strepera*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), killdeer (*Charadrius vociferus*), mallard (*Anas platyrhynchos*), and the pied-billed grebe (*Podilymbus podiceps*) (Pyle and Henderson, 1991). The majority of these bird species are present and feed in the coastal and open waters of the Pacific Ocean.

4.3.5.2 Oceanic Birds

Seabird species that may occur either offshore San Francisco or in the deployment area in the EPGP, including approximately 12 species of seabirds that breed in the San Francisco Bay area, and an additional 35 species of migrant seabirds which regularly visit the north-central Pacific Coast and its offshore islands (Pyle, 2001). Species breeding on the Farallon Islands include the American black oystercatcher (*Haematopus bachmani*), ashy storm-petrel (*Oceanodroma homochroa*), Brandt's cormorant (*Phalacrocorax penicillatus*), Cassin's auklet (*Ptychoramphus aleuticus*), common murre (*Uria aalge*), double-crested cormorant (*Phalacrocorax auritus*), Leach's storm-petrel (*Oceanodroma leucorhoa*), pelagic cormorant (*Phalacrocorax pelagicus*), pigeon guillemot (*Cepphus columba*), rhinoceros auklet (*Cerorhinca monocerata*), tufted puffin (*Fratercula cirrhata*), and western gull (*Larus occidentalis*). Migrant seabirds that are regular visitors to the Gulf of the Farallones, but do not breed there, include Pacific and red-throated loons (*Gavia pacifica* and *Gavia stellata*); red-necked and western grebes (*Podiceps grisegena* and *Aechmophorus occidentalis*); black-footed albatross (*Phoebastria nigripes*); pink-footed (*Puffinus creatopus*); Buller's (*Puffinus bulleri*); and black-vented shearwaters (*Puffinus opisthomelas*); herring and glaucous-winged gulls (*Larus argentatus* and *Larus glaucescens*); and black and surf scoters (*Melanitta americana* and *Melanitta* *perspicillata*). Furthermore, about 25 additional species of nonbreeding seabirds have been recorded rarely or as vagrants in the Farallones (Pyle, 2001).

4.3.5.3 North Pacific Subtropical Gyre

Orders of seabirds relevant to the project area include Procellariiformes (e.g., albatrosses, petrels); Pelecaniformes (e.g., pelicans, cormorants, boobies, frigate birds) (**Figure 4-2**); Charadriiformes (e.g., gulls, terns, alcids); Gaviiformes (loons); and Podicipediformes (grebes). Seabirds can be highly pelagic, coastal, or in some cases spend a part of the year away from the sea entirely.

Figure 4-2. Brown Booby (*Sula leicocaster*) spotted by The Ocean Cleanup in the Great Pacific Garbage Patch.

In the open ocean waters of the NPSG, mainly pelagic seabirds are present (**Table 4-12**), especially during their migratory period. Pelagic seabirds present in the Gyre, nest along coastal areas or on islands in the Pacific Ocean. Hawaii is an important nesting area for albatrosses, while other islands in the South Pacific or along the coast of California are used by seabirds for breeding (**Table 4-12**). In the North Pacific, breeding generally occurs during spring and summer. When not breeding, these birds forage along the Californian coastline or in the open ocean. The CCS is an attractive area for birds due to its high nutrient content and corresponding high prey availability (Sydeman et al., 2012). Species migrate great distances to feed within the CCS.

Table 4-12. Common birds in the North Pacific Ocean. Data compiled from IUCN and BirdLife International.

Common Name	Scientific Name	Foraging/ Migration Season	Foraging/Migration Area	IUCN Red List Status
Brown Booby	*Sula leucocaster*	Year Round	Pacific Ocean	Least Concern
Red footed Booby	*Sula sula*	March-October	Open Ocean, only in far South of Northeast Pacific and Hawaii	Least Concern
Masked Booby	*Sula dactylatra*	Year Round	Open Ocean, only in South Northeast Pacific and Hawaii	Least Concern
Black-footed Albatross	*Phoebastria nigripes*	May-October	North Pacific Ocean	Near Threatened
Laysan Albatross	*Phoebastria immutabilis*	August-November	North Pacific Ocean. Seen in Northeastern Pacific but prefers West Pacific side	Near Threatened
Short tailed Albatross	*Phoebastria albatrus*	June-October	North pacific-especially Alaska but spotted around Hawaii and California	Vulnerable
Ashy Storm-petrel	*Oceanodroma homochroa*	November-April	California Current System	Endangered

Table 4-12. (Continued).

Common Name	Scientific Name	Foraging/ Migration Season	Foraging/Migration Area	IUCN Red List Status
Black-vented Shearwater	*Puffinus opisthomelas*	July-February	California Current System and North Pacific	Near Threatened
Cassin's Auklet	*Ptychoramphus aleuticus*	Year Round	Along North American West Coast	Near Threatened
Murphy's Petrel	*Pterodroma ultima*	November-April	Between Hawaii and California, at least 64 km (35 nmi) offshore	Near Threatened
Pink-footed Shearwater	*Puffinus creatopus*	April - October	Along continental shelf of U.S. West coast and Canada	Vulnerable
Wedged-Tailed Shearwater	*Ardenna pacifica*	Year Round	Tropical oceans (35°N-35°S)	Least Concern
Sooty Shearwater	*Ardenna grisea*	April - October	Circular migration, Full Pacific Ocean	Near Threatened
Leach Storm Petrel	*Hydrobates leucorhous*	November-April	Pacific Ocean	Least Concern

IUCN = International Union for Conservation of Nature.

4.3.6 Protected Areas

There are no protected areas in the vicinity of the OCS deployment location in the EPGP. However, depending on the exact towing route chosen, the OCS will be towed through or near several MPAs including the Monterey Bay National Marine Sanctuary (NMS), Greater Farallones NMS, and Cordell Bank NMS (**Figure 4-3**). Summary characteristics of these protected areas are presented in **Table 4-13**.

Table 4-13. Summary characteristics of the marine protected areas offshore California in the vicinity of the towing routes for the Ocean Cleanup System.

Name	Area (km^2/nmi^2)	Designated (Year)	Major Features
Monterey Bay National Marine Sanctuary	15,783/4,602	1992	The Monterey Bay National Marine Sanctuary is the largest national marine sanctuary (NMS) in the United States, covering 444 km (276 miles) of shoreline from just north of San Francisco south to Cambria, California. The NMS is a productive marine ecosystem as a result of upwelling from the California Current System. The NMS includes beaches, tidal flats, kelp forests, and open ocean habitat that is home to numerous species of fish, marine mammals, and seabirds (MPAtlas, 2017a).
Greater Farallones National Marine Sanctuary	3,320/968	1981	Located just north and west of San Francisco Bay, this NMS includes protected open ocean, tidal flats, rocky intertidal areas, coastal wetlands, subtidal rocky reefs, and coastal beaches. Located within the California Current System that drives coastal upwelling, the nutrient rich waters of the area support a productive ecosystem. The NMS is known to support breeding and feeding for more than 25 endangered species, 36 species of marine mammals and numerous species of seabirds (MPAtlas, 2017b)
Cordell Bank National Marine Sanctuary	1,369/399	1989	Encompasses Cordell Bank, a seamount located approximately 80 km (50 miles) northwest of San Francisco where the water depth is less than 35 m (115 ft). The NMS supports a variety of rich ecosystems and serves as host to feeding and breeding grounds for marine mammals, birds, and fish due to upwelling caused by the California Current System (MPAtlas, 2017c).

km^2 = square kilometers; nmi^2 = square nautical miles.

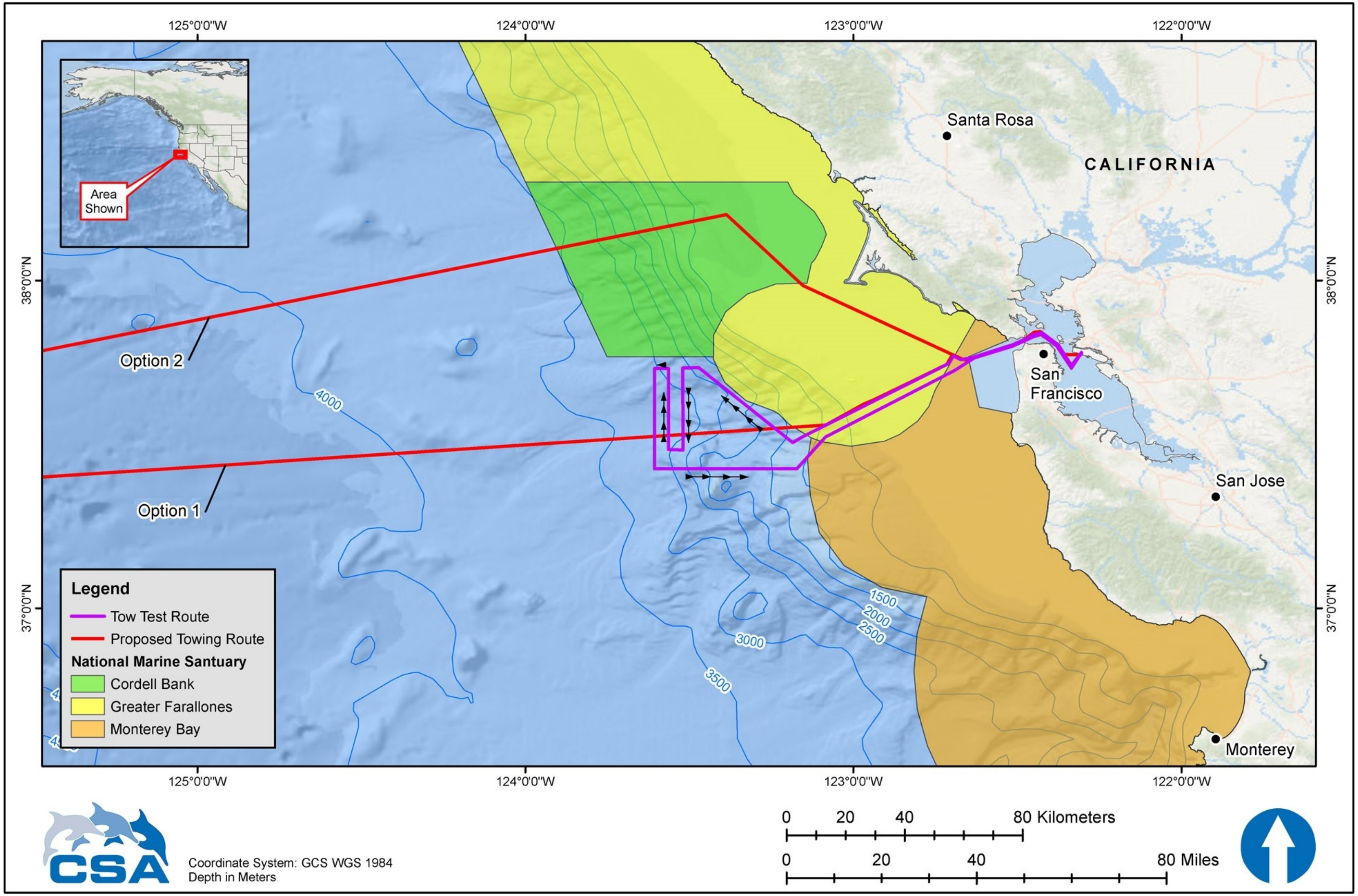

Figure 4-3. National Marine Sanctuaries and proposed towing routes in the vicinity of San Francisco.

4.4 SOCIAL ENVIRONMENT

4.4.1 Commercial and Military Vessels

Military Warning Areas (MWAs) W-513 and W-260 are located offshore of California in the vicinity of the towing route (**Figure 4-4**). It is not expected that the vessels will enter the MWA, though military vessels may be present in the vicinity. Numerous commercial and recreational vessels will be located within and near San Francisco Bay during towing of the OCS out of the Bay. **Figure 4-5** presents established shipping lanes and MWAs in the vicinity of San Francisco Bay.

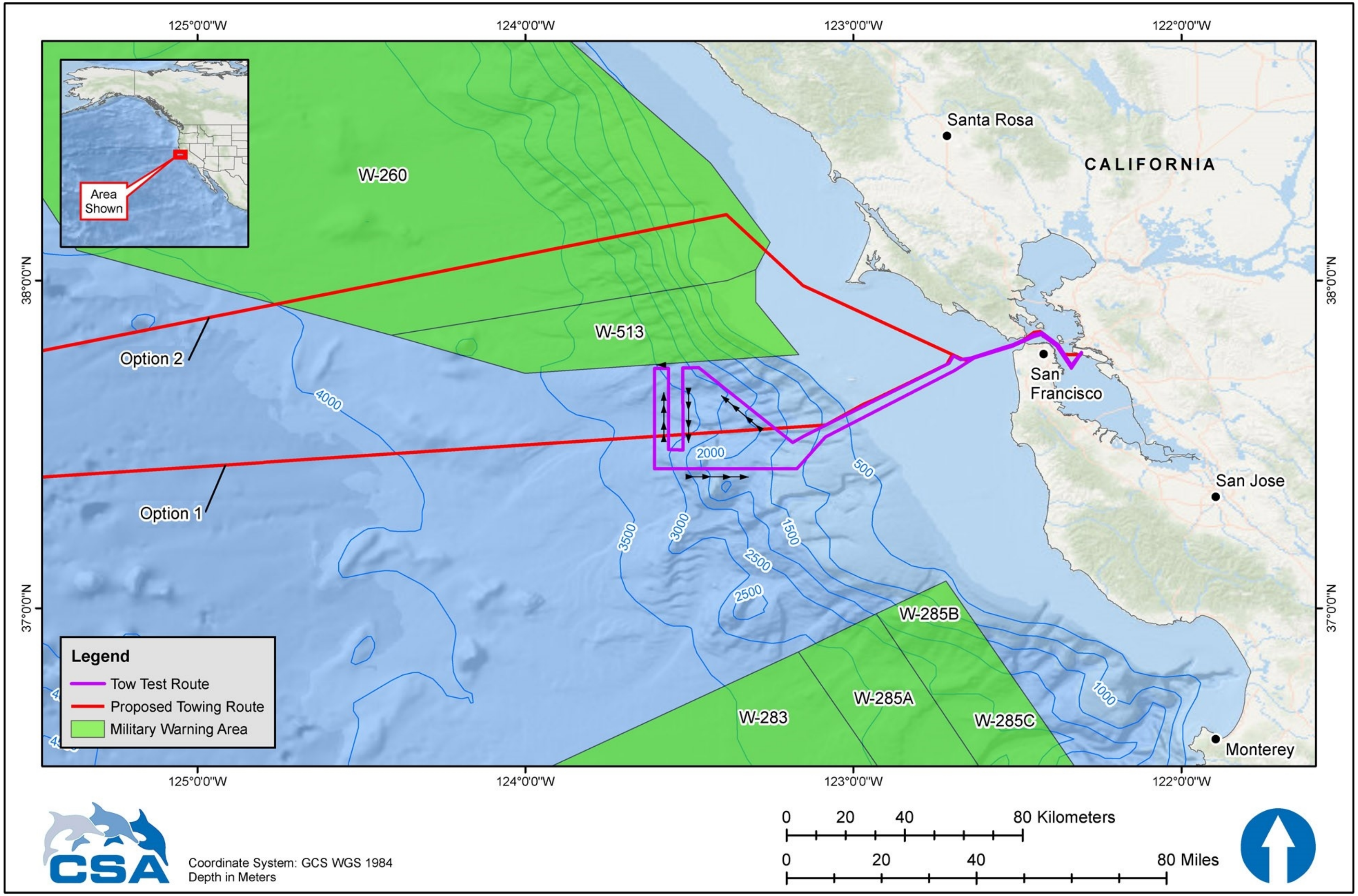

Figure 4-4. Military Warning Areas and proposed towing routes in the vicinity of San Francisco.

