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The Ocean Cleanup

Protected Species Observations

Analysis of Acoustic and Visual Data Recorded during
The Ocean Cleanup
North Pacific Trials and Deployment in the North Pacific
Garbage Patch

September 2018 – January 2019

Loraine Grant
2019

Executive Summary

Seiche Ltd conducted the environmental monitoring survey on behalf of The Ocean Cleanup during deployment of Ocean Cleanup System 001 (OCS1). Seiche provided protected species observers to monitor for protected species in waters near and around OCS1. The methods for data collection involved recording presence and absence of protected species, weather conditions and operational activities. Visual monitoring for protected species was conducted for 1012 hours 45 minutes over the course of the 141 days of system 001 project. Before specific operation such as installation of the system or plastic extraction Seiche's observers coupled visual observation with the deployment of drift buoys for passive acoustic monitoring of the waters around OCS1. The methods for data collection involved the deployment and recovery of the drift buoys from the monitoring vessel offshore. Two drift buoys were deployed and recovered multiple times during the study to record far field measurements and gather passive acoustic data and position data for marine mammal monitoring. Acoustic monitoring was conducted for 32 hours 13 minutes of the duration of the project.

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Abbreviations

ADD	Acoustic Deterrent Device
DLSR	Digital Single Lens Reflex (Camera)
EEZ	Exclusive Economic Zone
GPGP	Great Pacific Garbage Patch
NMFS	National Marine Fisheries Service
OCS1	Ocean Cleanup System 001
PAM	Passive Acoustic Monitoring
PSO	Protected Species Observer

1 Introduction

1.1 Survey Objectives

The Ocean Cleanup conducted a testing and deployment of their passive drifting system, Ocean Cleanup System 001 (OCS1), otherwise called the barrier, to collect and remove buoyant plastic debris from the Great Pacific Garbage Patch (GPGP). A trial was conducted outside the United States economic exclusion zone (EEZ) with the fully assembled 600 m (1,969 ft) barrier. The trial involved towing the barrier from San Francisco to the trial location, testing the closing lines connection procedure, observing the barriers behaviour in offshore, open-ocean conditions, testing attached sensors, navigation aids and environmental monitoring equipment. Immediately following the completion of these trials, the barrier was towed to the GPGP. The pre-selected location for deployment was located at 1,015 nautical miles offshore. Once released the barrier moved and orientated passively with the wind and surface currents. Data from the trials and deployment in GPGP will provide information needed to refine future efforts.

1.2 Survey Location and Duration

Mobilisation of the project was from Alameda, San Francisco on 08th September 2018. The project took place in two locations of North Pacific between California and the Hawaiian Islands. The first location was known as the “Pacific Trial” and ran for 19 days approximately 300 nautical miles offshore San Francisco and was the first deployment of the OCS1. Immediately following the Pacific Trial, the project moved to its second deployment site approximately 1,015 nautical miles offshore San Francisco and ran for 75 days. The first 43 days of the project were conducted from the 90m tug/supply vessel *Maersk Launcher*, 08th September 2018 to 21st October 2018. There was a crew and equipment change from the *Maersk Launcher* to *Maersk Transporter* at Honolulu, Hawaii between October 25th and 28th 2018. The remainder of the study was conducted from the 73m *Maersk Transporter* between 30th October 2018 and 27 January 2019. During this time there was crew change onboard the *Maersk Transporter* at San Francisco on 08 December 2018. Due to structural issues on 27th December 2018 OCS1 was towed back to port in Big Island, Hawaii for repairs. The *Maersk Transporter* then travelled to San Francisco for demobilisation of crew and scientific equipment.

1.3 Monitoring Vessel

The Ocean Cleanup chartered two vessels, *Maersk Launcher* and *Maersk Transporter*, which Seiche conducted their environmental monitoring from. Details of the vessel are:

ANCHOR HANDLER

Maersk Launcher

The Maersk Supply Service multi-purpose Anchor Handling Tug Supply Vessels (AHTS) are uniquely designed for a variety of work roles including deep water anchor handling and mooring operations, towing of rigs, subsea and ROV support work, as well as general supply and cargo support operations for customers world-wide. These specialized vessels have highly skilled crews, optimal safety conditions and state-of-the-art equipment to help our customers achieve their goals in a professional and cost-effective manner.



Key vessel features

- Dynamic position class 2
- 263 t bollard pull
- 66 person accommodation
- 810 m² open deck area
- 500 t double drum anchor handling / towing winches
- 2 x secondary winches
- 200 t Anchor Recovery Frame





Maersk Launcher

Classification

	+100A1 Offshore Tug/Supply Ship NAV1
Dynamic Positioning	DP2
Reference systems	2 x DGPS Kongsberg 1 x HIPAP Kongsberg 1 x Fanbeam MDL
Motion reference units	3 x Gyrometer Raytheon 2 x Motion sensor Seatex 2 x Wind sensor Gill

Deck Equipment

Anchor handling winches	2 x 500 t
Secondary winches	1 x 170 t + 1 x 145 t
Chain lockers	2 x 338 m ² + 2 x 234 m ²
Shark jaws	2 x 700 t
Stern rollers	2 x 3.25 m x 4.0 m
Stern roller SWL	2 x 800 t
Towing pins	2 x 300 t
Capstans	2 x 15 t
Tugger winches	2 x 20 t

Anchor Recovery Frame

Capacity	200 t
	Stowed flush with main deck

Dimensions

Length (LOA)	90.3 m
Beam	23 m
Depth	9.5 m
Draft scantling	7.8 m
Deadweight	4699 t
Gross tonnage	6798

Deck capacities

Deck load capacity	2080 t
Deck strength	Aft 15 t/m ² Fwd 10 t/m ²
Free deck area	810 m ²
Length	41.6 m
Width	19.5 m

Propulsion / Bollard pull

Main engines	23500 BHP 4 x MAK 9M32C
Thrusters	2 x CP main propellers 2 x bow tunnel 2040 BHP 2 x stern tunnel 1200 BHP
Bollard pull	263.0 t

Accommodation

Person capacity	66
-----------------	----

Tank capacities

Base oil	899 m ³
Brine	752 m ³
Drill/ballast water	2796 m ³
Fresh water	945 m ³
Fuel	1894 m ³
Oil based mud	602 m ³
	Including multi-purpose tanks

Fuel consumption per 24 hrs

Maximum speed	85 t @ 16.7 kn
Eco speed	20 t @ 10 kn

**All figures and data believed to be correct, but not guaranteed*

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Contact information

For further information on vessel specifications, capacities or vessel availability, please do not hesitate to contact the Commercial Department at chartering@maersksupplyservice.com or +45 73 73 73 73



Vessel Number: 17

ANCHOR HANDLER

Maersk Transporter

The Maersk Supply Service multi-purpose Anchor Handling Tug Supply Vessels (AHTS) are uniquely designed for a variety of work roles including deep water anchor handling and mooring operations, towing of rigs, subsea and ROV support work, as well as general supply and cargo support operations for customers world-wide. These specialized vessels have highly skilled crews, optimal safety conditions and state-of-the-art equipment to help our customers achieve their goals in a professional and cost-effective manner.



Key features

- Dynamic position class 2
- 172 t bollard pull
- 600 m² open deck space
- 400 t anchor handling/towing winches
- Clean Design/Comfort Class



 **MAERSK**
SUPPLY SERVICE

Maersk Transporter

Classification

	A1 Offshore Support Vessel (TOW, Supply) OSR-S1 HAB++(WB) ACCU LR FIF11 Compliant
Dynamic positioning	DP2
Reference systems	2 x DGPS Kongsberg 1 x Fanbeam Renishaw 1 x HiPAP Kongsberg 1 x Mini Radscan
Motion reference units	2 x Gyro Anschütz 2 x Wind sensor Gill 2 x Motion sensor Kongsberg

Deck Equipment

Anchor handling winch	1 x 400 t
Tow winches	2 x 400 t
Chain lockers	1 x 245 m ³ + 1 x 264 m ³
Shark jaws	2 x 700 t
Stern rollers	2 x 3.0 m x 3.0 m
Stern roller SWL	2 x 800 t
Towing pins	2 x 200 t
Capstans	2 x 15 t
Tugger winches	2 x 17 t

Dimensions

Length (LOA)	73.2 m
Beam	20.0 m
Depth	9.1 m
Draft scantling	7.75 m
Deadweight	3370 t
Gross tonnage	4678

Deck capacities

Deck load capacity	1030 t
Deck strength	Aft 15 t/m ² Fwd 10 t/m ²
Free deck area	600 m ²
Length	35.8 m
Width	16.8 m

Propulsion / Bollard pull

Main engines	13872 BHP 2 x MAN 8-27/38 + 2 x MAN 7-L27/38
Thrusters	2 x CP main propellers 2 x bow tunnel 1200 BHP 2 x stern tunnel 680 BHP
Bollard pull	172 t

Accommodation

Person capacity	30
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Tank capacities

Base oil	129 m ³
Brine	769 m ³
Drill/ballast water	1800 m ³
Dry bulk	200 m ³
Fresh water	618 m ³
Fuel	1191 m ³
Oil based mud	640 m ³
Oil recovery	769 m ³
	Including multi-purpose tanks

**All figures and data believed to be correct, but not guaranteed*

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Contact information

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Version Number 1.3

1.4 Animals in the Project Area

Twenty-five species of marine mammals could potentially be observed in the project area, including six species of mysticetes, 18 species of odontocetes and one species of pinniped (Table 1). Of the 25 species potentially observed in the project area, four are listed as endangered on the Endangered Species Act (ESA), including blue, fin, sei and sperm whales; all of which are also listed as depleted under the Marine Mammal Protection Act (MMPA). Fourteen species of birds could potentially be observed in the project area (Table 2). Of the fourteen species potentially observed in the project area, one is listed as endangered, two are listed as vulnerable, six are listed as near threatened and five are listed as least concern. Five species of marine turtle may have been observed in the project area (Table 3). Of these five species potentially observed in the project area, one is listed as critically endangered, two are listed as endangered and two are listed as vulnerable (CSA, 2018).

