

MONITORING AND MITIGATION REPORT

FOR THE

THE AGULHAS RETURN CURRENT RESEARCH PROJECT (ARC12):
A PHYSICAL OCEANOGRAPHIC SURVEY BY THE U.S. NAVAL
RESEARCH LABORATORY, 23 JANUARY TO 08 FEBRUARY 2012



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LIST OF ACRONYMS AND ABBREVIATIONS

AC	Agulhas Current
ACC	Antarctic Circumpolar Current
ADCP	Acoustic Doppler Current Profiler
ARC	Agulhas Return Current
CTD	conductivity-temperature-depth
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
ft	foot
GI	Generator-Injector
GMSDD	Navy Global Marine Species Density Database
IHA	Incidental Harassment Authorization (under the U.S. MMPA)
in	inch
kHz	kilohertz
km	kilometer
kt	knot
L-ADCP	Lowered ADCP
LDEO	Lamont-Doherty Earth Observatory
LR-ADCP	Long-Range ADCP
m	meter
MBES	Multibeam echosounder
mi	mile
min	minute
MMPA	(U.S.) Marine Mammal Protection Act
ms	millisecond
NEPA	(U.S.) National Environmental Policy Act
NMFS	(U.S.) National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NRL	Naval Research Laboratory
Nm	nautical mile
OEA	Overseas Environmental Assessment
PSO	Protected Species Observer
pk/p	peak
rms	root mean square
s	second
SBP	Sub-bottom Profiler
SO	Seismic Oceanography
SPL	sound pressure level
TTS	Temporary Threshold Shift
VMP	Vertical Microstructure Profiler
XBT	Expendable bathythermograph
XCTD	Expendable CTD



EXECUTIVE SUMMARY

Overview

The U.S. Naval Research Laboratory (NRL) conducted a physical oceanographic research survey from 23 January to 8 February 2012 in the southwest Indian Ocean, approximately 150 to 400 nautical miles (278 km to 1100 km) off the coast of South Africa. The purpose of the research project was to further elucidate processes of diapycnal mixing in the region of the Agulhas Return Current (ARC); a key mechanism governing the exchange of waters across major ocean fronts, such as the ARC, and a fundamental process involved in global ocean circulation. To accomplish this research, the Navy used a high resolution seismic oceanographic (SO) technique to image the physical structure of the water column across the Agulhas front. Similar to seismic reflection profiling used to image the solid earth beneath the ocean floor, SO employs a towed array of two low-energy 105 in³ GI-guns to image the thermohaline characteristics of the water column.

Pursuant to Executive Order 12114, Department of Defense (DoD) regulations listed under 32 Code of Federal Regulations (CFR) Part 187, DoD Directive 6050.7, and Chief of Naval Operations (CNO) Instruction (OPNAVINST) 5090.1C, the Navy conducted an Overseas Environmental Assessment (OEA) for the ARC12 research project, which determined that the operation of the two GI guns which were to be used for seismic oceanography (SO) research, would potentially harass 2412 cetacea by sound pressure levels ≥ 160 dB re 1 μ Pa.rms. Of the total number of cetaceans which might potentially be harassed, the Navy identified 62 marine mammals ESA-listed as Endangered; 29 fin, 1 humpback, 11 sei, 1 southern right, and 20 sperm whales.

Because the National Marine Fisheries Service (NMFS) considers marine mammals exposed to sound pressure levels ≥ 160 dB re 1 μ Pa.rms to be a form of harassment, permission to conduct the research is required under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). On 15 August 2011, NRL submitted an Incidental Harassment Authorization (IHA) request and a Biological Assessment (BA) to the NMFS Office of Protected Resources as part of formal consult for conducting the proposed action (Federal Register / Vol. 77, No. 17 / Thursday, January 26, 2012 / Notices / P. 4014).

On 20 January 2012, the Navy was issued an IHA by NMFS for Level B incidental harassment of 2412 cetacea. NMFS also issued a Biological Opinion (BO) and Incidental Take Statement (ITS) under Section 7 of the ESA in response to the Navy's request for consultation on the potential Level B harassment of 62 marine mammals that are ESA-listed as Endangered. The BO concluded the Navy's oceanographic research survey met the terms of Section 7 of the ESA and Section 101 of the MMPA.

The IHA and ITS were issued to the Navy for operation the two low-energy 105 in³ GI-guns. NMFS and the Navy concluded that operation of the multibeam echosounder (MBES), sub-bottom profiler (SBP), and deployed acoustic Doppler profilers (ADCPs) were not expected to result in any significant adverse impact on, or taking of, marine mammals or sea turtles. The IHA and ITS authorizations granted to the Navy were valid from 23 January 2012 through 07 March 2012 for Navy activities conducted in the area of the Agulhas Plateau within the coordinates of 36°S to 43°S and 19°E to 30°E.



All research actions were contingent upon the terms and conditions of the IHA and ITS. NRL was required to implement monitoring and mitigation measures that would protect marine mammals and sea turtles, and report to NMFS on the outcomes of these measures. To minimize incidental takes by harassment, NMFS required mitigation measures that included establishment of an exclusion zone (EZ), speed or course alteration, GI-gun ramp-up procedures, and GI-gun shutdowns when marine mammals and sea turtles were observed within the EZ.

The monitoring and mitigation program employed during the ARC12 cruise was established and conducted according to NMFS and Navy requirements described in the IHA and ITS. The objectives of the monitoring program were:

- Use real-time sighting data of marine mammals and sea turtles to mitigate any potential harassment;
- Estimate the number and identity of any marine mammals and sea turtles observed within or outside the EZ;
- Determine the behaviors of marine mammals and sea turtles exposed to sounds produced by the dual GI-gun array; and
- Provide data on the numbers of animals observed to be harassed.

Monitoring and mitigation procedures used during the ARC12 cruise were developed through coordination between the Navy and Scripps Institute of Oceanography (SIO), and implemented through communication and co-operation between three (3) trained and experienced Protected Species Observers (PSO), NRL scientists, and RV *Melville* crew and technicians. One to two PSOs conducted visual monitoring for marine mammals and sea turtles in shifts of 4-hours duration or less (e.g., single and dual observer watches). PSOs employed 7 x 50 reticle binoculars, 25 x 150 Big-eye reticle binoculars, naked eye during daylight observations, and night vision devices during evening hours.

Visual monitoring began on 23 January 2012, when the *Melville* departed Cape Town, and continued until 8 February 2012 when the *Melville* returned to port (~16 days). No acoustic monitoring was planned or conducted during the ARC12 cruise. PSOs observed around the clock during SO survey activities (~97 hrs) and, for all other phases of the ARC12 cruise, PSOs performed only daylight observations, from dawn to dusk, which spanned a period of approximately 13 hours. PSOs scanned surface waters from various vantage points on the *Melville*: An observation platform is located one deck below and forward of the *Melville* bridge (12.5 meters, or ~41 feet above the waterline), and provided a relatively unobstructed 180 degree view forward. Aft views were obtained along the port, starboard, and stern decks.

Estimated Takes

IHA request and BA takes estimates were based on operation of the dual GI-gun array for 14 days, 24 hrs/day, towed at a speed of ~4 knots (~7.4 km/hr) approximately 2 to 9 meters (m) below the surface. This resulted in an estimated SO survey distance of approximately 1344 Nm (2489 km), which, for the 160 dB re 1 μ P.rms isopleth, yielded an estimated ensonified area of ~3335 km². Based on the average (“best”) population density estimates presented in the IHA and BA:



- 2412 cetacea were estimated to be potentially be exposed to sound pressure levels ≥ 160 dB re 1 μ Pa.rms during the oceanographic survey;
- Of the total number of cetaceans estimated to be exposed, the Navy identified 62 marine mammals ESA-listed as Endangered: 29 fin ($< 0.2\%$ of the southern hemisphere population); 1 humpback ($< 0.004\%$ of the S. hemisphere population); 11 sei ($< 0.2\%$ of the population south of 30° S); 1 southern right ($< 0.004\%$ of the S. hemisphere population); and 20 sperm ($< 0.02\%$ of the S. hemisphere population) whales.

Actual Takes

Actual exposures were significantly less than estimates provided in the IHA request and BA. PSO visual monitoring efforts are summarized as follows:

- PSO efforts produced 21 sightings totaling 620 individuals;
- Individual sightings were comprised of 618 cetacea and 2 pinnipeds;
- Of the cetacea, 2 ESA-listed species were sighted; the sperm (13 individuals) and fin whale (2 individuals);
- The vast majority of sightings were delphinids (580 individuals, 94% of all animals detected);
- There were no observations of sea turtles during the ARC12 research cruise; and
- No takes were observed during the ARC12 cruise.

This Monitoring and Mitigation Report communicates the monitoring and mitigation activities conducted for the ARC12 oceanographic research survey onboard the RV *Melville*, and fulfills the reporting requirements stated in Section 6 of the IHA permit, and Terms and Conditions of the ITS.



1.0 NMFS FEDERAL PERMITTING AND CONSULTATION OVERVIEW

The U.S. Naval Research Laboratory (NRL) conducted a physical oceanographic research survey from 23 January to 8 February 2012, in the southwest Indian Ocean, approximately 150 to 400 nautical miles (278 km to 1100 km) off the coast of South Africa within the coordinates 36°S 22°E and 40°S 26°E.