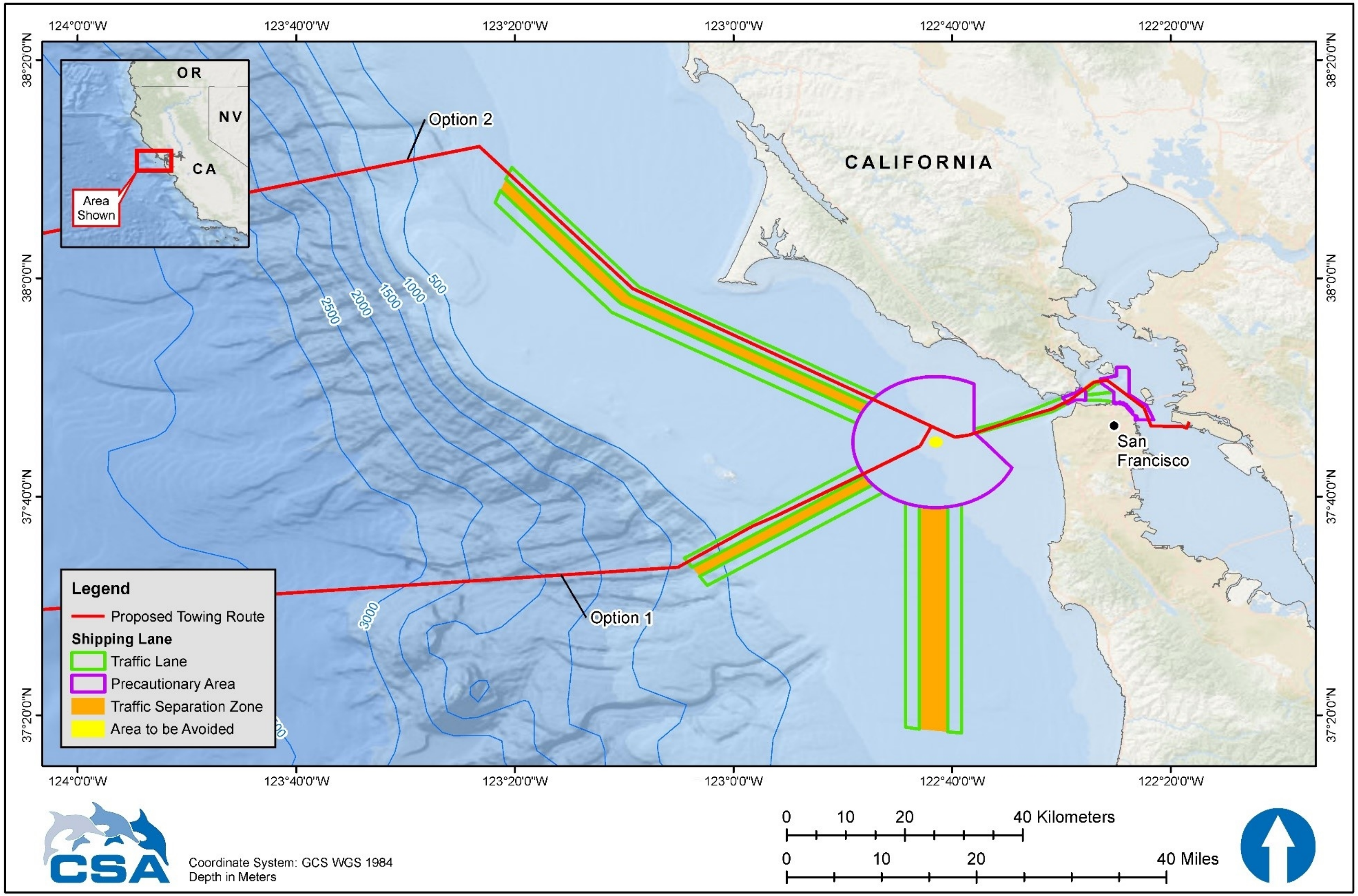

Figure 4-5. Shipping routes and the proposed towing routes in the vicinity of San Francisco.

5.1 IMPACT ASSESSMENT METHODOLOGY

Based on the project description (**Section 2.0**), impact producing factors (IPFs) associated with the OCS towing and deployment have been identified. A preliminary screening exercise was completed (**Section 4.1**) to identify biological and social resources that will not be affected by The Ocean Cleanup activities or where impact consequence was deemed, *a priori*, to be negligible. Resources for which more extensive analysis will not be performed as part of this EIA include air quality; sediment quality; water quality; benthic communities; biodiversity; archaeological resources; human resources, land use, and economics; recreational resources and tourism; and physical oceanography.

Table 5-1 identifies the potential sources of impacts associated with the proposed activities and the biological and social resources that may be affected by particular activities. Some IPF's that are expected to result in similar or identical impacts to a particular resource were combined to reduce redundancy in reporting.

Table 5-1. Matrix of potential impacts from The Ocean Cleanup proposed towing and deployment activities.

Project Activity/ Impact Producing Factor (IPF)	Environmental Resource						
	Biological						Social
	Fish and Fishery Resources	Plankton	Marine Mammals	Sea Turtles	Coastal and Oceanic Birds	Protected Areas	Commercial and Military Vessels
Towing Operations	--	--	--	--	--	●	●
OCS – Entanglement/Entrapment	--	●	●	●	--	--	--
OCS – Attraction/Ingestion of Plastics	●	--	●	●	●	--	--
Vessel – Physical Presence/Strikes	●	--	●	●	●	●	●
Noise and Lights	●	--	●	●	●	--	--
Loss of Debris	--	--	●	●	●	--	--
Accidental Fuel Spill	●	●	●	●	●	●	--

● indicates a potential impact to a resource; - indicates no or negligible potential for impact. OCS = The Ocean Cleanup System.

The only accident evaluated in this EIA is a fuel spill, as there are no activities proposed by The Ocean Cleanup that have a reasonable likelihood of resulting in a large spill of crude oil or other chemicals. Most small spills that occur during offshore operations are ≤1 barrel (bbl)[1] in volume. In the Gulf of Mexico, median volume for spills of 1 to 10 bbl is 3 bbl (Anderson et al., 2012). The most common cause of a small spill would be a rupture of the fuel transfer hose resulting in a loss of contents (<3 bbl of fuel). Consequently, a spill size of 3 bbl is used as a hypothetical spill scenario for this EIA.

Other potential accidents involving the OCS could include : (1) breaking up at sea, (2) sinking, or (3) becoming entangled with vessels. Such incidents are considered unlikely due to the engineering design of the OCS, sensor and positioning system redundancy, and multi-layered safety precautions. Safety measures have been put in place during the design and building phases to avoid and minimize

[1] One barrel equals 42 U.S. gallons, 35 Imperial gallons, or approximately 159 L.

potential impacts resulting from mechanical failure of the OCS. If damage that potentially interferes with the safe operation of the OCS is detected, the OCS (or any broken parts) will be brought to shore immediately. The 600-meter long pipe, made of material which is naturally buoyant, consists of 24 water-tight compartments separated by welded bulkheads, each pressure-tested. This design minimizes the likelihood that a rupture in one (or more) compartments of the OCS could flood the entire system, leading to the unlikely scenario of the OCS sinking. Each compartment is also equipped with two bilge sensors that can detect water intrusion and communicate to the nearby monitoring vessel and via satellite to The Ocean Cleanup headquarters. The fourteen foam filled stabilizers spaced across the OCS will provide additional floatation and extra safety.

15 GPS devices are evenly distributed along the length of the OCS, allowing remote monitoring of the shape and position of the system. In the event the OCS separates at sea, the GPS signals will show the separated parts further apart than designed. To the extent feasible, with due consideration to risks to human and marine health and safety, The Ocean Cleanup will recover the OCS parts and debris potentially generated by the system breaking apart. In the unlikely event that such an accident were to occur, potential environmental impacts are anticipated to be negligible to minor, as all the major parts of the OCS are intended to remain floating and be recovered.

Potential impacts to the biological and social environment may result from multiple sources (i.e., IPFs). Impacts may result from either routine, project-related activities or an accident (i.e., fuel spill). IPFs were evaluated on a resource by resource basis. The consequence of potential impacts was evaluated, taking into account the nature of the impact, including extent and duration. The following impact consequence categories were used, as defined in **Table 5-2**:

- Beneficial;
- Negligible;
- Minor;
- Moderate; and
- Severe.

The likelihood of impact occurrence was rated using the following categories:

- Likely (>50% likelihood);
- Occasional (10% to 49% likelihood);
- Rare (1% to 9% likelihood); and
- Remote (<1% likelihood).

Table 5-2. Definitions of impact consequence.

Consequence Category	Resource Category	
	Biological Environment	Social Environment
Beneficial	Likely to cause some enhancement to the environment or social/economic benefits	
Negligible	No changes, or small adverse changes unlikely to be noticed or measurable against background activities	
Minor	Adverse changes that can be monitored and/or noticed, but are within the scope of existing variability and do not meet any of the “severe” or “moderate” impact definitions (below)	
Moderate	Likely to result in one or more of the following: • Localized damage to coral reefs, mangroves, marshes, seagrass beds, or other sensitive habitats; • A few deaths or injuries of protected species; occasional, temporary disruption of their critical activities (e.g., breeding, nesting, nursing) and/or localized damage to their critical habitat	Likely to result in the following: • Extensive displacement of commercial and military vessels from planned transit routes

Table 5-2. (Continued).

Severe	Likely to result in one or more of the following: • Extensive damage to coral reefs, mangroves, marshes, seagrass beds, or other sensitive habitats; • Extensive damage to non-sensitive habitats to the extent that ecosystem function and ecological relationships would be altered; • Numerous deaths or injuries of a protected species and/or continual disruption of their critical activities (e.g., breeding, nesting, nursing), and/or destruction of their critical habitat	Likely to result in the following: • Permanent displacement of commercial and military vessels from planned transit routes

Impacts are evaluated or predicted 1) prior to the implementation of mitigation measures; and 2) following implementation of these measures. Mitigation measures are identified based on industry best practice or international standards (e.g., MARPOL requirements). Impacts that remain after adoption or implementation of mitigation measures are described as residual impacts. To summarize the overall significance of each impact, impact consequence and likelihood were combined using professional judgment and a risk matrix, as shown in **Table 5-3**. According to this matrix, the overall impact significance for biological and social negative impacts using a numeric, descriptive, and color-coded approach is rated as follows:

- 1 – Negligible;
- 2 – Low;
- 3 – Medium; and
- 4 – High.

Table 5-3. Matrix combining impact consequence and likelihood to determine overall impact significance.

Likelihood vs. Consequence		Decreasing Impact Consequence ←				
		Beneficial	Negligible	Minor	Moderate	Severe
Decreasing Impact Likelihood ↓	Likely	Beneficial (no numeric rating applied)	1 – Negligible	2 – Low	3 – Medium	4 – High
	Occasional		1 – Negligible	2 – Low	3 – Medium	4 – High
	Rare		1 – Negligible	1 – Negligible	2 – Low	4 – High
	Remote		1 – Negligible	1 – Negligible	2 – Low	3 – Medium

Impacts of Negligible consequence were assigned the lowest overall significance value (1 – Negligible), regardless of impact likelihood. Severe impacts were assigned the highest significance value (4 – High) if the impacts were Likely, Occasional, or Rare and assigned a lower value (3 – Medium) if the likelihood was Remote. The most significant impacts (those rated as 3 – Medium or 4 – High) were primary candidates for mitigation. Mitigation was also considered for lower overall significance levels (1 – Negligible and 2 – Low) to further reduce the likelihood or consequence of impacts. A comprehensive discussion of the mitigation measures and corporate/subcontractor policies that The Ocean Cleanup will follow during their proposed activities is presented under separate cover in an Environmental Management Plan.

5.2 POTENTIAL IMPACTS FROM PROPOSED ACTIVITIES

The long-term beneficial impacts from The Ocean Cleanup project are discussed in **Chapter 5.2.1**, the environmental consequences discussed in subsequent sections of **Chapter 5** address the potential impacts that could be incurred as a result of the towing, testing, and operation of the OCS. For each resource, the IPFs identified in **Table 5-1** were further examined and refined to identify aspects of those factors specific to the resource under evaluation. The impact assessment for each resource will include a list of the relevant IPFs, a discussion concerning the effects of the IPF on the resource, and the significance of the impact on the resource from the IPF. Summary impact tables are presented for the impact rating for determining impact significance prior to and following implementation of mitigation measures.

5.2.1 Long-Term Impacts from Project Activities

Plastics are manufactured from polymers, retrieved from fossil fuels (gas, coal or oil). Plastic gets its characteristics due to a blend of added chemicals called additives. Because of its light, cheap, strong and durable character, plastic is an ideal product for manufacturing everyday items (Thompson et al., 2009). The production of plastic has increased exponentially over the past 60 years and continues to increase, especially in areas with growing economies such as China and Southeast Asia (Plastics Europe, 2016). In 2015, 322 million tons of plastic were produced, an increase of 11 million tons since 2014. Most of the plastic are either HDPE or Low-Density Polyethylene, Polypropylene, Polyethylene terephthalate or Polyvinylchloride.

Because of their environmental persistence, plastic can stay in oceans for decades (Barnes et al., 2009). Studies show that in 2010, 4.8 to 12.7 million metric tons enter the ocean from coastal populations (Jambeck, et al., 2015), while plastic input from rivers is estimated to add between 1.15 and 2.41 million tons to oceans (Lebreton et al., 2017). As the total plastic production in 2010 was 265 million tons (PlasticsEurope, 2011), this leads to a plastic pollution of approximately 2.25 to 5.72% of the total worldwide production.

When macroplastics break down due to degradation (mechanical, biological or UV degradation), microplastics can form. Microplastics are hard if not impossible to remove form the marine environment, and their numbers will increase exponentially over time when macroplastics break down (Thompson et al., 2004). It was found that microplastic content in the North Pacific increased by 2 orders in terms of weight and numbers between 1972-1987 and 1999-2010 (Goldstein et al., 2012). A recent study performed by The Ocean Cleanup estimated an amount of 78 kilotons of plastic in an area of 1.6 million km^2. Approximately six kilotons were defined as microplastic, while the remaining was considered macroplastic.

Both microplastics and macroplastic fragments are often mistaken for food and are ingested by organisms on all trophic levels. Although ingestion of plastic is not directly lethal to the individual (only in 4% of the cases), it does have negative effects such as reduced fitness, toxicity caused by absorption of toxins, a false feeling of satiation and eventually starvation (Gall and Thompson, 2015). Birds are especially vulnerable to the effects of plastic ingestion, due to their small gizzards and inability to regurgitate indigestible items (Azzarello and van Vleet, 1987).

Because of the increased surface area, microplastics release more chemicals. Some of these additives are highly toxic, or can increase the risk of diseases. Examples of such additives are residual monomers, which are considered toxic to humans and ecosystems (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection [GESAMP], 2016). These additives are released after ingestion and accumulate in individuals (Wright et al., 2013). Additives are stored in body tissue, resulting in food chain pollution by bioaccumulation (Hammer et al., 2012). In addition, plastics in the ocean attract other chemicals because of its hydrophobic nature, increasing the overall toxicity of the floating plastics (Andrady, 2011).