Table 1 - Marine Mammals potentially observed in the project area

Scientific Name	Common Name	MMPA Status	ESA Status
<i>Megaptera novaeangliae</i>	Humpback Whale	not listed	not listed
<i>Balaenoptera acutorostrata</i>	Minke Whale	not listed	not listed
<i>Balaenoptera brydei</i>	Bryde's Whale	not listed	not listed
<i>Balaenoptera borealis</i>	Sei Whale	depleted	endangered
<i>Balaenoptera physalus</i>	Fin Whale	depleted	endangered
<i>Balaenoptera musculus</i>	Blue Whale	depleted	endangered
<i>Physeter macrocephalus</i>	Sperm Whale	not listed	not listed
<i>Ziphius cavirostris</i>	Cuvier's Beaked Whale	not listed	not listed
<i>Indopacetus pacificus</i>	Longman's Beaked Whale	not listed	not listed
<i>Mesoplodon densirostris</i>	Blainville's Beaked Whale	not listed	not listed
<i>Steno bredanensis</i>	Rough-Toothed Dolphin	not listed	not listed
<i>Tursiops truncatus</i>	Bottlenose Dolphin	not listed	not listed
<i>Stenella attenuata</i>	Pantropical Spotted Dolphin	not listed	not listed
<i>Stenella longirostris</i>	Spinner Dolphin	not listed	not listed
<i>Stenella coeruleoalba</i>	Striped Dolphin	not listed	not listed
<i>Lagenodelphis hosei</i>	Fraser's Dolphin	not listed	not listed
<i>Grampus griseus</i>	Risso's Dolphin	not listed	not listed
<i>Peponocephala electra</i>	Melon-Headed Whale	not listed	not listed
<i>Feresa attenuata</i>	Pygmy Killer Whale	not listed	not listed
<i>Pseudorca crassidens</i>	False Killer Whale	not listed	not listed
<i>Orcinus orca</i>	Killer Whale	not listed	not listed
<i>Globicephala macrorhynchus</i>	Short-Finned Pilot Whale	not listed	not listed
<i>Kogia breviceps</i>	Pygmy Sperm Whale	not listed	not listed
<i>Kogia sima</i>	Dwarf Sperm Whale	not listed	not listed
<i>Zalophus californianus</i>	California Sea lion	not listed	not listed

Table 2 - Birds potentially observed in the project area

Scientific Name	Common Name	Foraging / Migration Season	Foraging / Migration Area	IUCN Red List Status
<i>Sula leucocaster</i>	Brown Booby	Year Round	Pacific Ocean	Least Concern
<i>Sula sula</i>	Red footed Booby	March – October	Open Ocean, only in far South of Northeast Pacific and Hawaii	Least Concern
<i>Sula dactylatra</i>	Masked Booby	Year Round	Open Ocean, only in South Northeast Pacific and Hawaii	Least Concern
<i>Phoebastria nigripes</i>	Black-footed Albatross	May – October	North Pacific Ocean	Near Threatened
<i>Phoebastria immutabilis</i>	Laysan Albatross	August – November	North Pacific Ocean. Seen in Northeastern Pacific but prefers West Pacific side	Near Threatened
<i>Phoebastria albatrus</i>	Short tailed Albatross	June – October	North Pacific – especially Alaska but spotted around Hawaii and California	Vulnerable
<i>Oceanodroma homochroa</i>	Ashy Storm-petrel	November – April	California Current System	Endangered
<i>Puffinus opisthomelas</i>	Black-vented Shearwater	July – February	California Current System and North Pacific	Near Threatened
<i>Ptychoramphus aleuticus</i>	Cassin’s Auklet	Year Round	Along North American West Coast	Near Threatened
<i>Pterodroma ultima</i>	Murphy’s Petrel	November – April	Between Hawaii and California, at least 64km (35nmi) offshore	Near Threatened
<i>Puffinus creatopus</i>	Pink-footed Shearwater	April – October	Along continental shelf of U.S. West coast and Canada	Vulnerable
<i>Ardena pacifica</i>	Wedge-tailed Shearwater	Year Round	Tropical oceans (35°N-35°S)	Least Concern
<i>Ardena grisea</i>	Sooty Shearwater	April – October	Circular migration, full Pacific Ocean	Near Threatened
<i>Hydrobates leucorhous</i>	Leach Storm Petrel	November - April	Pacific Ocean	Least Concern

IUCN = International Union for Conservation of Nature
 CSA, 2018. The Ocean Cleanup: Environmental Impact Assessment

Table 3 - Marine Turtles potentially observed in the project area

Scientific Name	Common Name	IUCN Red List Status
<i>Dermochelys coriacea</i>	Leatherback Turtle	Vulnerable
<i>Chelonia mydas</i>	Green Turtle	Endangered
<i>Eretmochelys imbricata</i>	Hawksbill Turtle	Critically Endangered
<i>Caretta caretta</i>	Loggerhead Turtle	Endangered
<i>Lepidochelys olivacea</i>	Olive Ridley Turtle	Vulnerable

CSA, 2018. The Ocean Cleanup: Environmental Impact Assessment

2 Protected Species Monitoring and Mitigation Program

The aim of the vessel-based monitoring program was to ensure that any possible disturbance or risk for protected species, including marine mammals, sea turtles and other protected species was recognised and where possible mitigated.

The primary purposes of the monitoring and mitigation program:

Monitoring: Perform visual and acoustic observations to determine whether protected species were present inside the project area, including relevant exclusion zones and to document behaviours as best as practically possible.

Mitigation: An action or activity implemented to minimize the risk of a potential impact occurring to a protected species, this activity could take place as precautions measure, or once observed or detected inside the designated exclusion zones; for example: delay of operation or shut down of operation, if feasibly possible.

The following mitigation measures were adopted for visual and acoustic monitoring for protected species during the testing and trial period. The mitigation measures implemented included:

- Exclusion zones
- Operational delay procedures
- Operational shut down procedures
- Acoustic deterrent device procedures

Additionally, measures were implemented for vessel strike avoidance (low speed < 14 knots at all time). Dedicated procedure was planned if need would arise to report a deceased or injured

protected species. The mitigation measures and monitoring protocols are detailed here. An abbreviated summary and decision flow chart are provided in Appendix A.

2.1 Mitigation Requirements

2.1.1 Exclusion Zone

An exclusion zone of 500m for delay and shut downs, was established and monitoring for the presence or absences of protected species by a dedicated protected species observer (PSO). The exclusion zone and surrounding areas were monitored visually during hours of daylight. The exclusions zones were monitored acoustically and visually 60 minutes prior to any operational action on the barrier, such as installation, relocation and plastic extraction. This 60-minute monitoring period was immediately followed by 15 minutes of acoustic deterrent device (ADD). The exclusion zone was based on the radial distance from the barrier.

2.1.2 Operational Delay Procedures

Prior to any operational activities on the barrier, the 500m exclusion zone was visually and acoustically monitored for the presence of protected species for a minimum of 60 minutes, followed by 15 minutes acoustic deterrent device. If a protected species was detected approaching, entering or within the exclusion zone either visually and/or acoustically, all operations were delayed until 30 minutes had elapsed from the last visual or acoustic detection of protected species in the 500m exclusion zone.

2.1.3 Operational Shut Down Procedures

If a protected species was visually and/or acoustically detected within the 500m exclusion zone or about to enter the zone whether due to the animal's movement, the barriers movement, or because the animal surfaced inside the exclusion zone then the operational activities on the barrier were immediately stopped, once deemed safe by the TOC superintendent and captain. A shut down of operational activities on the barrier were also implemented for acoustic detections where the distance from the barrier was uncertain or unknown. The operations were delayed until 30 minutes had elapsed from the last visual or acoustic detection of marine mammals in the 500m exclusion zone.

2.1.4 Acoustic Deterrent Device

An Acoustic Deterrent Device was powered on for 15 minutes immediately after the 60-minute pre-watch period. If a protected species was recorded approaching, entering or within the exclusion zone

before or during activation of ADD then an assessment on best practice was conducted (Appendix A). A PSO also monitored the 500m exclusion zone during this period.

2.2 Protected Species Survey Methodology

2.2.1 Visual Monitoring

Visual monitoring for protected species were conducted by a NMFS approved PSO during daytime operations regardless of operational activities on the barrier, as well as during transit to and from port.

Watches were primarily conducted from the navigation deck (bridge and bridge wings) and top deck, approximately 18m and 20m above sea surface, respectively (Figure 1 and 2).