Pursuant to Executive Order 12114, Department of Defense (DoD) regulations listed under 32 Code of Federal Regulations (CFR) Part 187, DoD Directive 6050.7, and Chief of Naval Operations (CNO) Instruction (OPNAVINST) 5090.1C, the Navy conducted an Overseas Environmental Assessment (OEA) for the ARC12 research project, which determined that 2412 cetacea had the potential to be harassed by sound pressure levels \geq to 160 dB re 1 μ Pa.rms generated by the two GI-guns used for seismic oceanographic (SO) research purposes. Of the total number of cetaceans potentially harassed, the Navy identified 62 marine mammals ESA-listed as Endangered; 29 fin, 1 humpback, 11 sei, 1 southern right, and 20 sperm whales.

Because the National Marine Fisheries Service (NMFS) considers exposure of marine mammals to sound pressure levels \geq 160 dB re 1 μ Pa.rms to be a form of harassment, permission to conduct the research is required under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). On 15 August 2011, NRL submitted to the NMFS Office of Protected Resources an Incidental Harassment Authorization (IHA) request and Biological Assessment (BA) as part of formal consult for conduct of the proposed action (Federal Register / Vol. 77, No. 17 / Thursday, January 26, 2012 / Notices / P. 4014).

On 20 January 2012, the Navy was issued an IHA for Level B harassment only, incidental to the physical oceanographic survey to be conducted in the southwest Indian Ocean. NMFS also issued a Biological Opinion (BO) and Incidental Take Statement (ITS) under Section 7 of the ESA in response to the Navy's request for consultation on the potential Level B harassment of 62 marine mammals that are ESA-listed as Endangered. The IHA and ITS were issued to the Navy for operation of two low-energy 105 in³ GI-guns, to be used for high resolution SO imaging of the water column fine structure across various frontal conditions. Through IHA review and Section 7 consult, NMFS and the Navy concluded that sounds generated during the operation of the dual GI-gun array may have the potential to cause marine mammals in the survey area to be exposed to sounds \geq 160 dB re 1 μ Pa.rms causing temporary, short-term changes in behavior, consistent with Level B harassment. NMFS and the Navy concluded that operation of the multibeam echosounder (MBES), sub-bottom profiler (SBP), and deployed acoustic Doppler profilers (ADCPs) were not expected to result in any significant adverse impact on, or taking of, marine mammals or sea turtles. The BO issued by NMFS determined that the proposed research activities may affect, but were not likely to jeopardize, the continued existence of U.S. ESA-listed species, their populations, or their habitats; a determination that concurred with the Navy's BA.



The IHA and ITS authorizations granted to the Navy were valid from 23 January 2012 through 07 March 2012 for Navy activities conducted in the area of the Agulhas Plateau, within the coordinates of 36°S to 43°S and 19°E to 30°E, and contingent upon the terms and conditions of IHA and ITS.

Under the terms and conditions presented, NRL was required to implement, and monitor, the effectiveness of mitigation measures for protection of marine mammals and sea turtles. To minimize incidental takes by harassment, NMFS required mitigation measures that included establishment of an exclusion zone (EZ), speed or course alteration, GI-gun ramp-up procedures, and GI-gun shutdowns when marine mammals or sea turtles were observed within the EZ. A report on the outcome of monitoring and mitigation efforts was required, and was to include species of animals, numbers of animals affected and any behavioral reactions.

2.0 REPORTING REQUIREMENTS

In order to be exempt from the prohibitions of Section 9 of the ESA and Section 101(a)(5) of the MMPA, NMFS Permits and Conservation Division and NRL must comply with the following terms and conditions of the IHA and ITS.

(a) NMFS IHA and ITS authorizations require reporting on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of expiration of the IHA or completion of surveying, whichever comes first. The report is to contain and summarize the following information:

- (i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all survey operations and marine mammal sightings;
- (ii) Species, group size, age, individual size, sex (if determinable) of all marine mammal sightings;
- (iii) Behavior of animal when first sighted and subsequent behaviors;
- (iv) Bearing and distance from the vessel, sighting cue, and exhibited reaction to the airgun sounds or vessel (e.g., none, avoidance, approach, etc.), behavioral pace, and depth at time of detection;
- (v) Fin/fluke characteristics and angle of fluke when an animal submerges to determine if the animal executed a deep or surface dive;
- (vi) Type and nature of sounds heard; and
- (vii) Any other relevant information.

(b) When shutdown is required for mitigation purposes, the following information will also be reported:

- (i) The basis for decisions resulting in shutdown of the GI-guns;
- (ii) Information needed to estimate the number of marine mammals potentially taken by harassment;
- (iii) Information on the frequency of occurrence, distribution, and activities of marine mammals in the study area;



- (iv) Information on the behaviors and movements of marine mammals during and without operation of the GI-guns; and
- (v) Any adverse effects the shutdown had on the research.

(c) A final report is to be submitted to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, 1315 East West Highway, Silver Spring, Maryland, 20910, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered the final report.

(d) In the unanticipated event that the survey operations clearly caused the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury, or mortality (e.g., ship-strike, gear interaction, and/or entanglement), the Navy was to immediately cease survey operations and report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and Michelle.Magliocca@noaa.gov. The report must include the following information:

- (i) Time, date, and location (latitude/longitude) of the incident;
- (ii) Name and type of vessel involved;
- (iii) Vessel's speed during and leading up to the incident;
- (iv) Description of the incident;
- (v) Status of all sound source use in the 24 hours preceding the incident;
- (vi) Water depth;
- (vii) Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- (viii) Description of marine mammal observations in the 24 hours preceding the incident;
- (ix) Species identification or description of the animal(s) involved;
- (x) Fate of the animal(s); and
- (xi) Photographs or video footage of the animal (if equipment is available).

In the event of a take, activities could not resume until NMFS was able to review the circumstances of the prohibited take, and advise the steps necessary to minimize the likelihood of further prohibited take. The Navy was not to resume activities until notified by NMFS via letter, email, or telephone.

(e) In the event that the Navy discovered an injured or dead marine mammal, and the lead protected species observer determined that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), the Navy was required to immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Michael.Payne@noaa.gov and Michelle.Magliocca@noaa.gov. Activities could continue while NMFS reviewed the circumstances of the incident. NMFS was to work with the Navy to determine if modifications in activities would be appropriate.

(f) In the event that the Navy discovered an injured or dead marine mammal, the lead protected species observer was to determine whether or not the injury or death was associated with, or related



to, the activities authorized in Condition 2 of the Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage). The Navy was required to report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Michael.Payne@noaa.gov and Michelle.Magliocca@noaa.gov within 24 hours of the discovery. The Navy was to provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities could continue while NMFS reviewed the circumstances of the incident.

3.0 FINDINGS

3.1 RESEARCH ACTIVITIES OVERVIEW

Seismic Oceanography Survey

The ARC12 research project was a collaborative effort between NRL Chief Scientists Dr. Warren Wood and Dr. Jeff Book, the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project, the University of Cape Town, South Africa, and the University of Kiel, Germany. The purpose of the research project was to further elucidate processes of diapycnal mixing in the region of the Agulhas Return Current (ARC); a key mechanism governing the exchange of waters across major ocean fronts, such as the ARC, and a fundamental process involved in global ocean circulation. To accomplish this, the Navy used a high resolution seismic oceanographic (SO) technique to image the physical structure of the water column across the Agulhas front. Similar to seismic reflection profiling used to image the solid earth beneath the ocean floor, SO employs a towed array of two low-energy 105 in³ GI-guns (Table 3.0) to image the thermohaline characteristics of the water column. SO data was acquired concurrent with other physico-chemical studies enabling a comprehensive, detailed investigation of ocean mixing dynamics across frontal regions associated with ARC.

TABLE 3.0 ACOUSTIC SOURCE: GI-GUN ARRAY

DESCRIPTION	FREQUENCY (Hz)	SOURCE LEVEL (dB re 1 PA.M)	SHOT-REPETITION RATE	DISCHARGE VOLUME	TOW DEPTH (m)
2-105 in ³ GI-guns	10-188	240 (p-p)	17 seconds	210 in ³	3 to 6

All research activities, to include marine mammal and sea turtle monitoring, were conducted from the RV *Melville*, owned by the U.S. Navy and operated by Scripps Institution of Oceanography (SIO) of the University of California, San Diego, CA. The RV *Melville* has a length of 97 m, a beam of 14 m, and a maximum draft of 5 m. The vessel is powered by two 1385 hp Propulsion General Electric motors and a 900 hp retracting bow thruster. The RV *Melville* operational speeds of 3.4 to 5.1 knots (~6 to 9.5 km/hr) were used during SO surveys.

When not conducting SO studies, the RV *Melville* was operated at cruise speeds of approximately 6-10 knots (~11-19 km/h), which occurred during transit to and from port, and between research locations. For the entire research cruise and SO transects, the Navy continuously acquired 75kHz



ADCP, MBEs, SBP, meteorological (MET), CTD (conductivity, temperature, and depth), underway CTD (mostly 2000 m), bathythermographic, and microstructure (turbulence) data. SO survey activities are as summarized below, and in Tables 3.1 and 3.2.