The ultimate goal of The Ocean Cleanup is to remove plastic debris from the oceans. While the remainder of **Chapter 5** discusses acute, potentially harmful impacts to the biological and social environment as a result of the OCS deployment, the long-term result of the OCS deployment has the potential for substantial beneficial impacts to numerous resources. It should be noted that while this EIA addresses a one-year OCS deployment in the EPGP, it is the long-term goal of The Ocean Cleanup to deploy numerous OCS in various plastic-polluted ocean basins throughout the world. The Ocean Cleanup estimates that the OCS in the EPGP may accumulate up to 1 ton of plastic per week.

Specifically for this EIA, several resources that were screened out of further analysis (**Chapter 4.1**), would likely benefit from the long-term reduction of floating plastics in the marine system, including: water quality (by reducing chemical-leaching plastics from the water), benthic communities (by reducing the potential for plastics to sink and contaminate seafloor communities), archaeological resources (by reducing potential for contamination of archaeological sites or shipwrecks), biodiversity (by collectively reducing impacts on the EPGP ecosystem and its species), and recreational resources and tourism (by reducing costs associated with debris removal and negative public perception of coastal or offshore recreational areas contaminated by debris).

All biological resources discussed in the subsequent sections **Chapter 5** would likely realize some positive benefit from the reduction of plastics on the North Pacific Ocean, but the most beneficial impacts would be on sea turtles and marine mammals because those resources could be subject to the most potentially harmful effects of floating plastics. Due to vulnerable and endangered populations of sea turtles and marine mammals that are easily impacted by entanglement or ingestion of marine debris (including plastics), these two resources would likely reap the greatest benefits as a result of the reduction in the amount of marine plastics in the EPGP.

Marine Mammals

According to NOAA (2014a), most cetaceans that become entangled in marine debris do so in actively fished gear. However, numerous examples have been documented of cetaceans becoming entangled in discarded or lost nets, monofilament line, or other abandoned gear. Baleen whale species that have documented entanglements with a definitive cause as marine debris (as opposed to actively fished gear) include the humpback, right, minke, gray, and bowhead whales (Laist, 1997; Baulch and Perry, 2012). All of these species except the bowhead whale may occur in The Ocean Cleanup project area.

It is not possible to estimate the number and species of marine mammals that may be prevented from becoming entangled in marine debris due to the removal of debris by the OCS. However, it is known that a significant number of marine mammals become entangled. For example, based on scars, Robbins and Mattila (2004) estimated that 46% to 68% of humpback whales had been entangled at some point in their life. Given the endangered status of many of the species of marine mammals that may be found within the EPGB, if successful at removing plastics and other marine debris, The Ocean Cleanup OCS will almost assuredly contribute to a **Beneficial** impact reducing marine mammal entanglements and deaths caused by discarded rope, nets, monofilament line, and other anthropogenic trash.

Sea Turtles

All species of sea turtles have been documented entangled with marine debris. Of particular concern in places such as the EPGP where large amounts of debris have accumulated is the tendency of juvenile turtles to seek shelter under or within floating objects.

Of the seven extant sea turtle species, five may be found in the EPGP in the vicinity of the OCS deployment. Due to trans-Pacific migratory pathways that transect the EPGP (Benson et al., 2011), leatherbacks may be the most likely to be present. However, juvenile loggerheads are also known to occur in the North Pacific (Abecassis et al., 2013). Leatherbacks and loggerheads have both been commonly observed entangled in monofilament line. Other debris that has been documented entangling sea turtles includes plastic six-pack rings, burlap bags, plastic bags, bottles, and other debris (Miller et al., 1995).

Similar to marine mammals, it is not possible to estimate the number and species of sea turtles that may be prevented from becoming entangled in marine debris due to the removal of debris by the OCS. However, because sea turtles are relatively common (as compared with some species of marine mammals), it is likely that a substantial number become entangled. A study by Bjorndal and Bolton (1995) documented more than 1,500 free swimming sea turtles and reported that approximately 5% of all turtles were entangled in some type of debris. This suggests that if successful at removing plastics and other marine debris, The Ocean Cleanup OCS will almost assuredly contribute to a **Beneficial** impact by reducing entanglements and deaths of sea turtles.

Other Resources

Other resources such as plankton, fish and fishery resources, coastal and marine birds, and protected areas would also benefit from the removal of plastics and marine debris from the EPGP. Removal of the plastic debris will reduce the potential for entanglement, ingestion, or contamination, numerous species and ecosystems. Overall, if successful, the result of The Ocean Cleanup project (both the currently proposed one-year deployment in the EPGP and future deployments around the world) will result in the removal of a variety of negative impacts caused by plastic pollution and consequently have a **Beneficial** impact to biological and social resources across the world.

Data Collection

Direct collection of scientific data from survey vessels operating in remote areas of ocean is rare due logistical limitations and cost. The Ocean Cleanup project will result in the collection of primary data that may further scientific knowledge about how marine life is attracted to offshore debris and interacts with floating plastic. Reports from PSOs onboard the debris retrieval vessel will provide a database of presence/absence data for marine mammals and sea turtles from the eastern Pacific. Furthermore, scientific equipment on the OCS will also collect a variety of meteorological and hydrographic data. Although difficult to quantify precisely, the collection of scientific data resulting from The Ocean Cleanup project will have a **Beneficial** impact by contributing to the base of scientific knowledge about marine life in the eastern Pacific.

5.2.2 Potential Impacts on Plankton

5.2.2.1 Impact Producing Factor(s)

- Towing Operations
- OCS – Entanglement/Entrapment
- OCS – Attraction/Ingestion of Plastics
- Accidental Fuel Spill

For plankton, the potential impacts during towing operations and the potential for entanglement/entrapment are similar and will be discussed together to avoid repetition.

5.2.2.2 OCS – Entanglement/Entrapment

Although the OCS is a passive system, it is likely that zooplankton, phytoplankton, and ichthyoplankton that have limited, or no mobility may become entrapped within the impermeable screen during towing or deployment in the EPGP. The OCS will intercept all plankton from the sea surface to the bottom of the impermeable screen approximately 3 m (9.8 ft) below the surface. Since the OCS floats passively and does not have an active water pumping system, any plankton that becomes trapped may be released if currents or waves result in shifting water flow. Small planktonic organisms may be able to escape during collection of the plastic, depending on the final design.

Gelatinous macroplankton (jellyfish) may also be entrapped during towing operations or during the passive drifting of the OCS. Due to the gelatinous nature of these animals, they are easily damaged, and any entrapped jellyfish will likely die due to interaction with the OCS. However, jellyfish are ubiquitous in the world's oceans and any deaths that occur as a result of the plastic extraction process will not have any population level effects.

Due to the localized nature of this impact relative to the vast open ocean area in the North Pacific, and the possibility that some of the entrapped plankton may become free, significant impacts to plankton will not occur. Impacts on plankton populations are considered likely and of negligible consequence severity. Overall impact significance prior to mitigation is rated **1 – Negligible**.

5.2.2.3 OCS – Attraction/Ingestion of Plastics

The potential exists for planktonic filter feeders to accidentally ingest plastic particles and this risk will be heightened in the vicinity of the OCS due to the increased density of plastic particles collected by the OCS. Moore et al. (2001) completed plankton tows in the NPSG and reported that plankton abundance was higher than plastic abundance, but the mass of plastic was higher than the plankton mass in most samples. The high amount of plastics relative to plankton mass indicates that the chance ingestion of plastic by filter feeders is common. However, the increased ingestion of plastics by filter feeders as a result of the OCS is a localized, temporary impact and the long-term impact of the deployment will be **Beneficial** due to removal of plastics from the gyre by the OCS. Impacts on plankton populations are considered likely and of negligible consequence severity. Overall impact significance prior to mitigation is rated **1 – Negligible**.

5.2.2.4 Accidental Fuel Spill

A diesel fuel spill could affect phytoplankton and zooplankton because they do not have the ability to avoid contact. Planktonic communities drift with water currents and recolonize from adjacent areas. Because of these attributes and their short life cycles, plankton usually recover rapidly to normal population levels following disturbances. Eggs and larvae of fishes will die if exposed to certain toxic fractions of diesel fuel, but due to the wide dispersal of early life history stages of fishes, a diesel fuel or intermediate fuel oil/heavy fuel oil release would not be expected to have significant impacts at the population level.

In the event of a diesel fuel spill, the area affected would be relatively small, and the duration of impact would presumably be only a few days. Due to the limited areal extent and short duration of water quality impacts, a small diesel fuel spill would be unlikely (rare) to produce significant impacts on plankton, and any impacts that do occur would be of negligible consequence. Overall impact significance prior to mitigation is rated **1 – Negligible**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Entrapment in The Ocean Cleanup System	Negligible	Likely	1 – Negligible
Ingestion of plastic particles	Negligible	Likely	1 – Negligible
Exposure to diesel fuel	Negligible	Rare	1 – Negligible

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Entrapment in The Ocean Cleanup System	None recommended.	1 – Negligible
Ingestion of plastic particles	None recommended.	1 – Negligible
Exposure to diesel fuel	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels. • **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	1 – Negligible

5.2.3 Potential Impacts on Fish and Fishery Resources

5.2.3.1 Impact Producing Factor(s)

- OCS – Attraction/Ingestion of Plastics
- Vessel – Physical Presence/Strikes
- Noise and Lights
- Accidental Fuel Spill

For fish and fishery resources, the attraction of fish and fishery resources to structures (often due to lighting) are related and will be discussed together to avoid repetition.

5.2.3.2 OCS and Vessel – Attraction/Ingestion of Plastic/Physical Presence/Strikes

Fish species are attracted to offshore structures such as oil and gas platforms and various types of flotsam (Fabi et al., 2004; Franks, 2000; Shomura and Matsumoto, 1982). These structures can provide substrate habitat for invertebrates, protective habitat for finfish, and lighting. Studies have shown that different fish species have different utilization patterns of offshore structures which may be influenced by physical factors such as temporal variation in temperature and oceanographic conditions as well as biological factors such as prey availability, species-specific sedentary/migratory behavior, and life cycle stages of individuals (e.g., Stanley and Wilson, 1997; Schroeder and Love, 2004; Love et al., 2005; Love et al., 2006; Page et al., 2007; Fujii, 2016; Fujii and Jamieson, 2016). The OCS and monitoring vessel, as a floating structure in an open-ocean environment, will likely act as fish aggregating devices (FAD). In oceanic waters, the FAD effect would be most pronounced for epipelagic fishes such as tunas, dolphin, billfishes, and jacks, which are commonly attracted to fixed and drifting surface structures (Higashi, 1994, Relini et al., 1994, Holland, 1990). The FAD effect could possibly enhance the feeding of epipelagic predators by attracting and concentrating smaller fish species.

The OCS would introduce new hard substrate that could provide habitat for some prey species, which subsequently could attract managed species in the upper water column (Fujii, 2015) and at night the operational lights create a small "halo" of light in the water that attracts fish and predators (Barker, 2016). The OCS and its support vessel(s) will stand out in the project area as possibly the only artificial light sources. Lights would be used during evening and night hours on the OCS and support vessel(s). Fishes may be attracted by the OCS nighttime light-field and the light attracts phototaxic prey and provides an enhanced lighting condition to locate and capture prey while foraging within the light-field surrounding the structure or vessel. Fish foraging in the light field may also attract larger predators, rendering each in turn vulnerable to other predators. However, the light-field produced by the OCS and associated vessel(s) is expected to cover a significantly smaller area than what is produced by an oil and gas platform. Additionally, the light field will move as the OCS drifts with the current and no one location will receive a steady light field. Vessel strikes are not expected to occur to fish and fishery resources.

Plastic debris accumulating in the marine environment is known to fragment into smaller pieces, which increases the potential for ingestion by smaller marine organisms (Ryan et al., 2009). Additionally, the buoyancy of smaller pieces of plastic increases the likelihood for mixing with surface food sources. Once attracted to the OCS, fish and fishery resources will have a greater chance of ingesting plastics that have accumulated in the EPGP through either direct feeding on the plastic or by consuming lower trophic level organisms that have fed on plastics. Studies have shown a wide variety of fishes with plastics in their guts including planktivorous fish to larger predatory species, migratory and non-migratory species, and species inhabiting various depth ranges (Boerger et al., 2010; Carson, 2013; Choy and Drazen, 2013; Choy et al., 2013; Davison and Asch, 2011; Gassel et al., 2013; Rochman et al., 2014; and Ryan et al., 2009). The ingestion of plastics can affect fish in a variety of different ways (**Figure 5-1**) including impacts to the immune system of the fish, both chemically (through the absorption of toxic components) and physically by obstructing the digestive system (Espinosa et al., 2016).

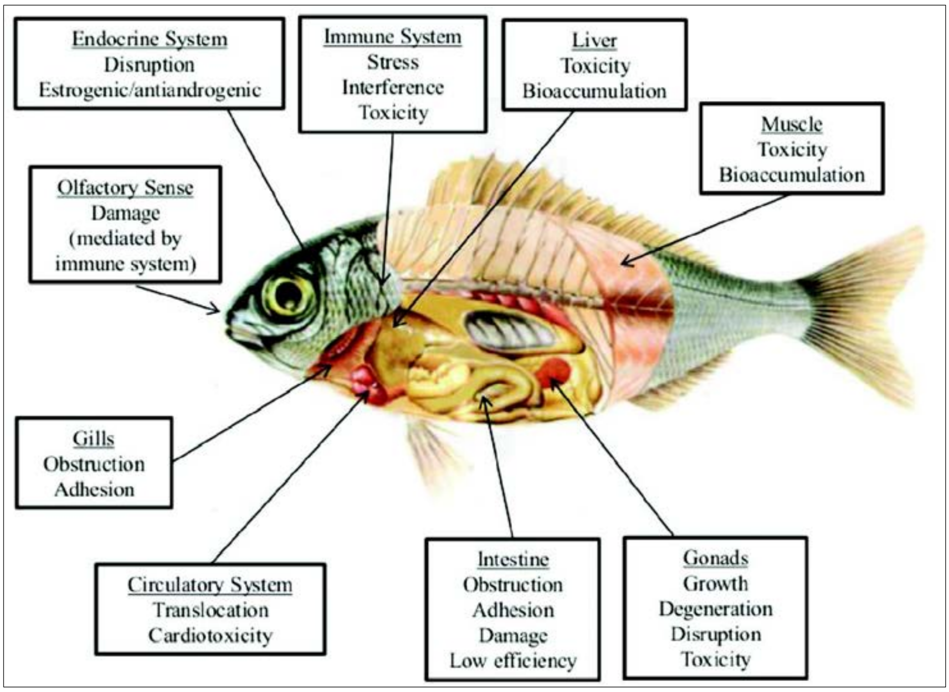

Figure 5-1. The principal effects of microplastics on fish (From: Espinosa et al., 2016).

Plastic extraction activities may result in the capture, injury, or death of small numbers of individual fishes in the purse seine net. However, it is expected that the small number of potentially impacted fishes will not be significant on the regional or population level for any species. Effects on fish and fishery resources from attraction, due to the physical presence and lighting of the OCS and support vessel(s), and the subsequent increased chance of ingestion of plastics are considered **2 – Low** and no population-level effects on fish communities would be expected. Because the OCS is a single, non-stationary, temporary structure, impacts on fish populations, whether beneficial or adverse, are considered occasional/likely and minor.