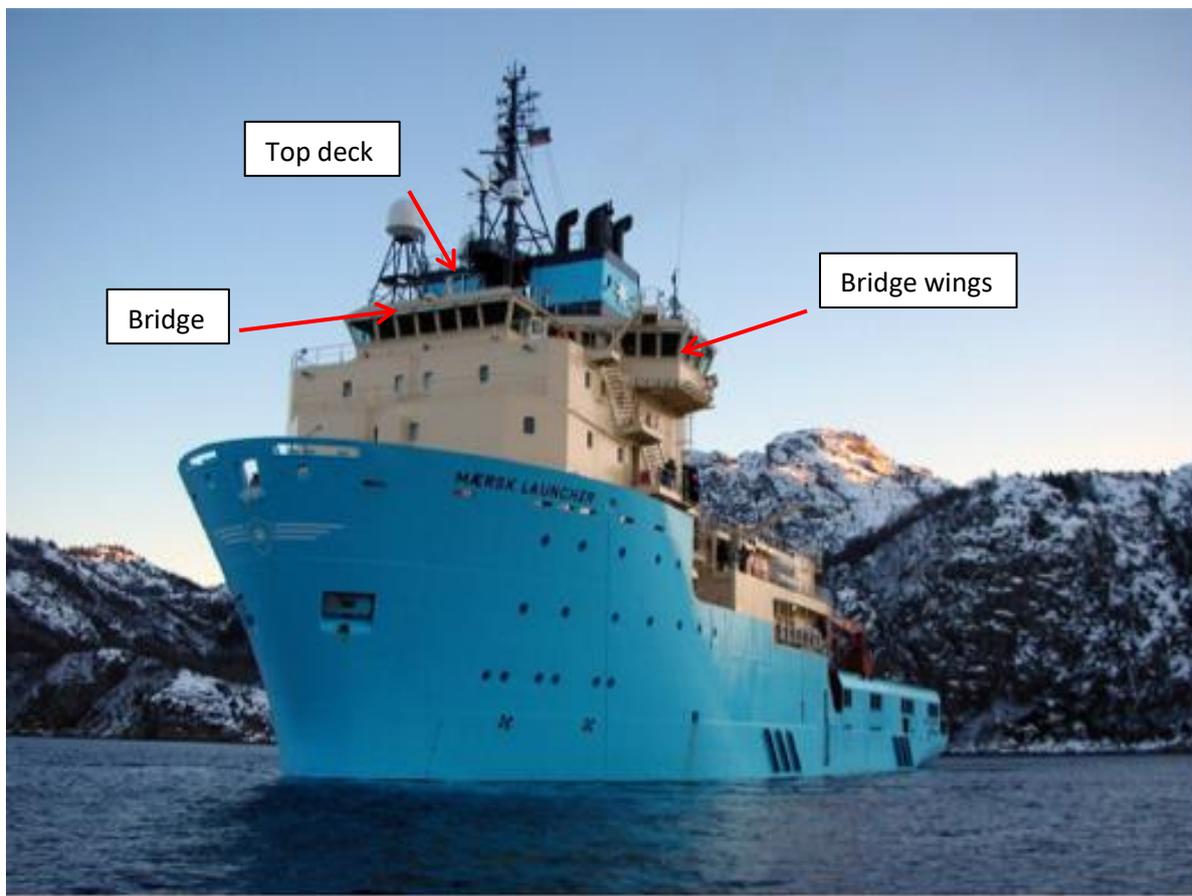


Figure 1 - Locations of visual observations on the Maersk Launcher

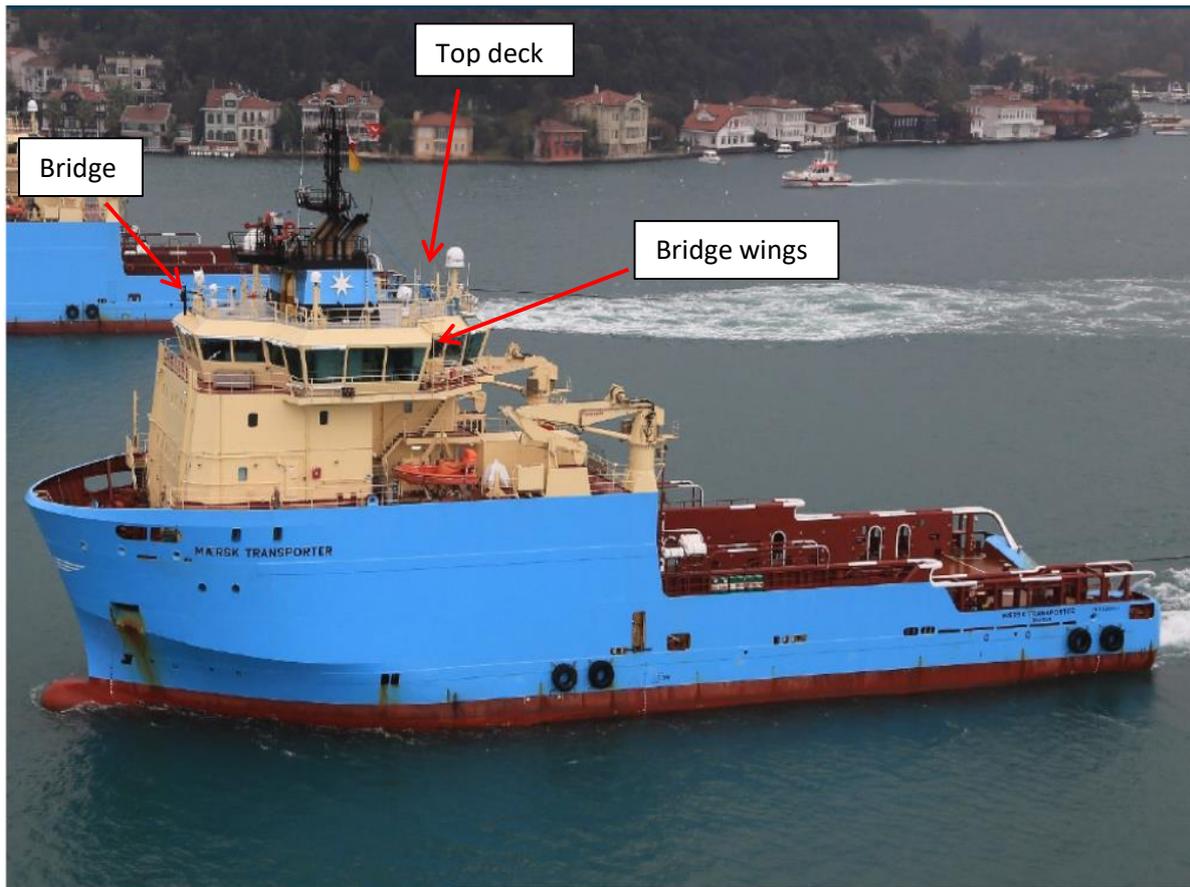


Figure 2 - Locations of visual observations on the Maersk Transporter

The PSO scanned the sea surface with the naked eye and 7x50 marine reticle binoculars. DLSR cameras were available for photographing observed wildlife, with a lens up to 300mm.

Distance to observed protected species was estimated using reticle binoculars and by using known reference distances (distance astern of the barrier, distance to passing vessels etc.). Species were identified based upon physical characteristics and behaviours. Identification was facilitated by consulting relevant field guides or by observer experience.

Upon making a visual detection, the PSO determined whether the presence of the marine species immediately warranted a mitigation action. The PSO maintained visual contact with the animal until the protected species could no longer be observed, whether because the animal dove or the distance at which the PSO could maintain visual contact had been exceeded. Mitigation actions were implemented when appropriate and were made directly to The Ocean Cleanup offshore party chief or vessel's captain via hand held radios or direct verbal communications. Notes on the detection, such as behaviour of the animal, distance to the animal from the barrier, bearing to the animal,

animal direction of travel, number of individuals, etc. were maintained by the PSO throughout their monitoring period using field notebooks. Details on operations, vessel position, and weather conditions were also recorded at regular intervals or when conditions and/or operations changed. All data was recorded electronically in an Excel Spreadsheet.

2.2.2 Passive Acoustic Monitoring (PAM)

Acoustic monitoring for marine mammals was conducted by an experienced passive acoustic monitoring (PAM) operator prior to any operational activities on the barrier. Monitoring began no less than 60 minutes prior to any operational activities on the barrier. Acoustic monitoring was conducted from the bridge onboard both the Maersk *Launcher* (Figure 3) and Maersk *Transporter* (Figure 4).



Figure 4 - Acoustic monitoring station on the bridge of Maersk Launcher



Figure 5 - Acoustic monitoring station on the bridge of Maersk Transporter

During the acoustic monitoring period, the PAM operator aurally monitored the signal from the hydrophones while monitoring pertinent visualization modules in *PAMGuard*. Upon making an acoustic detection of marine mammal vocalizations, the PAM operator would immediately collect audio recordings, make note of vessel and barrier position and water depth, collect screen images of the *PAMGuard* visualization displays, and continue to monitor for vocalizations. Detections were monitored until no longer detected aurally and/or visually in *PAMGuard*. Mitigation actions were implemented when appropriate and were made direct to The Ocean Cleanup offshore manager or vessel's captain via hand held radios or direct verbal communications. Notes on the detection including vocalization type, frequency, duration etc. were collected throughout the detection event. Details on operations and vessel position were also recorded during the monitoring period.

A detection was defined as any acoustic event during which cetacean vocalizations were aurally and/or visually observed in *PAMGuard*, regardless of the total duration of the event. Cetacean vocalizations detected greater than 10 minutes apart were considered separate detections.

Acoustic identification of species can be challenging, particularly with delphinid species. As such species were identified to the lowest level of confidence (unidentified cetacean, unidentified odontocete, unidentified delphinid etc.), unless the operator was confident in their species identification or there was visual confirmation.

2.2.3 Passive Acoustic Monitoring Equipment

2.2.3.1 PAM Hardware

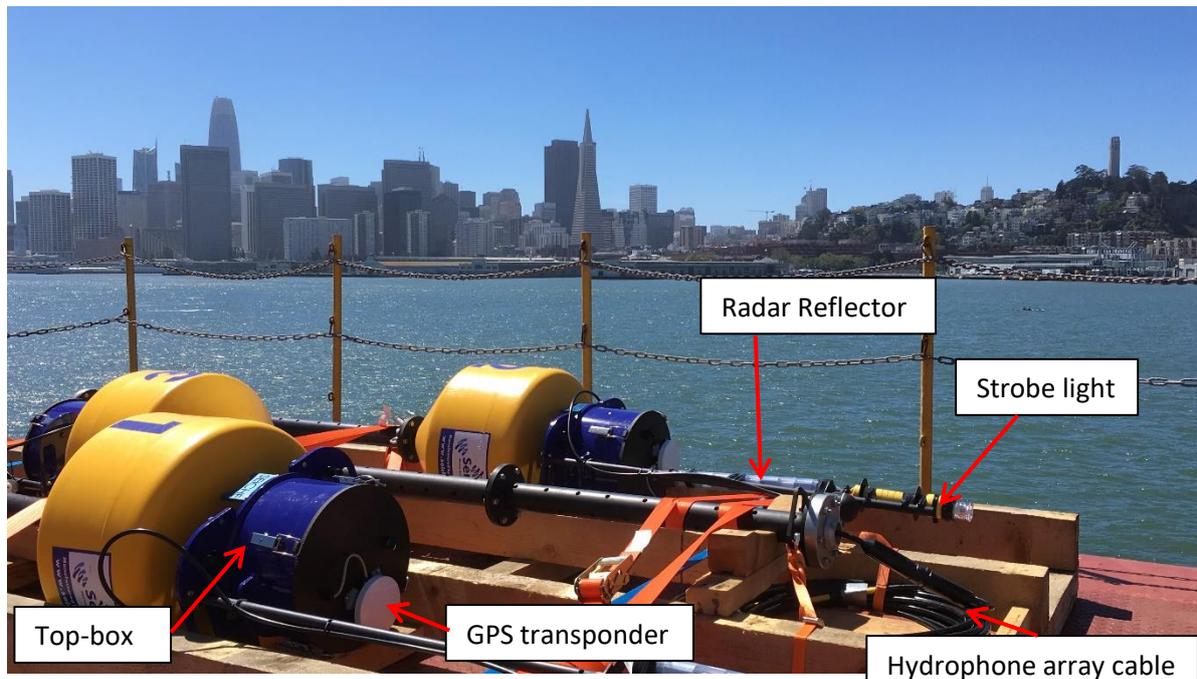


Figure 7 -PAM buoys secured on Maersk Launcher

Three drift buoys, designed and manufactured by Seiche Limited, were made ready for use as part of the equipment to be utilised for Passive Acoustic Monitoring; two buoys were intended for operational use with one spare. The Seiche acoustic buoys were assembled and configured to remotely record underwater sounds from a suspended 30m, multi-element hydrophone array cable and integrated PAM system, housed within a watertight top-box with a battery, GPS transponder, mast with radar reflector and a hydrophone cable with potted hydrophones. Hydrophones hang vertically in the water and configured for depths of 30m (Figure 5 and Table 4).