- The RV *Melville* departed Cape Town, South Africa, on 23 January 2012 at 1800 hours, and returned to port in Cape Town on 8 February 2012 at 0715 hours (16 days).
- The total distance traveled during the survey was 4266.4 km (2303.5 Nm).
- One 75 kHz ADCP mooring was deployed on 27 January 2012 at 1000 hours, at 39°24 S and 24°42 E (~ 10,300 feet; 3100 meters), and recovered on 4 February 2012 at 0800 hours.
- For most of the research cruise (27 January to 8 February; 13 days), and the entire SO survey, the Navy continuously acquired 75kHz ADCP, MBES, SBP, meteorological, CTD (conductivity, temperature, and depth), underway CTD (mostly 2000 meters), bathythermographic, and microstructure (turbulence) data.
- SO surveys were conducted over a seven (7) day period from 27 January 2012, 15:55 hrs, to 3 February 2012, 19:25 hrs.
- GI-guns were active for a total of ~96.7 hrs and towed at an average speed of 4.3 knots (~7.9 km/hr) approximately 3 to 6 m below the surface over a total linear distance of ~750 km (405 Nm).
- Multiplying the total distance of the SO survey by the area ensonified to the 160 dB re 1 μ P.rms isopleth (1340 m) yields an actual total ensonified area of ~1005 km², versus the estimated 3335 km² presented in the IHA and BA.
- All research activities were conducted within the coordinates 36°S 22°E and 40°S 26°E over the northwestern slope of Agulhas Plateau, in waters ranging in depth from approximately 1,000 to 5,200 meters.

Ramp-Up and Shut-Down Procedures

Ramp-ups, or soft starts, were comprised of gradually activating the two 105 in³ GI-guns in sequence until the desired operating level was reached. During a ramp up, one GI gun was activated and 6 to 10 minutes later the second GI gun was activated. The ramp-up procedure ensured that the source level of the array increased in steps not exceeding 6 dB per 5-min period as required by the IHA and ITS.

- **Ramp-Ups:** GI-guns were ramped up three (3) times over the course of the SO survey. Ramp-up occurred only during daylight hours. Ramp-up procedures accounted for ~0.4 % of the GI-gun activity (~23 minutes). During ramp up, PSOs monitored surface waters for the presence of marine mammals and sea turtles during ramp-up. No marine mammals or sea turtles were sighted during ramp-ups.
- **Shut-Downs:** There were no (0) shut-downs associated with the potential take of marine mammals or sea turtles. The GI-guns were shutdown briefly on one occasion for maintenance activities.



TABLE 3.1 SUMMARY OF ARC12 CRUISE

DATE GMT	ACTION	NOTE	START GMT	END GMT	TIME GI-GUNS FIRING	LAT.	Lon.
1/23/2012	Depart	RV Melville departs Cape Town, South Africa	18:00			33°54.23 S	18°25.44 E
1/27/201	Mooring Deployment	One 75 kHz ADCP mooring was deployed	10:00	16:00		39°24.0 S	24°42.0 E
1/27/2012	Array Deployed	0 Guns Firing	15:55			39°26.4 S	24°35.8 E
	Begin Ramp-Up	1 Gun Started	15:56			39°26.4 S	24°35.8 E
	Ramp-Up	2 Guns Firing	16:04			39°26.4 S	24°35.2 E
	Shut Down for Maintenance	0 Guns Firing	16:16			39°26.1 S	24°34.3 E
	Begin Ramp-Up	1 Gun Started	16:36			39°25.1 S	24°33.8 E
	2 guns firing	2 Guns Firing	16:42			39°25.3 S	24°34.2 E
	Both guns off			17:22	~1.75 hr		
1/28/2012	Array Deployed	0 Guns Firing	14:12			39°17.2 S	24°22.2 E
	Begin Ramp-Up	1 Gun Started	15:36			39°18.3 S	24°17.8 E
	Ramp-Up	2 Guns Firing	15:44			39°18.4 S	24°17.3 E
1/30/2012	GI-guns Off			02:18	~34.7 hr	38°32.5 s	25°02.7 e
2/1/2012	Array Deployed	0 Guns Firing	07:00			39°39.5 S	23°00.3 E
	Begin Ramp-Up	1 Gun Started	08:25			39°39.1 S	23°00.0 E
	Ramp-Up	2 Guns Firing	08:34			39°38.1 S	22°59.9 E
2/3/2012	GI-guns Off			19:25	~60.25 hr	39°18.7 S	24°12.8 E
2/4/2012	Mooring Recovery	One 75 kHz ADCP mooring was recovered	08:00	10:00		39°24.0 S	24°42.0 E
2/8/2012	Return	Returned to Port in Cape Town		07:15		33°54.23 S	18°25.44 E

TABLE 3.2 SUMMARY OF SO SURVEY

TOTALS	ACTUAL	ESTIMATED (IHA/BA)
GI-guns: Days of Operation	8 d (intermittent)	14 d (24 hrs/d)
GI-guns: Time Operated	96.7 hrs	336 hrs
GI-guns: Distance Operated	750 km (405 Nm)	2489 km (1344 Nm)
GI-guns: Ensonified Area	1005 km ²	3335 km ²

3.2 SOUND PROPAGATION RADII AND EXCLUSION ZONES

Based on L-DEO modeling, sound propagation radii for the two 105 in³ GI-guns were estimated to be 20 m, 70 m, 160 m, and 670 m for the 190-, 180-, 170- and 160 dB re 1 μPa.rms regulatory isopleths, respectively (Table 3.3). Because empirical data indicated that, for deep water (>1000 meters), the L-DEO model tend to overestimate the received sound level at a given distance, the proposed sound propagation radii and respective exclusion zones (EZ) were considered conservative, and the actual distance at which received sound levels were 160 dB re 1 μPa.rms or greater was expected to be less than that implemented for takes estimates purposes. For monitoring and mitigation during the ARC12 cruise, the 180 dB isopleth was employed as the EZ, which corresponded to a distance of 70 m from the R/V *Melville* GI-gun array.



TABLE 3.3 EXCLUSION ZONES FOR THE DUAL 105 IN³ GI-GUN ARRAY

ACOUSTIC SOURCE	FREQUENCY (Hz)	SOURCE LEVEL (dB re 1 Pa@1M)	SHOT-REPETITION RATE	RECEIVED LEVELS (dB re 1 PA.RMS)			
				190	180	170	160
				(distance)			
2 - 105 in ³ GI-guns	10-188	240 (p-p)	17 seconds	20 m	70 m	160 m	670 m

3.3 MONITORING AND MITIGATION

3.3.1 Protected Species Observers

The monitoring and mitigation program employed during the ARC12 cruise was established and conducted according to NMFS and Navy requirements described in the IHA and ITS. The objectives of the monitoring program were:

- Use real-time sighting data of marine mammals and sea turtles to mitigate any potential harassment;
- Identify and estimate the numbers of any marine mammals and sea turtles observed within or outside the EZ;
- Determine the behaviors of marine mammals and sea turtles exposed to sounds produced the dual GI-gun array; and
- Provide data on the numbers of animals observed to be harassed.

Monitoring and mitigation procedures used during the ARC12 cruise were developed through coordination between the Navy and SIO, and implemented through communication and co-operation between three (3) trained and experienced Protected Species Observers (PSO), NRL scientists, and RV *Melville* crew and technicians. One to two PSOs conducted visual monitoring for marine mammals and sea turtles in shifts of 4-hours duration or less, throughout the cruise (e.g., single and dual observer watches). PSOs employed 7 x 50 reticle binoculars, 25 x 150 Big-eye reticle binoculars, naked eye during daylight observations, and night vision devices during evening hours. No acoustic monitoring was planned or conducted during the ARC12 cruise. When only one PSO was available, NRL scientists and SIO crew and technicians assisted, as much as possible, in the observation efforts. The primary PSO searched ahead of the RV *Melville* concentrating primarily on a sector from the trackline to approximately 90° abeam the RV *Melville*, while the second PSO covered waters 90° abeam and sternward.

Visual monitoring began on 23 January 2012, when the RV *Melville* departed Cape Town, and continued until 8 February 2012 when the RV *Melville* returned to port (~ 16 days). PSOs observed around the clock during SO survey activities (~96.7 hrs). PSOs performed only daylight observations during all other phases of the ARC12 research cruise, from dawn to dusk, which spanned an average period of approximately 13 hours. PSOs scanned surface waters during the cruise from various vantage points on the *Melville*: An observation platform is located one deck below and forward of the



Melville bridge (12.5 meters (~41ft) above the waterline), and provided a relatively unobstructed 180 degree view forward. Aft views were obtained along the port, starboard, and stern decks. All PSO effort was considered useable effort in data analysis. Sea states and lighting conditions were good to excellent throughout the cruise.

Each time sightings were recorded, PSOs logged the RV *Melville's* position, environmental conditions, time, GI-gun activity status, and data requirements as per the IHA and ITS. All information on positions and headings of observed animals were logged relative to the RV *Melville's* heading.

Throughout the ARC12, cruise sea state was generally low ranging from 0 to 5, averaging 3.3 on the Beaufort scale. Visibility at 4-5 kilometers was good, and constant. Water clarity was also good. No other ship traffic was detected in the area. In general, there were very few hours of monitoring effort impeded by environmental conditions. Raw data recorded during visual monitoring efforts is provided in Appendix A. ARC12 monitoring efforts are summarized as follows and in Figures 3.0 and 3.1, and Table 3.4:

- Total ARC12 cruise distance was 4266 km (2303.5 Nm), and total cruise time was 373.25 hours;
- PSOs aboard the *Melville* were on watch for a total of ~2493 km over 248.2 hours, which comprised a 58 % and 66% effort over the duration of the cruise, respectively;
- Of the total observation effort, 208 hours occurred during daylight hours, and 40.2 hours (~16%) (326 km) occurred under conditions of darkness;
- Most of the visual monitoring effort occurred during daylight hours (~84%);
- At least one PSO was on watch during 100% of daylight operations (~2167 km; 1170 Nm; 208 hours), and two PSOs on watch for ~62% of daylight operations (~1343 km; 725 Nm; 129 hours);
- There was 100% PSO effort while GI-guns were firing during the SO survey; and
- Two observers were on watch for ~72% (234 km; 29 hours) of nighttime GI-gun operations, and one observer was on watch during ~28% (~91 km; 11 hours) of nighttime SO survey.