5.2.3.3 Noise and Lights

Fishes inhabiting or transiting the project area could be subjected to noise from support vessel traffic for the OCS; impacts from lighting are discussed in the previous section. A support vessel is expected to monitor the OCS and an additional vessel will make periodic roundtrips (every six weeks) to collect the concentrated plastics. Vessels cause a path of physical disturbance in the water that could affect the behavior of certain fish species, depending on the type of vessel and life history of the fish species.

Vessel noise is a combination of narrow-band (tonal) and broadband sound (Richardson et al., 1995). Tones typically dominate up to approximately 50 Hz, whereas broadband sounds may extend to 100 kHz. Usually, the larger the vessel or the faster the vessel is moving, the greater the noise generated (Richardson et al., 1995). Depending on the vessel, source levels can range from less than 150 decibels (dB) to over 190 dB (Richardson et al., 1995). Noise levels from vessels and equipment are within the general hearing reception range of most fishes (Amoser et al., 2004). Engines from the vessels may radiate considerable levels of noise underwater that may contribute significantly to the low-frequency spectrum. Machinery necessary to drive and operate a ship produces vibration within the frequency range of 10 Hz to 1.5 kHz resulting in the radiation of pressure waves from the hull (Mitson and Knudsen, 2003). In addition to broadband propeller noise, there is a phenomenon known as "singing," when a discrete tone is produced by the propeller which can result in very high tone levels within the frequency range of fish hearing.

Vessel noise may disturb pelagic fish and alter their behavior by inducing avoidance, potentially displacing them from preferred habitat, alter swimming speed and direction, and alter schooling behavior (Sarà et al., 2007). Pressure waves from vessel hulls could displace fish near the surface and cause injury or mortality to non-swimming and weakly swimming fish life stages and fish prey. Cavitation of bubbles generated by vessel hull structures and vibrations from vessel pumps could result in barotraumatic injury and mortality of epipelagic non-swimming and weakly swimming fish life stages and fish prey (Hawkins and Popper, 2012). Additionally, vessel noise can mask sounds that affect communication between fishes (Purser and Radford, 2011).

Fish may exhibit avoidance behavior when subjected to loud noises from a vessel. Abnormal fish activity may continue for some time as the vessel travels away. However, vessel noise is inherently transient, rendering adverse impacts temporary. Fish in the immediate vicinity of vessels may also exercise avoidance. Although vessel and equipment noise would increase in project area, negative effects on fish behavior are considered likely, however, they are expected to be short-term and localized. For these reasons, the impacts of vessel noise on fish and fisheries resources are of minor consequence and expected to be **2 – Low**.

5.2.3.4 Accidental Fuel Spill

A small diesel fuel spill in offshore waters would produce a thin slick on the water surface and introduce concentrations of petroleum hydrocarbons and their degradation products. The extent and persistence of impacts would depend on the meteorological and oceanographic conditions at the time and the effectiveness of spill response measures. Adult and juvenile fishes may actively avoid an accidental fuel spill. Moreover, in the event of a diesel fuel spill, the area affected would be relatively small, and the duration of impact would presumably be only a few days.

Due to the limited areal extent and short duration of water quality impacts, a small diesel fuel spill would be unlikely to produce significant impacts on fish and fishery resources. The impacts to fish and fishery resource is considered rare and of negligible consequence severity. Overall impact significance prior to mitigation is rated **1 – Negligible**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Attraction to The Ocean Cleanup System (OCS) and ingestion of plastics collected by the OCS	Minor	Occasional	2 – Low
Attraction to vessel(s) and lights	Minor	Likely	2 – Low
Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Minor	Likely	2 – Low
Hydrocarbon contamination from an accidental fuel spill	Negligible	Rare	1 – Negligible

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Attraction to the Ocean Cleanup System and ingestion of plastics	None recommended.	2 – Low
Attraction to vessel(s) and lights	None recommended.	2 – Low

Impact	Mitigation Measures	Residual Impact Significance
Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	**Elimination of unnecessary acoustic energy:** The levels of anthropogenic noise will be kept as low as reasonably practicable.	2 – Low
Exposure to diesel fuel	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels. • **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	1 – Negligible

5.2.4 Potential Impacts on Marine Mammals

5.2.4.1 Impact Producing Factor(s)

- Towing Operations
- OCS – Entanglement/Entrapment
- OCS – Attraction/Ingestion of Plastics
- Vessel – Physical Presence/Strikes
- Noise and Lights
- Loss of Debris
- Accidental Fuel Spill

For marine mammals, the potential impacts during towing operations and potential for entanglement/entrapment are similar and will be discussed together to avoid repetition.

5.2.4.2 OCS – Entanglement/Entrapment

There is a risk of entanglement any time gear, particularly lines and cables, are put in the water. Gall and Thompson (2015) reviewed previous literature and reported that 52 species of marine mammals have reported entanglement records with marine debris, the majority of which were caused by fishing gear or nets. Allen and Angliss (2011) estimate there are a minimum of 3.3 gray whale mortalities per year along the U.S. west coast attributed to fishing gear entanglement.

In 2016, 71 separate cases of entangled whales were reported off the west coast of the United States. Humpback whales were the predominant species reported as entangled (54 of the 71 cases in 2016). Other identified entangled species included gray whales, blue whales, killer whales, and fin whales. Entanglement cases were associated with specific fishing gear type from the Dungeness crab commercial trap fishery, gillnet fisheries, spot prawn trap fishery, sablefish trap fisher, Dungeness crab recreational trap fishery, and the spiny lobster fishery (NOAA, 2017b).

Stelfox et al. (2016) conducted a literature review of the effect that ghost gear entanglement on marine megafauna, namely mammals, reptiles and elasmobranchs. They reviewed 76 publications and other sources of grey literature were assessed that highlighted that individuals from 40 different species were recorded as entangled in, or associated with, ghost gear from the Atlantic, Pacific, and Indian Ocean basins. Overall, 27 marine mammal species, seven reptile species, and six elasmobranchs species were identified as having been reported as entangled in ghost gear, with marine mammals making up the majority of all entanglements (70%). Ghost gear responsible for the entanglements included ghost fishing nets, monofilament lines, ropes from traps and pots, unknown ropes, or a combination of net and line.

Species recorded as entangled in the review by Stelfox et al. (2016) that could be present within the study area include the Guadalupe and Northern fur seals, the California sea lions, Northern elephant seals, Harbor Seals, Gray, Humpback, Sei, and Sperm Whales.

Porpoise and other small cetacean mortality from gillnet entanglement has been documented by Tregenza et al. (1997). Entanglement data for mysticetes may reflect a high interaction rate with active fishing gear rather than with discarded trash and debris (Laist, 1996). Entanglement records for odontocetes that are not clearly related to bycatch in active fisheries are almost absent (Laist, 1996).

As the impermeable screen portion of the OCS does not contain polypropylene, holes or hooks that could potentially entangle marine mammals, the probability of entanglement in the OCS itself is small. Ropes and chains are present; however, the system will move slowly during both towing and deployment and therefore the chances of entanglement is low as marine mammals may be able to visually identify the OCS and actively avoid contact. Entanglement in marine plastics or other debris that have concentrated within the OCS is more likely, especially as marine mammals may become attracted to the structure and cover that the OCS provides and some marine mammals may mistake congregated plastics as a food source.

By design, the OCS is expected to accumulate marine debris, which may include ropes, nets, and other materials that have the potential to entangle marine mammals. However, the likelihood of a marine mammal becoming entangled is considered rare, partially due to the relatively small size of the OCS as compared to the EPGP and the North Pacific and the relatively low density of marine mammals. ADD or AHD pingers may be attached to the purse seine net during plastic extraction operations to deter marine mammals from the vicinity, making entanglement unlikely. If a marine mammal did become entangled in ropes or chains connected to the OCS or in marine debris, nets, or ropes accumulated within the OCS, the individual could be harmed or drown if it were unable to untangle itself. In the case of the death of an endangered marine mammal (such as the North Pacific Right Whale), such an incident could be significant at the population level to that species. It should be noted that while possible, the death of a marine mammal due to the deployment of the OCS is considered rare and that overall, the long-term impacts of the OCS on marine mammals should be **Beneficial** due to the removal of large amounts of plastics and other marine debris from the EPGP. However, because of the possibility of harm or death of marine mammals due to the OCS deployment, the consequence severity is rated moderate. Overall, the rare likelihood and the moderate consequence severity result in an overall impact significance rating of **2 – Low.**

5.2.4.3 OCS – Attraction/Ingestion of Plastics

Some marine mammals may be attracted to offshore structures, while others will avoid the floating OCS. Marine mammals have been known to ingest trash and debris. Gall and Thompson (2015) reported that 30 species of marine mammals have ingestion records with marine debris. Debris items may be mistaken for food and ingested, or the debris item may have been ingested accidentally with other food. Marine mammals that are either attracted to the OCS or encounter it by chance may have a high probability of ingesting plastics due to the plastic-congregating feature of the OCS. If a marine mammal mistakes the congregated plastic for a food source, a substantial amount of plastic could be ingested by a single individual. Debris ingestion can lead to loss of nutrition, internal injury, intestinal blockage, starvation, and death (NOAA, 2015). However, records suggest that entanglement is a far more likely cause of mortality to marine mammals than ingestion-related interactions (Laist et al., 1999).

By design, the OCS is expected to accumulate marine debris, which may include ropes, nets, and other materials that have the potential to be ingested by marine mammals The Ocean Cleanup estimates that up to 1 ton of plastic and debris may accumulate each week within the OCS. Regular plastic extraction trips will occur and will serve to minimize the length of time that large amounts of debris are present in the OCS. Despite the long-term benefits that may occur as a result of plastic removal from the EPGP, due to the possibility of harm or death of marine mammals resulting from plastic ingestion, the consequence severity is considered moderate with a rare likelihood of impacts. Overall, the impact significance is rated **2 – Low**.

5.2.4.4 Vessel – Physical Presence/Strikes

Some marine mammals may be attracted to offshore structures, while others will avoid the towing vessel and monitoring vessel. Attraction to the vessels could provide an opportunity for marine mammals to pass through the routine discharge plume from the monitoring vessel, where localized increased in water column concentrations of suspended solids, nutrients, and chlorine may be present. Due to the high level of dilution expected, and the relatively benign nature of the composition of routine discharges, impact consequence from routine discharges on marine mammals are not expected to be significant.

There is a remote possibility of the towing vessel or monitoring vessel striking a marine mammal during routine operations. Collisions with whales and particularly dolphins are considered highly unlikely; most dolphins are agile swimmers and are unlikely to collide with vessels. Most reports of collisions involve large whales, but collisions with smaller species have been reported as well (van Waerebeek et al., 2007). Laist et al. (2001) provided records of the vessel types associated with collisions with whales. From these records, most severe and lethal whale injuries involved large ships of lengths >80 m (262 ft). Vessel speed was found to be a significant factor as well, with 89% of the records involving vessels moving at 14 knots or greater.

Marine mammals at risk in the North Pacific Ocean for possible vessel strikes include slow-moving species and deep-diving species while on the surface (e.g., Bryde's whales, sperm whales, pygmy/dwarf sperm whales, beaked whales). Of the large whale species found off the coast of California, blue whale, fin whale, humpback whale, and gray whales are considered the most at-risk for vessel strikes because they migrate in nearshore areas where vessel traffic is heaviest (NOAA, nd).

Vessels associated with The Ocean Cleanup proposed activities will travel at relatively slow speeds. The towing vessel will travel at less than 3 knots, while the monitoring vessel may be stationary or nearly stationary as it tracks the drifting OCS. The debris retrieval vessels will transit to and from San Francisco at an estimated speed of 10 knots. When considering the level of commercial traffic off the western United States coast, the proposed activities by The Ocean Cleanup do not contribute significantly to the overall vessel traffic in the region. Based on these factors, the likelihood of a collision between a project-related vessel and a marine mammal is considered unlikely. If a collision did occur, it could result in the injury or death of the individual. Potential collisions with marine mammals are not expected to occur with high enough frequency to have population level effects on any species. Consequently, the overall impact on marine mammals from vessel collisions is expected to be **2 – Low**.

5.2.4.5 Noise and Lights

The Ocean Cleanup proposed activities will generate vessel and equipment noise that could disturb marine mammals. The types of sounds produced by these sources are classified as non-pulsed, or continuous. Vessel noise is a combination of narrow-band (tonal) and broadband sound (Richardson et al., 1995). Tones typically dominate up to approximately 50 Hz, whereas broadband sounds may extend to 100 kHz. Analyses of radiated sound from ships have revealed that they are the dominant source of underwater noise at frequencies below 300 Hz in many areas (Okeanos, 2008).

Vessel and equipment noise from project vessels, including the towing, monitoring, and debris retrieval vessels would produce sound levels typically <190 dB_{rms} re 1 μPa 1 m. The current acoustic thresholds established by NMFS (2016) for injurious exposure (PTS onset) and noninjurious (TTS onset) exposure to a continuous noise source, based on marine mammal hearing group, are presented below in **Table 5-4**.

Table 5-4. Underwater Acoustic Thresholds from Continuous Sound (Nonimpulsive) for Onset of Permanent (PTS) and Temporary (TTS) Threshold Shifts in Marine Mammal Hearing Groups (From: NOAA, 2016).

Marine Mammal Hearing Group	PTS Onset Thresholds (Received Level)	TTS Onset Thresholds (Received Levels)
Low-Frequency Cetaceans (baleen whales)	199 dB	179 dB
Mid-Frequency Cetaceans (dolphins, toothed whales, beaked whales, and bottlenose whales)	198 dB	178 dB
High-Frequency Cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchids)	173 dB	153 dB
Phocid Pinnipeds (Underwater)	201 dB	181 dB
Otariid Pinnipeds (Underwater)	219 dB	199 dB

dB = decibels; NOAA = National Oceanic and Atmospheric Administration.

The current acoustic threshold for behavioral effect exposure is 120 dB_{rms} re 1 μPa. The behavioral effect threshold was based on avoidance responses observed in whales, specifically from research on migrating gray whales and bowhead whales (Malme et al., 1983, 1984, 1988; Richardson et al., 1986, 1990; Dahlheim and Ljunblad, 1990; Richardson and Malme, 1993). Mysticete whales, such as the Bryde’s whale, are especially vulnerable to impacts from vessel noise because they produce and perceive low-frequency sounds (Southall, 2005). Broadband propulsion source levels for vessels are within the audible frequency range for most cetacean species (including Bryde’s whales) and, near these sources, are anticipated to be in the range of 170 to 180 dB re 1 µPa m at the source. In the open ocean deepwater environment where spherical spreading conditions apply, an attenuation of 60 re 1 µPa m dB (e.g., reduction from a source level of 180 dB re 1 µPa m to the 120-dB continuous noise threshold) would occur within 1 km (0.6 mi) of the source. Where modified spherical spreading conditions may apply, the distance from source to the 120-dB threshold would be greater.

In addition to direct injurious or sub-injurious exposures, an additional effect of increased ambient noise on marine mammals is the potential for that noise to mask biologically significant sounds.