2.2.3.2 Technical Specification

- The buoy system consists of Electronics securely fitted within water tight housing
- National Instruments cDAQ9181 card with a NI9222 interface transmitting acoustic data over ethernet
- Ubiquity Wi-Fi module transmitting data wirelessly over coax cable leading to external antenna located on the mast
- Additional filtering module to reject noise introduced in the audio signal path

Table 4 - Drift buoy PAM system information

Parameter	Description
Cable Length	30 m
Diameter	14 mm
Connector	Seiche
Hydrophone Elements	Frequency
Hydrophone 1	Low frequency: 10 Hz to 24 kHz
Hydrophone 2	2 kHz to 200 kHz

The signal was captured at a sampling rate in excess of 500 ks/s at 16-bit. The system was configured to record the data remotely at a receiving station on board the monitoring vessel (i.e. *Maersk Launcher* or *Maersk Transporter*). The buoy system consisted of Radio Frequency (RF) link to enable signals to be transmitted in real time to the monitoring vessel. GPS was used to locate the buoys accurately. A single buoy provided a coverage area of approximately 2.5km². A vessel based receiving unit was provided to receive the signal transmitted from the buoy. The signal was channelled through an interface unit for signal conditioning and conversion prior to analysis and display. A low frequency audio was also used. *PAMGuard* software was used for real time analysis and local data storage. The system was set up for both single and multiple buoy deployment.

2.2.4 PAM Buoy Deployment

The acoustic buoys were deployed prior to specific operations near or on OCS1. The acoustic buoys were deployed by a crane and quick release from the monitoring vessel and allowed to drift alongside the barrier (Figure 6). After the operations were completed the PAM buoys were retrieved and serviced in preparation for the next deployment (Figure 7 - 10). This process was repeated several times throughout the project.



Figure 8 - PAM buoys drifting alongside OCS1



Figure 9 - PAM buoy deployment from Maersk Launcher



Figure 10 - PAM buoy recovery from Maersk Launcher



Figure 11 - PAM buoy deployment from Maersk Transporter



Figure 12 - PAM buoy recovery from Maersk Transporter

2.2.4.1 PAM Software

PAMGuard is an open source software program for passive acoustic monitoring developed with the support from the OGP E&P Sound and Marine Life Program. The software can be configured by the user to meet any specific project requirements. The user can add in various modules that will allow for visualization of the raw and/or filtered signal from the hydrophones, implementation of detectors for tonal and pulsed vocalizations, permit recording of one to multiple hydrophone channels, and provide tracking and localisation capabilities.

The PAM system was configured to monitor for low, mid, and high frequency cetacean vocalisations using *PAMGuard* version 1.15.15 (64 bit). A click detector was incorporated to detect high frequency clicks produced by echolocating delphinids, *Kogia*, and beaked whales. The trigger threshold was set to 10dB for this click detector. A mid frequency spectrogram was configured with a frequency range of 0 – 24 kHz, this had a 48 kHz decimated input, for detecting dolphin whistles and sperm whales. A low frequency spectrogram was configured to a frequency range of 0 – 3 kHz, this had a 6 kHz decimated source, and was used to detect humpbacks and other baleen whales.

2.2.5 Acoustic Deterrent Device (ADD)

Initiation of ADD was conducted by the passive acoustic monitoring (PAM) operator prior to any operational activities on the barrier. The ADD (Figure 11) consisted of a control unit and a transducer. The control unit contained a pulse generator and an amplifier to transmit random bursts of audio frequency signals to the transducer – this is then converted into intense sound. The ADD transmitted 191 dB/ μ Pa/m at an optimal frequency – between 10 and 20 kHz – for deterring marine mammals. The ADD was powered up for 15 minutes directly after visual monitoring (see 2.1.4 of report).



Figure 13 - Acoustic Deterrent Device

2.3 Communication and Reporting

All communications were made directly to either The Ocean Cleanup offshore manager or vessel's captain using a handheld radio or via direct verbal communications. Notification of the monitoring periods was given at least 90 minutes prior to the start of any operational activities on the barrier, along with a clearance check prior to the operational activities on the barrier. Requests for mitigations were relayed immediately and communication was maintained until operations resumed.

Throughout the initial 43 days of the project a daily report was submitted to The Ocean Cleanup offshore manager onboard the *Maersk Launcher*. The report included information on observer effort (visual and acoustic), marine mammal detections and mitigation actions. For the remainder of the project a weekly report was submitted to The Ocean Cleanup offshore manager onboard the *Maersk Transporter*. The report included information on observer effort (visual and acoustic), weather, marine mammal detections and mitigation actions.

3 Survey Results

3.1 Observer Effort and Sighting Conditions

3.1.1 Visual Monitoring

Visual monitoring for marine mammals was conducted for 1012 hours 45 minutes over the course of the project, including 179 hours 02 minutes (17.13% of project) during transit to and from port. All observations took place during hours of daylight.

3.1.1.1 Environmental Conditions

Environmental conditions can influence an observer’s ability to detect marine mammals visually, therefore details on various environmental conditions were recorded by the PSO as often as possible or when conditions changed.

Winds during the project were predominantly from the North, Northwest and Southeast (North at 19.44%, Northwest at 19.02% and Southeast at 18.04% of all records; Figure 12) and a force between 3 to 5 on the Beaufort scale (force 3 at 19.86%, force 4 at 23.35% and force 5 at 20.00% of all records; Figure 13) for visual observations.

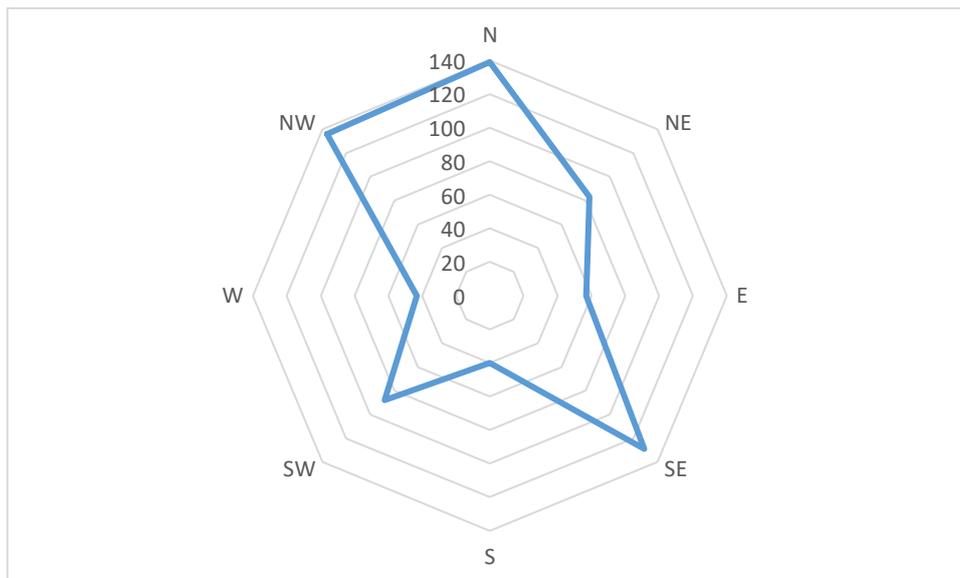


Figure 14 - Wind direction recorded during the project

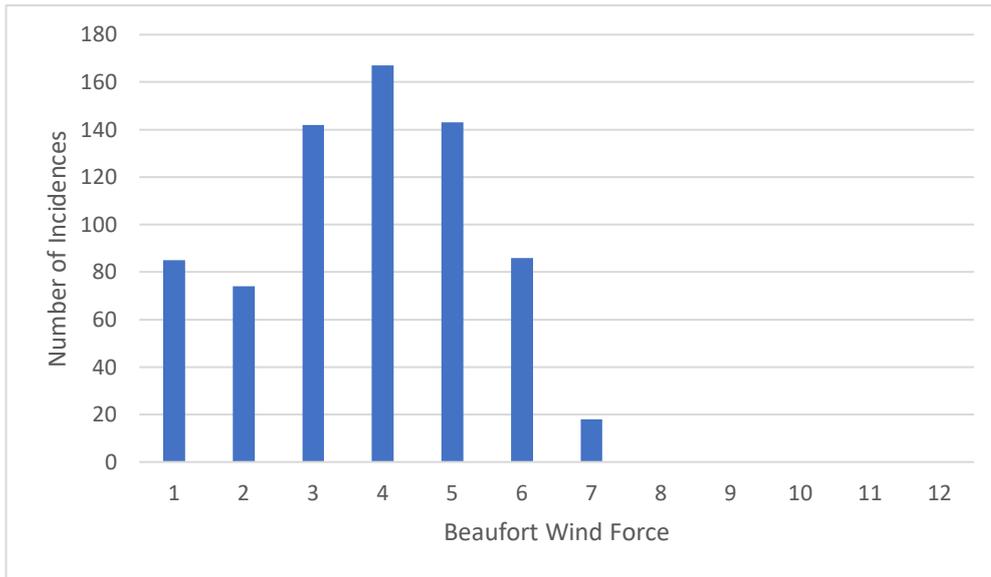


Figure 15 - Beaufort wind force recorded during the project

Sea surface conditions varied from glassy to rough (Figure 14), with slight conditions (small wavelets with few whitecaps) occurring most often (51.32% of all records). There were very few days, 1.25% of all records, recorded as having rough conditions (large waves, foam crests and spray) during the project (Figure 14). Swell height was <4m of the visual survey effort for most of the project (<2m at 49.09% and 2-4m at 43.49% of all records; Figure 15).