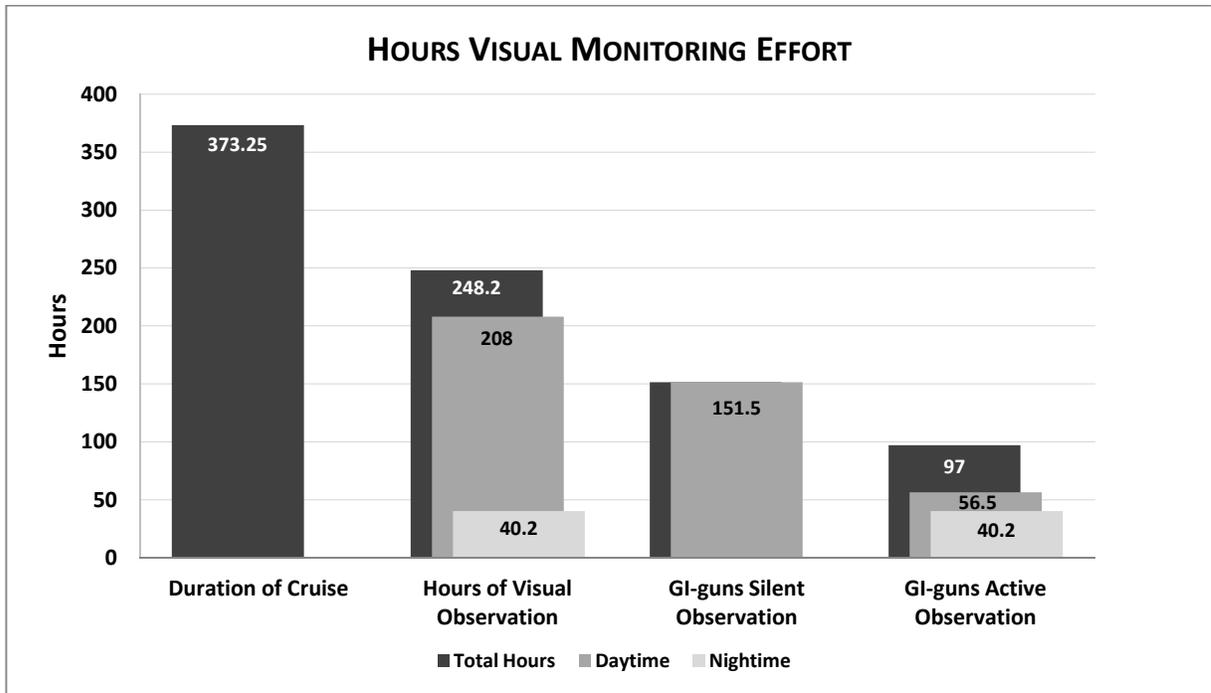


FIGURE 3.0 TOTAL HOURS OF PSO VISUAL MONITORING EFFORT

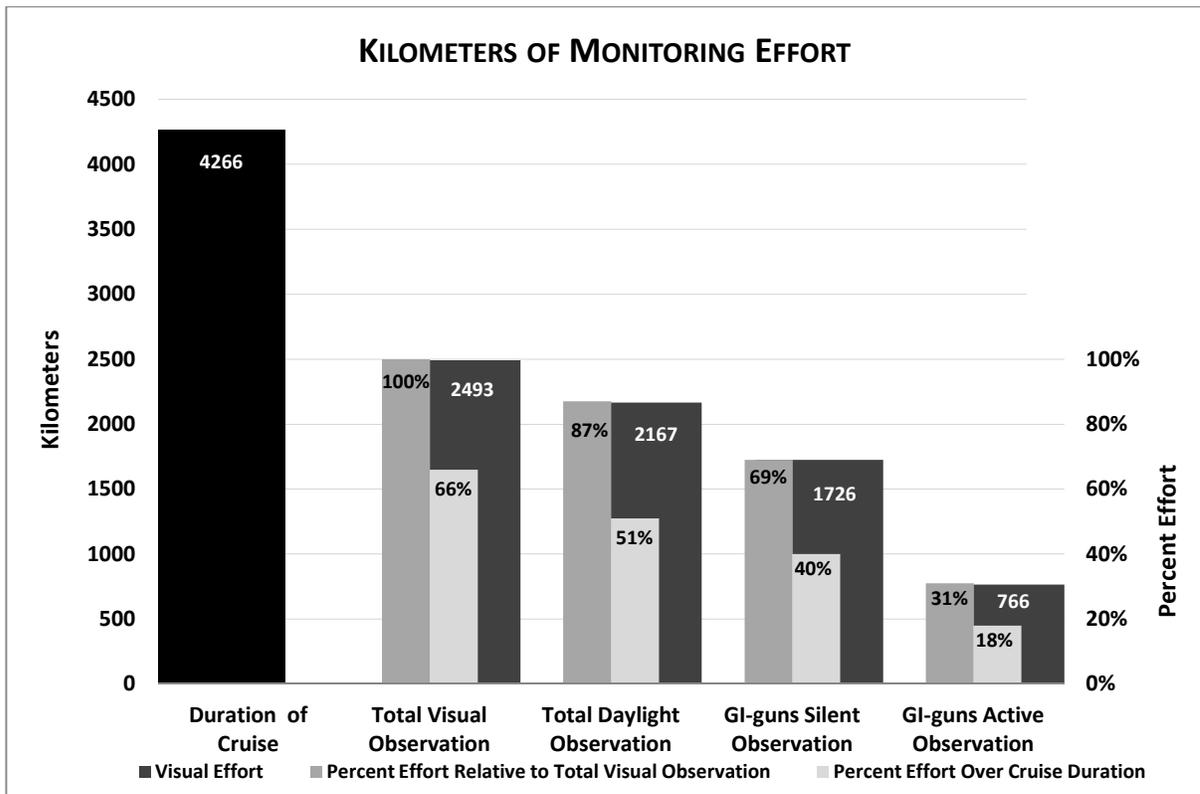


FIGURE 3.1 TOTAL KILOMETERS OF PSO VISUAL MONITORING EFFORT



TABLE 3.4 VISUAL MONITORING EFFORT SUMMARY

	TOTAL	DAYTIME	NIGHTTIME	DISTANCE
Duration of Cruise	373.25 h	-	-	4266 km
Hours of Visual Observation	248.2 h	208 h	40.2 h	2493 km
% Effort of Total Observation Period	100%	84%	16%	
% Effort Over Duration of Cruise	66%	56%	11%	
GI-guns Active Observation	97 h	56.5 h	40.2 h	766 km
% Effort of Total Observation Period	39%	23%	16%	
% Effort Over Duration of Cruise	26%	15%	11%	
GI-guns Silent Observation	151.5 h	151.5 h	-	1726 km
% Effort of Total Observation Period	61%	61%	-	
% Effort Over Duration of Cruise	41%	41%	-	

3.3.2 Sightings and Takes

Estimated Takes

IHA request and BA takes estimates were based on operation of the dual GI-gun array for 14 days, 24 hrs/day, towed at a speed of 4 knots (~7.4 km/hr) approximately 2 to 9 m below the surface. This resulted in an estimated SO survey distance of approximately 2489 km (1344 Nm), which, for the 160 dB re 1 μP.rms isopleth, yielded an estimated ensonified area of ~3335 km². Based on the average (“best”) population density estimates presented in the IHA and BA:

- 2412 cetacea were estimated to potentially be exposed to sound pressure levels ≥160 dB re 1 μPa.rms during the oceanographic survey;
- Of the total number of cetaceans estimated to be exposed, the Navy identified 62 marine mammals ESA-listed as Endangered: 29 fin (< 0.2% of the S. hemisphere population); 1 humpback (<0.004% of the S. hemisphere population); 11 sei (< 0.2% of the population south of 30°S); 1 southern right (< 0.004% of the S. hemisphere population); and 20 sperm (< 0.02% of the S. hemisphere population) whales.

Actual Takes

Observed exposures were significantly less than estimates provided in the IHA and authorized by NMFS. PSO visual monitoring efforts are summarized below and in Appendix A.

- PSO efforts produced 21 sightings totaling 620 individuals;
- Individual sightings were comprised of 618 cetacea and 2 pinnipeds;
- Of the cetacea, 2 ESA-listed species were sighted; the sperm (13 individuals) and fin whale (1 individual);
- The vast majority of sightings were delphinids (~580 individuals, 94% of all animals detected);
- There were no observations of sea turtles during the ARC12 research cruise; and
- No takes were observed during the ARC12 cruise.