Studies of vessel noise on Gulf of Mexico sperm whales indicated a significant decrease in the total number of acoustic clicks detected as a tanker ship approached an area (Azzara et al., 2013). Individuals of several small toothed whale and dolphin species have been observed to avoid boats when they are within 0.5 to 1.5 km (0.3 to 0.9 mi), with occasional reports of avoidance at greater distances (Richardson et al., 1995). Most beaked whales tend to avoid vessels (Würsig et al., 1998; Aguilar-Soto et al., 2006) and may dive for an extended period of time when approached by a vessel (Kasuya, 1986). Dolphins may tolerate boats of all sizes, often approaching and riding the bow and stern waves (Shane et al., 1986; Barkaszi et al., 2012). At other times, dolphin species that typically are attracted to boats will avoid them. Such avoidance is often linked to previous boat-based harassment of the animals (Richardson et al., 1995). Coastal bottlenose dolphins that are the object of whale watching activities have been observed to swim erratically (Acevedo, 1991), remain submerged for longer periods of time (Janik and Thompson, 1996; Nowacek et al., 2001), display less cohesiveness among group members (Cope et al., 1999), whistle more frequently (Scarpaci et al., 2000), and display restless behavior (Constantine et al., 2004) when boats are nearby.

The additional volume of vessel traffic associated with The Ocean Cleanup proposed activities would not constitute a significant increase to the existing vessel traffic offshore of the California coast, but the presence of a monitoring vessel in the EPGP could present a novel, persistent noise source. Additionally, the potential use of ADD or AHD pingers during plastic extraction activities will add novel anthropogenic noise to the local oceanic soundscape. Impacts to marine mammals from project-related vessel and equipment noise are likely but are expected to have a minor impact consequence that would include temporary disruption of communication or echolocation from auditory masking; disturbance (behavioral disruptions) of individual or localized groups of marine mammals; and limited, localized, and short-term displacement of individuals of any species, including strategic stocks, from localized areas around the vessels. Because the operation will occur in the open ocean, animals are expected to avoid the sound source and the potential for resultant auditory injuries. Consequently, impacts to marine mammals from project-related noise is expected to be **2 – Low**.

5.2.4.6 Loss of Debris

Global entanglement records with trash and debris for marine mammals show that entanglement is most common in pinnipeds, less common in mysticetes, and rare among odontocetes (Laist et al., 1999). As discussed in **Section 5.2.4.3**, marine mammals have been known to ingest trash and debris.

MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL includes regulations aimed at preventing and minimizing pollution from ships (accidental and that from routine operations) and currently includes six technical Annexes. Special areas with strict controls on operational discharges are included in most Annexes. Annex V ("Prevention of Pollution by Garbage from Ships") deals with different types of trash and debris, specifying the distances from land and the manner in which they may be disposed of; the most important feature of Annex V is the complete ban imposed on the disposal into the sea of all forms of plastics. The revised Annex V prohibits the discharge of all trash and debris into the sea, except as provided otherwise. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste.

Taking into account the USCG and MARPOL regulations, the accidental loss of trash and debris from the towing, monitoring, or debris retrieval vessels activities is expected to be rare, and as such, the associated impact consequence is expected to be minor. Consequently, debris entanglement and ingestion impact significance from lost debris on marine mammals is expected to be **1 – Negligible**.

5.2.4.7 Accidental Fuel Spill

Diesel fuel most often is a light, refined petroleum product classified by the API as a Group 1 oil based on its specific gravity and density, and is not persistent within the marine environment (Mediterranean Decision Support System for Marine Safety [MEDESS4MS], 2017). When spilled on water, diesel oil quickly spreads to a thin sheen; marine diesel, however, may form a thicker film of dull or dark colors. Because diesel oil is lighter than water (specific gravity is between 0.83 and 0.88, compared with 1.03 for seawater), it cannot sink and accumulate on the seafloor as pooled or free oil unless adsorption with sediment occurs. However, diesel oil dispersed by wave action may form droplets small enough to be kept in suspension and moved by currents (NOAA, 2017d). As diesel spreads on the sea surface, evaporation of the oil's lighter components occurs. Evaporation rates increase in conditions of high winds and sea state as well as high atmospheric and sea surface temperatures (American Petroleum Institute [API], 1999; MEDESS4MS, 2017; NOAA, 2017d). Small diesel spills usually evaporate and disperse naturally within a day.

Marine mammals could be affected by spilled diesel fuel. Effects of spilled oil on marine mammals are discussed by Geraci and St. Aubin (1980, 1982, 1985, 1990) as well as Lee and Anderson (2005) and within spill-specific study results (Frost and Lowry, 1994; Paine et al., 1996; Hoover-Miller et al., 2001; Peterson et al., 2003). Quantities of diesel fuel on the sea surface may directly affect marine mammals through various pathways: surface contact of the fuel with skin and mucous membranes of eyes and mouth; inhalation of concentrated petroleum vapors; or ingestion of the fuel (direct ingestion or by the ingestion of oiled prey).

Whales and dolphins apparently can detect slicks on the sea surface but do not always avoid them; therefore, they may be vulnerable to inhalation of hydrocarbon vapors, particularly those components that are readily evaporated. Ingestion of the light hydrocarbon fractions found in diesel fuel can be toxic to marine mammals. Ingested diesel fuel can remain within the gastrointestinal tract and be absorbed into the bloodstream and, thus, irritate and/or destroy epithelial cells in the stomach and intestines. Certain constituents of diesel fuel (i.e., aromatic hydrocarbons, PAHs) include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains. While some hydrocarbon components may be metabolized, recent data indicate that acute exposure to hydrocarbons (i.e., crude oil from the *Deepwater Horizon* spill) exhibited symptoms of hypoadrenocorticism, consistent with adrenal toxicity as previously reported for laboratory mammals exposed to oil (Schwacke et al., 2013). Released fuel may also foul the baleen fibers of mysticete whales, thereby impairing food-gathering efficiency or result in the ingestion of fuel or fuel-contaminated prey.

The likelihood of a fuel spill during project activities is considered remote, and the potential for contact with and impacts to marine mammals would depend heavily on the size and location of the spill as well as weather and sea conditions at the time of the spill. For this scenario, fuel spilled on the sea surface is assumed to rapidly spread to a thin layer and break into narrow bands or windrows that are aligned parallel to the wind direction. Lighter volatile components of the fuel would evaporate almost completely in a few days.

Because of the thickness of the slick and rapid weathering, it is not likely that many animals would come into contact with the fuel on the surface. Potential impacts are assumed to be limited to minor mucous membrane irritation and behavioral alteration (temporary displacement) from the affected area. The impact significance of spilled fuel to marine mammals is expected to be **2 – Low**, depending on the species and number of individuals coming into contact with the spilled fuel and their exposure time to the spilled fuel.

Impact Rating

Impact	Consequence	Likelihood	Significance
Entanglement in the Ocean Cleanup System (OCS) or accumulated debris resulting in injury or death	Moderate	Rare	2 – Low
Attraction to the OCS; ingestion of congregated plastics resulting in injury or death	Moderate	Rare	2 – Low
Exposure to routine discharges from vessel; vessel strike	Moderate	Rare	2 – Low
Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Minor	Likely	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	Minor	Rare	1 – Negligible
Diesel fuel exposure, including inhalation of vapors, ingestion, fouling of baleen	Minor	Rare	2 – Low

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Entanglement in the Ocean Cleanup System (OCS) or accumulated debris resulting in injury or death	• Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS. • Rescue attempts of entangled marine mammals in distress may be attempted according to the Environmental Management Plan.	2 – Low
Attraction to the OCS	• Potential use of Acoustic Deterrent Devices or Acoustic Harassment Devices during plastic extraction activities to deter marine mammals from entering the vicinity of the OCS.	2 – Low
Ingestion of congregated plastics resulting in injury or death	• Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS.	2 – Low
Exposure to routine discharges from vessel; vessel strike resulting in injury or death	• **Visual monitoring** – Monitoring during the project will identify marine mammals that may be near vessels. • Debris retrieval vessels will maintain a watch for marine mammals and when travelling to and from the Eastern Pacific Garbage Patch. • Support vessel(s) traveling between the project area and shore will travel at slow speeds (<14 knots).	2 – Low
Behavioral modification changes (e.g., evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	• **Elimination of unnecessary acoustic energy:** The levels of anthropogenic noise will be kept as low as reasonably practicable.	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	• Verify compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	1 – Negligible

Impact	Mitigation Measures	Residual Impact Significance
Diesel fuel exposure, including inhalation of vapors, ingestion, fouling of baleen	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under MARPOL 73/78 will be maintained.	1 – Negligible
Diesel fuel exposure, including inhalation of vapors, ingestion, fouling of baleen (cont'd).	• **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels. • **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	1 – Negligible

5.2.5 Potential Impacts on Sea Turtles

5.2.5.1 Impact Producing Factor(s)

- Towing Operations
- OCS – Entanglement/Entrapment
- OCS – Attraction/Ingestion of Plastics
- Vessel Strikes
- Noise and Lights
- Loss of Debris
- Accidental Fuel Spill

For sea turtles, potential impacts during towing operations and potential for entanglement/entrapment are similar and will be discussed together to avoid repetition.

5.2.5.2 OCS – Entanglement/Entrapment

The physiology of turtles makes them susceptible for entanglement, as their surface area is large, and they are not as streamlined as marine mammals. Sea turtle feeding behavior makes turtles susceptible for entanglement, as many species tend to forage near surface waters where floating debris often concentrates. Hamelin et al. (2017) summarized recent incidental captures of leatherback turtles offshore Canada in the Atlantic Ocean and reported that entanglements were most common in pot gear that utilized polypropylene line near the surface. Numerous other studies report that sea turtles are common bycatch in gillnet and longline fisheries (Byrd et al., 2016).

As the impermeable screen component of the OCS does not contain polypropylene, holes, or hooks that could potentially entangle turtles, the probability of entanglement in the OCS itself is small. Ropes and chains are present; however, the system moves slowly and therefore the chances of entanglement is low because it is expected that turtles would be able to visually identify the OCS and actively avoid contact during towing and deployment in the EPGP. Entanglement in marine plastics that have concentrated within the OCS is more likely, especially as turtles may become attracted to the structure and cover that the OCS provides. However, the use of deterrent turtle lights on the purse seine net is expected to deter sea turtles from the vicinity of plastic extraction activities and make impacts relatively unlikely.

Impacts on sea turtles from entanglement/entrapment are considered rare and of moderate consequence severity (injury or death of individual turtles). Overall impact significance prior to mitigation is rated **2 – Low**.

5.2.5.3 OCS – Attraction/Ingestion of Plastics

Certain sea turtles, especially loggerheads, may be attracted to offshore structures (Lohoefener et al., 1990; Gitschlag et al., 1997) and thus may be more susceptible to impacts from other risk factors at the OCS deployment location, including sounds produced during routine operations and vessel strikes.

Due to the expected relatively high concentrations of marine plastics in the vicinity of the OCS, any turtles attracted to the structure of the OCS may be at increased risk of consuming plastic particles. Ingestion of debris can kill or injure sea turtles and is considered a significant stressor (Laist, 1987; Lutcavage et al., 1997; Fukuoka et al., 2016). In a recent review, Gall and Thompson (2015) reported that all species of sea turtles have published reports of entanglement or ingestion of marine debris. Olive ridley turtles are considered to have the highest risk for consuming plastics because they spend a majority of their life in the pelagic environment (Bolten, 2003) and because their foraging strategy on zooplankton and fish often occurs in current convergence zones that correspond to areas where plastics tend to collect (Schuyler et al., 2016). Fukuoka et al. (2016) reported that green turtles had higher encounter-ingest ratios than did loggerheads when studied using turtle mounted cameras, but Pham et al. (2017) reported than 83% of juvenile loggerheads investigated in the North Atlantic gyre has ingested plastic. Leatherback turtles can also be susceptible to floating plastics, particularly plastic bags, because they resemble their preferred food of jellyfish (Mrosovsky et al., 2009). A recent study (Clukey et al., 2017) investigated stomach contents of 55 sea turtles that were caught as bycatch in the Pacific Ocean and found that all olive ridley (n= 37), 90% of green (n= 10), 80% of loggerhead (n= 5), and 0% of leatherbacks (n= 5) had plastics in their stomachs or intestines. It should be noted however, that not all turtles were caught from the same area and exposure to plastics for all specimens may not have been equal.

Any impacts on turtles due to attraction to the OCS would likely be short-term and negligible; but impacts from plastic ingestion could cause chronic impacts to affected individuals. However, due to the relatively small size of the OCS and the low density of sea turtles in the remote open ocean area of the OCS deployment, it is not expected that impacts to turtles from plastics ingestion will be biologically significant to sea turtle populations. However, juvenile turtles are mostly pelagic spending most of their time in the open ocean. Juvenile loggerhead turtles are known to utilize the project area (Kobayashi et al., 2008; Abecassis et al., 2013; Briscoe et al., 2016a,b) and may be vulnerable to impacts from plastic ingestion. Loggerhead turtles, which are known to migrate through the area of the OCS deployment are known to eat plastic bags, possibly due to a resemblance to their preferred food of jellyfish. Impacts to regional populations are possible, but considered unlikely. Impacts on sea turtles from attraction to the OCS and the associated ingestion of plastics are considered occasional and of moderate consequence severity. Overall impact significance prior to mitigation is rated **3 – Medium**.

It is also important to note, however, that the presence of plastics in the ocean, in particular abandoned fishing gear and lines, present a significant danger to turtle species. The OCS, by facilitating removal of these materials from the environment, presents a potential for long-term **Beneficial** impact to sea turtle species.

5.2.5.4 Vessel – Physical Presence/Strikes

There is a remote possibility of the tow vessel, monitoring vessel, or debris retrieval vessels striking a sea turtle during operations. Vessel strikes are among the threats affecting the endangered population status of several sea turtle species (NRC, 1990). The risk for this project is similar to that associated with existing vessel traffic in the region. Studies indicate that sea turtles are at the sea surface only about 10% of the time and readily sound (dive) to avoid approaching vessels (Byles, 1989; Lohoefener et al., 1990; Keinath and Musick, 1993; Keinath et al., 1996). In the event a support vessel strikes a sea turtle, the impact consequence is considered to be moderate. Due to the slow speed of the tow and monitoring vessels, and the limited number of round-trips required for the debris retrieval vessels, the likelihood of striking any sea turtle is considered rare. Overall impact significance is rated **2 – Low**.

5.2.5.5 Noise and Lights

Sea turtles have low-frequency hearing capabilities, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol and Ketten, 2006; Lenhardt, 1994; Ridgway et al., 1969). Hearing below 80 Hz is less sensitive but may be important biologically (Lenhardt, 1994). A recent summary of sea turtle hearing capabilities has been prepared by Bartol (2014).

By species, hearing characteristics of sea turtles include:

- Loggerhead sea turtle: greatest sensitivities around 250 Hz or below for juveniles, with the range of effective hearing from at least 250 to 750 Hz (Lavender et al., 2012a,b,c);
- Green sea turtle: greatest sensitivities are 300 to 400 Hz (Ridgway et al., 1969); juveniles and subadults detect sounds from 100 to 500 Hz underwater, with maximum sensitivity at 200 and 400 Hz (Bartol and Ketten, 2006) or between 50 and 400 Hz (Dow et al., 2008); peak response at 300 Hz (Yudhana et al., 2010a);
- Hawksbill sea turtle: greatest sensitivities at 50 to 500 Hz (Yudhana et al., 2010b);
- Olive ridley sea turtle: juveniles of a congener (Kemp's ridley) found to detect underwater sounds from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz (Bartol and Ketten 2006); and
- Leatherback sea turtle: a lack of audiometric information is noted in this species; their anatomy suggests hearing capabilities are similar to other sea turtle species, with functional hearing assumed to be 10 Hz to 2 kHz.