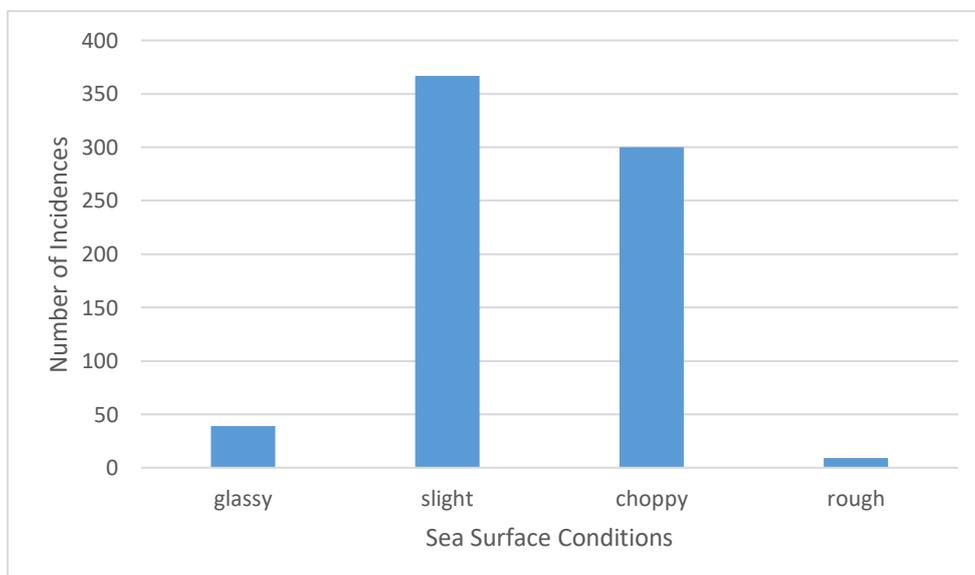


Figure 16 - Sea surface conditions recorded during the project

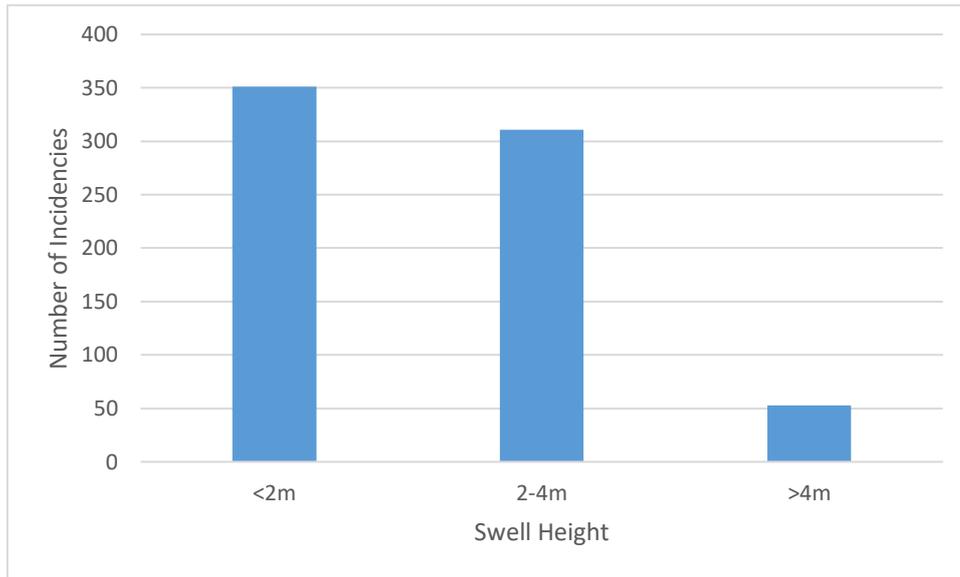


Figure 17 - Swell height recorded during visual observation periods during the project

Visibility was good, with clear conditions allowing for observations at ranges greater than 5km (Figure 16), however there were numerous periods of strong glare throughout the project which made observation difficult in the direction of the glare (Figure 17). Brief periods of light to moderate rain showers were encountered as small squalls moved through the project area, with most showers consisting of only light levels of precipitation. Most of the project experienced no rain fall (Figure 18).

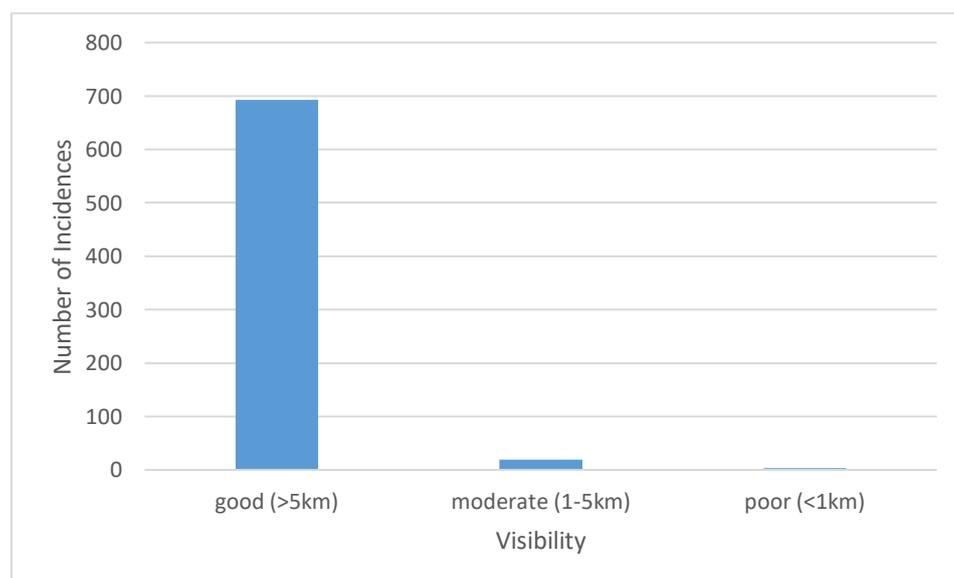


Figure 18 - Range of visibility throughout the project

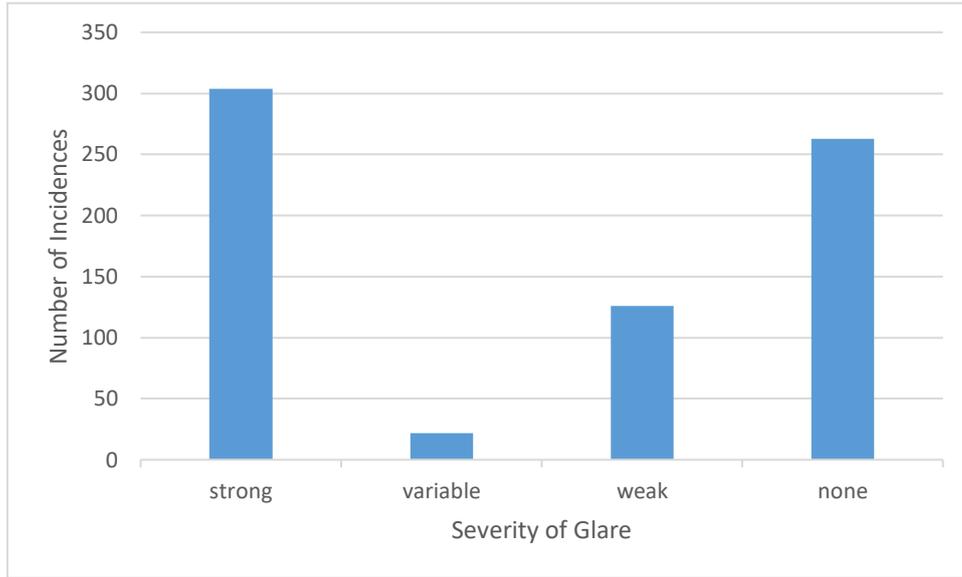


Figure 19 - Glare severity observed during the project

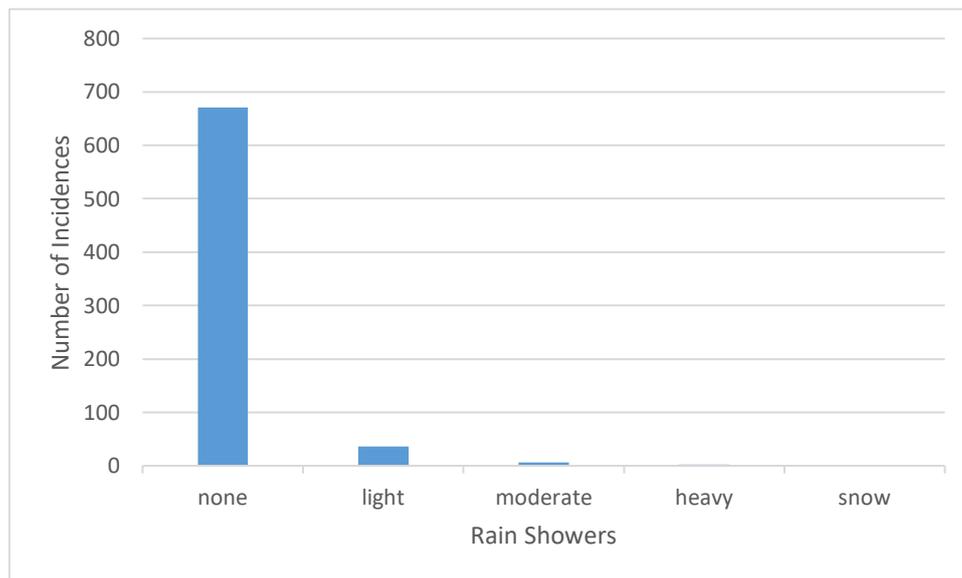


Figure 20 - Rain showers observed during the project

3.1.2 Passive Acoustic Monitoring

Passive acoustic monitoring was conducted for 32 hours 13 minutes of the duration of the project. All acoustic monitoring was carried out during daylight hours.