Sighting Rates

The majority of sightings of cetacea (14 out of 21; totaling 612 individuals) occurred offshore in the region of the northwestern slope of the Agulhas Plateau where SO studies were conducted (Tables 3.5 and 3.6, Figures 3.2 and 3.3). Waters in the area of the western slope of the Plateau ranged in depths from ~5000 m (16,000 ft) at the foot of the slope, to 2400 m (8000 ft) toward the plateau shelf. Excluding the sightings of ~580 individual delphinids in this area, 32 individual cetacea (out of 38 total non-delphinid cetacea sighted) were observed over the northwest slope of the Agulhas Plateau, to include sperm, fin, and southern bottlenose whales. Of the non-delphinid species, the remaining six (6) individuals, unidentified other than Balaenoptera, were sighted in nearshore environments over the continental shelf, within 75 km of the shoreline, in waters < 300 m in depth.

There were three (3) sighting of delphinid species, all of which were over the northwest slope of the Agulhas Plateau, with only one sighting resulting in identification; a group of ~100 striped dolphins. The other two (2) delphinid sightings were groups of 150 and 330 unidentified individuals.

Out of the 19 cetacean sightings, only the striped dolphin, and sperm, fin, and southern bottlenose whales, were identified. There were 2 sightings (1 individual each) of South African (Cape) fur seals over the continental shelf break on return to port in Cape Town.

Most sightings (18 out of 21) occurred when GI-guns were not operating (Table 3.7). Only three sightings occurred during the SO survey; i.e. 1 sighting of 1 unidentified beaked whale at ~2000 m, and 2 sightings of 330 and 150 unidentified delphinids at ~7000 m and 6700 m, respectively.

The northwest region of the Agulhas Plateau, where the majority of sightings occurred, is also where the bulk of visual monitoring efforts were conducted. Out of 16 days total visual effort, 10 days (27 January 2012 – 5 February 2012) of effort were conducted over the northwest Agulhas slope, which corresponded to ~172 out of a total ~248 hours of visual observation effort (~69%). However, visual monitoring efforts in this region alone does not likely account for increased sightings rates; waters west and south of the Agulhas Plateau shelf see enhanced levels of biological production relative to the surrounding oligotrophic waters of the Southern Ocean.

The Agulhas Return Current, carrying warm water from the Indian Ocean (ranging in temperature from 57 to 79 °F (14 to 26 °C) at the surface), forms a major frontal system with the Subtropical Convergence (STC) and is an area of intense eddy activity, both of which are governed by interaction of the ARC and frontal system with the southern and western boundaries of the Agulhas Plateau. The Agulhas system is a convergence zone that causes the upwelling of cold, nutrient rich waters south of the current, and tends to increase the concentration of plankton in and around the Agulhas system. Both of these factors result in enhanced primary production as compared to the surrounding waters, and are especially true for Agulhas Return Current waters, where chl-a concentrations tend to be significantly higher than the surrounding South Indian Ocean and South Atlantic Ocean waters. The enhanced biological production relative to surrounding waters likely increases forging opportunities for a variety of marine mammal species.



TABLE 3.5 OVERVIEW OF MARINE MAMMAL SIGHTINGS

	ESA	REQ. IHA	NO. OF OBSERVATIONS (DISTANCE)			NO. TAKEN
			< 100 M	100-1000 M	> 1000 M	
Balaenidae						
Fin Whale (<i>Balaenoptera physalus</i>)	E	29		2		0
Antarctic Minke Whale (<i>Balaenoptera bonaerensis</i>)		14				
Blue Whale (<i>Balaenoptera musculus</i>)	E	0				
Bryde's Whale (<i>Balaenoptera edeni</i>)		1				
Common Minke Whale (<i>Balaenoptera acutorostrata</i>)		103				
Humpback Whale (<i>Megaptera novaeangliae</i>)	E	1				
Sei Whale (<i>Balaenoptera borealis</i>)	E	11				
Southern Right Whale (<i>Eubalaena australis</i>)	E	1				
<i>Unidentified Balaenidae</i>					3	
Neobalaenidae						
Pygmy Right Whale (<i>Caperea marginata</i>)		0	0			
Ziphiidae						
Arnoux's Beaked Whale (<i>Berardius arnuxii</i>)		15				
Cuvier's Beaked Whale (<i>Ziphius cavirostris</i>)		12				
Gray's Beaked Whale (<i>Mesoplodon grayi</i>)		11				
Hector's Beaked Whale (<i>Mesoplodon hectori</i>)		9				
Strap-toothed Whale (<i>Mesoplodon layardii</i>)		9				
True's Beaked Whale (<i>Mesoplodon mirus</i>)		10				
Southern Bottlenose Whale (<i>Hyperoodon planifrons</i>)		21			5	0
<i>Unidentified Ziphiidae</i>					1	
Physeteroidea						
Dwarf Sperm Whale (<i>Kogia sima</i>)		0				
Pygmy Sperm Whale (<i>Kogia breviceps</i>)		0				
Sperm Whale (<i>Physeter macrocephalus</i>)	E	20			13	0
Delphinidae						
Striped Dolphin (<i>Stenella coeruleoalba</i>)		626			100	0
Common Bottlenose Dolphin (<i>Tursiops truncatus</i>)		141				
Dusky Dolphin (<i>Lagenorhynchus obscurus</i>)		0				
Long-beaked Common Dolphin (<i>Delphinus capensis</i>)		1				
Pantropical Spotted Dolphin (<i>Stenella attenuata</i>)		20				
Fraser's Dolphin (<i>Lagenodelphis hosei</i>)		0				
Heaviside's Dolphin (<i>Cephalorhynchus heavisidii</i>)		0				
Hourglass Dolphin (<i>Lagenorhynchus cruciger</i>)		3				
Indo-pacific Bottlenose Dolphin (<i>Tursiops aduncus</i>)		0				
Indo-pacific Hump-backed Dolphin (<i>Sousa chinensis</i>)		0				
Risso's Dolphin (<i>Grampus griseus</i>)		210				
Rough-toothed Dolphin (<i>Steno bredanensis</i>)		2				
Short-beaked Common Dolphin (<i>Delphinus delphis</i>)		799				
Spinner Dolphin (<i>Stenella longirostris</i>)		16				
Killer Whale (<i>Orcinus orca</i>)		30				
False Killer Whale (<i>Pseudorca crassidens</i>)		1				
Long-finned Pilot Whale (<i>Globicephala melas</i>)		180				
Pygmy Killer Whale (<i>Feresa attenuata</i>)		1				
Short-finned Pilot Whale (<i>Globicephala</i>)		86				
Southern Right Whale Dolphin (<i>Lissodelphis peronii</i>)		29				
<i>Unidentified Delphinidae</i>					480	
Phocidae						
South African/Cape Fur Seal				2		
Unknown						
<i>Unidentified Large Cetacea</i>				3	1	
<i>Unidentified Med. Size Cetacea</i>					4	
<i>Unidentified Small Cetacea</i>					6	
Total		2412	0	7	613	0

E – U.S. ESA Listed as Endangered

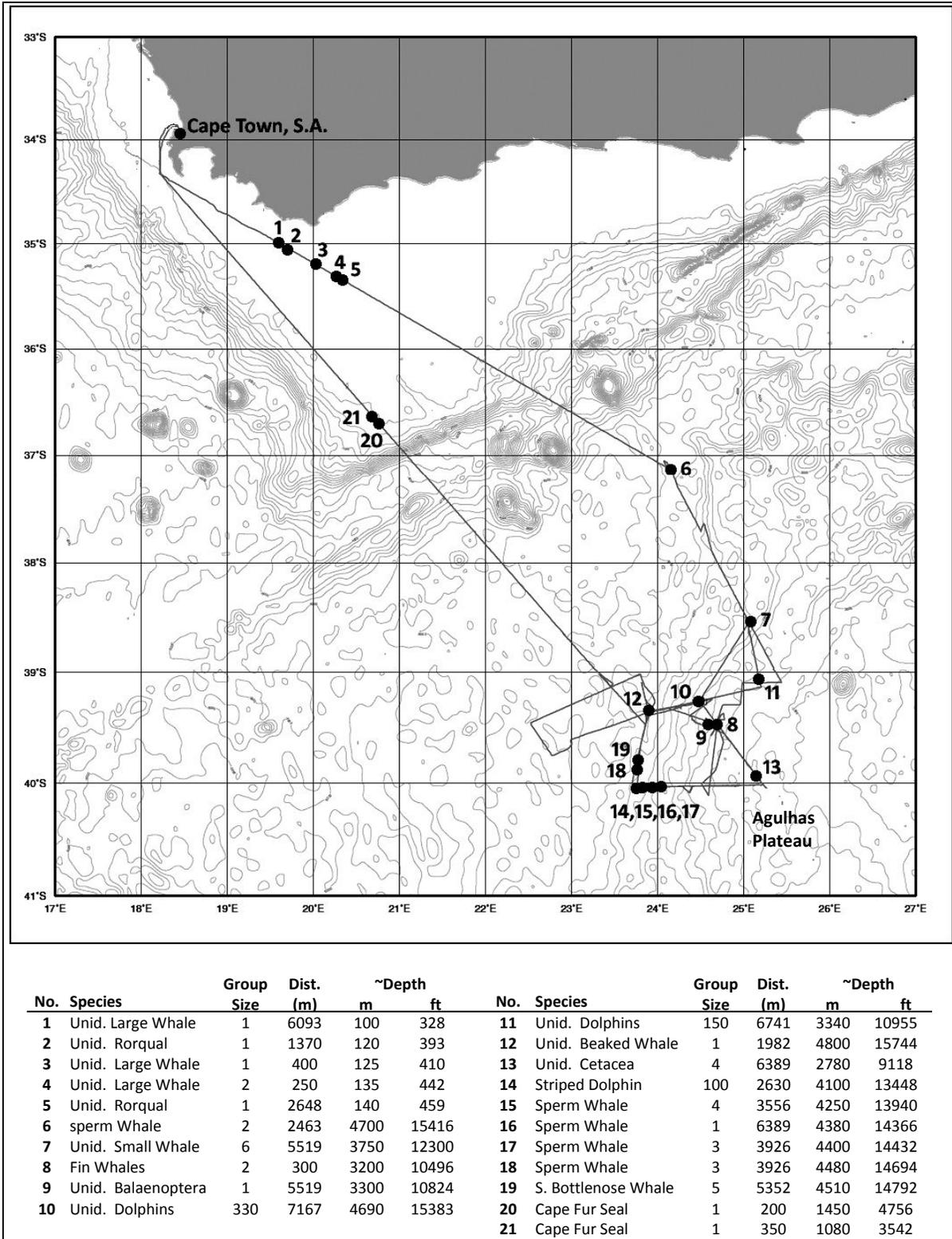


FIGURE 3.2 LOCATION OF MARINE MAMMAL SIGHTINGS: Location and number of sightings during the ARC12 research cruise off the coast of South Africa (No. – sighting number; Dist.- distance; Unid. – unidentified; m – meters; ft – feet).