Sounds have the potential to impact a sea turtle in several ways: masking of biologically significant sounds, alteration of behavior, trauma to hearing (temporary or permanent), and trauma to non-hearing tissue (barotraumas) (McCarthy, 2004). Anthropogenic noise, even below levels that may cause injury, has the potential to mask relevant sounds in the environment. Masking sounds can interfere with the acquisition of prey, affect the ability to locate a mate, diminish the ability to avoid predators, and, particularly in the case of sea turtles, adversely affect the ability to properly identify an appropriate nesting site (Nunny et al., 2008); however, there are no data demonstrating masking effects for sea turtles.

The most likely effects of vessel and equipment noise on sea turtles would include behavioral changes. Vessel and equipment noise is transitory and generally does not propagate at great distances from the vessel, and the source levels are too low to cause death or injuries such as auditory threshold shifts. Based on existing studies on the role of hearing in sea turtle ecology, it is unclear whether masking would realistically have any effect on sea turtles (Mrosovsky, 1972; Samuel et al., 2005; Nunny et al., 2008). Behavioral responses to vessels have been observed but are difficult to attribute exclusively to noise rather than to visual or other cues. It is conservative to assume that noise associated with survey vessels may elicit behavioral changes in individual sea turtles near vessels. These behavioral changes may include evasive maneuvers such as diving or changes in swimming direction and/or speed. This evasive behavior is not expected to adversely affect these individuals or the population, and impacts are not expected to be significant. Impact consequence from all noise sources to sea turtles is expected to be minor. Given the likely nature of this impact, overall impact significance prior to mitigation is rated **2 – Low**.

5.2.5.6 Loss of Debris

The disposal of trash and debris in the ocean is prohibited under MARPOL, and all project vessels will ensure adherence to MARPOL. However, the occasional and unintentional loss of debris may occur (e.g., floating trash, buckets containing paints or other chemicals). Materials accidentally lost overboard during the project may also float on the ocean surface or within the water column (e.g., plastic bags, packaging materials). Floating debris, especially plastics and monofilament line, could entangle marine fauna, or cause injury through ingestion. It is also possible that the OCS will fail or break apart at sea during the deployment and become marine debris itself.

Marine debris is among the threats affecting the endangered population status of several sea turtle species (NRC, 1990). Ingestion of or entanglement with accidentally discarded debris can kill or injure sea turtles (Lutcavage et al., 1997). Leatherback turtles are especially attracted to floating debris, particularly plastic bags, because it resembles their preferred food, jellyfish. Ingestion of plastic and styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility.

Through adherence to MARPOL, impacts on sea turtles from the loss of debris are considered rare but would be of moderate consequence severity due to the vulnerability of some species of sea turtles, especially juveniles. Overall impact significance prior to mitigation is rated **2 – Low**.

5.2.5.7 Accidental Fuel Spill

Diesel fuel in the marine environment may affect sea turtles through various pathways: direct contact, inhalation of diesel fuel, its volatile components, and ingestion of diesel fuel (directly or indirectly through the consumption of fouled prey species). Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior, indiscriminate feeding in convergence zones, and inhalation of large volumes of air before dives (Milton et al., 2003). Diesel fuel can adhere to turtle skin or shells. Turtles surfacing within or near a diesel fuel release would be expected to inhale petroleum vapors. Ingested diesel fuel, particularly the lighter fractions, can be toxic to sea turtles. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters and are especially sensitive to released hydrocarbons (including diesel fuel).

Impact consequence to sea turtles from an accidental diesel fuel spill is expected to be minor due to the low volume of fuel spill, expected density of these resources, relatively short period of diesel fuel or presence on the sea surface, and high degree of dissolution, spreading, and evaporation. The likelihood of impacts on sea turtles from a fuel spill are considered rare and the overall impact significance prior to mitigation is rated **1 – Negligible**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Entanglement or entrapment with deployed Ocean Cleanup System (OCS) or accumulated debris	Moderate	Rare	2 – Low
Attraction to the OCS and ingestion of plastics collected by the OCS	Moderate	Occasional	3 – Medium

Impact	Consequence	Likelihood	Significance
Injury or mortality resulting from a vessel collision with a sea turtle	Moderate	Rare	2 – Low
Behavioral modification changes (e.g., diving, evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Minor	Likely	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	Moderate	Rare	2 – Low
Diesel fuel exposure, including inhalation of vapors, ingestion	Minor	Rare	1 – Negligible

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Entanglement or entrapment with deployed Ocean Cleaup System (OCS) or accumulated debris	• Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS. • Rescue attempts of entangled sea turtles in distress may be attempted according to the Environmental Management Plan.	2 – Low
Attraction to the OCS	Potential use of flashing green lights during plastic extraction activities to deter sea turtles from entering the vicinity of the OCS.	3 – Medium
Ingestion of plastics collected by the OCS	Routinely remove accumulated debris (e.g., plastics, fishing nets) within a reasonable time frame from the OCS.	3 – Medium
Injury or mortality resulting from a vessel collision with a sea turtle	• **Visual monitoring** – Monitoring during the project will identify sea turtles that may be near vessels. • **Support vessel operations** – Support vessel(s) traveling between the project area and shore will travel at slow speeds (<14 knots).	2 – Low
Behavioral modification changes (e.g., diving, evasive swimming, disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	**Elimination of unnecessary acoustic energy:** The levels of anthropogenic noise will be kept as low as reasonably practicable.	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	Verify compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	2 – Low
Diesel fuel exposure, including inhalation of vapors, ingestion	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under MARPOL 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels.	1 – Negligible

Impact	Mitigation Measures	Residual Impact Significance
Diesel fuel exposure, including inhalation of vapors, ingestion (cont'd)	• **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	

5.2.6 Potential Impacts on Coastal and Oceanic Birds

5.2.6.1 Impact Producing Factor(s)

- OCS – Entanglement/Entrapment
- OCS – Attraction
- Vessel – Physical Presence/Strikes
- Noise and Lights
- Loss of Debris
- Accidental Fuel Spill

For coastal and oceanic birds, the physical presence of the OCS and vessel(s) and the attraction of birds to these (often due to lighting) are related and will be discussed together to avoid repetition.

5.2.6.2 OCS and Vessel – Entanglement/Entrapment/Attraction/Physical Presence/Strikes

Many seabird species, such as frigatebirds, boobies, tropicbirds, albatrosses, gulls, jaegers, procellarid petrels, and some storm-petrels are attracted to offshore structures and vessels for a variety of reasons such as roosting sites, rest areas during migration, shelter during inclement weather, lighting, flaring, food availability, and other visual cues (Wall and Heinemann, 1979; Tasker et al., 1986; Montevecchi et al., 1999; Wiese et al., 2001; Black, 2005; Montevecchi, 2006; and Ronconi et al., 2015). Additionally, some birds engage in ship-following as a foraging strategy, especially with commercial or recreational fishing vessels (Garthe and Huppop, 1994).

As such, birds in the project area may experience both beneficial impacts as well as negative impacts from the presence of the OCS and support vessel(s). Some birds may use the OCS as a stopover site for resting and feeding, while some birds may be attracted to the OCS lights and become engaged in nocturnal circulations (Russell, 2005; Montevecchi, 2006). Others that are attracted to offshore structures may suffer mortality from collision or starvation (Russell, 2005; Montevecchi, 2006; Ellis et al., 2013; Ronconi et al., 2015). The presence of the OCS may also displace birds from otherwise suitable foraging habitat (Ronconi et al., 2015). However, the use of the OCS or supporting vessel(s) may increase the survivability of individuals using the structures to rest or as shelter during bad weather conditions in the open waters (Russell, 2005) or the OCS may provide additional foraging opportunities for seabirds (Tasker et al., 1986; Ronconi et al., 2015).

Additionally, birds using the OCS for roosting may be indirectly impacted by an increased possibility of entanglement or ingestion of plastic found in the EPGP. Birds such as albatrosses, petrels and shearwaters, storm petrels and diving petrels, have been observed to have ingested more plastics compared to other birds (Blastic, 2017). In addition, these birds have small gizzards and many of them are unable to regurgitate indigestible items, which makes them even more vulnerable to the effects of plastic ingestion (Li et al., 2016). Plastic ingestion can affect foraging behavior, diet, breeding, molting and distribution of species. Both the entanglement rate and amount of plastic ingested by seabirds varies with their foraging practices, feeding technique, and diet (Li et al., 2016).

Pelagic seabirds feed according to three different methods: diving, plunge diving and/or surface feeding (**Figure 5-2**). These three different feeding techniques will alter the type of encounter birds have with both the marine plastic and the OCS. Birds that use plunge diving or diving (e.g., albatross, boobies, gannets) have an increased chance of becoming entangled in debris, while surface feeders feeding on plankton have been shown to contain more plastic as during surface feeding it is often easier to mistake plastic as food (Azzarello and Van Vleet, 1987; Li et al., 2016).

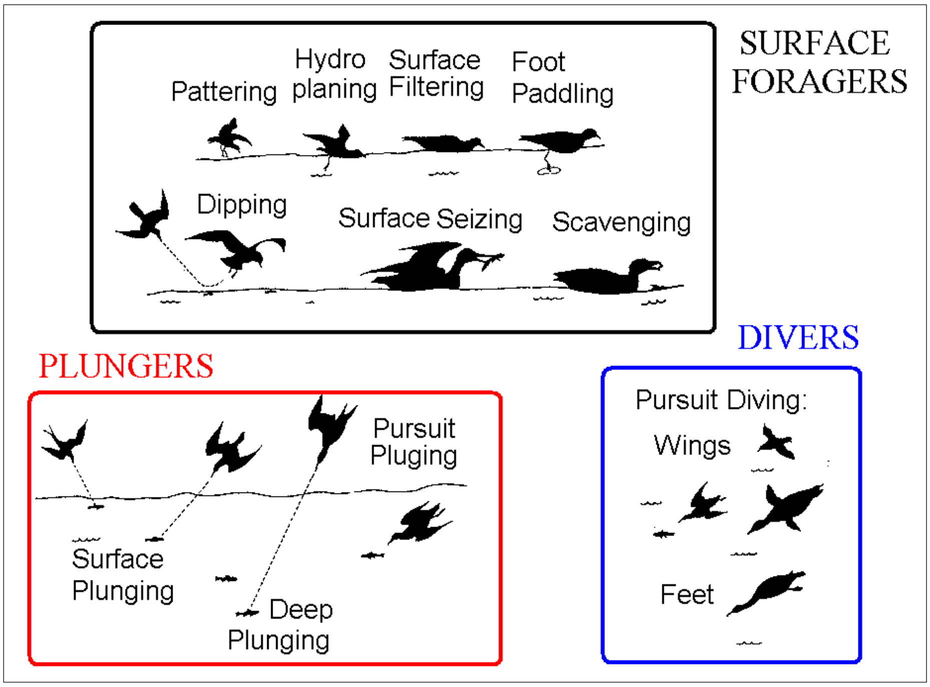

Figure 5-2. Seabirds feeding modes (From: Nevins et al., 2005).

The potential for bird strikes on a vessel is not expected to be significant to individual birds or their populations (Klem, 1989, 1990; Dunn, 1993; Erickson et al., 2005; Merkel, 2010). Given the low potential for collision, the impacts are not expected to result in mortality or serious injury to individual birds, resulting in limited direct impacts to these types of seabirds from vessel attraction. Shorebirds are not known to be attracted to vessels. However, these birds may fly in a lower altitude pattern for inclement weather conditions during migrations which may increase the potential for a vessel strike.

Most impacts from operations of the OCS and support vessel(s) would be localized to the site of the project infrastructure or along support vessel routes to port and would likely affect relatively few individuals or habitats since the OCS and support activities will occur far from the coastline and any sensitive bird habitats. Some mortality may be expected for birds colliding with support vessels, but impacts from such collisions are anticipated to affect relatively few birds and result in no population-level effects on birds. Plastic extraction activities are not expected to significantly affect oceanic birds due to the low bird density at the remote deployment location in the EPGP.

Impact consequence from entanglement/entrapment and attraction/ingestion of accumulated plastics associated with the OCS and the physical presence/strikes associated with vessels to coastal and oceanic birds is expected to range from minor to moderate. The likelihood of these impacts ranges from rare to occasional and the overall impact significance prior to mitigation is rated **2 – Low**.

5.2.6.3 Noise and Lights

Disturbance related impacts to seabirds and other migratory birds from vessel noise and lighting will vary depending on the type, intensity, frequency, duration, and distance to the disturbance source (Conomy et al., 1998; Blumstein, 2003). Seabirds may be affected by vessel noise in a variety of manners including disturbance resulting in behavioral changes (Béchet et al., 2004; Agness et al., 2008; Schoen et al., 2013); selection of alternative habitats or prey that may be suboptimal; creating barriers to movement or decreasing available habitat (Bayne et al., 2008); decreases in foraging time and efficiency (Schwemmer et al., 2011); reduced time spent resting or preening (Tarr et al., 2010); and increases in energy expenditures due to flight behavior (versus resting, preening, or foraging) (Agness et al., 2008; Agness et al., 2013). The primary potential direct impacts to seabirds from vessel noise are from underwater sound generated by propeller(s) and machinery. Potential indirect impacts include attraction to vessels and subsequent collision or entanglement, behavioral changes, and disturbance to feeding which area addressed under other IPFs in this section.

Overall disturbance-related and behavioral change impacts do not typically result in direct mortality (Larkin, 1996; Carney and Sydeman, 1999). Birds disturbed by the presence of project vessels may flee a habitat and may or may not return. Displacement would be short-term and transient in most cases and would not be expected to result in any lasting effects. Most of the underwater noise associated with vessels is low-frequency (<200 Hz) (Richardson et al., 1995) and on the lower end of bird hearing range (Dooling and Popper, 2007), potential impacts to diving seabirds are not expected to result in auditory injuries, but will be limited to disturbance (behavioral) reactions (e.g., interruption of activities, short- or long-term displacement). Due to the limited amount of noise and lighting that will be generated by the OCS and support vessel(s), impact consequence to birds from noise and light are expected to be negligible to minor. Given the likely nature of this impact, overall impact significance prior to mitigation is rated **2 – Low**.

5.2.6.4 Loss of Debris

The disposal of trash and debris in the ocean is prohibited under MARPOL, and all project vessels will ensure adherence to MARPOL. However, the occasional and unintentional loss of debris may occur. Materials accidentally lost overboard during the project may also float on the ocean surface or within the water column (e.g., plastic bags, packaging materials). Floating debris, especially plastics poses a potential hazard to seabirds, through entanglement and ingestion (Laist, 1987; Derraik, 2002, Li et al., 2016). The ingestion of plastic by coastal and oceanic birds can cause obstruction and ulceration of the gastrointestinal tract, which can result in mortality (Li et al., 2016). In addition, accumulation of plastic in seabirds has been shown to be correlated with the body burden of polychlorinated biphenyls, which can cause lowered steroid hormone levels and result in delayed ovulation and other reproductive problems (Pierce et al., 2004). Additional impacts include blockage of gastric enzyme secretion, diminished feeding stimulus, reproductive failure, and adults that manage to regurgitate plastic particles could pass them onto the chicks during feeding (Derraik, 2002).