3.1.3 Observer Effort on OSC1 Activities

Visual and acoustic monitoring was conducted for a total of 1044 hours and 58 minutes throughout the project. Over half, 56.96%, of this time spent monitoring for protected species was spent during operational phases of OCS1 (i.e. OSC1 was in its plastic catching configuration). A small percentage, 1.53% and 1.54%, was spent monitoring for marine mammals during extraction of plastic and testing on OCS1, respectively (Figure 19).

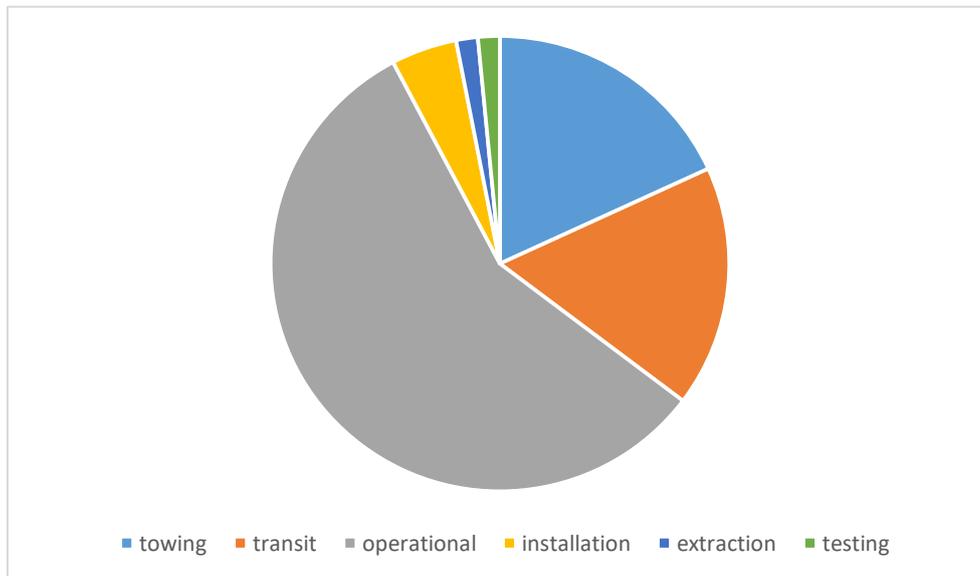


Figure 21 - Summary of visual and acoustic effort of OCS1

3.2 Wildlife Summary

3.2.1 Protected Species Observations

3.2.1.1 Visual Observations

63 marine mammals were recorded by the PSO or incidentally by another crew member throughout the project (Appendix B). 52 of these 63 recordings were cetaceans (82.53% of all recordings), this composed of 33 mysticetes records and 19 odontocetes records. Seven records belonged to pinniped, two from marine fissipeds and there was 1 recording of an unidentified turtle (Table 5).

Table 5 - Total of protected species recorded throughout the project

Marine Mammal	Number of Records	% of Records
Cetaceans	52	82.53
Pinnipeds	7	11.11
Marine Fissipeds	2	3.17
Unknown	1	1.58
Turtle	1	1.58
Total number of Records	63	

17 different species were recorded throughout the project with an additional 20 recorded as unidentified (note: as there were multiple recordings of unidentified mysticete, unidentified odontocete and 1 unknown marine mammal these were not included in the species diversity calculation). Most unique species recorded belonged to cetaceans (odontocetes, 11.1% and mysticetes, 7.9% of records; Table 6)

Table 6 - Total of unique species recorded throughout the project

Marine Mammal	Number of Unique Species	% of Records
Cetaceans	12	19
Pinnipeds	3	4.8
Marine Fissipeds	1	1.6
Turtle	1	1.6
Total number of unique species	17	

GPS coordinates were recorded for each protected species sighting (exception of sighting number 001, 002, 003 and 049). QGIS was used to map these sightings (Figure 20).

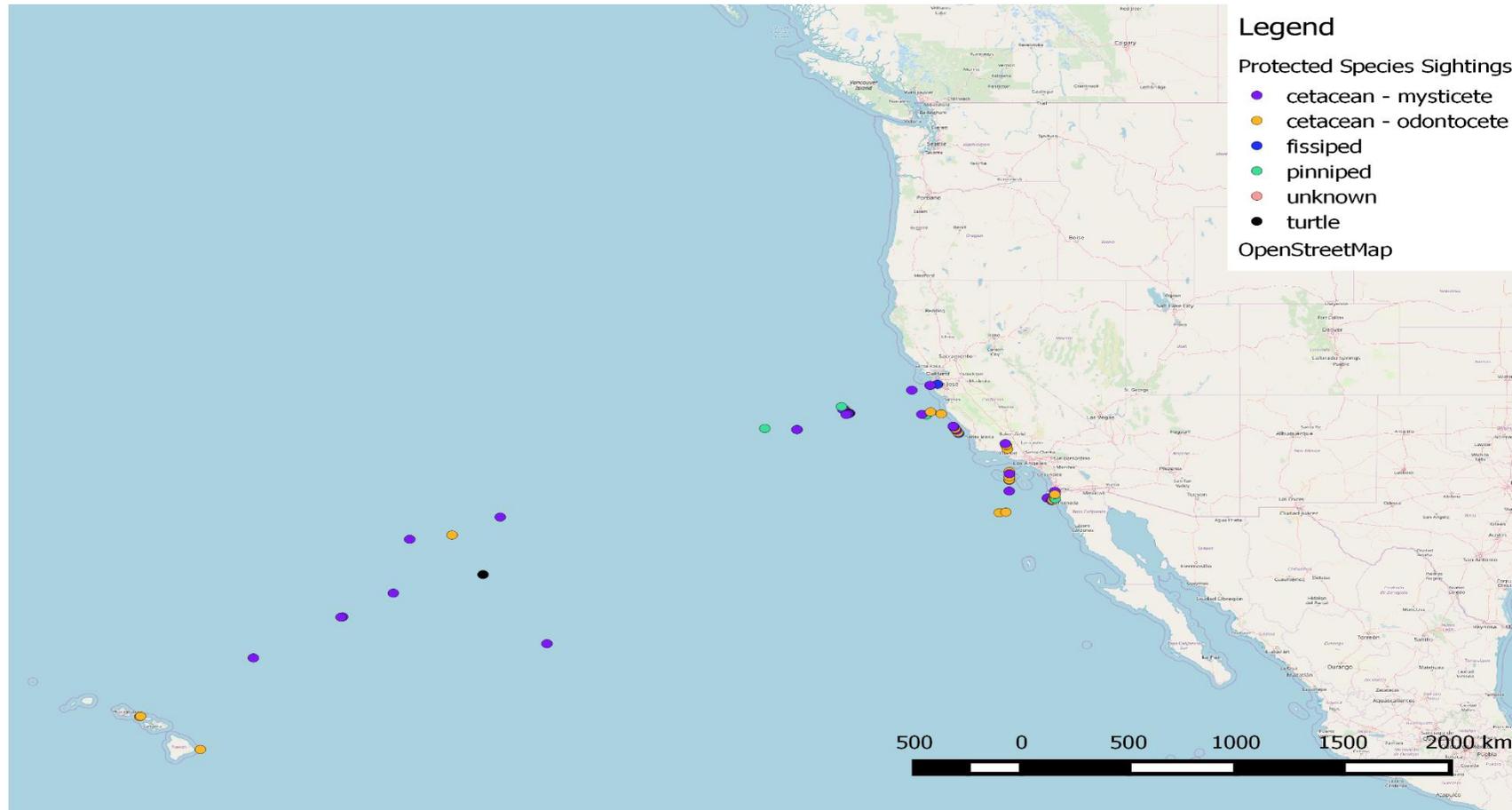


Figure 22 - Map of Protected Species Sightings. Note: sightings 26, 27, 28 and 29 have been plotted on land, this is an unknown

3.2.2 Acoustic Detections

There were no marine mammals detected by the PAM operator during the project.

3.2.3 Other Notable Wildlife

The PSO also recorded birds and fish observed while monitoring for marine mammals. 10 bird species were identified, including albatross, osprey, storm petrel, tropic bird, sanderling, booby and shearwater (Table 7; Figure 21, Appendix C).