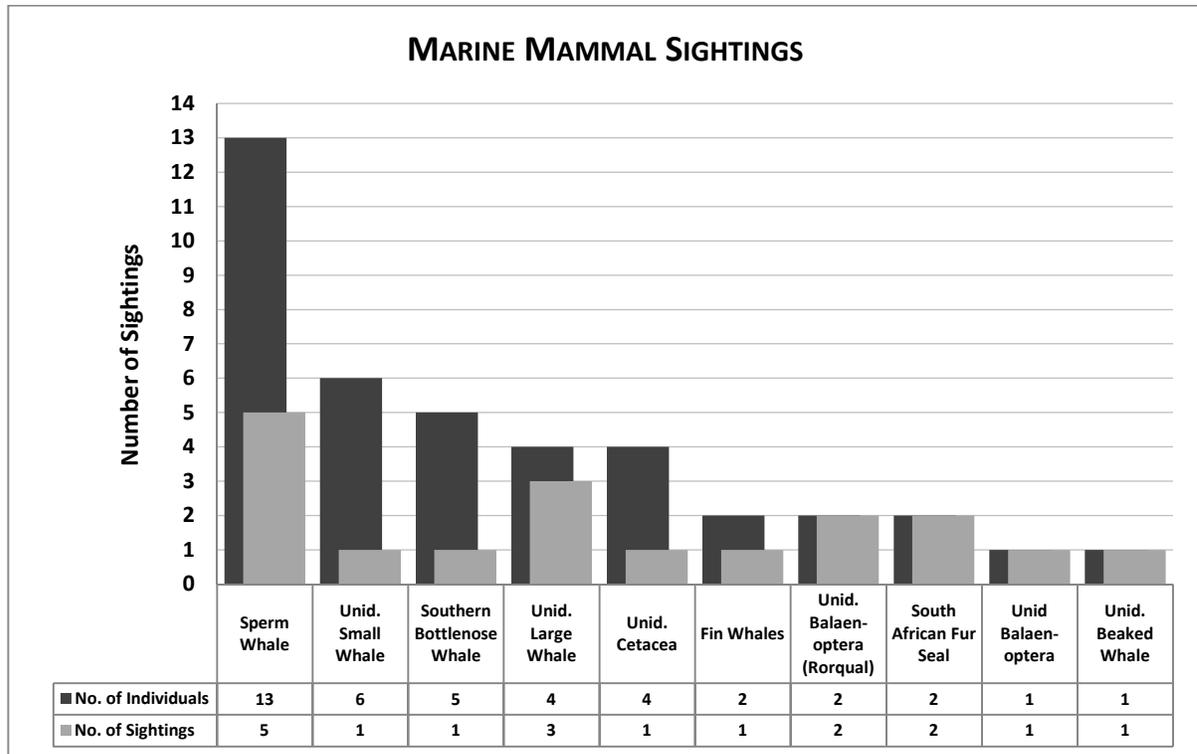


FIGURE 3.3 OVERVIEW MARINE MAMMAL SIGHTINGS: Numbers of sightings and total individuals sighted.

TABLE 3.6 MARINE MAMMAL SIGHTINGS: GI-GUNS ACTIVE VS. GI-GUNS OFF

Species	NON-SO SURVEY			SO SURVEY		
	SIGHTINGS	INDIV.	GROUP SIZE	SIGHTINGS	INDIV.	GROUP SIZE
Unidentified Large Whale	3	4	1, 1, 2			
Unidentified Balaenopterid (Rorqual)	2	2	1, 1			
Unidentified Balaenopterid	1	1	1			
Fin Whales (E)	1	2	2			
Sperm Whale (E)	5	13	2, 4, 1, 3, 3			
Unidentified Small Whale	1	6	6			
Unidentified Beaked Whale				1	1	1
Southern Bottlenose Whale	1	5	5			
Unidentified Cetacea	1	4	4			
Striped Dolphin	1	100	100			
Unidentified Dolphins				2	480	330, 150
South African Fur Seal	2	2	1, 1			
Total	18	139		3	481	
Summary						
Total Sightings	21					
Total Individuals	620					

* Indiv. – number of individual animals



3.3.3 Closest Point of Approach

Closest point of approach (CPA) data is based on few sightings (21), and small numbers of groups and individuals, particularly for periods when GI-guns were operating. Bearing these limitations in mind, Table 3.7 summarizes information on the observed (CPA). Sea state and visual conditions were largely very good throughout the ARC12 cruise, and most sightings were well over 2 km from the RV *Melville*, with a mean CPA for all marine mammals observed of 3902 meters. The closest CPA for cetacea was fin whales, at 300 meters, and unidentified large whales at 350-400 meters.

TABLE 3.7 CLOSEST OBSERVED POINTS OF APPROACH (CPA)

SIGHTING/SPECIES	NO. INDIVIDUALS	DISTANCE (METERS)		MEAN
		NON-SO SURVEY	SO SURVEY	
Delphinidae				
Unid. Dolphins	330		7167	6954
Unid. Dolphins	150		6741	
Striped dolphin	100	2630		-
Balaenidae				
Unid. Rorqual	1	1370		2459.3
Unid. Rorqual	1	2648		
Fin Whales	2	300		
Unid. Balaenopterid	1	5519		
Ziphiidae				
Southern Bottlenose Whale	5	5352		-
Unid. Beaked Whale	1		1982	-
Physeteroidea				
Sperm Whale	2	2463		4052
Sperm Whale	4	3556		
Sperm Whale	1	6389		
Sperm Whale	3	3926		
Sperm Whale	3	3926		
Phocidae				
South African Fur Seal	1	200		275
South African Fur Seal	1	350		
Unknown				
Unid. Large Whale	1	6093		2247.7
Unid. Large Whale	1	400		
Unid. Large Whale	2	250		
Unid. Small Whale	6	5519		-
Unid. Med. Sized Cetacean	4	6389		-

3.3.4 Line Transect Density Estimates

Ideally, visual efforts during the ARC12 research would provide marine mammal population density estimates in the area of study based on detected species; however, population density estimates cannot be provided in this report. The low number of sightings and few animals observed yields insufficient statistical power for any meaningful density estimates to be derived. For line transect data, a minimum sample size of 60 sightings for individual species, with 15 sightings of individuals an



absolute minimum, is typically recommended for estimating densities and detection functions (Barlow et al. 2006; Buckland et al. 2001). The ARC12 monitoring effort produced 21 sightings comprised of mysticetes, delphinids, and beaked whales, with only five sightings resulting in species identification.

3.3.5 Summary and Conclusions

Visual Monitoring

NRL's monitoring and mitigation effort during the ARC12 research cruise was successfully implemented and produced 248.2 hrs of visual observation, out of a total cruise time of 373.25 h (66% effort), and 2493 km of visual effort out of a total cruise distance of 4266 km. No takes were observed during the ARC12 cruise, and implementation of GI-gun shutdowns was not required, as related to sightings of marine mammals or sea turtles.

PSO monitoring efforts produced 21 sightings totaling 620 individuals. Individual sightings were comprised of 618 cetacea and 2 pinnipeds. Of the cetacea, 2 ESA-listed species were sighted; the sperm (13 individuals) and fin whale (1 individual). The vast majority of sightings were delphinids (~580 individuals, 94% of all animals detected). There were no observations of sea turtles during the ARC12 research cruise. The lack of identification of many of the individuals observed was largely due to the distance of the sightings. Most sightings were well beyond 2 km, with a mean CPA for all species of 3902 meters.

Takes Estimates

There is some disparity between estimated/requested takes, and the numbers of individuals visually detected and taken. Certainly, visual observations alone cannot account for the true number of marine mammals and sea turtles present in a given area due to normal surfacing and dive behaviors, which limit visual detection capabilities. Marine mammals spend the majority of their time subsurface, and visual detection of deep-diving cetaceans is limited, in the best of sighting conditions, by the short duration of their surface time compared to their dive time. This is particularly true for night hours when marine animals are not effectively observed and it is unlikely that, if marine mammals and sea turtles were present in the area, they would have been detected during nighttime monitoring efforts. Further, there was no visual observation effort at night when GI-guns were not firing.