Seabirds are also vulnerable to entanglement encounters, which can lead to mortality (Li et al., 2016). The effects of entanglement can be summarized as drowning, suffocation, laceration, reduced fitness, a reduced ability to prey or an increased probability of being caught (Laist, 1987; Derraik, 2002; Li et al., 2016). The entanglement incidence for a species depends on its behavior (Derraik, 2002). The plunge diving fishing method of some seabirds (e.g., gannets, boobies) has been shown to lead to a high rate of entanglement encounters, partly because the birds mistake floating plastic debris for fish or other food items (Li et al., 2016). This mode of feeding may be the primary reason for the entanglement encounters of seabirds. The accidental loss of trash and debris associated with the OCS is expected to be rare with adherence to MARPOL, as such, associated impact consequence is expected to be minor. Overall impact significance prior to mitigation is rated **1 – Negligible**.

5.2.6.5 Accidental Fuel Spill

Direct contact of coastal and oceanic birds with diesel fuel, particularly in close proximity to the spill location, may result in the fouling or matting of feathers with subsequent limitation or loss of flight capability or insulating or water-repellent capabilities; irritation or inflammation of skin or sensitive tissues, such as eyes and other mucous membranes; or toxic effects from ingested diesel fuel or the inhalation of diesel fuel and its volatile components (Kennicutt et al., 1991; Mazet et al., 2002). However, impact consequence to coastal and oceanic birds from a diesel fuel spill are expected to be minor due to the low volume of fuel spill, expected density of these resources, relatively short period of diesel fuel presence on the sea surface, and high degree of dissolution, spreading, and evaporation. The likelihood of impacts on coastal and oceanic birds from a fuel spill are considered rare and the overall impact significance prior to mitigation is rated **1 – Negligible**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Entanglement or entrapment with deployed Ocean Cleanup System (OCS)	Moderate	Rare	2 – Low
Attraction to the OCS and ingestion of plastics collected by the OCS	Minor	Occasional	2 – Low
Injury or mortality resulting from a vessel collision with a bird due to attraction from lights	Moderate	Rare	2 – Low
Behavioral modification changes (e.g., disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	Minor	Likely	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	Minor	Rare	1 – Negligible
Diesel fuel exposure, including inhalation of vapors, ingestion	Minor	Rare	1 – Negligible

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Entanglement or entrapment with deployed Ocean Cleanup System (OCS)	None recommended.	2 – Low
Attraction to the OCS and ingestion of plastics collected by the OCS	None recommended.	2 – Low
Injury or mortality resulting from a vessel collision with a bird due to attraction from lights	None recommended.	2 – Low

Impact	Mitigation Measures	Residual Impact Significance
Behavioral modification changes (e.g., disruption of activities, departure from the area) from noise exposure; avoidance of noise sources (support vessels)	**Elimination of unnecessary acoustic energy:** The levels of anthropogenic noise will be kept as low as reasonably practicable.	2 – Low
Entanglement with, or ingestion of, debris accidentally lost	Verify compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) restrictions and implementation of vessel Waste Management Plans, potentially reducing the likelihood of occurrence.	1 – Negligible
Diesel fuel exposure, including inhalation of vapors, ingestion	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under MARPOL 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels. • **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	1 – Negligible

5.2.7 Potential Impacts on Protected Areas

5.2.7.1 Impact Producing Factor(s)

- Towing Operations
- Vessel – Physical Presence/Strikes
- Accidental Fuel Spill

Due to the similarity of potential impacts, impact from towing operations and vessel/OCS physical presence are discussed together for potential impacts on protected areas.

5.2.7.2 Towing Operations/Vessel Physical Presence/Strikes

Depending on the final towing route selected, the towing vessel and support vessels will pass through the Greater Farallones NMS and Cordell Bank NMS, and near the Monterrey Bay NMS when traveling to the deployment area from the shorebase in San Francisco. No significant impacts are expected on these MPAs, but some minor disturbance of wildlife could occur due to the OCS being towed behind the vessel and vessel noise.

It is likely that wildlife in the three MPAs have likely become accustomed to disturbances associated with vessel traffic due to the ubiquity of vessel traffic in the region originating from the port in San Francisco. Vessel strikes are not expected to occur to resources within the protected areas, however, if a strike were to occur, impacts could be significant (**Sections 5.2.4**, **5.2.5**, and **5.2.6**). Impact consequence from all towing operations and the physical presence/strikes associated with project vessels to protected areas is expected to be minor. Based on the temporary and transient nature of the towing operations through the MPAs, the likelihood of any impacts is expected to be rare and the overall impact significance prior to mitigation is rated **1 – Negligible**.

5.2.7.3 Accidental Fuel Spill

An accidental diesel spill in a NMS during towing operations would dissipate rapidly and would only likely affect organisms in the immediate location of the release. Diesel fuel used for operation of support vessels is light and would float on the water surface. Diesel fuel spilled at the ocean surface will rapidly disperse and weather, with volatile components evaporating.

Impacts to protected species, including marine mammals, sea turtles, and coastal and oceanic birds, will be similar to those previously noted for these resources (i.e., direct contact; inhalation of volatile components; ingestion directly or indirectly through the consumption of fouled prey species; fouling or matting of feathers with subsequent limitation or loss of flight capability or insulating or water-repellent capabilities; irritation or inflammation of skin or sensitive tissues).

Impact consequence to protected areas and habitats of concern from a diesel fuel spill is expected to be minor due to the low volume of a potential fuel spill, the relatively short period of diesel fuel presence on the sea surface, and high degree of dissolution, spreading, and evaporation. The likelihood of impacts on protected areas from a fuel spill are considered rare and the overall impact significance prior to mitigation is rated **1 – Negligible**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Disturbance of wildlife in marine protected areas from towing activities	Minor	Rare	1 – Negligible
Exposure to diesel fuel, fouling of habitat	Minor	Rare	1 – Negligible

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Disturbance of wildlife in marine protected areas from towing activities	The towing vessel traveling between to the project area will travel at slow speeds (<3 knots).	1 – Negligible
Diesel fuel exposure, including inhalation of vapors, ingestion	• **Shipboard Oil Pollution Emergency Plan (SOPEP)** – Contractor will ensure that a SOPEP is in place on towing, monitoring, and debris retrieval vessels, and that an Oil Record Book as required under the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 will be maintained. • **Spill equipment on board** – Sorbent materials will be used to clean up any minor spill on board the survey vessels.	1 – Negligible

Impact	Mitigation Measures	Residual Impact Significance
Diesel fuel exposure, including inhalation of vapors, ingestion (cont'd)	• **Fuel transfer protocols** – Strict fuel transfer procedures will be implemented to prevent an accidental release during the loading of fuel at the port of mobilisation and during the time at sea, if necessary. Fuel hoses will be equipped with dry-break couplings. Any re-fuelling required will only be undertaken in safe working weather conditions and good lighting. • **Reporting procedures** – In the event of an accidental release of oil or other products, the incident will be immediately reported through the contractor chain-of-command to The Ocean Cleanup, and other regulatory bodies.	1 – Negligible

5.2.8 Potential Impacts on Commercial and Military Vessels

5.2.8.1 Impact Producing Factor(s)

- Towing Operations
- Vessel – Physical Presence/Strikes

Due to the similarity of potential impacts, impact from towing operations and vessel/OCS physical presence are discussed together for potential impacts on commercial and military vessels.

5.2.8.2 Towing Operations/Vessel Physical Presence/Strikes

Towing operations out of San Francisco Bay will likely require a temporary disruption of vessel traffic in and around the towing route due to the size of the towed OCS. It is expected that a NTM will be issued to alert interested parties of the timing and nature of any closures of shipping channels or other waterways in an around San Francisco Bay. Once offshore, it is not expected that the tow vessel or monitoring vessel will have interactions with commercial or military vessels.

Once out of San Francisco Bay, the tow vessel will remain in established shipping channels. The proposed tow route passes near MWAs W260 and W513 (**Figure 4-4**), both of which are special-use airspace zones primarily used for military training exercises. It is not expected that the tow vessel will pass through the MWAs and no impacts on military training activities are expected. However, The Ocean Cleanup will comply with any U.S. military mandated area restrictions.

The impact consequence from towing operations is expected to be minor on commercial and military vessels. Given the likely nature of this impact, overall impact significance prior to mitigation is rated **2 – Low**.

Impact Rating

Impact	Consequence	Likelihood	Significance
Temporary disruption of vessel traffic within San Francisco Bay	Minor	Likely	2 – Low

Mitigation Measures

Impact	Mitigation Measures	Residual Impact Significance
Temporary disruption of vessel traffic within San Francisco Bay	Issue a Notice to Mariners with information on timing and nature of proposed activities that may affect waterway closures.	2 – Low

6.0 Conclusion

A preliminary screening was conducted to identify the resources at risk from the towing and deployment of the OCS in the EPGP. Resource areas that were screened out included air quality; sediment quality; water quality; benthic communities; biodiversity; human resources, land use and economics; recreational resources and tourism; and physical oceanography. An impact assessment on the remaining resources (plankton, fish/fishery resources, marine mammals, sea turtles, coastal and oceanic birds, protected areas, commercial and military vessels) was conducted from a risk-based perspective to determine the overall significance of each potential impact based on its consequence and likelihood.

The initial analysis of routine operations (i.e., prior to application of mitigation measures) produced impact determinations that were predominately in the Negligible or Low categories. No High level impacts were noted. Impacts from an accidental fuel spill were identified based on the accidental release of diesel fuel. Given the relatively small potential spill volume and weathering factors, the impacts to various resources from a fuel spill release were rated Negligible or Low.

It is recommended that The Ocean Cleanup prepare an environmental management plan (EMP) to identify and describe mitigation measures that may be employed to reduce or eliminate the potential environmental impacts identified in this EIA. Overall, when proper mitigation measures, maritime regulations, and industry best practices are applied, the significance of potential impacts of the proposed activities will generally be Negligible or Low. Additionally, it is expected that the long-term positive impacts as a result of removing large amounts of floating plastic from the EPGP will likely provide a beneficial impact to all biological resources in the region.

73 FR 12024. Endangered and threatened species; endangered status for North Pacific and North Atlantic Right Whales. Thursday, March 6, 2008. Pp. 12024-12030.

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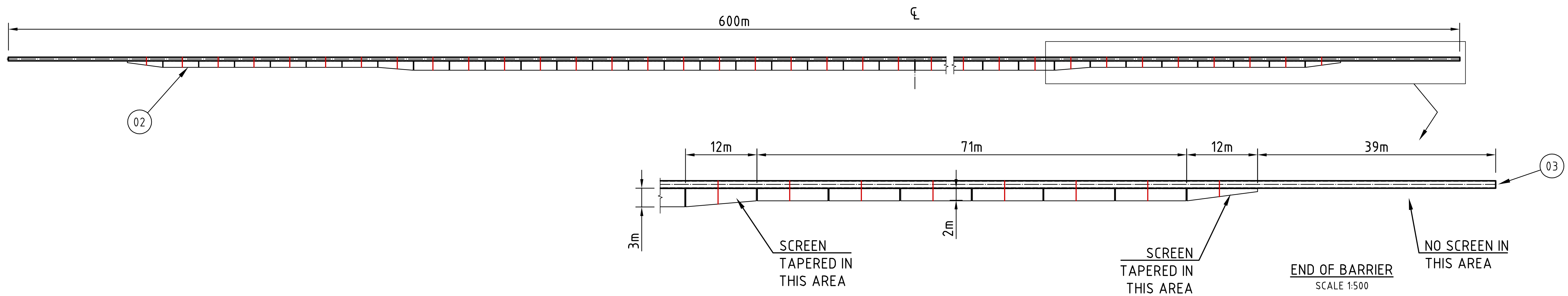
Appendices

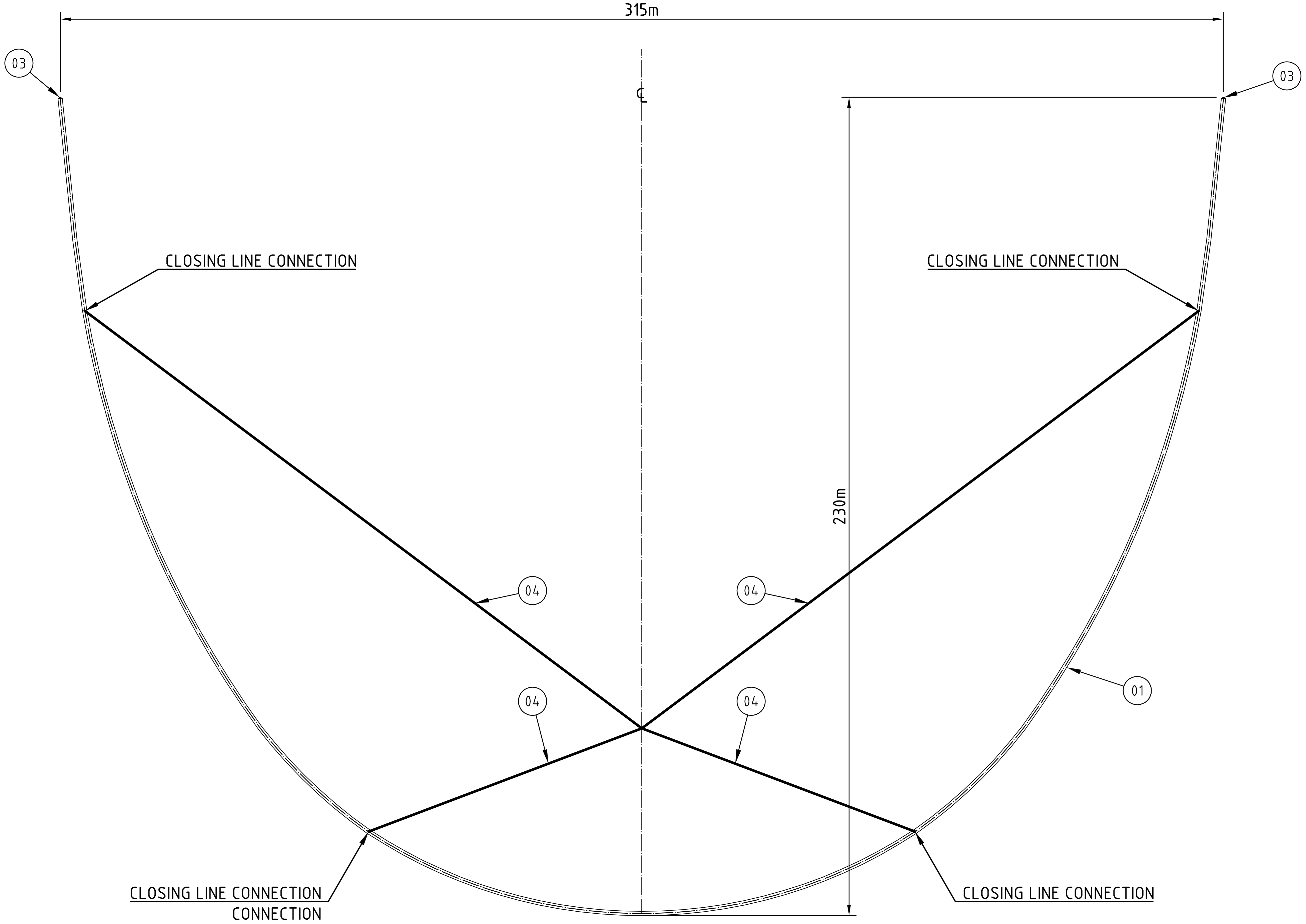
Appendix A

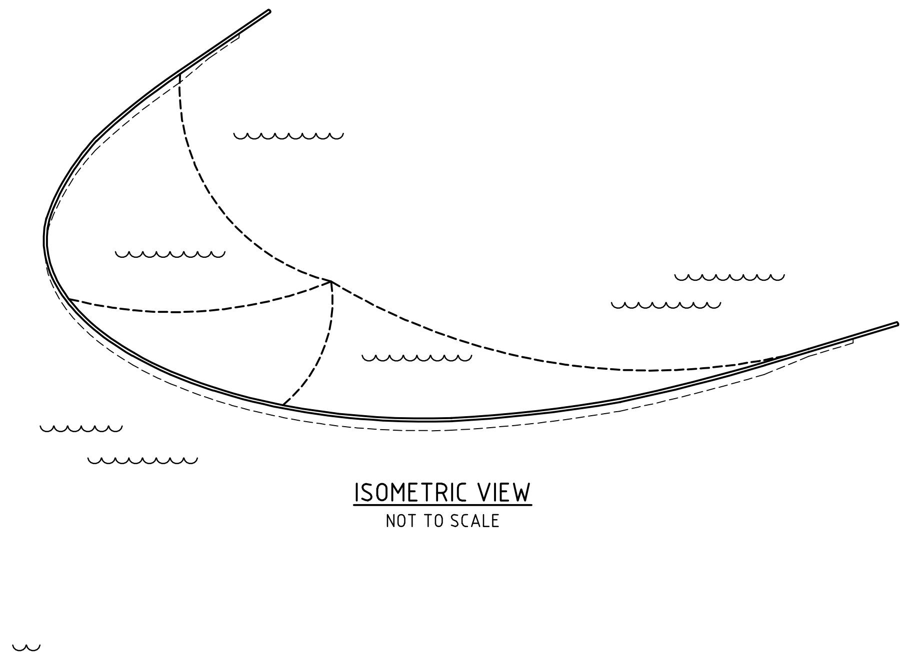
Ocean Cleanup System Conceptual Drawings