Table 7 - Summary of birds found during the project

Family	Common Name
Diomedeidae	Black-footed albatross
	Laysan albatross
Phaethontidae	Red-tailed tropicbird
	White-tailed tropicbird
Sulidae	Blue footed booby
	Masked booby
	Brown booby
Hydrobatidea	Rump-band storm petrel
Pandionidae	Osprey
Scolopacidae	Sanderling

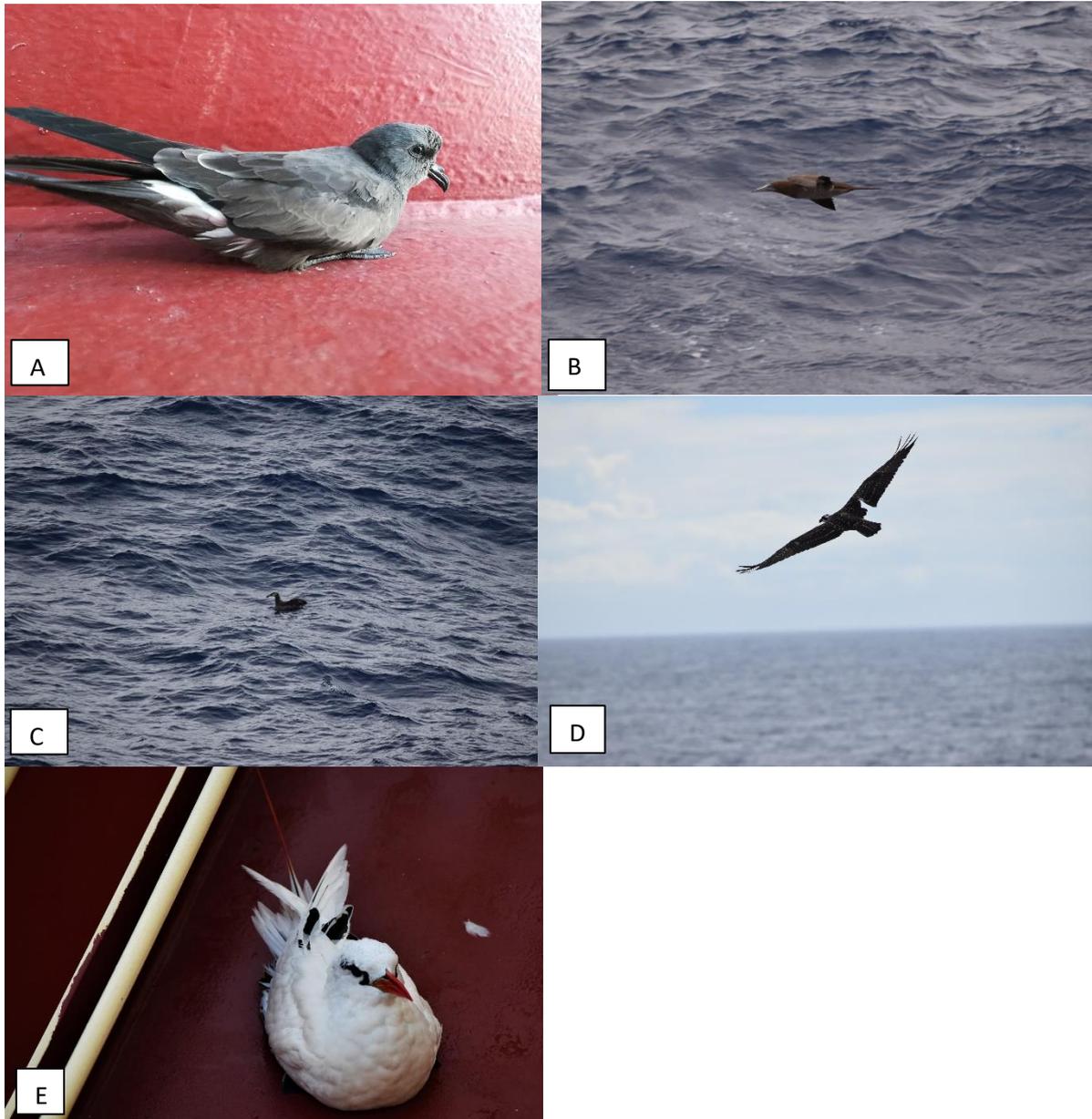


Figure 24 - Avifauna observed by the PSO: rump-band storm petrel (A), brown booby (B), black-footed albatross (C), osprey (D), red-tailed tropicbird (E)

Numerous flying-fish and a few larger fish, including mahi mahi, sunfish and yellow fin tuna were also observed throughout the project (Figure 22).



Figure 26 - Fish observed by PSO; mahi mahi (A)

3.3 Mitigation Actions

Throughout the project there were no shut down or delay to operations required.

On 08 September 2018 a single sealion (*Zalophus californianus*, sighting 001) was recorded at a range of 500 m from the OCS1. The sealion was travelling in a southerly direction as the OCS1 was in its towing configuration. No mitigation action was required.

On 11 and 15 September 2018 a single sealion (*Zalophus californianus*, sighting 007 and 009) was recorded at closest approach of 10 m from the OCS1. At both sightings the sealion was travelling in variable directions, surfacing and diving at the bow and alongside port and starboard side of vessel. No mitigation actions were required as the OCS1 was in its towing configuration.

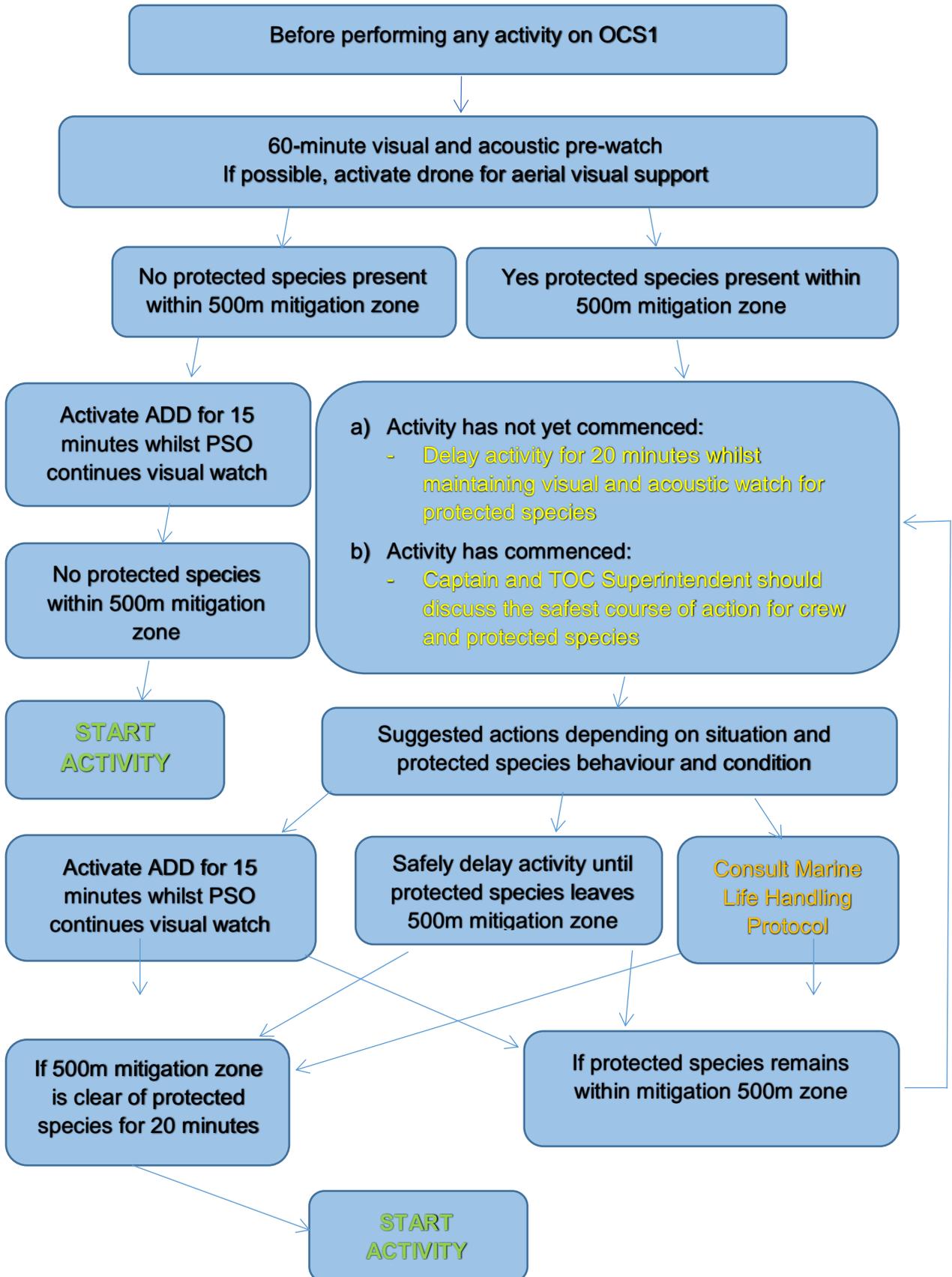
On 17 November 2018 a single adult Sei whale (*Balaenoptera borealis*, sighting number 016) was recorded at its closest approach of 50 m from the OCS1. The Sei whale, travelling in a south westerly direction, surfaced at the stern of OCS1 and remained at the surface for a prolonged period, it then changed direction and proceeded to travel parallel to OCS1 starboard side. The Sei whale was in the exclusion zone for a total of 25 minutes. No mitigation actions were required as OCS1 was in its operation configuration (i.e. passively collecting marine litter) and thus behaviour of animal and behaviour of animal towards OCS1 were continuously observed until the animal was out of sight.

On 05 January 2019 two adult humpback whales (*Megaptera novaeangliae*, sighting number 051) were recorded at a range of 500 m from animal to OCS1. The humpback whales were travelling in a

south easterly direction. The animals were surfacing, blowing and diving as they travelled towards the OCS1. They proceeded to travel beneath the OCS as it was in its towing configuration.