Where whale-surfacing behavior is unique among each species of marine mammal, in general, the surface time for most species of whales is on the order of minutes. An in-depth discussion of this topic is beyond the scope of this report; however, a few examples are provided. Minke whale inter-breath interval (IBI), or surface time, has been observed to average ~70 seconds (Christiansen et al. 2011); sperm whales 3-9 min after commonly diving for 40-50 minutes (Acevedo-Gutiérrez et al. 2002; Drouot et al. 2004; Watwood et al. 2006); and Cuvier's and Mesoplodon beaked whales 2-3 minutes (Barlow et al. 2006). Blue whales off California coast have been observed to average 7-10 minutes at the surface, and spend 94% of time subsurface (Lagerquist et al. 2000). Similarly, humpback and fin whales have been observed to spend ~10% and 25 % of their time at the surface, respectively (Díaz López et al. 2000). Right whales have been found to spend ~20% of time at the



surface, with a mean surface time of 1 to 10 min for juvenile and adults, respectively (Hain et al. 1999).

If, at surface, the probability of detecting certain species of marine mammals also varies relative to an animal's size, distance from the vessel, and regional population density. Where visual detection is a viable method for detecting many species of marine mammals, it is not particularly effective for certain species such as beaked whales and smaller less conspicuous whales and porpoises (e.g., *Kogia* spp.). By example: The effective search width for beaked whales is commonly considered to be 1 km for experienced observers using binoculars under excellent or good sighting conditions. Further, the encounter rate for beaked whales decreases rapidly as survey conditions deteriorate from Beaufort sea state of 1 to 5. Barlow (1999, 2006) noted that under good observational conditions, perhaps only 23% of Cuvier's and 45% of Mesoplodon beaked whales are visually detected when located directly on the trackline (Barlow 1999; Barlow et al. 2006). In general, the probability of visually detecting beaked whales is considered very low and visual monitoring is of limited efficacy for these species.

While there are too few sightings and insufficient numbers of individuals to provide any spatial distribution statistics (e.g., density estimates and detection probabilities), other transect survey-based studies provide some insight into the likelihood of visual detection of certain species of cetacea. Heide-Jorgensen et al. (2007) found a detection probability of 0.5 for minke whales in Greenlandic waters at 200 m (Heide-Jorgensen et al. 2007), and Stern (1992) estimated the probability of a minke whale surfacing within 1 km of a vessel traveling at 3, 6, and 12 kts to be 0.96, 0.88, and 0.47 respectively (Stern 1992). Similarly, Barlow and Rankin (2004) estimated a detection probability for sperm whales of 0.63, at a truncation distance of 6 km, in a study in the eastern Pacific Ocean (Barlow and Rankin 2004). The detection probability for fin and humpback whales has been observed to be approximately 0.2 and 0.3, respectively, at a distance of 1 km, for waters off British Columbia (Williams and Thomas 2007).

Detection probabilities vary relative to environmental conditions, species numbers, behavioral characteristics, and distributions; however, the few examples provided are illustrative of the fact that visual detection is inherently limited by nature, and visual efforts on the ARC12 cruise necessarily under-represent the actual number of marine mammals and sea turtles present in the area in which activities were conducted.

Bearing the limitations of visual monitoring and considering the disparity between estimated takes versus the number of individuals taken, let alone observed, it is likely that takes estimates provided in the IHA request overestimated the numbers of individuals potentially exposed to sounds ≥ 160 dB re 1 μ Pa.rms, as opposed to this disparity deriving from visual observation efforts alone. Marine mammal population density estimates provided in the IHA request were derived from the Navy Global Marine Species Density Database (GMSDD), which provides 3 separate density estimates for any given region, across all four seasons: a minimum, average, and maximum estimated density. The IHA request used GMSDD "average" population density estimates for January-February period in which activities were conducted. NRL employed the average density estimates, as these are the most commonly employed by federal agencies, academic institutions, and the oil and gas industry, when assessing takes.



While no statistical analyses (e.g., Density (D), sighting probability density $f(0)$) can be presented due to the limited numbers sightings, and number of individuals sighted, empirical observation of the data in Table 3.8 suggests use of GMSDD average populations density estimates, in this instance, likely overestimated the numbers of takes. Where average population density estimates yielded 2412 estimated takes, GMSDD minimum population density estimates yield 852 exposures to sound pressure ≥ 160 dB re 1 μ Pa.rms. When evaluating exposures using average density estimates, and using the area of waters actually ensonified to ≥ 160 dB during the ARC21 cruise (1005 km² versus the estimated 3335 km²), takes estimates are 728. When evaluating minimum population density estimates, takes estimates are 852 and 255, based on the original estimated ensonified area of 3335 km², and the actual ensonified area of 1005 km², respectively.

Considering no takes were observed and the few numbers of marine mammals sighted in the area, and bearing in mind detection probabilities for individual species in a given area, minimum population density estimates, for this area and time of year, appear to yield a more reasonable estimate of the number of individuals potentially exposed to sound ≥ 160 dB re 1 μ Pa.rms.

In summary, PSO visual efforts suggest that the number of marine mammals exposed to ≥ 160 dB re 1 μ Pa.rms was significantly below the number of “takes” estimated prior to the SO survey. Out of 2412 estimated takes of marine mammals, none were observed. PSO monitoring efforts produced 21 sightings totaling 620 individuals, and of these, the vast majority of sightings were delphinids (580 individuals, 94% of all animals detected).

TABLE 3.8 ESTIMATED NUMBER OF MARINE MAMMALS EXPOSED TO ≥ 160 dB RE 1 PA.RMS

	EST. EXPOSURES TO ≥ 160 dB RE 1 PA.RMS BASED ON:				NO. OF ANIMALS OBSERVED / EXPOSED TO ≥ 160 dB
	AVE. POP. DENS. EST: IHA REQ. [3335 KM ²]	AVE. POP. DENS. EST. [1005 KM ²]	MIN. POP. DENS. EST. [3335 KM ²]	MIN. POP. DENS. EST. [1005 KM ²]	
Balaenidae					
Fin Whale (<i>Balaenoptera physalus</i>)	29	9	1		2/0
Antarctic Minke Whale (<i>Balaenoptera bonaerensis</i>)	14	4	9	3	
Blue Whale (<i>Balaenoptera musculus</i>)	0				
Bryde's Whale (<i>Balaenoptera edeni</i>)	1				
Common Minke Whale (<i>Balaenoptera acutorostrata</i>)	103	31	67	20	
Humpback Whale (<i>Megaptera novaeangliae</i>)	1				
Sei Whale (<i>Balaenoptera borealis</i>)	11	3	1		
Southern Right Whale (<i>Eubalaena australis</i>)	1				
<i>Unidentified Balaenidae</i>					3/0
Total Balaenidae	160	47	78	23	5/0
Neobalaenidae					
Pygmy Right Whale (<i>Caperea marginata</i>)	0		0		
Ziphiidae					
Arnoux's Beaked Whale (<i>Berardius arnuxii</i>)	15	4			
Cuvier's Beaked Whale (<i>Ziphius cavirostris</i>)	12	4	2	1	
Gray's Beaked Whale (<i>Mesoplodon grayi</i>)	11	3	2		
Hector's Beaked Whale (<i>Mesoplodon hectori</i>)	9	3	1		
Strap-toothed Whale (<i>Mesoplodon layardii</i>)	9	3	2		



EST. EXPOSURES TO ≥160 dB RE 1 PA.RMS BASED ON:

TABLE 3.8 CONT'D

	AVE. POP. DENS. EST: IHA REQ. [3335 km ²]	AVE. POP. DENS. EST. [1005 km ²]	MIN. POP. DENS. EST. [3335 km ²]	MIN. POP. DENS. EST. [1005 km ²]	NO. OF ANIMALS OBSERVED / EXPOSED TO ≥160 dB
Ziphiidae (cont'd)					
True's Beaked Whale (<i>Mesoplodon mirus</i>)	10	3	1		
Southern Bottlenose Whale (<i>Hyperoodon planifrons</i>)	21	6	1		5/0
<i>Unidentified Ziphiidae</i>					1/0
Total Ziphiidae	87	26	9	1	6/0
Physteridae					
Dwarf Sperm Whale (<i>Kogia sima</i>)	0				
Pygmy Sperm Whale (<i>Kogia breviceps</i>)	0				
Sperm Whale (<i>Physeter macrocephalus</i>)	20	6	3	1	13/0
Total Physteridae	20	6	3	1	13/0
Delphinidae					
Striped Dolphin (<i>Stenella coeruleoalba</i>)	626	189	92	28	100/0
Common Bottlenose Dolphin (<i>Tursiops truncatus</i>)	141	43	36	11	
Dusky Dolphin (<i>Lagenorhynchus obscurus</i>)	0				
Long-beaked Common Dolphin (<i>Delphinus capensis</i>)	1				
Pantropical Spotted Dolphin (<i>Stenella attenuata</i>)	20	6			
Fraser's Dolphin (<i>Lagenodelphis hosei</i>)	0				
Heaviside's Dolphin (<i>Cephalorhynchus heavisidii</i>)	0	3	3	1	
Hourglass Dolphin (<i>Lagenorhynchus cruciger</i>)	3	1			
Indo-pacific Bottlenose Dolphin (<i>Tursiops aduncus</i>)	0		1		
Indo-pacific Hump-backed Dolphin (<i>Sousa chinensis</i>)	0				
Risso's Dolphin (<i>Grampus griseus</i>)	210	63	144	44	
Rough-toothed Dolphin (<i>Steno bredanensis</i>)	2				
Short-beaked Common Dolphin (<i>Delphinus delphis</i>)	799	241	426	128	
Spinner Dolphin (<i>Stenella longirostris</i>)	16	5	13	4	
Killer Whale (<i>Orcinus orca</i>)	30	9	11	3	
False Killer Whale (<i>Pseudorca crassidens</i>)	1				
Long-finned Pilot Whale (<i>Globicephala melas</i>)	180	54	4	1	
Pygmy Killer Whale (<i>Feresa attenuata</i>)	1				
Short-finned Pilot Whale (<i>Globicephala macrorhynchus</i>)	86	26	29	9	
Southern Right Whale Dolphin (<i>Lissodelphis peronii</i>)	29	9	3	1	
<i>Unidentified Delphinidae</i>					480/0
Total Delphinidae	2145	649	762	230	580/0
<i>Unidentified Large Cetacea</i>					4/0
<i>Unidentified Med. Size Cetacea</i>					4/0
<i>Unidentified Small Cetacea</i>					6/0
Total Unidentified					11/0
Total	2412	728	852	255	618/0