Rev.	Date	Drawn by	Approved by	Description



END OF BARRIER
SCALE 1:500





ISOMETRIC VIEW
NOT TO SCALE

Item	Qty	Description	Material	Remarks
04	4	CLOSING LINE		
03	2	TOW HEAD	STEEL	
02	2	SCREEN	GEOTEXTILE	
01	1	BARRIER	HDPE	48" SDR 17 L=600m

Projection	Tolerances unless note otherwise:	Dimensions	Size	Scale
Third Angle ISO drawing	Linear: ± 0.5 mm / ± 0.02 inch Angular: ± 0.5°	mm	A2	1 : 1000

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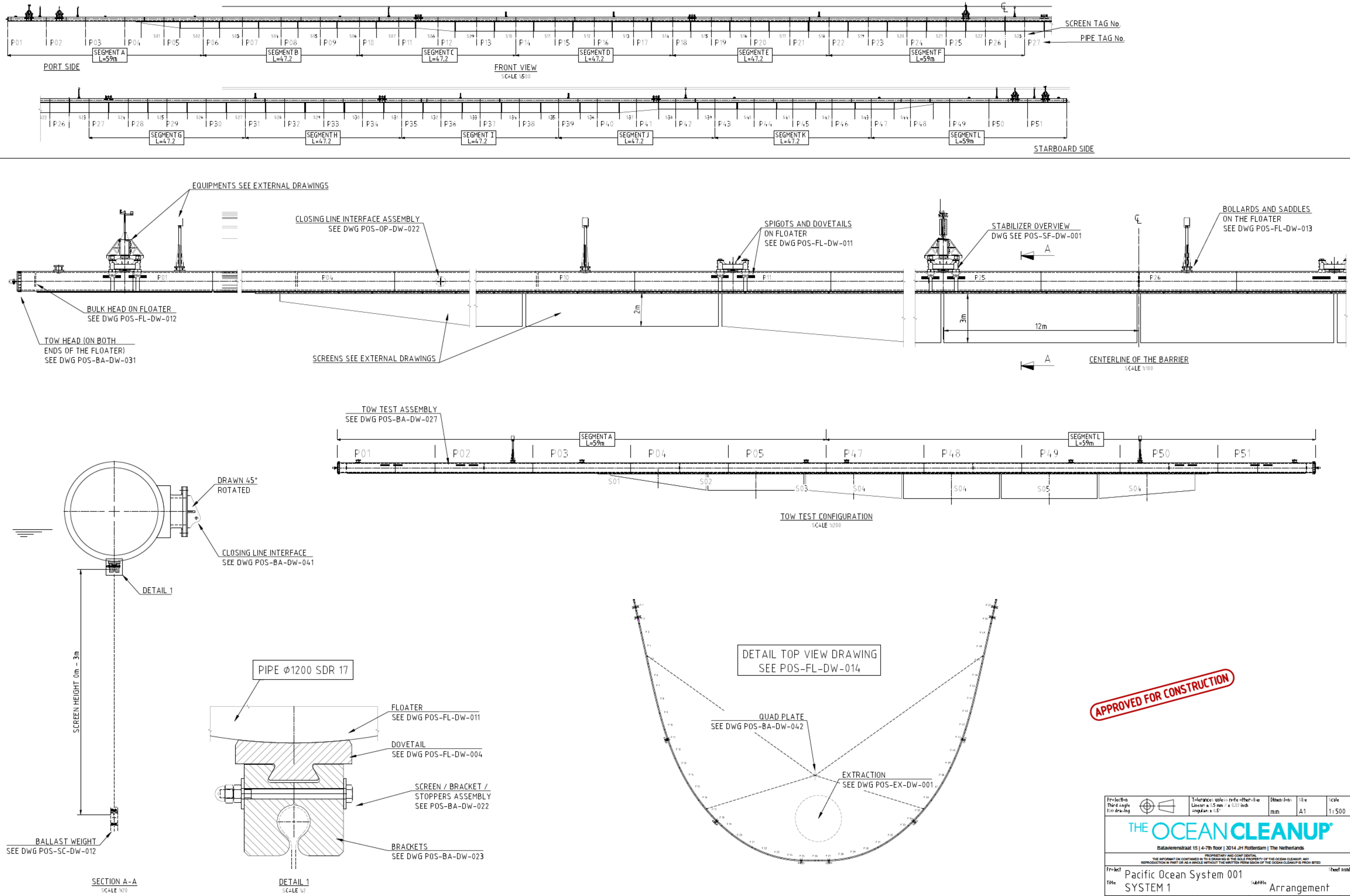
Project	Pacific Ocean System Pilot (POS-P)		Sheet number
Title	Pilot System	Subtitle	Arrangement

Created	Drawn by	Approved by	Drawing no.	Rev.
17-07-2017	Jaap Spaans		POS-GE-DW-005	

Rev.	Date	Drawn by	Approved by	Description
1.0	11 July 2018	Jaap Spaans	Ruud Schrama	First Issue



Projection Third angle ISO drawing	Tolerances unless note otherwise: Linear ± 0.5 mm / ± 0.02 inch, Angular ± 0.5°	Dimension mm	Size A1	Scale 1:500

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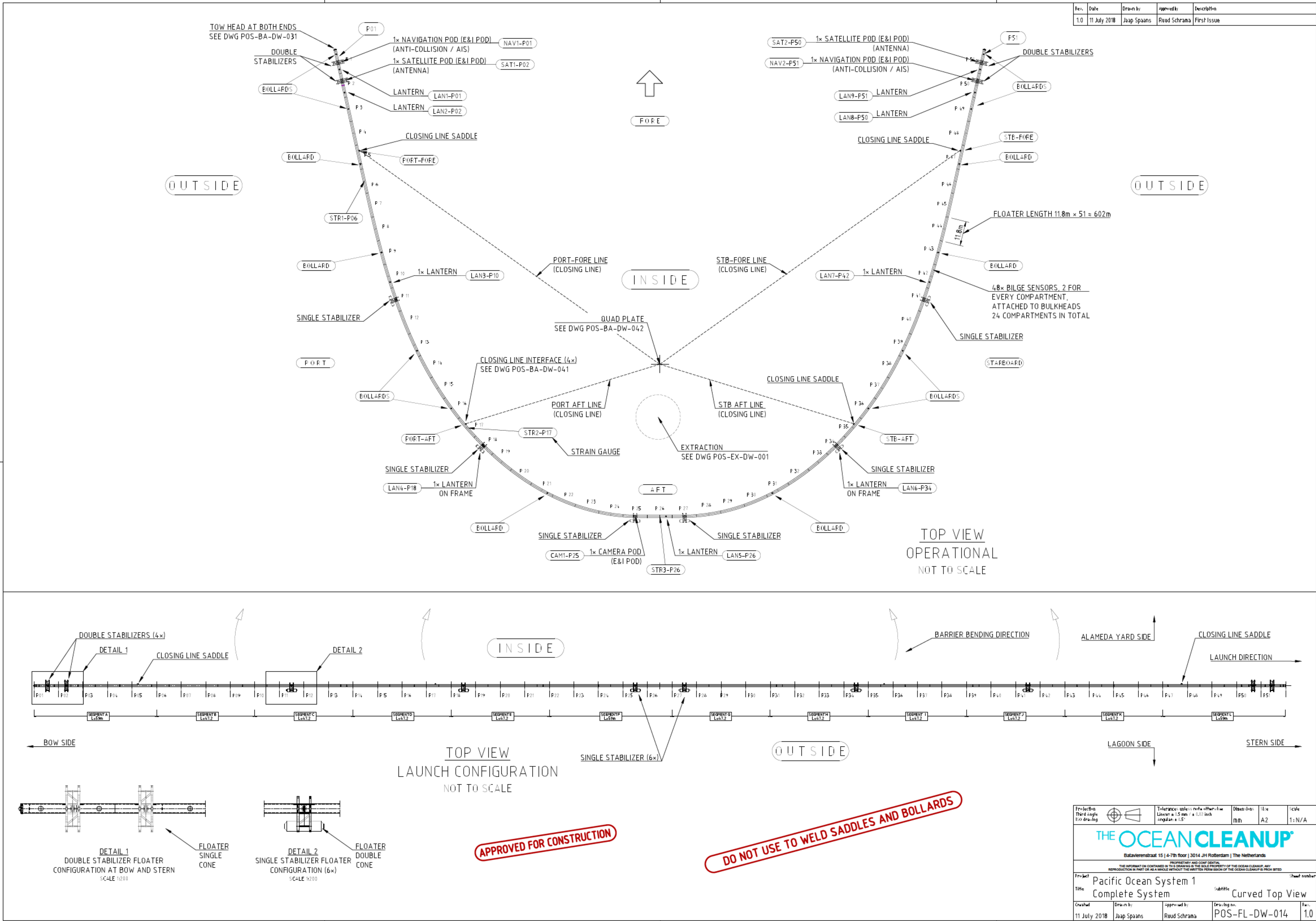
Project	Pacific Ocean System 001
Title	SYSTEM 1
Subtitle	Arrangement
Sheet number	

Created	Drawn by	Approved by	Drawing no.	Rev.
11 July 2018	Jaap Spaans	Ruud Schrama	POS-BA-DW-021	1.0



Rev. | Date | Drawn by | Approved by | Description
1.0 | 11 July 2018 | Jaap Spaans | Ruud Schrama | First Issue
TOW HEAD AT BOTH ENDS
SEE DWG POS-BA-DW-031
P01
DOUBLE STABILIZERS
1x NAVIGATION POD (E&I POD)
(ANTI-COLLISION / AIS)
NAV1-P01
1x SATELLITE POD (E&I POD)
(ANTENNA)
SAT1-P02
BOLLARDS
LANTERN
LAN1-P01
LANTERN
LAN2-P02
CLOSING LINE SADDLE
BOLLARD
PORT-FORE
OUTSIDE
STR1-P06
BOLLARD
1x LANTERN
LAN3-P10
SINGLE STABILIZER
PORT
BOLLARDS
CLOSING LINE INTERFACE (4x)
SEE DWG POS-BA-DW-041
PORT-FORE LINE
(CLOSING LINE)
INSIDE
QUAD PLATE
SEE DWG POS-BA-DW-042
PORT AFT LINE
(CLOSING LINE)
PORT-AFT
STR2-P17
STRAIN GAUGE
SINGLE STABILIZER
LAN4-P18
1x LANTERN
ON FRAME
BOLLARD
SINGLE STABILIZER
CAM1-P25
1x CAMERA POD
(E&I POD)
STR3-P26
1x LANTERN
LAN5-P26
SINGLE STABILIZER
AFT
EXTRACTION
SEE DWG POS-EX-DW-001
FORE
SAT2-P50
1x SATELLITE POD (E&I POD)
(ANTENNA)
NAV2-P51
1x NAVIGATION POD (E&I POD)
(ANTI-COLLISION / AIS)
P51
DOUBLE STABILIZERS
BOLLARDS
LAN9-P51
LANTERN
LAN8-P50
LANTERN
CLOSING LINE SADDLE
STB-FORE
BOLLARD
OUTSIDE
FLOATER LENGTH 11.8m x 51 ≈ 602m
11.8m
STB-FORE LINE
(CLOSING LINE)
BOLLARD
LAN7-P42
1x LANTERN
48x BILGE SENSORS, 2 FOR
EVERY COMPARTMENT,
ATTACHED TO BULKHEADS
24 COMPARTMENTS IN TOTAL
SINGLE STABILIZER
STARBOARD
CLOSING LINE SADDLE
BOLLARDS
STB AFT LINE
(CLOSING LINE)
STB-AFT
SINGLE STABILIZER
1x LANTERN
ON FRAME
LAN6-P34
BOLLARD
TOP VIEW
OPERATIONAL
NOT TO SCALE
DOUBLE STABILIZERS (4x)
DETAIL 1
CLOSING LINE SADDLE
DETAIL 2
INSIDE
BARRIER BENDING DIRECTION
ALAMEDA YARD SIDE
CLOSING LINE SADDLE
LAUNCH DIRECTION
BOW SIDE
TOP VIEW
LAUNCH CONFIGURATION
NOT TO SCALE
SINGLE STABILIZER (6x)
OUTSIDE
LAGOON SIDE
STERN SIDE
DETAIL 1
DOUBLE STABILIZER FLOATER
CONFIGURATION AT BOW AND STERN
SCALE 1:200
FLOATER
SINGLE
CONE
DETAIL 2
SINGLE STABILIZER FLOATER
CONFIGURATION (6x)
SCALE 1:200
FLOATER
DOUBLE
CONE
APPROVED FOR CONSTRUCTION
DO NOT USE TO WELD SADDLES AND BOLLARDS
Projection Third Angle ISO drawing
Dimension mm
Size A2
Scale 1:N/A
THE OCEAN CLEANUP
Batavierenstraat 15 | 4-7th floor | 3014 JH Rotterdam | The Netherlands
Project Pacific Ocean System 1
Title Complete System
Subtitle Curved Top View
Created 11 July 2018
Drawn by Jaap Spaans
Approved by Ruud Schrama
Drawing no. POS-FL-DW-014
Rev. 1.0

The Ocean Cleanup

Environmental Impact Assessment

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02	12/11/17	Revised draft	J. Tiggelaar R. Cady	A. Pittman	K. Olsen
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FIN-REV05	07/05/18	Final revised	J. Tiggelaar	N/A	J. Tiggelaar

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