4 Appendices

Appendix A – Environmental Mitigation Procedure Flow Chart



Appendix B - Protected Species Sightings

Date (dd/mm/yy)	Sighting Number	Species or Species Group	Activity when Animals First Detected	Position of Vessel	Figure Number
08/09/18	001	Californian Sealion	Towing	37° 49' N 122° 28' W	-
08/09/18	002	Marine Otter	Towing	37° 49' N 122° 28' W	-
08/09/18	003	Humpback	Towing	37° 44.71' N 122° 59.49' W	23
08/09/18	004	Humpback	Towing	37° 44.71' N 122° 59.49' W	24
09/09/18	005	Humpback	Towing	37° 22.93' N 123° 40.23' W	-
09/09/18	006	Unknown	Towing	36° 37.27' N 126° 36.02' W	-
11/09/18	007	Californian Sealion	Towing	36° 35.98' N 126° 40.65' W	25
11/09/18	008	Fin Whale	Towing	36° 35.50' N 126° 42.22' W	26
15/09/18	009	Californian Sealion	Towing	35° 49.06' N 129° 8.43' W	-
17/09/18	010	Unidentified Mysticete	Towing	35° 43.78' N 128° 43.44' W	-
17/09/18	011	Unidentified Mysticete	Towing	35° 43.87' N 128° 43.44' W	-
13/10/18	012	Unidentified Mysticete	Towing	31° 31.70' N 141° 4.35' W	27
19/10/18	013	Sperm Whale	Operation	30° 44.99' N 143° 54.63' W	28
30/10/18	014	Short Fin Pilot Whale	Transit	21° 23.52' N 157° 22.68' W	-
30/10/18	015	Short Fin Pilot Whale	Transit	21° 25.90' N 157° 19.33' W	-
17/11/18	016	Sei Whale	Operation	30° 24.10' N 145° 4.03' W	29
05/12/18	017	Sperm Whale	Transit	31° 52.99' N 119° 56.78' W	30
05/12/18	018	Mixed Spinner & Common Dolphin	Transit	31° 55.47' N 119° 28.50' W	31
07/12/18	019	Unidentified Whale	Transit	32° 56.30' N 119° 13.47' W	-
07/12/18	020	Sperm Whale	Transit	32° 59.50' N 119° 13.30' W	32
07/12/18	021	Fin Whale	Transit	33° 0.78' N 119° 13.22' W	33
07/12/18	022	Common Dolphin	Transit	33° 4.83' N 119° 13.12' W	34
07/12/18	023	Common Dolphin	Transit	33° 10.32' N 119° 13.09' W	-
07/12/18	024	Common Dolphin	Transit	33° 23.12' N	35

Date (dd/mm/yy)	Sighting Number	Species or Species Group	Activity when Animals First Detected	Position of Vessel	Figure Number
				119° 12.87' W	
07/12/18	025	Humpback Whale	Transit	33° 38.04' N 119° 12.81' W	36
07/12/18	026	Unidentified Dolphin	Transit	34° 5.32' N 119° 21.95' W	-
07/12/18	027	Humpback Whale	Transit	34° 7.04' N 119° 26.86' W	37
07/12/18	028	Unidentified Dolphin	Transit	34° 7.04' N 119° 26.86' W	38
07/12/18	029	Humpback Whale	Transit	34° 7.93' N 119° 30.48' W	-
08/12/18	030	Marine Otter	Transit	35° 26.08' N 121° 35.07' W	-
08/12/18	031	Dalls Porpoise	Transit	35° 30.90' N 121° 38.64' W	-
08/12/18	032	Blue Whale	Transit	35° 40.40' N 121° 45.12' W	-
08/12/18	033	Unidentified Whale	Transit	35° 46.66' N 121° 49.74' W	-
08/12/18	034	Dalls Porpoise	Transit	35° 48.11' N 121° 50.80' W	-
08/12/18	035	Unidentified Whale	Transit	35° 55.73' N 121° 56.37' W	-
08/12/18	036	Californian Sealion	Transit	35° 59.24' N 121° 58.81' W	-
08/12/18	037	Humpback Whale	Transit	35° 59.24' N 121° 58.81' W	-
08/12/18	038	Unidentified Dolphin	Transit	36° 11.44' N 122° 7.75' W	-
08/12/18	039	Californian Sealion	Transit	36° 11.26' N 122° 7.61' W	-
08/12/18	040	Humpback Whale	Transit	36° 13.90' N 122° 9.59' W	-
08/12/18	041	Common Dolphin	Transit	36° 16.16' N 122° 11.24' W	-
13/12/18	042	Common Dolphin	Transit	36° 24.90' N 125° 57.67' W	39
13/12/18	043	Fin Whale	Transit	36° 18.91' N 126° 13.00' W	40
13/12/18	044	Unidentified Whale	Transit	36° 17.39' N 126° 16.94' W	-
13/12/18	045	Unidentified Mysticete	Transit	36° 16.75' N 126° 18.56' W	-
13/12/18	046	Unidentified Whale	Transit	36° 15.66' N 126° 21.21' W	-
13/12/18	047	Unidentified Mysticete	Transit	36° 13.05' N 126° 27.73' W	41
13/12/18	048	Fur Seal	Transit	36° 4.87' N 126° 48.30' W	42

Date (dd/mm/yy)	Sighting Number	Species or Species Group	Activity when Animals First Detected	Position of Vessel	Figure Number
17/12/18	049	Unidentified Turtle	Transit	28° 50.54' N 142° 19.06' W	-
01/01/19	050	Unidentified Mysticete	Towing	27° 58.10' N 146° 2.21' W	-
05/01/19	051	Humpback Whale	Towing	26° 38.80' N 148° 34.27' W	-
05/01/19	052	Unidentified Whale	Towing	26° 37.16' N 148° 41.00' W	-
08/01/19	053	Humpback Whale	Towing	24° 29.20' N 152° 25.20' W	43
17/01/19	054	Bottlenose Dolphin	Transit	19° 50.03' N 154° 57.42' W	44
21/01/19	055	Unidentified Whale	Transit	25° 0.22' N 139° 38.87' W	-
26/01/19	056	Gray Whale	Transit	32° 2.28' N 117° 46.38' W	-
26/01/19	057	Gray Whale	Transit	32° 11.12' N 117° 27.83' W	-
26/01/19	058	Unidentified Beaked Whale	Transit	32° 14.01' N 117° 22.61' W	-
26/01/19	059	Unidentified Mysticete	Transit	32° 19.36' N 117° 12.96' W	-
26/01/19	060	Unidentified Whale	Transit	32° 19.36' N 117° 12.96' W	-
26/01/19	061	Harbour Seal	Transit	32° 19.78' N 117° 12.20' W	-
27/01/19	062	Gray Seal	Transit	32° 55.21' N 117° 13.53' W	-
27/01/19	063	Unidentified Dolphin	Transit	32° 36.98' N 117° 13.63' W	-

- *Towing: the barrier was attached to the vessel with the vessel towing the barrier from one location to another*
- *Operation: the barrier was in a plastic catching configuration*
- *Transit: the vessel was in transit away from or towards the barrier as it was in plastic catching configuration (i.e. the barrier was not attached to the vessel. For example, the vessel was travelling to port for crew change)*



Figure 23 - Sighting Number 003 Humpback



Figure 24 - Sighting Number 004 Humpback



Figure 25 - Sighting Number 007 Californian Sealion



Figure 26 - Sighting Number 008 Fin Whale



Figure 27 - Sighting Number 012 Unidentified Mysticete



Figure 28 - Sighting Number 013 Sperm Whale



Figure 29 - Sighting Number 016 Sei Whale



Figure 30 - Sighting Number 017 Sperm Whale



Figure 31 - Sighting Number 018 Mixed Spinner and Common Dolphin



Figure 32 - Sighting Number 020 Sperm Whale



Figure 33 - Sighting Number 021 Fin Whale



Figure 34 - Sighting Number 22 Common Dolphin



Figure 35 - Sighting Number 024 Common Dolphin



Figure 36 - Sighting Number 025 Humpback Whale



Figure 37 - Sighting Number 027 Humpback Whale



Figure 38 - Sighting Number 028 Unidentified Dolphin



Figure 39 - Sighting Number 042 Common Dolphin



Figure 40 - Sighting Number 043 Fin Whale



Figure 41 - Sighting Number 047 Unidentified Mysticete



Figure 42 - Sighting Number 048 Fur Seal



Figure 43 - Sighting Number 053 Humpback Whale



Figure 44 - Sighting Number 054 Bottlenose Dolphin

Appendix C - Incidental Bird Sightings

Date		Common Name <i>Scientific Name</i>	Position of Vessel*
Month/Year	Day		
September 2018	28	Red-tailed tropic bird	37° 49' N 122° 28' W
October 2018	09 15	<i>Phaethon rubricauda</i>	37° 49.30' N 135° 43.25' W 31° 4.69' N 143° 5.77' W
October 2018	01 17 – 18	Black-footed albatross <i>Phoebastria nigripes</i>	34° 41.92' N 128° 13.02 W 30° 51.33' N 143° 50.22 W – 30° 48.09' N 143° 53.32' W
December 2018	14 – 23 26 - 31		34° 37.00' N 130° 26.12' W – 27° 36.70' N 144° 31.09' W 27° 31.27' N 145° 24.67' W – 27° 54.94' N 145° 52.41 W
January 2019	01 – 08 12 22		27° 54.58' N 145° 52.36' W – 24° 45.55' N 152° 45.55' W 21° 48.99' N 154° 3.46' W 26° 21.71' N 135° 33.13' W
October 2018	02	Osprey <i>Pandion haliaetus</i>	34° 36.45' N 128° 9.97' W
October 2018	07 - 09	Band-rumped storm-petrel <i>Oceanodroma castro</i>	33° 22.42' N 133° 23.00' W – 32° 48.50' N 135° 46.37' W
October 2018	10	Blue footed Booby <i>Sula leucogaster</i>	32° 25.18' N 137° 26.73' W
October 2018	10 14	Sanderling <i>Calidris alba</i>	32° 42.99' N 136° 8.06' W 31° 30.96' N 141° 12.67' W
October 2018	10	Masked Booby <i>Sula dactylatra</i>	32° 25.18' N 137° 26.73' W
January 2019	07 11 - 18		25° 31.96' N 150° 46.84' W 22° 28.69' N 153° 41.27' W – 20° 41.01' N 152° 24.97' W
January 2019	03 05 18	White-tailed tropic bird <i>Phaethon lepturus</i>	27° 46.92' N 146° 22.56' W 26° 39.91' N 148° 30.57' W 20° 41.01' N 152° 24.97' W
December 2018	13	Laysan Albatross	36° 30.00' N 125° 45.39' W

Date		Common Name <i>Scientific Name</i>	Position of Vessel*
Month/Year	Day		
	16	<i>Phoebastria immutabilis</i>	30° 45.99' N 138° 58.33' W
	18		27° 52.19' N 143° 59.63' W
	30 – 31		27° 53.22' N 145° 56.89' W –
			27° 51.10' N 145° 52.92' W
January 2019	05 - 06		26° 39.91' N 148° 30.57' W –
	19		26° 1.66' N 149° 48.05' W 22° 10.12' N 148° 4.00' W
January 2019	16	Wedge tailed shearwater <i>Puffinus pacificus</i>	20° 8.75' N 154° 52.76' W

*Position of vessel as recorded on PSO effort for specific date, thus the GPS is an approximation for position of bird

5 References

CSA. 2018. *The Ocean Cleanup: Environmental Impact Assessment*.



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