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APPENDIX 1

Table A.1 Marine Mammal Sighting Summary

Animal Information			GMT Date & Time		Ship and Position Information			Airgun State	Weather				Animal Behavior					
No.	Species	Grp. Size	Y/M/D	Time	LAT	LON	Ship Speed (kt)	No. Gi-guns Active	Sea State	Sun Glare	Visibility		At First Sighting	After Initial Sighting	Apparent Reaction	Heading (degree)	Bearing (degree)	Dist. in Meters
											km	Light/dark						
1	Unid. Large Whale	1	12/1/2024	0615	34° 59.2	19° 34.9	7.4	0	4	none	5	light	blow	dove	none	Unk.	27	6093
* Single blow just below horizon line.																		
2	Unid. Rorqual	1	12/1/2024	0638	35° 1.1	19° 38.9	10	0	5	12,3	5	light	blow	dove	none	Unk.	38	1370
* Large tall columnar blow, no animal observed breaking the surface.																		
3	Unid. Large Whale	1	12/1/2024	0925	35° 14.5'	20° 7.2'	9.3	0	5	11,0	5	light	blow	dove	none	Unk.	50	400
* Observed two low bluish blows spaced 1 minute apart at 300 to 400 m. Waves were too choppy to identify the animal																		
4	Unid. Large Whale	2	12/1/2024	1031	35° 20.0'	20° 18.7'	10	0	5	10,1	5	light	blow	dove	none	Unk.	25	250
* Low bluish blow, animal just beneath surface, could not be identified. Initially at 25 degrees right and 250-300 m. Second observation was a blow at ~ 150 degrees right at ~ 500 m.																		
5	Unid. Rorqual	1	12/1/2024	1040	35° 20.8'	20° 20.2'	10	0	5	11,1	5	light	blow	dove	none	Unk.	78	2648
* Tall columnar blow 12' to 14', consistent with Balaenoptera. Two successive respirations, then no activity. No skin or fin was visible.																		
6	Sperm Whale	2	12/1/2025	1527	37° 13.7'	24° 12.1'	4.8	0	1	4,2	5	light	blow	fluked	none	340	-60	2463
* Low puffy forward blows given repeatedly while whales "logged" at the surface. Two animals fluked out. 10 minutes later observed an animal at the surface, breathing for ~ 12 respirations before fluking out.																		
7	Unid. Small Whale	6	12/1/2026	0750	38° 32.2'	25° 3.5'	2.5	0	3	10,1	5	light	blow	dove	none	160	-48	5519
* Low diffuse blows close together. Observed two quick glimpses of head and one of dorsal fin, but animals could not be identified.																		
8	Fin Whales	2	12/1/2027	747	39° 28.3'	24° 42.3'	9.3	0	4	9,2	5	light	Splash/fast travel	feeding	none	100	50	300
* Two Fin whales observed at ~ 300 m, trigger like dorsal fins, dark steel gray rostrum, white lip. Whales were surface lunging. At least one whale circled back towards ship before continuing on same direction ~ 130 degrees relative to ship direction.																		
9	Unid. Balaenopterid	1	12/1/2027	1400	39° 28.6'	24° 42.6'	1	0	4	7,1	5	light	blow	Unk.	none	Unk.	100	5519
* Tall columnar blows from at least one large whale. Could not be identified.																		
10	Unid. Dolphins	330	12/1/2029	548	39° 15.4'	24° 30.7'	5.1	2	3	1,3	5	light	Splash/fast travel	ran out of sight	none	0	35	7167



	<p>* Medium sized dolphins. Too distant to discern markings or coloration. Running when first observed at 6-7 kts. Tight formation. Dorsal fins present. 10-15 petrels and albatross over school. Common or striped dolphins are best guess. Continued to speed away, a fair amount of jumping as they traveled.</p>																	
11	Unid. Dolphins	150	12/1/2029	1341	39° 9.6'	25° 3.3'	3.4	2	4	8,1	5	light	Splash/fast travel	Unk.	none	20	-42	6741
	<p>* Observed one unidentified dolphin leap out of the water and splash back down at ~ 3.6 Nm. Active, fast movement at ~ 4 kts, splashing, perhaps chasing prey.</p>																	
12	Unid. Beaked Whale	1	12/2/2003	1531	39° 26.8'	23° 52.3'	4.4	2	2	9,3	5	light	Body/slow travel	Unk.	none	unk	28	1982
	<p>* Dark moderate sized unidentified whale, small dorsal fin. Individual moving at ~ 270 degrees relative to bow, at 1-2 kts. Appeared to be swimming slowly. No blows, disappeared with no re-sighting at 1-1.5 Nm</p>																	
13	Unid. Cetacean	4	12/2/2004	1615	39° 58.13'	25° 11.1'	4.9	0	3	4,3	5	light	Splash/fast travel	Unk.	none	160	38	6389
	<p>* Moderate size, strong, short, puffy blows. Rooster tail in the wake. Perhaps beaked whales; B. adnaxii, T. sheperdi, or H. planifrons. Fast swimming, blowing hard at surface, close together. Disappeared with no re-sighting.</p>																	
14	Striped Dolphin	100	12/2/2005	558	40° 01.99'	24° 04.18'	6	0	2	none	5	light	Splash/fast travel	Unk.	none	160	45	2630
	<p>* Tight group traveling at first 180 to 110 degrees rel. to bow. Jumping, porpoising, traveling fast at ~ 6 kts. Continued moving starboard. Momentarily changed direction to move in same direction as vessel. Vessel stopped. Whole group quieted down, staying low in water. Vessel continued.</p>																	
15	Sperm Whale	4	12/2/2005	932	40° 2.5'	23° 57.1'	8	0	3	5,1	5	light	Blow/slow travel	Slow Travel	none	0	80	3556
	<p>* Black body, small dorsal nub, angled blow forward. 2 individuals of approx. equal size. Surfaced and blew very close together. Tight group traveling in same direction.</p>																	
16	Sperm Whale	1	12/2/2005	1005	40° 2.1'	23° 49.6'	9.3	0	2	4,1	5	light	blow	Fluked	none	340	17	6389
	<p>* Low puffy blows, tail fluke, large and black. Moving at ~ 2 kts at 3.45 Nm.</p>																	
17	Sperm Whale	3	12/2/2005	1020	40° 2.07'	23° 47.5'	9.3	0	2	4,1	5	light	blow	Spyhop, Blow	none	0	61	3926
	<p>* At least one young animal, one large animal, on medium sized animal, logging at surface, and moving at 1.5 kts at 2.12 Nm</p>																	
18	Sperm Whale	3	12/2/2005	1329	39° 50.3'	23° 47.1'	10.1	0	3	10,1	5	light	blow	Slow Travel	none	200	-60	3926
	<p>* Black dorsal hump, forward left blow. Blowing slowly and logging/slow swimming at surface. Two individuals traveling very close together, blowing one after the other. One at 2.12 Nm, another at 3-4 Nm</p>																	
19	S. Bottlenose Whale	5	12/2/2005	1533	39° 38.1'	23° 48.6'	4.7	0	3	9,2	5	light	fast travel	Unk.	none		65	5352
	<p>* Large 19-20' whales in tight formation, swimming fast. Observed dorsal fin on large rounded unmarked backs. Only other large whales in this region would be Tasmacetus or Arneaux's beaked whale. Both are ruled out - one for lack of coloration and slender body, the other based on small size of the whale and differing characteristics. Puffy blows. Group was moving away at a good clip when first spotted. Multiple puffy blows issued almost simultaneously.</p>																	



20	South African/Cape Fur Seal	1	12/2/2007	721	36° 42.1'	20°45.7'	11.5	0	3	4,1	4	light	Body/resting at surface	Resting at Surface	took flippers out of air and rolled once, then flippers back up	none	25	200	
* Observed flippers only. resting at surface.																			
21	South African/Cape Fur Seal	1	12/2/2007	724	36° 41.8'	20° 45.3'	11.5	0	3	4,1	4	light	Body/resting at surface	Resting at Surface	none	none	85	350	
* Observed flippers only. resting at surface.																			

* No. – sighting number; Grp. – group; Dist. – distance; Unk. – unknown; kt - knot